Energy Transition Pathways for the 2030 Agenda

SDG 7 Roadmap for Timor-Leste

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 Timor-Leste

**Developed using the National Expert SDG 7
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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The ESCAP secretariat supports inclusive, resilient and sustainable development in the region by generating action-oriented knowledge, and by providing technical assistance and capacity-building services in support of national development objectives, regional agreements and the implementation of the 2030 Agenda for Sustainable Development.

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United Nations publication

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Foreword: ESCAP

As an island state fully dependent on imported petroleum fuels, Timor-Leste faces a profound challenge in securing reliable, affordable and sustainable energy services. Strengthening efforts towards achieving Sustainable Development Goal (SDG) 7 is timely and essential, as advancing a sustainable, secure and cost-effective energy system will play a pivotal role in supporting Timor-Leste's development pathway. It will, of course, also accelerate progress towards the broader 2030 Agenda.

ESCAP extends its sincere appreciation to the General Directorate for Regulation of the Electricity, Water and Sanitation Sectors (Direção-Geral para a Regulação dos Setores de Eletricidade, Água e Saneamento (DGREAS)) of Timor-Leste for its strong leadership and close collaboration in developing the SDG 7 Road Map. This joint endeavour reflects the Government's commitment to achieving the ambitious objectives of SDG 7 and the Paris Agreement. The Road Map provides a comprehensive assessment of existing energy policies and plans, identifies critical gaps and offers targeted recommendations for strengthening policy frameworks and deploying appropriate technological interventions. Importantly, it also presents an in-depth analysis of energy transition pathways toward net zero emissions by 2050.

Developed using the National Expert SDG Tool for Energy Planning (NEXSTEP) framework, the Road Map adopts a holistic and evidence-based approach to energy planning. It identifies practical technological options and policy measures to guide Timor-Leste's sustainable energy transition, including expanding access to clean cooking technologies, electrifying the transport sector and implementing energy-efficient cooking practices. Formulated through extensive consultation with national policymakers and experts, the Road Map reflects a nuanced understanding of Timor-Leste's unique context, resource endowments and development aspirations, ensuring strong alignment with national strategies and global commitments.

While Timor-Leste is on track to achieve universal access to electricity by 2030, intensified efforts are required to extend access to clean cooking fuels to nearly half of the population that continues to rely on polluting alternatives. The Road Map underscores the importance of prioritizing energy efficiency—particularly in the transport sector—to reduce dependence on petroleum products and enhance long-term energy security. The collaboration between ESCAP and DGREAS demonstrates a shared vision and collective resolve to translate the Sustainable Development Goals into tangible national outcomes.

This Road Map is a strategic blueprint for continued prosperity, resilience and inclusive growth. I look forward to the successful implementation of this Road Map and its contribution to building a secure, sustainable and healthy energy future for the people of Timor-Leste.

Armida Salsiah Alisjahbana
Under-Secretary-General of the United Nations and
Executive Secretary of the Economic and Social Commission
for Asia and the Pacific

Foreword: Timor-Leste

It is with great appreciation that I acknowledge the invaluable support provided by ESCAP and all key stakeholders to the Direcao-Geral para a Regulacao dos Setores de Eletricidade, Agua e Saneamento (DGREAS) in the development of the Sustainable Development Goal 7 (SDG 7) Road Map for Timor-Leste. SDG 7 serves as a cornerstone for achieving the broader Sustainable Development Goals and lays the foundation for a sustainable, affordable, and long-term energy transition for the country. This Road Map addresses essential dimensions of the energy system, including access to modern energy services, renewable energy deployment, and improvements in energy efficiency.

The collaborative effort between DGREAS and ESCAP has provided a timely and important opportunity to review Timor-Leste's progress toward SDG 7 targets and the Nationally Determined Contribution (NDC). Guided by the National Expert SDG Tool for Energy Planning (NEXSTEP), the Road Map adopts an integrated and holistic approach to energy transition planning. I am encouraged that a comprehensive assessment of the energy sector has bee nundertaken, resulting in clear and actionable recommendations for policy enhancement and sectoral reforms.

The findings reaffirm that Timor-Leste is on track to achieve universal access to electricity by 2030. However, they also highlight the urgency of addressing the continued reliance on polluting cooking fuels, which may affect nearly one million people by 2030 without targeted interventions. The analysis further underscores the need for a substantial increase in the share of renewable energy in total final energy consumption, given the country's current dependence on petroleum fuels. Encouragingly, the SDG scenario demonstrates that a rise from 0.1 per cent in 2021 to 25.5 per cent in 2030 is attainable by harnessing Timor-Leste's abundant indigenous renewable resources. Achieving the national energy efficiency objectives will also require the introduction of minimum energy performance standards (MEPS), building energy codes,and the promotion of electric mobility.

This Road Map is the result of an open, transparent, inclusive, and participatory consultation process, reflecting the collective commitment of all involved. The successful partnership between ESCAP and DGREAS highlights our shared dedication to advancing Timor-Leste's sustainable energy vision and contributing to the achievement of the 2030 Agenda for Sustainable Development.

I look forward to continued collaboration as we move toward implementing the recommendations outlined in this Road Map and supporting a resilient, equitable, and sustainable energy future for Timor-Leste.
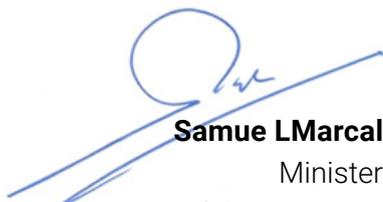
Samue LMarcal
Minister
Ministry of Public Works

Abbreviations and acronyms

BAU	business-as-usual		MCDA	Multi-Criteria Decision Analysis
CBA	cost-benefit analysis		MEPS	minimum energy performance standard
CO_2	carbon dioxide			
CPS	current policy scenario		MJ	megajoule
EE	energy efficiency		MJ/USD_{2017}	megajoules per US$ of gross domestic product in terms of power purchase parity in 2017
ESCAP	United Nations Economic and Social Commission for Asia and the Pacific			
EV	electric vehicle		MTF	Multi-Tier Framework
GDP	gross domestic product		Mtoe	million tons of oil equivalent
GHG	greenhouse gas		MW	megawatt
GW	gigawatt		MWh	megawatt-hour
GWh	gigawatt-hour		MWh/kWp	megawatt-hour per kilowatt-peak
ICS	improved cooking stove		NDC	Nationally Determined Contributions
IEA	International Energy Agency			
IPCC	Intergovernmental Panel on Climate Change		NEXSTEP	National Expert SDG Tool for Energy Planning
IRENA	International Renewable Energy Agency		PP	power plant
			PV	photovoltaic
IRR	Internal Rate of Return		RE	renewable energy
$MtCO_2$-e	million tons of carbon dioxide equivalent		SDG	Sustainable Development Goals
			TFEC	total final energy consumption
ktoe	thousand tons of oil equivalent			
kWh	kilowatt-hour		TPES	total primary energy supply
LCOE	levelized cost of electricity		US$	United States dollar
LEAP	Low Emissions Analysis Platform		WHO	World Health Organization
LPG	liquified petroleum gas		W/m^2	watts per square metre

Executive Summary

Transitioning the energy sector to achieve the goals of the 2030 Agenda for Sustainable Development and the objectives of the Paris Agreement presents a complex and difficult task for policymakers. It requires sustaining economic growth, responding to increasing energy demand, reducing emissions, and considering and capitalizing on the interlinkages between SDG 7: Affordable and Clean Energy and the other SDGs. 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.

This *SDG 7 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 of Timor-Leste to consider. The key objective is to assist the Government in developing enabling policy measures to achieve the SDG 7 targets through a matrix of technological options and policy actions. The Road Map introduces three key scenarios: the business-as-usual (BAU) scenario; the current policy scenario (CPS); and the Sustainable Development Goals (SDG) scenario. These scenarios are expected to enable the Government to make informed decisions for developing and implementing a set of policies to achieve SDG 7 by 2030, together with the NDCs.

A.   Highlights of the Road Map

Achieving universal access to electricity is a priority for the Government which aims to reach a 100 per cent access rate by 2030. In 2021, 97 per cent of the population of Timor-Leste had access to electricity, which is an indication that the country is on track to achieve universal access by 2030. However, universal access to clean cooking technology and fuel has been and is expected to remain limited under the current policy scenario (CPS). In 2021, 14.3 per cent of the population had access to clean cooking technology and this rate is estimated to increase to 28.5 per cent by 2030, in the current policy context, leaving about 1 million people still relying on unclean fuel for cooking in 2030. Therefore, well-planned and concerted efforts will be needed to achieve universal access to clean cooking by 2030.

While Timor-Leste produces a substantial amount of energy resources (oil and gas), these are exported and the country meets its domestic energy needs through imports. As an island nation heavily reliant on imported energy resources, energy security remains high on the country's development agenda. Therefore, key aims should include diversification of the power generation mix, with a focus on indigenous sources (such as solar and wind), and a reduction in the reliance on imported petroleum fuel. This aligns with the SDG 7 target on renewable energy, as achieving this goal will require the share of renewable energy (RE) in the total final energy consumption (TFEC) to grow significantly from the 2021 share of 0.1 per cent (excluding traditional biomass).

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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.

Furthermore, improvements in energy efficiency are required across different sectors, as energy intensity in Timor-Leste declined at an average annual rate of 2.4 per cent between 2002 and 2010. To achieve national targets, an average annual increase rate of 4.8 per cent will be needed between 2010 and 2030.

B.   Achieving SDG 7 and NDC targets in Timor-Leste by 2030

1. Universal access to electricity

In 2021, the electrification rate in Timor-Leste was 97 per cent. Based on the historical trend, it is expected that universal access to electricity will be achieved by 2030. The Timor-Leste Strategic Development Plan 2011-2030 aims to provide electricity access for all households either through the conventional expansion of the national grid system or using renewable energy systems by 2030 (Timor-Leste, 2011). NEXSTEP analysis suggests that mini/off-grid technologies, such as solar mini-grid and solar home systems are the more appropriate technologies, given their cost-effectiveness, climate resilience and potential to reduce reliance on imported fossil fuels.

2. Universal access to clean cooking technology

Access to clean cooking fuels and technologies in Timor-Leste has been and is expected to remain low in the absence of concerted efforts from all stakeholders. Under the current policy scenario, access to clean cooking is projected to reach only 28.5 per cent in 2030 from 14.3 per cent in 2021 (figure I). This would leave about 1 million people (or just over 200,000 households) still relying on polluting solid fuel stoves (assuming biomass as the primary fuel) for cooking in 2030,exposing them to harmful household air pollution and increasing the risks of non-communicable diseases such as strokes, ischaemic heart disease, chronic obstructive pulmonary disease and lung cancer, particularly among women and children (WHO, 2024).

Figure I.   **Access to clean cooking under the business-as-usual (BAU), current policy (CP) and Sustainable Development Goals (SDG) scenarios in Timor-Leste[2]**
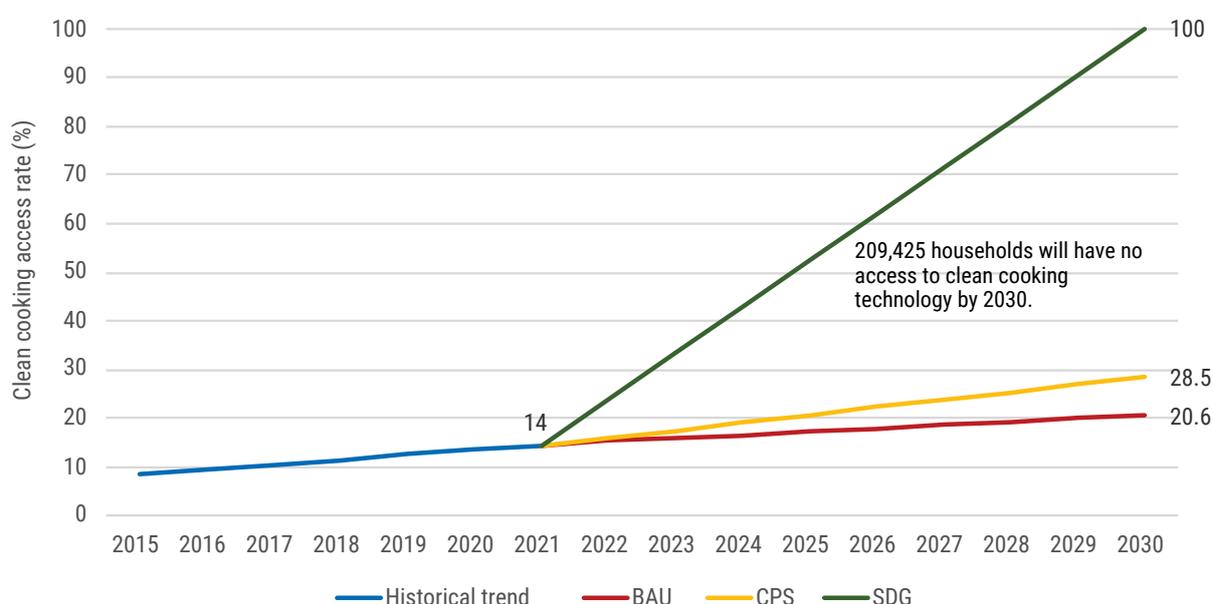
Source: ESCAP.

Note: BAU = business-as-usual scenario; CPS = current policy scenario; SDG = Sustainable Development Goals scenario.

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2   Historical trend projection is based on the access rate data for the year 2000, provided by the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP), "Asia Pacific Energy Portal", 2022a. The 2021 access rate was provided by the national consultant.

NEXSTEP identifies electric cooking stoves as the most appropriate solution for Timor-Leste, given their cost and environmental effectiveness, particularly in urban areas. In locations where access to reliable electricity supply might be difficult, improved cooked stoves (ICS) can serve as a transitional technology until suitable electricity networks become available.

3. Renewable energy

In 2021, the share of modern renewable energy (excluding traditional biomass usage in residential cooking) in the total final energy consumption (TFEC) was 0.04 per cent. Based on the current policy scenario, the share of renewable energy is projected to increase to 17.9 per cent by 2030 due to the projected increase in renewable electricity. In the SDG scenario, the share of renewable energy is projected to improve to 25.5 per cent of TFEC in 2030. The additional 7.6 percentage point increase can be attributed to the phase-out of traditional biomass use and the application of several energy efficiency measures.

4. Energy efficiency

A doubling of the 1990-2010 improvement rate is required to achieve the SDG 7.3 target. Since Timor-Leste gained independence in 2002, the improvement rate has been calculated for the period between 2002 and 2010. During this time, energy intensity in Timor-Leste declined at an average annual rate of 2.4 per cent. Therefore, achieving the SDG 7.3 target requires an average annual increase rate of 4.8 per cent between 2010 and 2030.

Under the current policy scenario, the energy intensity is projected to drop from 1.8 MJ/USD_{2017} in 2021 to 1.6 MJ/USD_{2017} in 2030. The energy efficiency target is met under the SDG scenario, reaching 1.3 MJ/USD_{2017} by 2030. This is primarily due to the phase-out of inefficient cooking technologies and their replacement with more efficient LPG stoves and ICS. In addition, further reductions in energy intensity can be achieved through the proposed measures for the residential and transport sectors. Increasing the adoption of minimum energy performance standards and labelling (MEPSL) for lighting, refrigeration and air-conditioning. Introducing electric vehicles for government ministries can also be a viable solution for Timor-Leste to reduce overall energy demand.

5. Nationally Determined Contributions (NDCs)

In its Nationally Determined Contributions (NDCs), Timor-Leste chose not to set a GHG reduction target and instead committed to activities that would reduce emissions in sectors including transport, agriculture, forestry, energy and waste. Under the BAU scenario, emissions are expected to increase at an average annual growth rate of 3.7 per cent. In the SDG scenario, total emissions are expected to be 643.7 $ktCO_2$-e by 2030. This corresponds to a 495.4 $ktCO_2$-e (or a 43.5 per cent) reduction compared to the BAU scenario (figure II).

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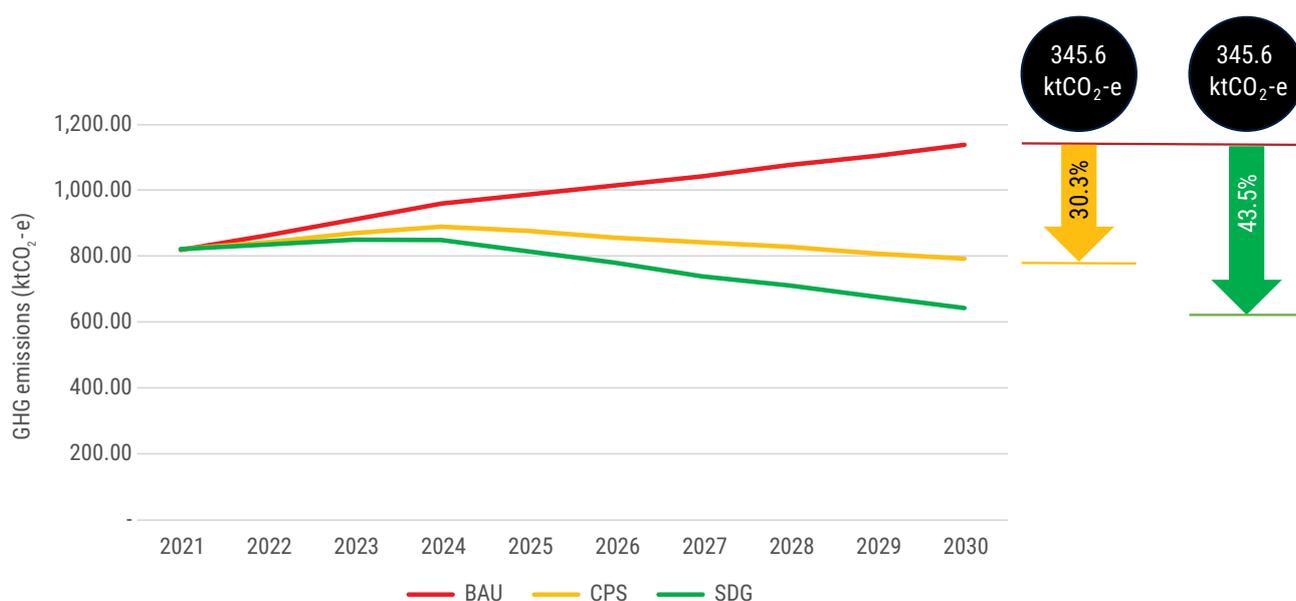
Source: ESCAP.

Note: BAU = business-as-usual scenario; CPS = current policy scenario; SDG = Sustainable Development Goals scenario.

C.   Important policy directions

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

(1) **Adopt strong policy measures to address the gaps in access to clean cooking by 2030.** Achieving universal access to clean cooking technologies remains one of the biggest challenges for Timor-Leste. Expanding the adoption of electric cook stoves and ICS in both urban and rural areas would significantly help improve access to clean cooking. The combined cost of deploying electric cook stoves and ICS is estimated to be US$ 20.8 million by 2030.

(2) **Increase the efficiency of energy use in residential and commercial sectors.** Ample energy saving opportunities are available in the residential and commercial sectors. Policies such as appliance MEPSL schemes, as well as building codes, should be considered to leverage the potential for energy reduction, while providing positive financial gains.

(3) **Implement energy efficiency measures in the transport sector and advance e-mobility as key strategies for achieving substantial energy savings and emissions reductions.** The transport sector accounts for the highest share of energy demand, largely relying on imported oil products. To achieve SDG energy efficiency targets and enhance energy security, progressive transport policies should be considered, such as adopting minimum fuel economy standards, increasing the utilization of public transport, encouraging cycling and walking, and maintaining passenger vehicles regularly.

(4) **Decarbonize the power supply as a key strategy to achieve net zero emissions by 2050.** Decarbonizing the power sector is important to prevent emissions from shifting between sectors when implementing policies, particularly those related to clean cooking and electric vehicles. This would also be essential if the country plans to move towards carbon neutrality or net zero by 2050.

1. Introduction

1.1. Background

Transitioning the energy sector to achieve the goals of the 2030 Agenda for Sustainable Development and the objectives of the Paris Agreement presents a complex and difficult task for policymakers. It requires sustaining economic growth, responding to increasing energy demand, reducing emissions, and considering and capitalizing on the interlinkages between SDG 7: Affordable and Clean Energy and the other SDGs. 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 as the emission 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 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 Ministerial Declaration advises ESCAP to support its member States, upon request, in developing national SDG 7 Road Maps.

1.2. SDG 7 targets and indicators

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

- Target 7.1. "By 2030, ensure universal access to affordable, reliable and modern energy services". Two indicators are used to measure this target: (a) the proportion of the population with access to electricity; and (b) the proportion of the population with primary reliance on clean cooking fuels and technology.

- Target 7.2. "By 2030, increase substantially the share of renewable energy in the global energy mix". This is measured by the renewable energy share in TFEC. It is calculated by dividing the consumption of energy from all renewable sources by total energy consumption. Renewable energy consumption includes consumption of energy derived from hydropower, solid biofuels (including traditional use), wind, solar, liquid biofuels, biogas, geothermal, marine and waste. Due to the inherent complexity of accurately estimating the traditional use of biomass, NEXSTEP focuses entirely on modern renewables for this target.

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

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

1.3. Nationally Determined Contributions

Nationally Determined Contributions (NDCs) represent pledges by each country to reduce national emissions and are the stepping stones for implementing the Paris Agreement. Since the energy sector accounts for the largest share of GHG emissions in most countries, decarbonizing energy systems should be prioritized. Key strategies for reducing emissions from the energy sector include increasing renewable energy in the generation mix and improving energy efficiency.

Timor-Leste chose not to set a GHG reduction target and instead committed to activities that would reduce emissions in sectors including transport, agriculture, forestry, energy and waste. As part of the conditional strategy, Timor-Leste plans to scale-up renewable energy technologies and improve energy efficiency.

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. 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. Figure 1 demonstrates different components of the NEXSTEP methodology.

Figure 1.   Components of the NEXSTEP methodology
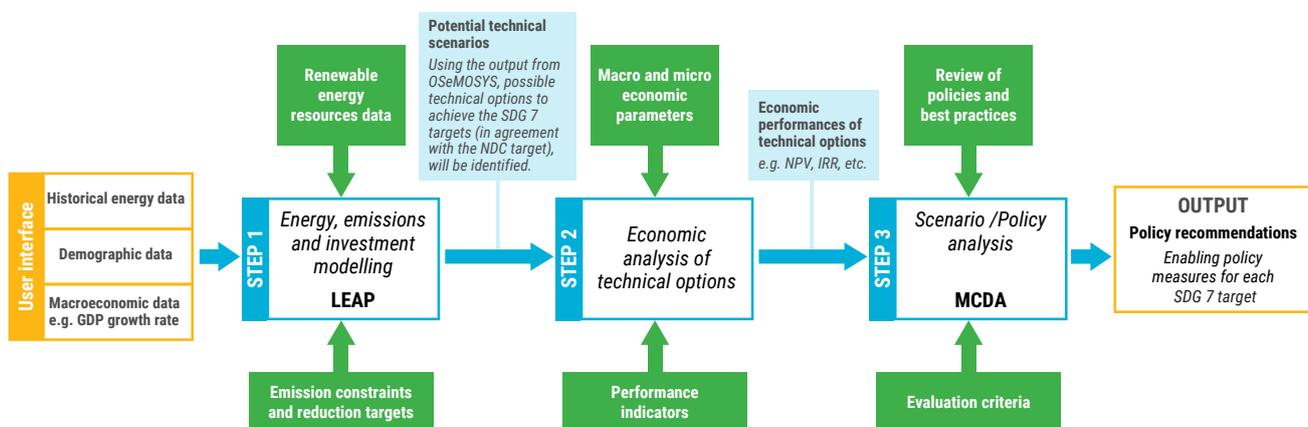
Source: ESCAP.

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. This widely-used proprietary software is utilized by many countries to develop scenarios for the energy sector, policy analysis and develop NDC targets.

1.4.2. Economic analysis

The second step builds on the selection of appropriate technologies through an economic 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 in the MCDA tool can include the following, stakeholders may wish to add/remove criteria to suit the local context:

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

This step is performed using the NEXSTEP online portal,[3] as a means to suggest the best way forward for the countries by prioritizing the scenarios. Stakeholders can update this scenario ranking using various criteria and their specific 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.

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3   The NEXSTEP portal is available at https://nexstepenergy.org/

2. Country overview

2.1. Demographic and macroeconomic profile

Geography and climate: Timor-Leste is a South-East Asian nation located 550 km north of Australia. It is the smallest and most eastern island of the Malay Archipelago and includes the enclave of Oecussi-Ambeno on the western (Indonesian) side of the island, as well as the islands of Atasúro and Jaco. The north and south coasts of the country are divided by mountain ranges, with Mount Ramelau being the most elevated point at 2972 metres. Its vegetation is characterized by an abundance of teak, sandalwood, coconuts and eucalyptus trees (Timor-Leste, 2025). Timor-Leste is characterized by a tropical climate that is hot and humid with frequent rains.

Population and economy: The total population of Timor-Leste was around 1.32 million people in 2021, with an annual growth rate of 1.6 per cent between 2020 and 2021. The urban population was estimated at 28.6 per cent. The majority of the population is of Malay-Polynesian and Papua origin, with minorities of Chinese, Arabs and Europeans.

In 2021, the GDP of Timor-Leste was estimated at US$ 2.72 billion, with an annual growth rate of 5.3 per cent between 2020 and 2021. The GDP per capita has been increasing from just $ 948 in 2000 to $ 2,061 in 2021 (World Bank, 2021).

2.2. Energy sector overview

2.2.1. National energy profile

Energy demand: The following section describes the estimated national energy consumption based on data collected through a bottom-up approach, using activity levels and energy intensity indicators for different sectors. The bottom-up estimation closely aligns with the national energy statistics in terms of total energy supply and total final energy consumption (TFEC) by fuel type.

In 2021, the TFEC was 175.5 ktoe (figure 2). Most of the demand came from the transport sector (66.0 per cent), followed by the residential sector (30.7 per cent), the commercial sector (2 per cent) and the industrial sector (1.3 per cent).

Within the transport sector only, 99.7 per cent of energy was consumed by passenger transport and 0.3 per cent by freight transport. In the passenger transport category, 53.9 per cent of energy was used by motorcycles. Passenger cars accounted for 21.9 per cent and minibuses accounted for 13.4 per cent of energy demand. The remaining share was consumed by taxis, buses and other transport modes.

In the residential sector, 50.3 per cent of energy was consumed for cooking purposes. This high share of residential cooking demand was supplied mainly by biomass. The distribution of cooking technology will be discussed in section 5.2.2. The remaining 49.7 per cent was used for lighting (15.2 per cent), refrigeration (13.1 per cent), air conditioning (8.2 per cent), television (7.4 per cent) and other appliances such as irons, washing machines, electric fans, water pumps, among others (estimated to be around 5.8 per cent).

In the commercial sector, shopping malls accounted for 44.8 per cent of the energy demand, followed by private offices and government buildings combined (27.8 per cent). Healthcare facilities consumed 27 per cent of commercial energy demand, while around 0.4 per cent was used by hotels and educational institutions.

In the industrial sector, 99.9 per cent of energy demand came from the wood and wood products industry, while the remaining share was used by the food and beverages industry, including coffee production.

Figure 2.   **Share of total final energy consumption by sector in 2021**

Industry 1.3%
Commercial 2.0%
Residential 30.7%
175.5 Mtoe
Transport 66.0%
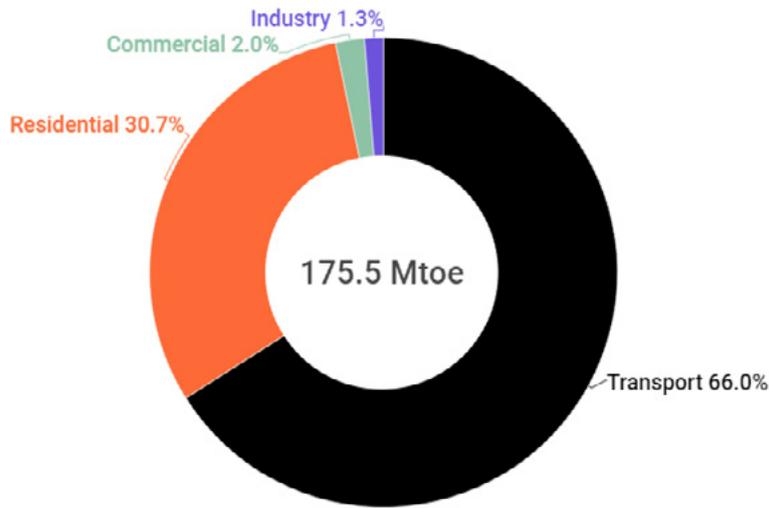
Source: ESCAP.

In terms of fuel usage in TFEC, oil products (including petroleum, diesel and crude oil) contributed the highest amount (65.3 per cent) followed by electricity (22.9 per cent) and biomass (11.8 per cent). The transport sector, which operated predominantly with internal combustion engine vehicles, was the main consuming sector for oil products.

Energy supply: In 2021, the total primary energy supply (TPES) was 291.4 ktoe. The energy supply mix comprised of oil products at 92.9 per cent; biomass at 7.1 per cent; and wind and solar at approximately 0.02 per cent. In terms of electricity supply in 2021, diesel power plants accounted for 99.8 per cent of power generation, while the remaining 0.2 per cent came from renewable energy. Figure 3 presents the distribution of TPES by fuel type, while figure 4 shows the Sankey Diagram with energy flows and sources.[4]

Figure 3.   **Share of total primary energy supply by fuel type in 2021**

Solar 0.4%
Biomass 39.9%
50.3 ktoe
Oil products 59.7%
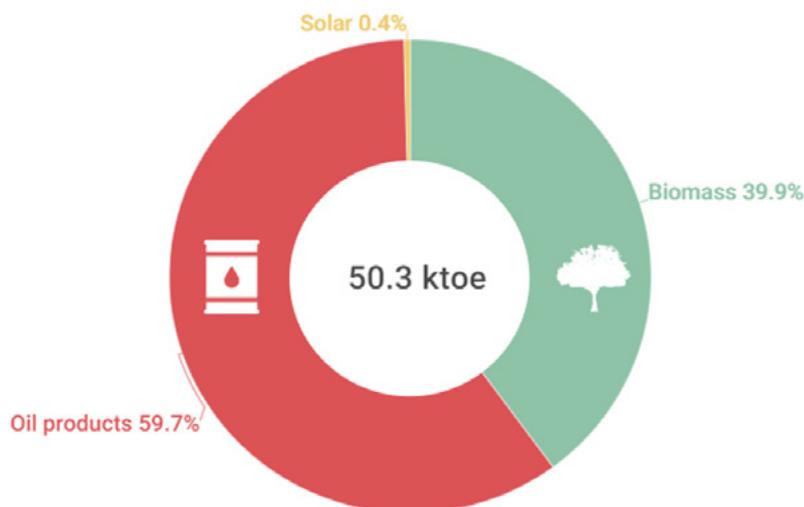
Source: ESCAP.

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4   The production of natural gas and LNG has been excluded from the Sankey diagram as its magnitude makes visualization difficult.

Figure 4. Sankey diagram illustrating energy flows and sources in 2021
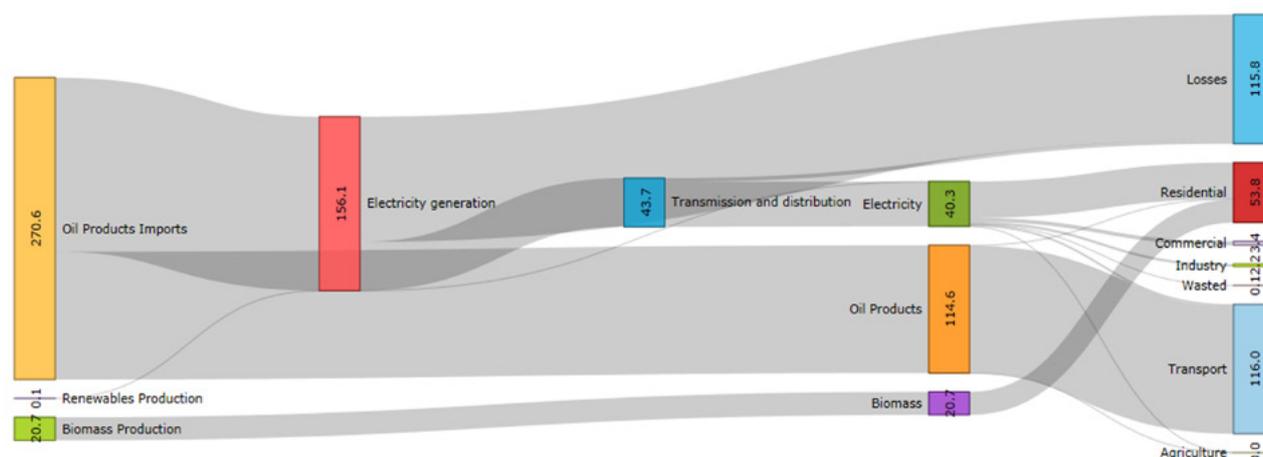
Source: ESCAP analysis.

Note: Unit: ktoe

Access to modern energy services: In 2021, the electrification rate in Timor-Leste was 97 per cent. However, the access to clean cooking was estimated at only 14.3 per cent.[5] The remaining 85.7 per cent of the population, which corresponds to 214,533 households, still relied on unclean and polluting kerosene and biomass stoves as their primary cooking technology. Overall, electric cooking stoves were the most dominant primary clean cooking technology, with an estimated share of 12.9 per cent followed by LPG stoves estimated at 1.4 per cent, as shown in figure 5. According to the National Designated Authority Public Institute (NDA, I.P.) during the stakeholder consultation workshop held in January 2024, there are plans to distribute about 450,000 of improved cookstoves (ICS), of which 16,484 units were distributed to communities in 2022.

Figure 5. Share of electricity and clean cooking access

Source: ESCAP.

Note: LPG = liquified petroleum gas

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5   Estimated based on the cooking distribution data provided for urban and rural sectors provided by the national consultant.

Renewable energy: Renewable energy delivered approximately 11.8 per cent of TFEC in 2021. This includes traditional biomass usage in residential cooking, which corresponds to an estimated 20.7 ktoe (11.8 per cent of TFEC). Excluding traditional biomass usage, the renewable share would be 0.04 per cent of TFEC. Despite being endowed with an abundance of renewable potential, Timor-Leste relies heavily on fossil fuels, particularly oil products, to meet its stationary and mobile energy needs. While, a few rooftop solar PVs have been installed in the country's capital by the private sector, the installed capacity of rooftop PV

system was unknown at the time of this report's preparation.

Energy efficiency: A doubling of the 1990-2010 improvement rate is required to achieve the SDG 7.3 target. Since Timor-Leste gained independence in 2002, the improvement rate has been calculated for the period between 2002 and 2010. Energy intensity in Timor-Leste declined at an average annual rate of 2.4 per cent between 2002 and 2010. Therefore, it requires an average annual increase rate of 4.8 per cent between 2010 and 2030 to achieve the SDG 7.3 target (figure 6).

Figure 6. **Energy efficiency (EE) target for Timor-Leste**
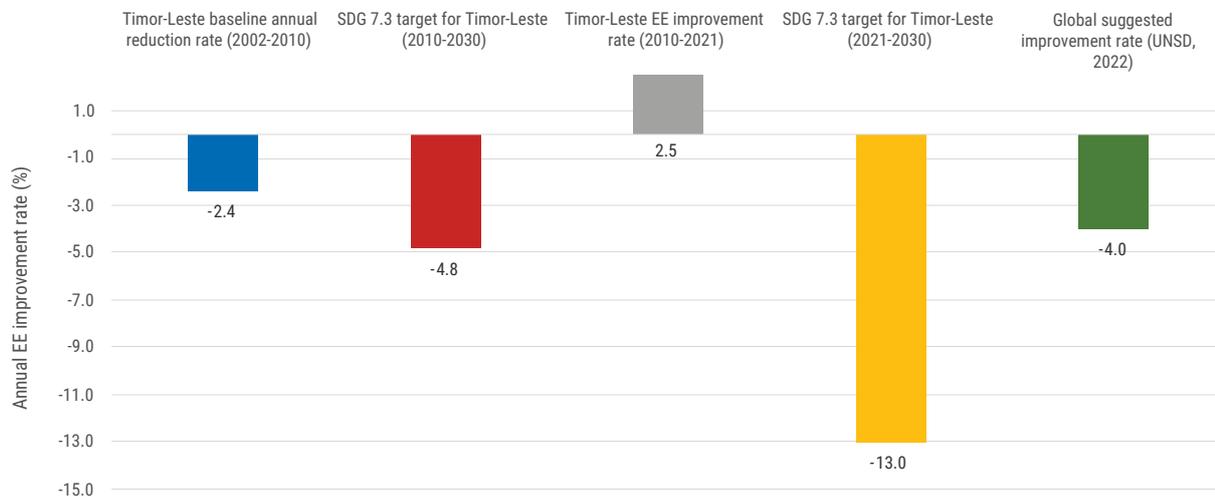
Source: ESCAP, calculations based on data from the "Asia Pacific Energy Portal", 2022a. Available at https://asiapacificenergy.org/

However, between 2010 and 2021, the energy intensity increased at a rate of 2.5 per cent per year. To reach the expected 2030 intensity, the annual improvement rate between 2021 and 2030 must be around 13 per cent, which is quite challenging. Therefore, NEXSTEP analysis suggests that the energy intensity target of Timor-Leste must be aligned with the global annual improvement target of 4.0 per cent (IEA, 2024). This corresponds to a 2030 energy intensity target of 1.3 MJ/USD$_{2017}$.

Electricity generation: The total installed electrical generation capacity in 2021 was 284.1 MW. Total electricity generation was 508.8 GWh, comprising 99.8 per cent diesel generation and 0.2 per cent solar PV.

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. In 2021, GHG emissions from the energy sector were estimated at 820.2 ktCO$_2$-e. Emissions from electricity generation were the largest at 475.5 ktCO$_2$-e (58 per cent), followed by emissions from the transport sector arising from direct fuel combustions in internal combustion engines, estimated at 334.7 ktCO$_2$-e (40.8 per cent). The residential sector emitted only 10 ktCO$_2$-e.

2.2.2. National energy policies, plans, strategies and institutions

Energy sector development in Timor-Leste is guided by several national policies and legislations. These policies have been used as guiding references for the NEXSTEP modelling, to better understand the country context and provide recommendations that align with the national government's overarching strategic direction. Where applicable, only currently implemented and adopted policies or regulations are considered in the current policy scenario to identify gaps in achieving the SDG 7 targets. The following policies or strategic documents have been consulted.

- **The Timor-Leste Strategic Development Plan 2011-2030** aims to transition Timor-Leste from a low income to upper middle-income country, with a healthy, well-educated and safe population by 2030. In this regard, access to energy is considered a basic right and the foundation for economic growth. Targets are set to provide electricity access to all households by 2030 either by the conventional expansion of the electric system or using renewable energy. In terms of clean cooking solutions, the target was that no families in Dili would have to cook with firewood by 2020 (Timor-Leste, 2011).

- **Regulation No. 1/2014 of 2014 on Fuel, Biofuel, and Lubricant Quality Standards and Specifications** sets forth the specifications for usage of fuel, biofuel and lubricants, and the rules applicable to their determination and amendment. The blending of biofuel is limited up to a maximum threshold of 20 per cent by volume (Timor-Leste, 2014).

- **Updated Nationally Determined Contribution (NDC):** Timor-Leste chose not to set a GHG reduction target and instead committed to activities that would reduce emissions in sectors including transport, agriculture, forestry, energy and waste. As part of the conditional strategy, Timor-Leste plans to scale-up renewable energy technologies and improve energy efficiency (Timor-Leste, 2014).

- **The Program of the 9th Constitutional Government** presents the central public policies to strengthen government sectors that encompass six main areas, including infrastructure and economy development. In the energy sector, the Government committed to modernize and expand its energy system by utilizing renewable energy (Timor-Leste, 2023).

2.2.3. National energy resources and potentials

Timor-Leste produces a significant amount of oil products, however, these are used exclusively for exports. To meet domestic energy needs, the country imports fossil fuels, including oil products and LPG. Its solar potential is categorized as very good, with an average of 1.6 MWh/kWp available across half of the country. Most areas (about 90 per cent) of the country have less than 260 W/m^2. Timor-Leste has an excellent biomass potential measured at 10.5 tons of carbon per hectare per year (tC/ha/yr), which is about three times the global average (IRENA, 2023).

3. Modelling assumptions

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

3.1. Scenario definitions

NEXSTEP is designed for scenario analysis, using the LEAP modelling system to enable energy specialists to model energy system evolution based on current energy policies. The baseline year 2021 was chosen, as it is the most recent year with sufficient data information for modelling. In the NEXSTEP model for Timor-Leste, four scenarios have been developed. These include three core scenarios: (1) business-as-usual (BAU) scenario; (2) current policy scenario (CPS); and (3) Sustainable Development Goals (SDG) scenario.

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

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

3.1.2. The current policies scenario (CPS)

Inherited from the BAU scenario, this scenario considers initiatives implemented or scheduled to be implemented during the analysis period of 2021-2030. These are, for example, power

development plans and energy efficiency programmes. Otherwise, energy intensities from different demand sectors are assumed constant throughout the analysis period, with demand growth as detailed in Annex II. Only policies with concrete measures are considered in the scenario modelling. Plans/strategies/policy documents that lack concrete measures are not included, but they are compared with scenario results later in the 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, including universal access to electricity and clean cooking fuel, substantially increasing the renewable energy share and doubling the rate of energy efficiency improvement. For clean cooking, different technologies (electric cooking stoves, LPG cooking stoves and improved cooking stoves) have been assessed, with subsequent recommendation of the uptake of the most appropriate technology. Energy intensity has been modelled to help achieve the SDG 7 target. It also allows the achievement of the country's unconditional NDC target.

3.2. Assumptions

Energy demand is estimated by using the activity level and energy intensity in the LEAP model. The demand outlook throughout the NEXSTEP analysis period is influenced by factors such as annual population growth and annual GDP growth. The assumptions used in the NEXSTEP modelling are further detailed in Annex II, while table 1 provides a summary of key modelling assumptions for the three main scenarios (i.e., BAU, CPS and SDG scenarios).

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

Parameters	Business-as-usual scenario	Current policy scenario	Sustainable Development Goals scenario
Economic growth	3.2 per cent in 2022, 2.8 per cent in 2023, and 2.9 per cent from 2024 onwards.[6]		
Population growth	1.76 per cent per annum.[7]		
Urbanization rate	28.6 per cent in 2021, growing to 31.9 per cent in 2030. [8]		
Commercial floor space	Assumed annual energy consumption is increasing at the same growth rate as GDP.		
Industrial activity	Assumed annual energy consumption increasing at the same growth rate as GDP.		
Transport activity	Passenger transport activities and freight transport activities are assumed to grow at a rate comparable to the growth in GDP per capita.		
Residential activity	The appliance ownership for electrical appliances is projected to grow at a rate comparable to the growth in GDP per capita.		
Access to electricity	100 per cent electricity access by 2030 based on the Strategic Development Plan 2011-2030.		
Access to clean cooking fuels	Projected based on the historical penetration rate between the 2000-2020 period.		100 per cent clean cooking access rate.
Energy efficiency	Additional energy efficiency measures not applied.	Improvement based on current policy scenario.	Global improvement in energy intensity adopted.
Power plant	Considers 2021 share of renewable energy in power generation and grid emissions.	Considers capacity expansion based on data provided by national consultants.	

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6   Estimation from Asian Development Bank (ADB), "Economic forecasts for Timor-Leste", 2025. Available at https://www.adb.org/where-we-work/timor-leste/economy

7   Data from World Bank, 2021.

8   This assumes that the urbanization rate grows with an annual rate of 1.76 per cent, with reference to the national historical urbanization growth from 2010 to 2022.

4. Energy transition outlook in the current policy scenario (CPS)

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

4.1. Energy demand outlook

The current policy scenario considers policy measures that have been implemented or already have a concrete implementation timeline within the analysis period.[9] Otherwise, the energy intensities from the different demand sectors are assumed constant throughout the analysis period, with demand growth as detailed in table 1. The following policies have been considered.

- **Access to electricity:** The Timor-Leste Strategic Development Plan 2011-2030 sets a target to provide electricity access to all households by 2030 either by the conventional expansion of the electricity system or using renewable energy technologies (Timor-Leste, 2011).

- **Clean cooking:** The above-mentioned policy also seeks to ensure that there will be no families in Dili (the capital of the country) cooking with firewood by 2020.

- **Energy efficiency and renewable energy:** Regulation No. 1/2014 of 2014 on Fuel, Biofuel, and Lubricant Quality Standards and Specifications sets forth the specifications for fuel, biofuel and lubricants for use in Timor-Leste. The blending of biofuel is limited up to a maximum of 20 per cent by volume (Timor-Leste, 2014).

Power sector: Timor-Leste has a plan to accelerate the transition to cleaner energy supply utilizing solar energy. This includes 72 MW of solar PV installation in 2024 and 50 MW of wind turbine installation in 2026. In the CPS, electricity generation is expected to rise from 508.8 GWh in 2021 to 707.3 GWh in 2030. The renewable energy share of electricity supply (solar generation) is projected to increase from 0.2 per cent in 2021 to 35.4 per cent in 2030, with the remaining being supplied by diesel generation. The increased share is due to the rapid expansion of solar and wind capacities, as outlined in the Power Capacity Expansion Plan, during the analysis period (figure 7). This scenario assumes that the expansion plan is carried out according to the planned timeline. In terms of capacity, these additions are expected to increase the share of renewables in total installed capacity to 30.2 per cent in 2030.

Figure 7. Power Capacity Expansion Plan 2023-2030, by energy sources (current policy scenario)
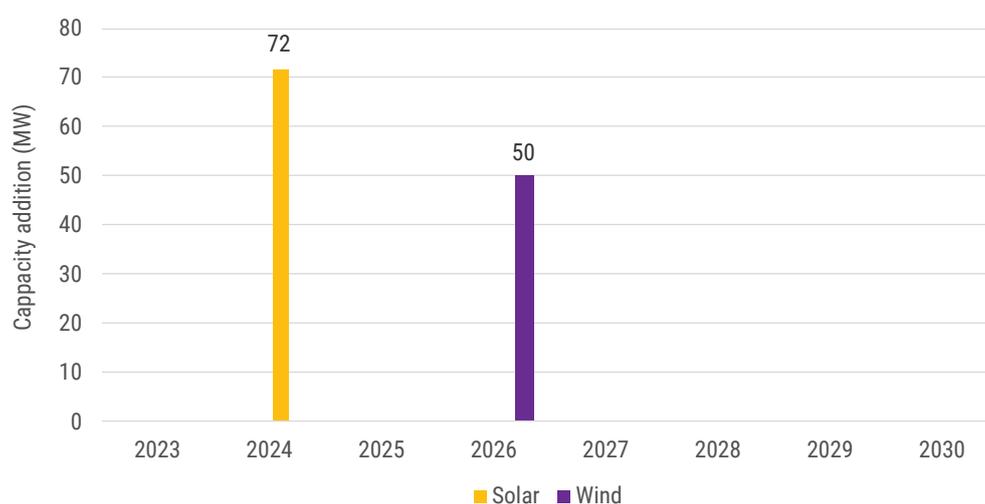
Source: ESCAP.

9   Only policies with concrete and implemented measures are considered in the scenario modelling for the current policy scenario. Furthermore, measures mentioned in strategy policy or planning documents that are yet to be enforced or implemented prior to October 2023 are not considered in the modelling of the current policy scenario.

Under the current policy scenario, the demand for total final energy is expected to increase from 175.5 ktoe in 2021 to 215.5 ktoe in 2030, indicating an average annual growth rate of 2.3 per cent. The 11 ktoe reduction in energy demand, as compared to the BAU scenario, is driven by the adoption of energy efficiency measures in the residential and commercial sectors. In 2030, energy consumption in the transport sector is projected to remain the largest at 65.1 per cent, followed by the residential sector at 31.5 per cent, the commercial sector at 2.1 per cent and the industrial sector at 1.3 per cent. Figure 8 shows the forecast of TFEC by sector under the CPS. The sectoral energy efficiency measures are further described below.

Figure 8.   Energy demand outlook in the current policy scenario, 2024 – 2030
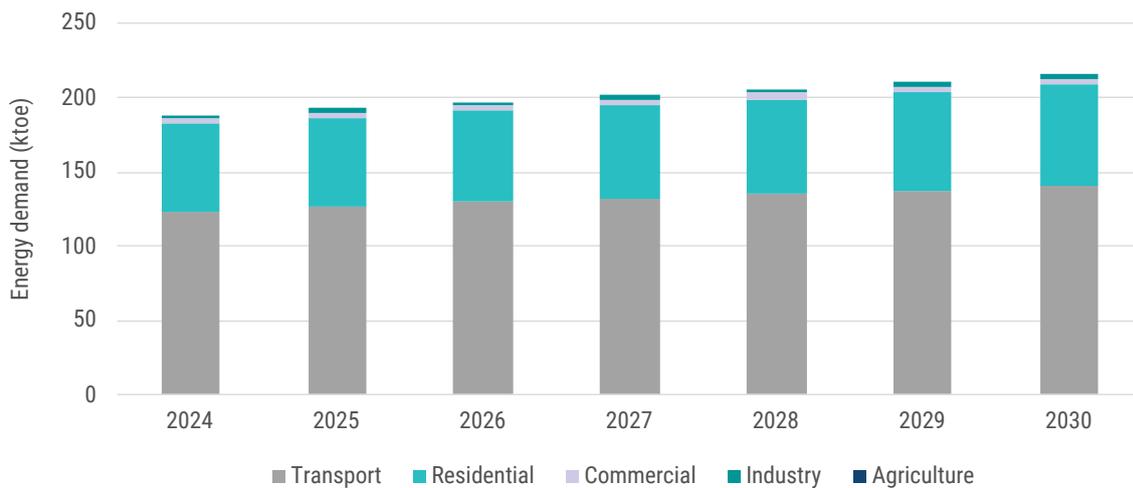
Source: ESCAP.

4.1.1. Transport sector

The transport sector of Timor-Leste will consume 140.3 ktoe, an annual growth of 2.1 per cent, which is an increase from 116 ktoe in 2021. The sector consists of only land transport, divided into passenger and freight transport, which will consume 99.7 per cent and 0.3 per cent of the energy requirement, respectively.

4.1.2. Residential sector

The residential sector will consume 67.8 ktoe in 2030, an annual growth of 2.6 per cent, which is an increase from 53.8 ktoe in 2021. The urban and rural split of energy consumption would be 45.1 per cent and 54.9 per cent, respectively. In terms of fuel, electricity will be the main energy source at 68.1 per cent, followed by biomass at 30.8 per cent and oil products at 1.1 per cent. Biomass and oil products are used mainly for cooking purposes.

4.1.3. Commercial sector

Under NEXSTEP methodology, the commercial sector consists of government buildings, shopping malls, restaurants, hotels, education institutions, workshop centres, etc. Total energy consumption in the commercial sector (including government buildings) under the CPS will increase from 3.4 ktoe in 2021, at an average annual growth of 2.9 per cent, to 4.5 ktoe in 2030. Government buildings, shopping malls and healthcare facilities together will account for 97.8 per cent.

Under the CP scenario, the energy efficiency improvement target will not be achieved, as it is projected to reach 1.6 MJ/USD2017, despite an 11 ktoe energy reduction compared with the BAU scenario. This saving will come from the distribution of around 23,000 ICS to households in Timor-Leste, as well as plans to increase biofuel blending up to 20 per cent. It is assumed that the diesel blending will be limited to 10 per cent in line with global standard practices (table 2).

Table 2.   **Power capacity expansion plan**

Sector	Measure	Energy demand reduction in 2030 (ktoe)
Residential − cooking	Distribution of around 23,000 ICS to households in Timor-Leste, particularly in Dili	1
Transportation − biofuel blending	20 per cent gasoline blending and 10 per cent diesel blending by 2030	10
Total		**11**

GHG emissions from the energy sector in the CP scenario are expected to decrease from 820.2 $ktCO_2$-e in 2021 to 793.5 $ktCO_2$-e in 2030, driven primarily by the introduction of significant renewable generation which will reduce diesel consumption in power generation. However, power generation would remain the largest source of emissions at 427.9 $ktCO_2$-e followed by the transport sector at 354.5 $ktCO_2$-e largely due to direct fuel combustions in internal combustion engines. The residential sector will contribute 11.1 $ktCO_2$-e from the combustion of solid fuels for cooking.

4.2. Energy supply outlook

In the current policy scenario, the TPES is forecasted to increase from 291.4 ktoe in 2021 to 321.5 ktoe in 2030. As illustrated in figure 9, oil products are the dominating fuel supply, followed by biomass and solar PV. The primary supply of solar energy has increased significantly, compared with the value in 2021, rising from 0.2 ktoe to 2.1 ktoe.

Figure 9.   **Total primary energy supply by fuel type, in the current policy scenario, 2030**
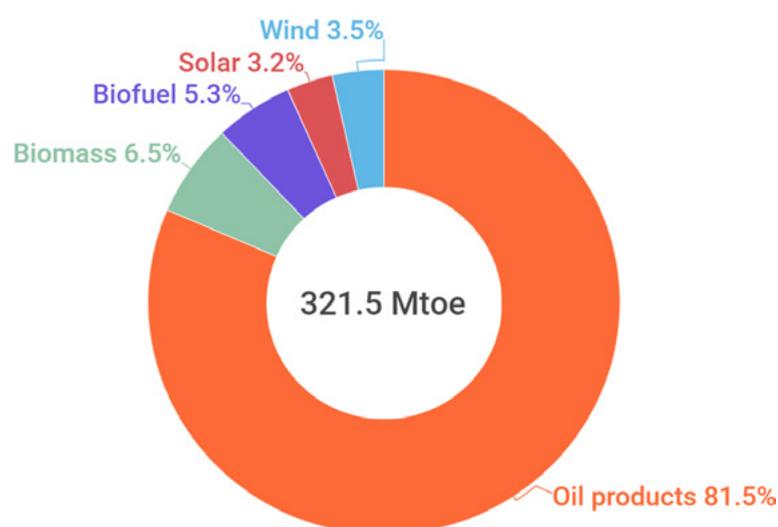
Source: ESCAP.

5. SDG scenario: An assessment of SDG 7 targets and indicators
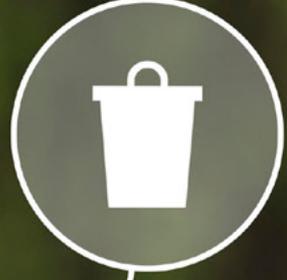
This chapter begins with a brief overview of the energy demand and supply projections under the SDG scenario. The results are then evaluated against the SDG 7 and NDC targets and other relevant indicators. Finally, current energy policies in Timor-Leste are evaluated based on the outputs from NEXSTEP analysis to highlight any policy gaps.

5.1. Energy demand outlook

In the SDG scenario, TFEC decreases from 175.5 ktoe in 2021 to 168.8 ktoe in 2030. Compared to the CP scenario, in 2030 the demand for energy will reduce by 46.7 ktoe. This additional reduction in the SDG scenario as compared to the CPS is driven by the phasing out of traditional kerosene and biomass fuel stoves in the residential sector, the introduction of biofuel as well as the adoption of higher energy efficiency measures. In 2030, the share of transport sector consumption will remain the largest at 65.1 per cent, followed by the residential sector at 30.8 per cent, the commercial sector at 2.4 per cent and the industrial sector at 1.7 per cent. Figure 10 displays the comparison of TFEC between the three main scenarios.

Figure 10. Comparison of energy demand between the business-as-usual (BAU), current policy (CP) and Sustainable Development Goal (SDG) scenarios
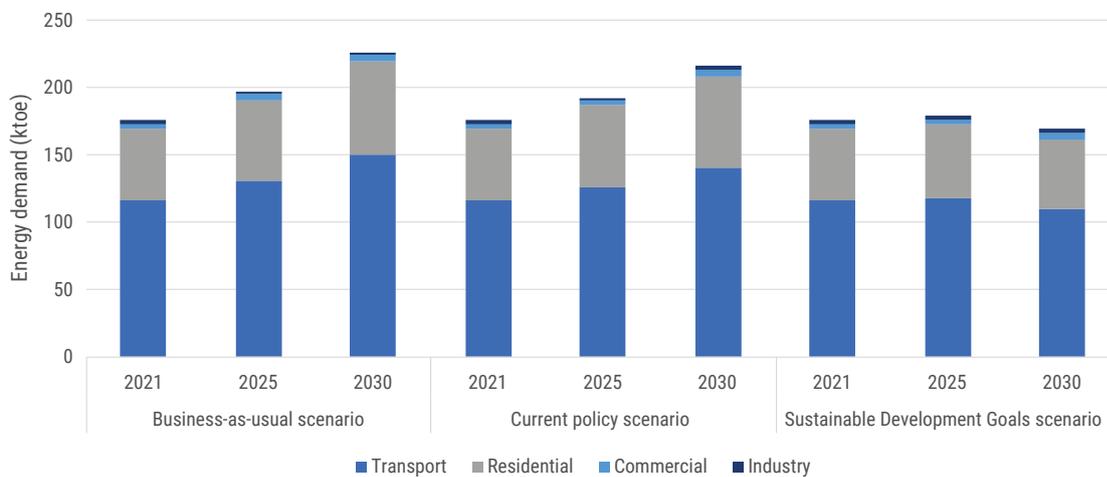
Source: ESCAP.

5.2. SDG 7 targets

5.2.1. Access to electricity

Achieving universal access to electricity is a priority for the Government of Timor-Leste. In 2021, around 3 per cent of the population lacked access to electricity, primarily in rural and informal settlements. The Strategic Development Plan 2011-2030 outlines the goal of achieving a 100 per cent access rate 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 remote areas where household distribution is quite sparse, stand-alone solar PV systems can be considered.

Table 3 presents an assessment of access to electricity for Timor-Leste.

Table 3. Assessment of access to electricity

Existing policy	NEXSTEP analysis – gaps and recommendations
Timor-Leste Strategic Development Plan 2011-2030 sets a target to provide electricity access to all households either by the conventional expansion of the electricity system or using renewable energy by 2030.	Timor-Leste will achieve universal access to electricity by 2030.

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 2021, 85.7 per cent of households relied on polluting cooking technologies, specifically kerosene and solid fuel stoves (assuming biomass as the primary fuel). Access to clean cooking fuels and technologies will not be achieved in the current policy scenarios despite the plan to distribute ICS – it will reach only 28.5 per cent in 2030 – leaving 71.5 per cent of the population relying on inefficient and hazardous cooking fuels and technologies. However, under the SDG scenario, universal access (100 per cent) to clean cooking is projected by 2030.

NEXSTEP analysis suggests electric cooking stoves as the most appropriate solution for Timor-Leste given their cost and environmental effectiveness, particularly in urban areas. Where a reliable electricity supply might be difficult, ICS can be considered. In the long run, electric cooking stoves may be considered, particularly as means to achieve the net zero target by 2050. Table 4 summarizes the estimated annualized cost of different cooking technologies for Timor-Leste, while table 5 presents a gap analysis of access to clean cooking.

Table 4. The annualized cost of cooking technologies

Technology	Annualized cost in US dollars
Electric cooking stove	$-124
Improved cooking stove (ICS)	$-67
LPG stove	$-445

Source: ESCAP.

Table 5. Assessment of access to clean cooking

Existing policy	NEXSTEP analysis − gaps and recommendations
The Government of Timor-Leste is implementing a project on sustainable bioenergy production from biomass, targeting 20,000 households to use improved cooking stoves (ICS) in Dili. International partners such as the United Nations Development Programme (UNDP) are working with local NGOs to support ICS manufacturers and promote market development.	**Gap:** NEXSTEP analysis projects that Timor-Leste may reach a 28.5 per cent clean cooking access rate in the current policy context. **SDG scenario:** NEXSTEP analysis suggests bridging the remaining gap with a combination of electric cooking stoves in the urban area and improved cooking stoves (ICS) in the rural area.

Box 1. Evaluation of clean cooking technologies

Electric cooking stoves

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

Improved 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 emission rates for clean cooking, only certain types of ICS technology comply, particularly when considering the fact that cooking stove emissions in the field are often higher than they are in laboratory settings used for testing.[a] Tier 3+ ICS, which meets the WHO clean cooking guidelines, has the potential to reduce GHG emissions and provide socioeconomic and health benefits, when it is promoted in carefully planned programmes.

LPG cooking stove

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

a World Health Organization, "Defining clean fuels and technologies", 2025. 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 encourages a "substantial" increase of the renewable energy share in TFEC. The share of renewable energy (excluding traditional biomass usage) in TFEC in 2030 will be 25.5 per cent in the SDG scenario compared to 17.9 per cent in the CPS (figure 11). The increase from 0.1 per cent in 2021 is attributed to the increased use of efficient cooking technologies, improvement in energy efficiency as well as a higher share of renewable energy installed capacity in power generation.

Figure 11. Share of renewable energy (RE) in TFEC comparison in the base year, current policy scenario (CPS) and Sustainable Development Goals (SDG) scenario, 2030
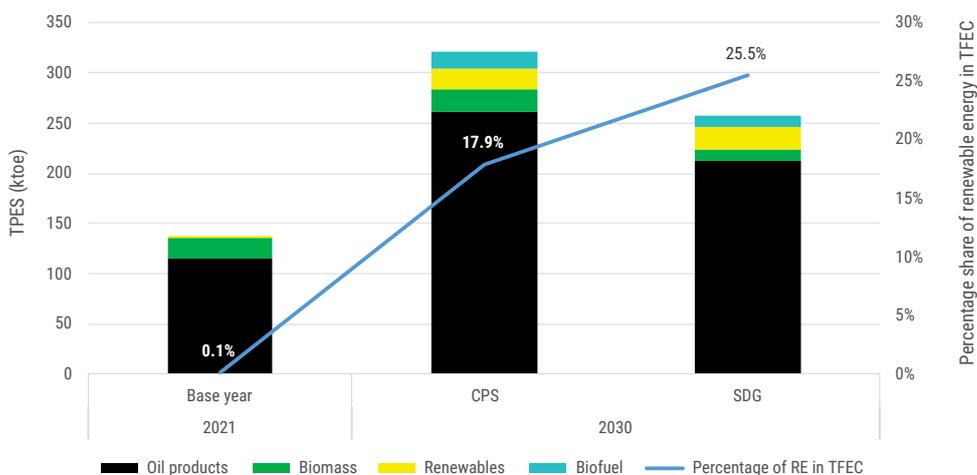
Source: ESCAP.

In both the SDG and CP scenarios, the share of renewable power generation has been further increased, while diesel power generation has been reduced (figure 12). This target is achieved by increasing solar capacity by 72 MW and wind capacity by 50 MW in 2024 and 2026, respectively. Table 6 presents a gap analysis for renewable energy share in TFEC.

Figure 12. Comparison of power generation in the base year, the current policy scenario (CPS) and the Sustainable Development Goals (SDG) scenario, 2030
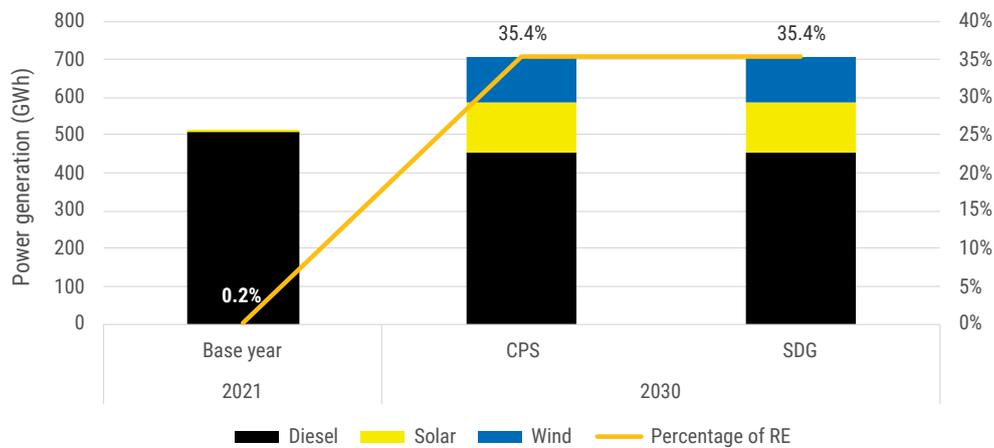
Source: ESCAP.

Table 6. Assessment of share of renewable energy in TFEC

Existing policy	NEXSTEP analysis – gaps and recommendations
While the policies and plans in Timor-Leste do not specify any quantitative target for renewable energy, they suggest increasing the use of renewable energy in various areas. These include using renewable energy systems to achieve 100 per cent access rate to electricity, scaling-up renewable energy technologies (as mentioned in the NDC), and modernizing and expanding the energy system by utilizing renewable energy. Additionally, the regulation on fuels quality, standards and specifications suggest increasing the blending of biofuel up to a maximum of 20 per cent.	CP scenario The renewable share in TFEC is projected to be 17.9 per cent in the CP scenario driven by the increase of planned renewable power capacities. SDG scenario The share of renewable energy in TFEC is projected to reach 25.8 per cent in 2030. As mentioned above, in addition to capacity expansion of renewable energy, this increase is attributed to the phasing out of inefficient traditional biomass and kerosene stoves, and replacing them with improved cooking stoves. Improvements in energy efficiency also contribute to this rise.

5.2.4. Energy efficiency

A doubling of the 1990-2010 improvement rate is required to achieve the SDG 7.3 target. However, the energy intensity of Timor-Leste increased at an average annual rate of 2.5 per cent between 2010 and 2021. This indicates that doubling the rate will cause the energy intensity to be higher. Therefore, it is suggested that Timor-Leste achieve a global improvement rate of 3.4 per cent, where the energy intensity in 2030 would need to reach 1.3 MJ/USD_{2017}.

Under the CP scenario, the energy efficiency improvement target will not be achieved, as energy intensity is expected to reduce to 1.6 MJ/ USD_{2017}. However, in the SDG scenario, energy intensity in 2030 is expected to further reduce to 1.3 MJ/USD_{2017} (equivalent to a 3.4 per cent energy efficiency improvement rate), thereby meeting the global energy efficiency target for SDG 7. This improvement is primarily due to the additional measures in the SDG scenario, such as the additional phase-out of inefficient cooking technologies in rural areas and their replacement with more efficient electric stoves. In addition, further reductions in energy intensity can be realised through additional proposed measures in the residential and transport sectors. Increasing the adoption of MEPS for lighting, refrigeration and air-conditioning, as well as introducing MEPS for electric fans and television can be viable solutions

for Timor-Leste to reduce energy demand. Further details of energy efficiency measures and their impacts are provided below.

(a) Transport sector

The Government of Timor-Leste can significantly reduce transport energy demand by promoting several measures. These include promoting the use of mass transport, such as buses and taxis, and encouraging bicycling and walking for short-distance travel to help reduce passenger kilometres travelled by private motorcycles.

Regular maintenance, such as applying oil-based rustproofing, undercoating and washing, is required to improve the fuel economy of passenger transport. In addition, the Government may consider increasing the penetration of electric cars and motorcycles by 20 per cent in 2030. This target will not only help Timor-Leste to achieve significant energy reduction but also help direct the country towards net zero emissions in the long term. As an initial step, the Government may

replace the public fleet of cars and motorcycles with electric vehicles before promoting electric vehicles to the general public. Table 7 shows additional energy-saving opportunities under the SDG scenario, compared with the CP scenario.

(b) Residential sector

In the residential sector, there will be an ambitious strategy to phase out inefficient cooking technologies and replace them with more efficient alternatives such as electric cooking stoves and ICS. This measure will be critical as it will support the country to achieve 100 per cent access to clean cooking by 2030. Additionally, the adoption of minimum energy performance standards (MEPS) will help reduce electricity consumption for lighting, refrigeration, television/video and air conditioning (the four appliances with the largest energy consumption). In the commercial sector, improvements in energy intensity in commercial buildings can be achieved by implementing green building code.

Table 7.   **Additional energy saving opportunities under the SDG versus CP scenario**

Sector	Measure	Energy demand reduction in 2030 (ktoe)
Residential - Cooking	Electric cook stove and ICS to remaining households	5.5
Residential – Minimum energy performance standards (MEPS)	Increase the adoption of energy-efficient lighting, air conditioner, refrigeration and television	10.3
Transport – Cycling, walking	reducing passenger km of motorcycle by 10 per cent by encouraging cycling/walking	30.5
Transport – Fuel economy	Implement routine inspection, maintenance, and scheduling in to reduce energy consumption by 15 per cent	
Transport – Electric vehicles	20 per cent electric motorbikes and 20 per cent electric cars	
Commercial – Green building code	Increase the adoption of energy-efficient appliance – 8 per cent electricity reduction	0.4
Total		**46.7**

Source: ESCAP.

Figure 13 illustrates additional energy saving opportunities under the SDG scenario, compared with the BAU scenario, and table 8 summarizes

each energy efficiency measure as well as identifies gaps.

Figure 13. **Additional energy saving measures under the SDG scenario compared to the CP scenario**
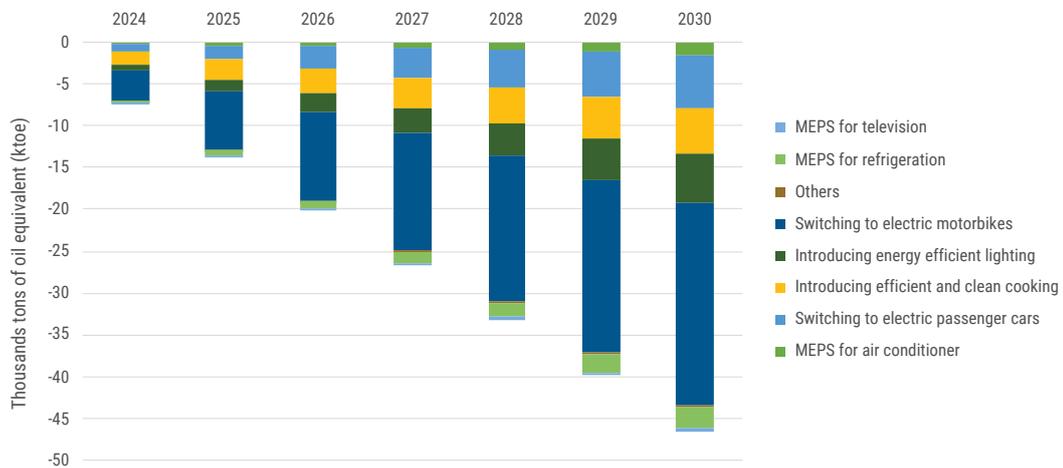
Source: ESCAP.

Table 8. **Assessment of energy efficiency**

Existing policy	NEXSTEP analysis – gaps and recommendations
Timor-Leste has not set a specific target for energy efficiency. The NDC suggests to improve energy efficiency across all sectors.	**Gap(s):** The CP scenario will not achieve the energy efficiency improvement target of 3.4 per cent or 1.3 MJ/USD$_{2017}$ in 2030. It is projected that the energy intensity in this scenario will be 1.6 MJ/USD$_{2017}$ in 2030. **SDG scenario:** The energy intensity is further reduced to 1.3 MJ/USD$_{2017}$ in 2030 or a 3.4 per cent energy efficiency improvement rate, which meets the global energy efficiency target. Achievement of this target requires phasing out inefficient cooking technologies, increasing MEPS adoption and improvement of passenger car fuel economy to realise an additional energy demand reduction of 46.7 ktoe in 2030, compared with the CP scenarios.

5.3. Energy supply outlook

In the SDG scenario, the total primary energy supply is estimated to be 257.9 ktoe by 2030, which is a reduction of 63.6 ktoe as compared with the CP scenario. The phase-out of traditional biomass for cooking will reduce supply of

biomass by 9.6 ktoe. The remaining reduction in primary energy will come from oil products due to additional energy efficiency improvements. This substantial decrease in primary energy supply not only reduces energy intensity, but also enhances energy security in Timor-Leste by reducing dependence on fuel imports.

The demand for electricity in 2030 is projected to be 642 GWh in the SDG scenario. The sectoral demand for electricity will be dominated by the residential sector at 72.6 per cent followed by the transport sector at 14.8 per cent, the commercial sector at 7.4 per cent and the industry sector at 5.2 per cent. It is estimated that the total electricity requirement (including generation and transmission losses) will be 698 GWh, which will be generated by 283.6 MW of diesel, 72.5 MW of solar PV and 50 MW of wind power plants.

5.4. Targets in the Nationally Determined Contributions

Energy sector emissions, from the combustion of fossil fuel, are calculated based on IPCC Tier 1 emission factors assigned in the LEAP model and expressed in terms of 100-year global warming potential (GWP) values. For the combustion of biomass and biomass products, carbon emissions are not attributed to the energy sector,

but are accounted for in the agriculture, forest and land-use change (AFOLU)[10] sectors as per the accounting system suggested by the IPCC. Nevertheless, the emissions of other GHGs, such as methane and nitrous oxide, are included in the total emissions in the energy sector.

Figure 14 displays emissions reductions under the SDG scenario, compared with the CP scenario. In the SDG scenario, total emissions are expected to decrease to 643.7 $ktCO_2$-e by 2030. This corresponds to a 549.4 $ktCO_2$-e (or a 46 per cent) reduction compared with the BAU scenario. The additional decrease in GHG emissions compared with the CP scenario is due to measures discussed in the previous section. Furthermore, improvements in the efficiency in the demand sector reduce the diesel requirement thereby lowering greenhouse gas emissions from the electricity generation sector. Figure 15 summarizes the SDG 7 indicators for the three main scenarios.

Figure 14. Additional emissions reduction measures under the SDG scenario
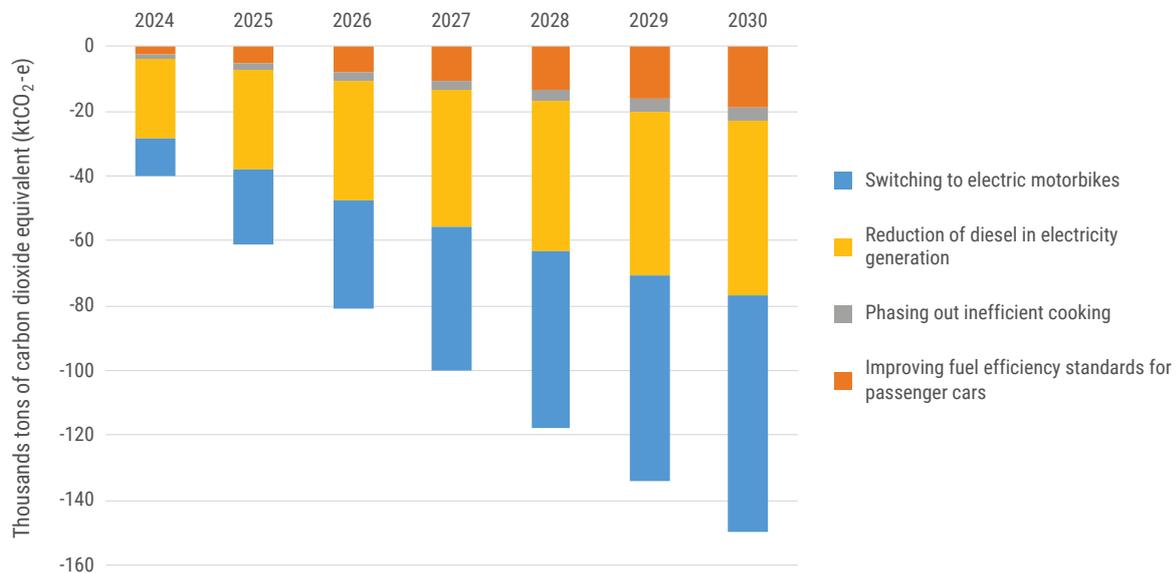
Source: ESCAP.

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

Figure 15. Summary of SDG 7 indicators for the business-as-usual (BAU), the current policy (CP) and Sustainable Development Goals (SDG) scenarios for Timor-Leste

Baseline year	Access to electricity 97% by 2021 Access to clean cooking 14.3% in 2021	Energy Efficiency 1.8 MJ/USD by 2021	Renewable Energy share in TFEC **0.1%** by 2021 Emissions **820.2** ktCO2$_e$ in 2021
Current Policy Scenario	Access to electricity 100% by 2030 Access to clean cooking 28.5% in 2030	Energy Efficiency 1.6 MJ/USD by 2030	Renewable Energy share in TFEC **17.9%** by 2030 Emissions **793.5** ktCO2$_e$ in 2030
Sustainable Development Goal 7	Access to electricity 100% by 2030 Access to clean cooking 100% in 2030	Energy Efficiency 1.3 MJ/USD by 2030	Renewable Energy share in TFEC **25.5%** by 2030 Emissions **643.7** ktCO2$_e$ in 2030
Scenario Development	**Access to modern energy**	**Energy efficiency**	**Renewable energy share in TFEC & GHG emissions**

Energy system trajectories

Source: ESCAP.

6. Scenario analysis and policy recommendations

6.1. Scenario evaluation

The BAU, CP and SDG scenarios have been evaluated and ranked, using the Multi-Criteria Decision Analysis (MCDA) tool, with a set of 12 criteria and weights assigned to each criterion (table 9). While the criteria and weights have been selected based on expert judgement, ideally the process should involve 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 weights of each criterion. The following factors have been considered to assume comparative weights across the set of criteria, where the total weight needs to be 100 per cent:

(a) Universal access to electricity to be achieved;

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

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

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

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

(f) Total investment should be kept low, but the net benefit should be high. Both indicators were assigned the same weight to ensure that a scenario is chosen based on value for money; and

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

Table 9. Criteria with assigned weights for MCDA

Criterion	Weight (percentage)
Access to clean cooking fuel	10
Energy efficiency	10
Share of renewable energy	11
Emissions targets in 2030	10
Alignment with the Paris Agreement	10
Fossil fuel subsidy phased out	5
Price on carbon	5
Fossil fuel phase-out	5
Cost of access to electricity	7
Cost of access to clean cooking fuel	7

Criterion	Weight (percentage)
Investment cost	10
Net benefit from the power sector	10
Total	**100**

Source: ESCAP.

Table 10 provides a summary of results obtained through this evaluation process. The scenario recommendation suggests that the SDG scenario is the highest-ranked energy transition pathway for Timor-Leste.

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

Scenarios	Weighted scores	Rank
Sustainable Development Goals scenario	65.0	1
Towards net zero	61.0	2
Current policy scenario	49.0	3
Business-as-usual scenario	17.0	4

Source: ESCAP.

Based on the above analysis, this Road Map recommends that Timor-Leste consider adopting the SDG scenario.

6.2. Policy actions for achieving SDG 7

6.2.1. Implement strong policy measures to address the gap in access to clean cooking by 2030.

Timor-Leste has been making good progress towards achieving universal electricity access, however a small gap remains. 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 technology's cost-effectiveness, climate resiliency and faster implementation. Achieving access to clean cooking technologies, on the other hand, seem to be one of the biggest challenges for Timor-Leste. The adoption of electric cook stoves and ICS in both urban and rural areas will significantly improve access to clean cooking. The deployment of electric cook stoves is estimated to cost $8.1 million whereas the deployment of ICS would require $12.7 million. Therefore, the total cost of achieving access to clean cooking by 2030 would be $20.8 million.

6.2.2. Increase the efficiency of energy use in residential and commercial sectors

A number of energy saving opportunities are available in the residential and commercial sectors. Policies such as appliance minimum energy performance standards and labelling schemes, as well as building codes, should be considered to leverage the energy reduction potential while providing positive financial gains. Both measures are projected to save energy demand by around 10.7 ktoe.

6.2.3. Prioritize transport sector energy efficiency improvement and e-mobility to achieve substantial energy savings and emissions reduction

The transport sector accounts for the highest share of energy demand, largely relying on imported oil products. Progressive transport policies, such as minimum fuel economy standards, increasing the utilization of public transport, encouraging cycling and walking, as well as regular maintenance of passenger transport, should be considered to reach the SDG energy efficiency targets, while enhancing energy security. Furthermore, Timor-Leste can promote the use of electric motorcycles and cars to aiming to reach a penetration rate of at least 20 per cent by 2030, in order to achieve global energy efficiency targets.

6.2.4. Decarbonize power supply to achieve net zero emissions by 2050

Decarbonization of the power sector is important to prevent the shifting of emissions from one sector to the other when implementing policies, particularly on clean cooking and electric vehicles. This would be also needed if the country plans to move towards carbon neutrality or net zero by 2050. Attempts to decarbonize will require a substantial increase in renewable capacities, which could be challenging technically and economically, but will help offer multiple benefits, including reducing emissions and improving energy security through the utilization of indigenous resources. In terms of electricity supply, it is predicted that 250 MW of hydropower, 111 MW of wind power and 1.2 GW solar PV are required to fulfill the rising electricity demand.

Box 2. 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 CO_2 emissions standard has accelerated the adoption of electric vehicles.[b]

Despite supply chain bottlenecks and the remaining impacts of 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]

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.

7. Building back better from the COVID-19 pandemic

Energy plays a key role in supporting long-term recovery and building resilience following the challenges and lessons of the COVID-19 pandemic. Two important dimensions of energy must be considered, particularly in relation to health crises.

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, as countries continue to strengthen 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.

While the COVID-19 pandemic caused widespread socioeconomic disruption globally and Timor-Leste was no exception, its public health response was effective in addressing the impacts. According to the WHO (2022), the Government's health strategies against the COVID-19 pandemic resulted in 5,22,827 confirmed cases and 130 fatalities until March 2022. A total of 1.3 million vaccine doses were administered (as of 29 March 2022). Notwithstanding, the country's GDP is estimated to have contracted by 7 per cent in 2020. Exports nearly halved due to the limited travel services and lower earnings from coffee export (World Bank, 2021). As Timor-Leste continues to strengthen its recovery from the pandemic, it should build on the lessons learnt from the pandemic to advance its progress and ambitions towards achieving the SDG targets, and build resilience against future challenges such as those posed by 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 withstand future shocks, such as those experienced during the COVID-19 pandemic, and to build long-term resilience. This *SDG 7 Road Map for Timor-Leste* identifies several key areas that will assist policymakers in strengthening policy measures to sustain progress made since the COVID-19 pandemic, while building resilience to future crises and maintaining momentum towards achieving the 2030 Agenda for Sustainable Development and the Paris Agreement. Figure 16 presents how the *SDG 7 Road Map* supports Timor-Leste to continue its recovery from COVID-19 and enhance preparedness.

Figure 16. **SDG 7 Road Map will increase the capacity of Timor-Leste to continue recovery from the COVID-19 pandemic**
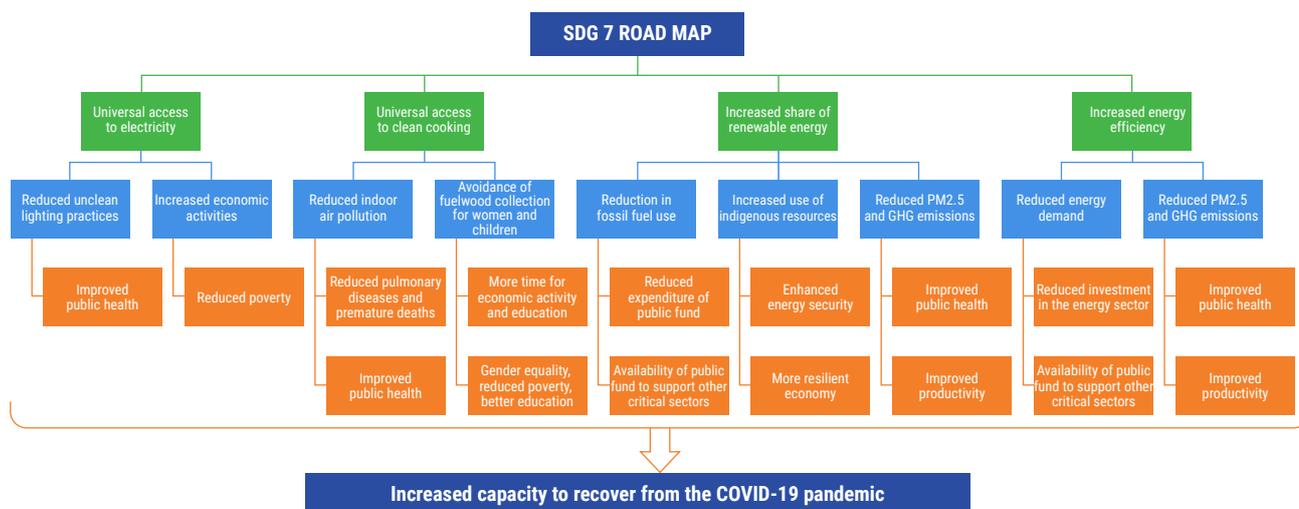
Source: Based on ***Beyond the Pandemic: Building Back Better from Crises in Asia and the Pacific*** (United Nations publication, 2021).

7.1. Accelerating access to clean and modern energy services

Access to clean and modern energy services is essential for helping rural populations to combat the challenges, such as those posed by the COVID-19 pandemic. Relying on traditional and hazardous technologies for cooking increases their susceptibility to the effects of the virus. Ongoing research is finding links between air pollution and the incidence of illness and death due to the COVID-19 pandemic. Recent research suggests that PM2.5[11] air pollution plays an important role in increased COVID-19 incidence and death rates. One such study reported that PM2.5 is a highly significant predictor of the number of confirmed cases of COVID-19 and related hospital admissions (Andrée, 2020). It is important to consider how the lack of access to clean cooking combines with the COVID-19 virus to affect the most vulnerable people.

Timor-Leste had around 85.7 per cent of the population, or around 214,412 households, that lacked access to clean cooking fuel in 2021. Women and children disproportionately bear the greatest health burden from polluting stoves, fuels and technologies in homes as they typically perform household chores, such as collecting firewood and cooking with inefficient methods which expose them to harmful smoke.

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 space heating, and is encouraging policymakers to adopt measures to address this challenge. In 2019, around 0.3 per cent of the population lived with household air pollution-related diseases in Timor-Leste (World Bank, 2022).

The *SDG 7 Road Map* has analysed and identified technical options for connecting the remaining population to cleaner fuel for cooking and heating. The benefits of this measure, in terms of reduced mortality and positive health impacts, outweigh the investment required to achieve 100 per cent coverage of clean cooking and clean heating.

11　Particulate matter (PM) 2.5 particles are produced during fossil fuel combustion and are able to 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.

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

NEXSTEP analysis identifies ample opportunities for Timor-Leste 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 mass transport, the improvement of fuel efficiency and the enforcement of fuel specifications and standards, in the SDG scenario, will be around 30.5 ktoe or around 220,000 barrels of oil equivalent in 2030. This will save Timor-Leste around $17.6 million[12] between the period 2025 to 2030. Savings from this improvement can be reinvested in other sectors, such as health, social protection and economic stimulus, which can continue supporting recovery from the COVID-19 pandemic and building resilience.

The electrification of the transport sector provides multiple additional benefits (in addition to energy saving), including the reduction of expenditure on importing petroleum products and reducing local air pollution. Increasing renewable power capacity as currently planned, with the goal of enabling cross-border power trade also provides additional revenue for the country. Collectively, these measures are crucial for strengthening recovery from the COVID-19 pandemic, building back better and ensuring a sustainable energy future.

7.3. 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 (World Economic Forum, 2020) 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. The average job creation for solar PV generation is around $7.24 million (Garrett-Peletier, 2017). In contrast, Garrett-Peletier (2017) found that only 2.65 full-time equivalent jobs are created for $1 million of spending in fossil fuels. In both the CPS and SDG scenario, $134.8 million is required for the deployment of solar PV between 2024 and 2030. Therefore, this investment in renewables will provide employment opportunities to around 976 people compared with only around 357 employment opportunities generated from the same amount of investment in fossil fuel.

Renewable generation also offers the opportunity to provide modern energy services to rural and underprivileged populations in Timor-Leste through decentralized systems, supporting poverty alleviation. This will strengthen the resilience of people to health and economic shocks, such as those posed by the COVID-19 pandemic.

7.4. Building sustainable recovery beyond the COVID-19 pandemic for Timor-Leste

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

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12   This is at the current price of oil – approximately $80/barrel as of 31 January 2024.

CHARGING   44 %
Remaing time   2 minute

8. Conclusion and the way forward

The 2030 Agenda for Sustainable Development and Paris Agreement provide a common goal for all countries to achieve sustainability and climate objectives. Achieving the SDG 7 and NDC targets is not an easy feat, but it will help to create a more sustainable and resilient society. This Road Map has presented a number of different scenarios together with their technical feasibility, investments, benefits, challenges and opportunities to inform policymakers of the different pathways that can be taken to achieve energy transition.

It is projected that Timor-Leste will achieve universal access to electricity by 2030. However, significant efforts are still required for Timor-Leste to achieve universal access to clean cooking by 2030. A coordinated approach from the private and public sectors is essential in addressing the gaps in access to clean cooking and provide the population with clean cooking technologies. Examples include electric cooking stoves and improved cooking stoves, which build on commonly used practices, while reducing fuel consumption and household indoor pollution.

The major concern of the energy sector of Timor-Leste is the heavy reliance on imported fossil fuel, particularly oil products. Ample opportunities exist in the residential, transport and commercial sectors to save a substantial amount of energy through the implementation of energy efficiency measures. The transport sector offers the biggest potential for energy savings and should be the main focus, as it holds the largest share of the country's energy consumption. Key measures include adopting fuel economy standards, encouraging mass transport and increasing the uptake of electric vehicles. Timor-Leste has the potential to increase its ambition beyond what is needed to meet the energy efficiency targets for SDG 7 and further reduce energy consumption in all sectors. For example, the introduction of minimum energy performance standards and labelling (MEPSL) for household, commercial and industrial appliances is a key policy area to be considered. Collectively, these measures will eventually reduce the energy sector's reliance on imported petroleum fuel.

Modern renewable energy delivered still accounted for a very small share, only 0.04 per cent of TFEC in 2021. Improving energy efficiency and increasing the share of modern renewable energy has the potential to increase the renewable energy share in TFEC to 25.5 per cent in 2030. Promoting the use of electric cooking stoves and electric vehicles in the long term will require a substantial amount of electricity in the future. Diversifying generation sources using solar PV and wind also holds the potential to help the country fulfil the increasing demand as well as improve energy security. The scenario analysis using the MCDA tool suggests that the Government should consider the SDG 7 scenario for transitioning the energy sector. In addition to achieving the SDG 7 targets, this scenario will also enable Timor-Leste to exploit its full potential for emission reduction in the long term. Finally, the energy transition pathway presented in this SDG 7 Road Map will support building back better after the COVID-19 pandemic. The proposed energy transition presents opportunities to reduce economic risks, both for public and private investment, and identifies areas for financial savings in the energy sector that can support the recovery of other critical sectors, such as the health sector.

Annexes

Annex 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	2021	2030
7.1. By 2030, ensure universal access to affordable, reliable, and modern energy services.	7.1.1. Proportion of population with access to electricity.	97%	100%
	7.1.2. Proportion of population with primary reliance on clean fuels and technology for cooking.	14.3%	100%
7.2. By 2030, increase substantially the share of renewable energy in the global energy mix.	7.2.1. Renewable energy share in total final energy consumption.	0.04% (excluding traditional biomass)	25.5%
7.3. By 2030, double the global rate of improvement in energy efficiency.	7.3.1. Energy intensity measured as a ratio of primary energy supply to gross domestic product.	1.8 MJ/US$ (2017) PPP	1.3 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 Timor-Leste (2002-2010):[13] -2.4 per cent (negative sign means that the energy intensity increased during the given period).

SDG 7.3. improvement rate for Timor-Leste (suggested global improvement rate): 3.4 per cent.

Annex II.   Key assumptions for NEXSTEP energy modelling

(a)   General parameters

Table II. 1. GDP, PPP and growth rate

Parameter	Value
GDP (2021)	US$ 2.72 billion
Growth rate	5.3%

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

Parameter	Value
Population (2021)	1.32 million
Population growth rate	1.6%
Number of households (2021)	250,189
Household size (constant throughout the analysis period)	5.28

(b)   Demand-side assumptions

(i) Transportation

- -Land 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 local consultant, and assumptions made by ESCAP and the local consultant, as local specific data is scarce.

- -Land transport activities in 2021 are estimated to have been 6,744 million km of which 6,708 million-km was for passenger transports (expressed as passenger-km) and 36 million-km was for freight transport (expressed as ton-km). The growth in both passenger transport and freight transport activities is assumed to be growing at the same rate as the population, at 1.6 per cent per annum.

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13   According to the methodology for determining improvement rate, base period is 1990-2010. However, as Timor-Leste gained its independence in 2002, the base period has been chosen to be 2002-2010.

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	24669 (gasoline) 12392 (diesel)	10000 10000	2.5 2.5	12 12	13.8
Motorcycle	133318 (gasoline)	9000	1.6	14	28.6
Bus	6 (gasoline) 471 (diesel)	40000 40000	40 40	8 8	14.2
Minibus	2,705 (gasoline)	60,000	8	8.3	19.4
Taxi	576 (gasoline) 7 (diesel)	32,500 32,500	8 8	8 8	0.7
Other	9,487 (gasoline) 1,349 (electricity)	8000 8000	18	10	23.3
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	3 (diesel) 123 (gasoline)	26,000 26,000	11 11	8.30 8.30	2 98

(ii) Residential

- The residential sector is further divided into urban and rural households. Urban households have achieved 100 per cent electricity access rate, while rural households have achieved 95.8 per cent electricity access rate; the overall clean cooking rate was 14.3 per cent in 2021. The breakdown is shown in table II.4.

Table II.4. Cooking distribution in urban and rural households[14]

Stove type	Energy intensity (GJ/household)	Urban (Percentage)	Rural (Percentage)
LPG stove	4.69	4.8	0
Electric stove	3.94	31.5	5.7
Biomass stove*	4.27	48.3	94.0
Kerosene stove*	0.15	15.4	0.3

* This is assumed as unclean fuel/technology.

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

- The residential appliance ownership data and energy use intensity in the baseline year were provided by the local consultant and validated by the Government. 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	468.0	100	360.0	100
Refrigerator	936.0	75	936.0	20
Air conditioner	1,589.8	45	-	-
Television	302.4	95	504.0	30
Electric stove/rice cooker	432.0	85	288	15
Electric fan	403.2	90	16.2	5
Washing machine	403.2	35	-	-
Water pump	108.0	80	-	-
Iron	96.0	95	96.0	4.4

(iii) Industry

- The industry sector is divided into seven subcategories. The fuel consumption by industry subcategories is detailed in table II.6.
- The industrial GDP is assumed to grow at an annual rate of 5.3 per cent, similar to the national GDP growth rate. The energy intensity is assumed constant throughout the analysis period in the absence of energy efficiency interventions.

Table II. 6. Fuel consumption by industry subcategories in 2021

Industry	Fuel consumption (ktoe)					
	Coal	Natural gas	Oil products	Electricity	Biomass	Total
Food and beverages	-	-	-	1.2	-	1.2
Furniture	-	-	-	2,201.2	-	2,201
Coffee production	-	-	-	1.0	-	1.0
Total	**-**	**-**	**-**	**2,203.4**	**-**	**2,203.4**

(iv) Commercial sector

- The total annual energy consumption in the commercial sector was 3,436.3 toe in 2021. It is projected to grow at an annual rate of 5.3 per cent, similar to the national GDP growth rate in the BAU scenario. However, energy savings are expected in the current policy scenario through the obligatory building standards.
- The commercial sector is further differentiated into four categories and the energy consumption by categories are shown in table II.7.

Table II. 7. Commercial sector fuel consumption in 2021

Category	Floor space (million m^2)	Fuel consumption (ktoe)
		Electricity
Private offices	0.011	60.6
Government buildings	0.12	894.2
Shopping malls	0.14	1,538.1
Hotels	0.0008	6.4
Hospitals	0.16	927.9
Universities	0.002	7.6
Religious temples	0.001	1.5
Total	**0.43**	**3,436.3**

Annex 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)	Maximum availability (Percentage)	Capital cost (US$/MW)	Fixed O&M (US$/MW-year)	Variable O&M (US$/MWh)
Diesel	28	18.7	1,100	8.0	6.4
Solar PV	100	36	830	15.0	-
Wind	100	30	1,500	60.0	-

Annex 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 1,623 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 (%)	Lifetime (years)	Stove cost (US$)	Variable O&M ($/year) (ESCAP estimation)	Fuel cost ($)
ICS	30 (ESCAP estimation)	4 (ESCAP estimation)	$25	10	0.22 per kg
LPG stove	65 (World Bank, 2014)	7 (Clean Cooking Alliance, 2021)	$30	10	3.23 per kg
Electric stove	84 (IEA ETSAP, 2012)	15 (IEA ETSAP, 2012)	$37	10	0.40 per kWh

Table IV. 2. Summary results for the scenarios

	2021	CPS scenario 2030	SDG scenario 2030
Universal access to electricity in 2030	97%	100%	100%
Universal access to clean cooking in 2030	14.3%	20.8%	100%, via electric stoves and ICS
Energy efficiency in 2030	1.8 MJ/US$	1.6 MJ/US$	1.3 MJ/US$
Renewable energy share in TFEC in 2030	0.04%	25.5%	25.5%
GHG emissions in 2030	820.2 ktCO$_2$-e	793.5 ktCO$_2$-e	643.7 ktCO$_2$-e
Renewable energy share in power generation in 2030	0.2%	35.4%	35.4%
Net benefits from the power sector	Not applicable	US$ 587.1 million	US$ 594.6 million
Total investment for the power sector up to 2030	Not applicable	US$ 134.8 million	US$ 134.8 million

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