Energy Transition Pathways for the 2030 Agenda

Sustainable Energy Transition Road Map for the City of Ormoc, the Philippines

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

NEXSTEP
National Expert SDG Tool for Energy Planning

Energy Transition Pathways for the 2030 Agenda

Sustainable Energy Transition Road Map for the City of Ormoc, the Philippines

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

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

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Foreword: ESCAP

The City of Ormoc was one of the leaders in the Philippines in using the United Nations Economic and Social Commission for Asia and the Pacific's (ESCAP) National Expert SDG Tool for Energy Planning (NEXSTEP) methodology to develop a Sustainable Energy Transition Road Map. ESCAP is pleased to partner with the City of Ormoc in its endeavour to realize a vision for the city's future based on holistic and sustainable development.

In its vision, Ormoc City aims to become the agro-commercial and industrial gateway in Eastern Visayas and the Renewable Energy Capital of the Philippines. The city has maintained a focus on its environmental protection measures, as shown by the fact that it has consistently been recognized as the cleanest and greenest city in Region VIII as well as one of the cleanest and greenest cities in the country. ESCAP's collaboration with the City of Ormoc in developing this Sustainable Energy Transition (SET) Road Map further raises the city's sustainable development ambition, by identifying the opportunities for the city's sustainable energy transition.

This Road Map takes a holistic approach to Ormoc's energy system. It evaluates the city's current progress towards the SDG7 targets, identifies the priorities for action and suggests opportunities for improvement. For example, the Road Map highlights the current gap in universal access to modern energy in the city, and proposes the appropriate long-term solutions for closing this gap that also enhances socio-economic development.

The Road Map also details a range of technical opportunities and policy options for reducing emissions and saving energy across the residential, transport and agricultural sectors. These opportunities include transport electrification as well as substantial reduction in the city's emissions through decarbonization of its power supply, while paving the way towards a net-zero society.

ESCAP would like to thank the City of Ormoc and other stakeholders for their continuous support and contributions, without which the development of this Sustainable Energy Transition Road Map would have not have been possible. I look forward to the City of Ormoc's continuing leadership in building a sustainable energy future.

Hongpeng Liu
Director, Energy Division, ESCAP

Foreword: City of Ormoc

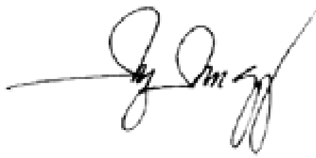
The City of Ormoc welcomes the development of this Sustainable Energy Transition Roadmap which is a critical step in our journey to a cleaner, more sustainable future.

As we know, the world is facing a climate crisis. The evidence is all around us: rising sea levels, more extreme weather events, and a decline in biodiversity. The science is also clear that burning fossil fuels for energy is one of the biggest drivers of global warming and climate change. Even if our city, and the Philippines, in general, have a small contribution to global greenhouse gas emissions causing the climate crisis, we still have a role to play and have the shared responsibility to slash emissions toward a net zero carbon future. We need to take urgent action now to address this crisis, and this roadmap provides a clear path forward.

Our city envisions becoming a renewable energy leader in the country, aside from becoming a resilient city in the face of climate emergency. We have implemented some related actions to this matter at the local level. Aside from hosting a solar farm and a geothermal power plant in Ormoc City, we have piloted our energy efficiency and conservation initiatives by installing solar panels and energy-efficient LED lighting in our public buildings and along our streets. The city government also partnered with a company running electric and solar-powered vehicles for cleaner transportation as part of our long-term plan to modernize our transport sector using clean energy.

This roadmap helps shed light on our current energy situation, identifies gaps, and recommends policy measures to pursue the pathway to low-carbon development. This will contribute to achieving global goals like Sustainable Development Goal 7: to ensure access to affordable, reliable, sustainable, and modern energy for all. This will also serve as our local contribution to the Paris Agreement's goal of limiting global warming to 1.5 degrees Celsius by rapidly slashing emissions to avoid irreversible and catastrophic climate change impacts. Above all, this road map will help us in our efforts to pursue a resilient and sustainable development that will benefit the people of Ormoc in the long run when adopted and acted upon by the stakeholders.

We are deeply grateful to the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) for giving Ormoc City this timely opportunity to pursue the path toward a low-carbon future. We also express our gratitude to our development stakeholders from the private sector, national government agencies, and local government offices, that provided the data requirements in crafting this roadmap. We urge our partners to continue joining our efforts in securing our future and making our city a safe and liveable place for all.



LUCY TORRES GOMEZ
Ormoc City Mayor

Abbreviations and acronyms

BAU	business-as-usual
BEV	battery electric vehicle
CBA	cost benefit analysis
CES	clean energy scenario
CO_2	carbon dioxide
CPS	current policy scenario
CREVI	Comprehensive Roadmap for the Electric Vehicle Industry
DOE	Department of Energy
DPS	decarbonization of power sector
EE	energy efficiency
ESCAP	(United Nations) Economic and Social Commission for Asia and the Pacific
GB Code	Green Building Code
GDP	gross domestic product
GHG	greenhouse gas
GWP	global warming potential
GW	gigawatt
GWh	gigawatt-hour
IEA	International Energy Agency
ktoe	thousand tonnes of oil equivalent
kWh	kilowatt-hour
LCOE	Levelized Cost of Electricity
LEAP	Long-range Energy Alternatives Planning
LPG	liquified petroleum gas
MCDA	Multi-Criteria Decision Analysis
MJ	megajoule
$ktCO_2$-e	thousand tonnes of carbon dioxide equivalent
MCCC	Modified Corona's Climate Classification
MTF	Multi-Tier Framework
MW	megawatt
MWh	megawatt-hour
MVUC	motor vehicle users charge
NDC	nationally determined contribution
NEXSTEP	National Expert SDG Tool for Energy Planning
PHP	Philippine peso
RE	renewable energy
REF	reference scenario
SDG	Sustainable Development Goal
SET	sustainable energy transition
TFEC	total final energy consumption
TGFA	total gross floor area
TNZ	towards Net Zero
TPES	total primary energy supply
TWh	terawatt-hour
UNEP	United Nations Environment Programme
US$	United States dollar
WHO	World Health Organization

Executive Summary

Transitioning the energy sector to achieve the 2030 Agenda for Sustainable Development and the objectives of the Paris Agreement presents a complex and difficult task for policymakers. It needs to ensure sustained economic growth as well as respond to increasing energy demand, reduce emissions, and consider and capitalize on the interlinkages between Sustainable Development Goal (SDG) 7 and 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 nationally determined contributions (NDCs). The initiative has been undertaken in response to the Ministerial Declaration of the Second Asian and Pacific Energy Forum (April 2018, Bangkok) and Commission Resolution 74/9, which endorsed its outcome. NEXSTEP also garnered the support of the Committee on Energy in its Second Session, with recommendations to expand the number of countries being supported by this tool.

The City of Ormoc, in collaboration with the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP), has developed this Sustainable Energy Transition (SET) Road Map to identify technological options and policy measures that will help the city to navigate the transition of its energy sector in line with the 2030 Agenda for Sustainable Development.

The Road Map presents three core scenarios (BAU, CPS and SDG) and one ambitious scenario (towards net zero carbon by 2050) that have been developed using local data, which consider existing energy policies and strategies and reflect on other development plans. The net zero carbon scenario by 2050 offers policymakers a strategic viewpoint on how Ormoc could plan for a carbon-free energy pathway in alignment with the global race to net zero carbon. These scenarios are expected to enable the city authority to make an informed decision to develop and implement a set of policies to navigate through the sustainable energy transition pathway.

A. Highlights of the Road Map

In 2020, Ormoc's population numbered 230,998 people, which comprised 56,048 households. The electrification rate in Ormoc had progressed to 100 per cent by 2020. On the other hand, about 15 per cent of the population, which corresponds to 8,407 households, still relied on unclean and polluting kerosene and biomass stoves as their primary cooking technology. Such practice exposes those people, mostly women, to negative health impacts. Well-planned and concerted efforts will be needed to achieve universal access to clean cooking by 2030.

Energy intensity, the indicator used to measure energy efficiency, was calculated as 6 MJ/USD$_{2017}$ in 2020. For Ormoc City to contribute to the global target of energy efficiency improvement of 3.2 per cent reduction per year between now and 2030, this needs to be reduced to 4.35 MJ/US\$$_{2017}$ by 2030, which will require energy efficiency measures to be implemented across the entire demand sectors. The total primary energy supply in Ormoc was similar to its total final energy consumption (TFEC) of 64.2 ktoe, as local electricity generation was minimal. Ormoc is connected to the Visayas grid, importing almost all (~100 per cent) of its electricity demand from the central grid. A small amount of electricity was supplied through the installations of a 99.45 kW$_p$ rooftop solar system with 255 panels of solar Photovoltaic (PV) within the city boundary, with an estimated generation in 2020 of 139 MWh. Renewable energy delivered

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.

approximately 17.6 per cent of TFEC in 2020, including traditional biomass use for residential cooking. When traditional use of biomass is excluded, the RE share in TFEC is 6.2 per cent.

B. Aligning the City of Ormoc's energy transition pathway with the SDG 7 and NDC targets by 2030

1. Universal access to modern energy

As of 2020, 100 per cent of Ormoc's population already had access to electricity. However, 15 per cent of the population lacked access to clean cooking fuels and technologies. More attention is required to providing universal clean cooking access to the population of Ormoc. Nearly one-sixth of the population rely on unclean cooking fuel and technologies for household cooking, specifically traditional biomass stoves (14 per cent of households) and kerosene stoves (1 per cent of households). Phasing out of unclean cooking technologies will improve health and well-being of householders through reducing indoor air pollution as well as ensure gender empowered socio-economic development. Electric cooking stoves stand out as an appropriate long-term solution, due to their cost-effectiveness, zero air pollution and minimal maintenance. In addition, coupling this technology with a decarbonized electricity supply results in an overall zero-carbon cooking solution. However, considering the possible lack of sufficient power supply capacity for some households (i.e., households connected to mini-grid or solar home systems) to meet the power demand of electric stoves, LPG stoves may be an appropriate transitional technology for those households.

2. Renewable energy

The share of renewable energy (RE) in the total final energy consumption (TFEC) in Ormoc was 6.2 per cent in 2020, excluding the traditional biomass usage. Under the Current Policy Scenario (CPS), the share of RE will increase to 9.3 per cent by 2030. This increase is driven by the high growth of the renewable energy share in grid electricity, which is projected to increase from 48.4[2] per cent in 2020 to 66.9 per cent in 2030, and a slight increase in biofuel usage in the transport sector. In the Sustainable Energy Transition (SET) scenario, the RE share in TFEC increases to 15.6 per cent. This additional increase of 6.3 percentage points from the CPS is a result both of increased use of RE due to a higher share of electricity in energy consumption and a further reduction in energy demand due to energy efficiency measures.

The RE share in TFEC for the Towards Net Zero (TNZ) by 2050 scenario is further increased to 28.4 per cent, as the scenario envisions a decarbonized electricity supply and aims to position the energy system towards achieving net-zero carbon. In the TNZ scenario, more electricity-based technologies are adopted in the transport and residential sectors, reducing overall energy demand and increasing renewable energy usage with a 100 per cent electricity supply. As described later in this Road Map, there are several pathways for achieving a decarbonized electricity supply, with the most promising and cost-effective one being through renewable energy auctions.

3. Energy efficiency

Ormoc's energy intensity, a proxy measure for energy efficiency improvement, is estimated to have been 6 MJ/US$$_{2017}$ in 2020. It is expected to be reduced to 5.39 MJ/US$$_{2017}$ by 2030 in the CPS, as GDP growth outpaces the growth in energy demand. This corresponds to an annual energy efficiency improvement rate of 1.1 per cent.

The SET scenario proposes several energy-efficiency interventions across the demand sectors, which further decreases the energy intensity to 4.31 MJ/US$$_{2017}$ by 2030. This corresponds to a 3.3 per cent

2 Based on the DOE 2020 Power Statistics, gross generation per grid, by plant type.

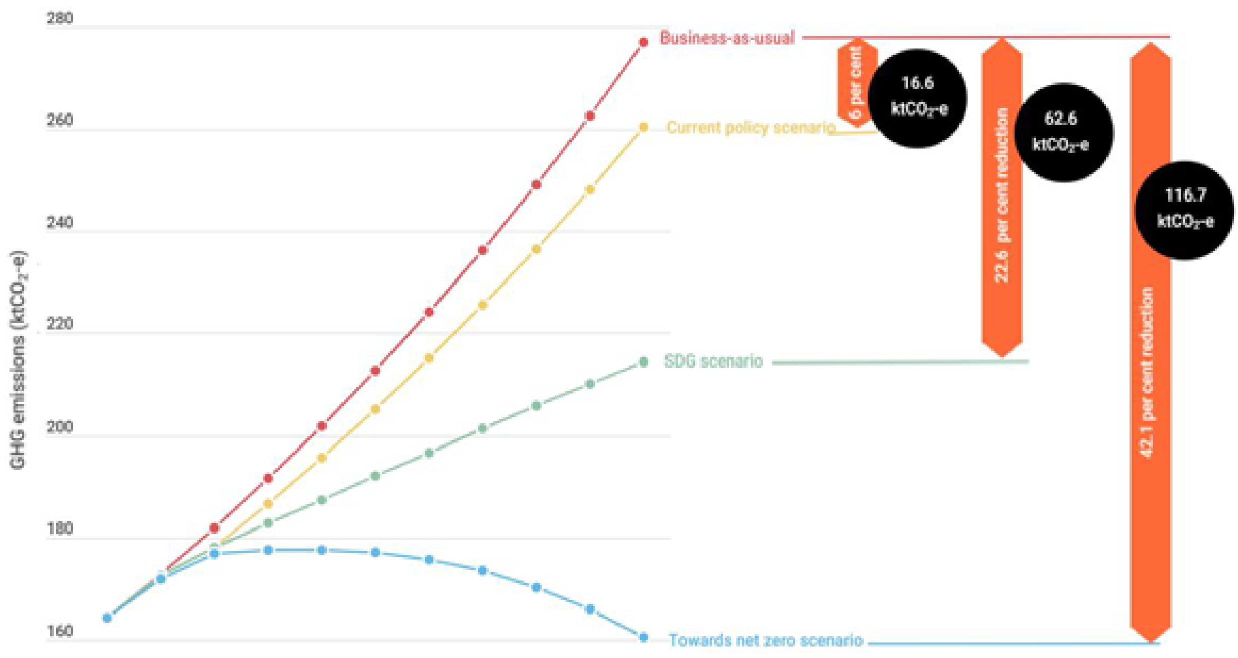
reduction per annum, aligning with the suggested global annual improvement rate of 3.2 per cent (UNSD, 2021). The transport sector accounted for around 69.6 per cent of the total energy demand in 2020, and energy efficiency measures in the sector may provide substantial savings. The Road Map proposes an increase of electric vehicle share in the transport fleet to 20 per cent by 2030. The projected result is a 13.3 thousand tonnes of oil equivalent (ktoe) reduction in energy demand, compared with the CPS due the high efficiency of electric vehicles. Other measures include phasing out of inefficient lighting appliances in the residential sector. The phasing out of inefficient, polluting cooking technologies allows an estimated energy reduction of 7 ktoe, clearly demonstrating the positive interaction between clean cooking access and energy efficiency.

The energy demand reduction can be significant should Ormoc follow a net zero carbon pathway, as suggested in the TNZ scenario. The energy intensity in this scenario is projected to decline to 3.85 MJ/US$$_{2017}$, corresponding to a 4.4 per cent energy efficiency improvement per annum.

4. Emissions

The greenhouse gas (GHG) emissions in 2020 are estimated to have been 164.2 ktCO_2-e, when considering the direct fuel combustion and emissions attributable to the purchased (grid) electricity. Figure ES 1 shows the GHG emission trajectories for the different scenarios. In BAU, the emissions are projected to increase to 277 ktCO_2-e by 2030. In CPS, emissions in 2030 will drop to 260.5 ktCO_2-e, and will further decrease to 214.5 ktCO_2-e in the SET scenario. A sharp decrease can be observed in the TNZ scenario, dropping to 160.4 ktCO_2-e driven by the increased adoption of electricity-based technologies in the transport and residential sectors. This entails having 100 per cent electric vehicle sales[3] starting from 2030 onwards to reach a 100 per cent penetration rate by 2050 and phasing out of LPG stoves for residential cooking. In the agricultural sector, diesel-powered water pumps are replaced with solar irrigation systems. The remaining emissions are from the use of large-scale diesel-powered agricultural machinery (i.e., harvester, rotovators and tractors) where electric-powered versions have not yet reached the commercialization stage.

Figure ES 1. Comparison of emissions, by scenario, 2020-2030



3 Electric vehicle sales rate is defined as the proportion of the number of electric vehicles compared to the total sales of vehicles in the area. Meanwhile, the electric vehicle penetration rate indicates the proportion of the number of electric vehicles compared to the total on-the-road vehicle in the area.

C. Important policy directions

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

(1) **Strong policy measures are required to address the remaining gap in clean cooking by 2030.** NEXSTEP proposes electric cooking stoves as a long-term clean technology substitute. LPG stoves are a strong contender; however, electric cooking stoves are more cost-effective and cleaner in terms of household indoor air pollution. In addition, the use of electric cooking stoves paves the way towards net zero emissions when the electricity supply is decarbonized. LPG stoves may, however, be promoted for households that lack sufficient power supply capacity, i.e., households utilizing decentralised renewable energy systems. The cost of deployment of clean cooking stoves would be $US1.9 million (US$ 0.8 million for LPG cooking stoves and US$ 1.1 million for electric cooking stoves).

(2) **Increasing the efficiency of energy use in the transport and residential sectors should be pursued, and transport electrification strategies provide multi-fold benefits in the long term.** The transport sector is the highest energy-consuming sector in Ormoc. Therefore, the encouragement of public transportation use can be considered. Total energy saving potential in the transport sector between 2023 and 2030 will be 19.3 ktoe with 53.3 ktCO_2-e of emission reduction. Vigorous adoption of electric vehicles reduces the demand for oil products, hence reducing Ormoc's reliance on petroleum fuel. At the same time, it can contribute to climate mitigation and improve local air quality. An adoption rate of 20 per cent for passenger cars, motorcycles and freight trucks by 2030 has the potential to cumulatively save energy by 34.4 ktoe and reduce emissions by 153.7 ktCO_2-e under the SET scenario between 2023 and 2030.

(3) **Raising the RE share in electricity supply through urban RE electricity generation, PPA and RE auctions.** Among the options for increasing the RE generation share, RE auctions provide the best financial case and financial savings due to low solar PV generation costs. In addition, solar rooftops would be a more feasible option. Fulfilling 50 per cent of electricity demand from solar rooftops will save around US$ 5.5 million in 2025 and around US$ 10.7 million in 2030 under the TNZ scenario. The required rooftop area will be around 73,202 m^2 by 2030. The opportunity for utilizing the biomass resource potential of the city for energy generation can also be explored.

(4) **Moving towards net-zero carbon.** A net-zero society requires a concerted effort, both by the city authorities and citizens. Total decarbonization of the power supply is essential, while increased electrification in the demand sectors is required, including phasing out of internal combustion engine vehicles, LPG stoves and diesel-powered water pumps. In this net zero scenario, the market sales of electric vehicles should be 100 per cent starting from 2030 onwards to reach a 100 per cent penetration rate by 2050.

1. Introduction

1.1. Background

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

The NEXSTEP tool has been specially designed to support policymakers in analysing the energy sector and developing an energy transition plan in the context of SDG7. Further details of the NEXSTEP methodology are discussed in section 1.3. While this tool has been designed to help develop SDG7 Road Maps at the national level, it can also be used for subnational energy planning.

The City of Ormoc (Ormoc), in collaboration with ESCAP, has developed a Sustainable Energy Transition (SET) Road Map, which seeks to assess Ormoc's baseline, and to identify technological options and policy measures that will help the city navigate the transition of the energy sector in line with the 2030 Agenda for Sustainable Development.

1.2. SDG 7 targets and indicators

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

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

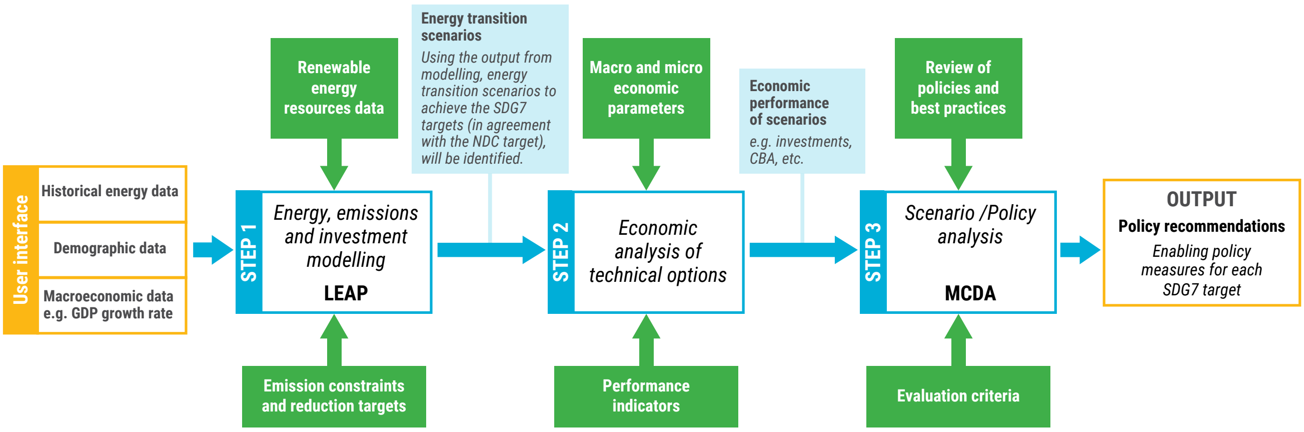
In addition to the above-mentioned targets, the SDG 7 goal also includes target 7.A – promote access, technology and investments in clean energy, and target 7.B – expand and upgrade energy services for developing countries. These targets are not within the scope of NEXSTEP.

1.3. NEXSTEP methodology

The main purpose of NEXSTEP is to help to design the type and mix of policies that would enable the achievement of the SDG 7 targets and the emission reduction target (under NDCs) through policy analysis.

The tool helps modelling energy, emissions and economics to analyse a range of policies and options for their suitability. This tool is unique in a way that no other tools look at developing policy measures to achieve SDG 7. One key feature is a back-casting approach to energy and emissions modelling, which is important in planning for SDG 7, where the trajectory is developed backwards from the (known) 2030 targets to the present day. Figure 1 shows different steps of the methodology.

Figure 1. Different components of the NEXSTEP methodology



1.3.1. Energy and emissions modelling

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

1.3.2. Economic analysis

The second step builds on the selection of appropriate technologies through an economic optimization process that 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 at 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.

1.3.3. Scenario analysis

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

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

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

4 Available at https://nexstepenergy.org/

2. City overview

2.1. Demographic and macro-economic profile

Geography and climate: Ormoc, officially known as the City of Ormoc, is first-class independent component city in the Eastern Visayas region, the Philippines and is composed of 85 *barangays*. The City of Ormoc is located on the north-western coastal plain of Leyte Island and lies around longitudes of 124°36' 27" and latitudes of 11° 00' 38". The city has a total land area of 613.6 square kilometres (sq.km.). Much of Ormoc's land area is used for agriculture, with rice, sugarcane, and coconut being the most important crops.

Ormoc's climate is characterized by not having a dry season with a very pronounced maximum rainfall during the months of November to December. Based on the observed seasonal rainfall from 1971-2000, the average annual rainfall is 2,456 mm. The driest month is April with an average of 131 mm. Most precipitation falls in November, with an average of 446 mm. The difference in precipitation between the driest month and the wettest month is 358 mm.

Population and economy: The City of Ormoc had a population of 230,998 in 2020. This is higher by 15,967 people compared to the 2015 Census of Population and Housing at 215,031 people. The increase in the city population translated into an annual growth rate at 1.52 per cent. Ormoc is the second-most populous city in the province of Leyte after the provincial capital of Tacloban.

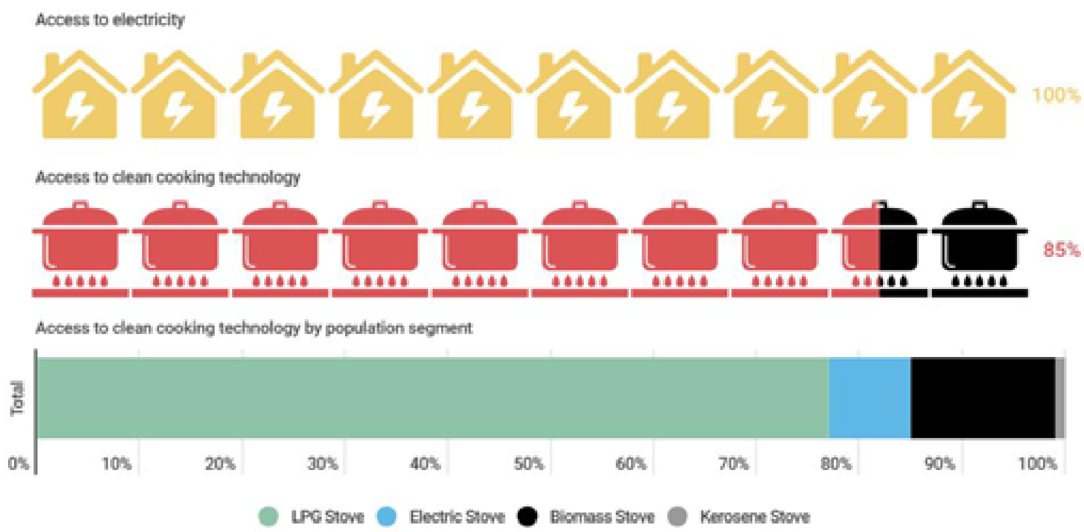
Ormoc is part of the Eastern Visayas region. The Eastern Visayas' main economic activities consist of agriculture, commercial and services, industrial, fisheries and mining. The Eastern Visayas' economy recovered to 6 per cent in 2021, from the 2020 reduction of -7.4 percent. The economic growth was led by the positive performance of all major industries. The total value of goods and services in the region as measured by the Gross Regional Domestic Product (GRDP) in 2020 was PHP 434.8 billion (US$ 8.8 billion). The city's GDP in 2020 is estimated to have been US$ 446.2 million and a GDP per capita of US$1,931.

2.2. Energy sector overview

2.2.1. National energy profile

Ormoc's population was 230,998 in 2020, which comprised of 56,048 households. The electrification rate in Ormoc had progressed to 100 per cent by 2020. On the other hand, about 15 per cent[5] of the population, which corresponds to 8,407 households, relied on unclean and polluting kerosene and biomass stoves as their primary cooking technology. Such practice exposes those people, mostly women and children, to negative health impacts. Overall, liquefied petroleum gas (LPG) stoves were the most dominant primary clean cooking technology, with an estimated share of 77 per cent. This was followed by electric cooking stoves, which were estimated at 8 per cent (figure 2).

Figure 2. Electricity and clean cooking access share



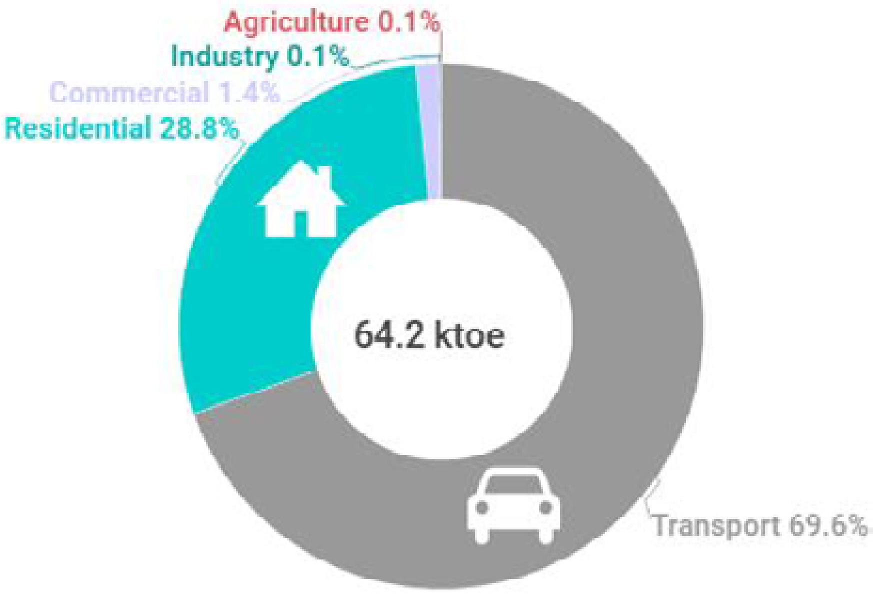
5 Estimated based on the cooking distribution data provided by the local consultant from Isabella University

The following details describe the estimated energy consumption using data[6] collected with a bottom-up approach, such as activity level and energy intensity for the different sectors. The majority of the following 2020 energy data have been provided by ESCAP's local consultant, unless stated otherwise. Further details on the data and assumptions used can be found in Annex II.

The total final energy consumption (TFEC) in 2020 was 64.2 ktoe. As shown in figure 3, the main energy consuming sector is the transport sector, which consumed 44.7 ktoe – 69.6 per cent of TFEC – in 2020. The existing transport fleet (in 2020) was almost exclusively made up of internal combustion engine vehicles, consuming diesel (68.5 per cent), gasoline (28.3 per cent) and a small amount of biodiesel (1.2 per cent) and ethanol (2 per cent).

The residential sector comes second in terms of the final energy consumption, consuming 18.5 ktoe, or 28.8 per cent of Ormoc's TFEC in 2020. Nearing a quarter (23 per cent) of the energy consumed was in the form of electricity, while biomass (39.5 per cent), LPG (37.2 per cent), and kerosene (0.3 per cent) were used for residential cooking purposes. In terms of electricity usage, 24.7 per cent was for air-conditioners, 23.1 per cent was used for refrigeration, 8.8 per cent was for electric fans, 7.9 per cent was for washing machines, 7.7 per cent for lighting, 5.5 per cent for televisions and the remainder for other appliances (ironing, water pumps, etc). The energy consumed in the commercial sector and industry sector is exclusively electricity, at 0.9 ktoe (1.4 per cent) and 0.07 ktoe (0.1 per cent) in 2020, respectively. The agricultural sector consumed 0.04 ktoe of oil products in 2020 for irrigation and machinery purposes.

Figure 3. Total final energy consumption, by sector, in 2020



Renewable energy delivered approximately 17.6 per cent of TFEC in 2020. This includes traditional biomass use in residential cooking, which corresponds to an estimated 7.4 ktoe (11.4 per cent of TFEC). If the traditional biomass was excluded, the modern renewable share was 6.2 per cent of TFEC. A total of 99.45 kWp solar PV system capacity has been installed within the city boundary, which produced 139 MWh in 2020, assuming a 16 per cent capacity factor.[7] The electricity requirement of the region is met almost exclusively by purchased electricity from the central grid, i.e., the Visayas grid. The Eastern Visayas (Leyte-Samar) grid is already 100 per cent

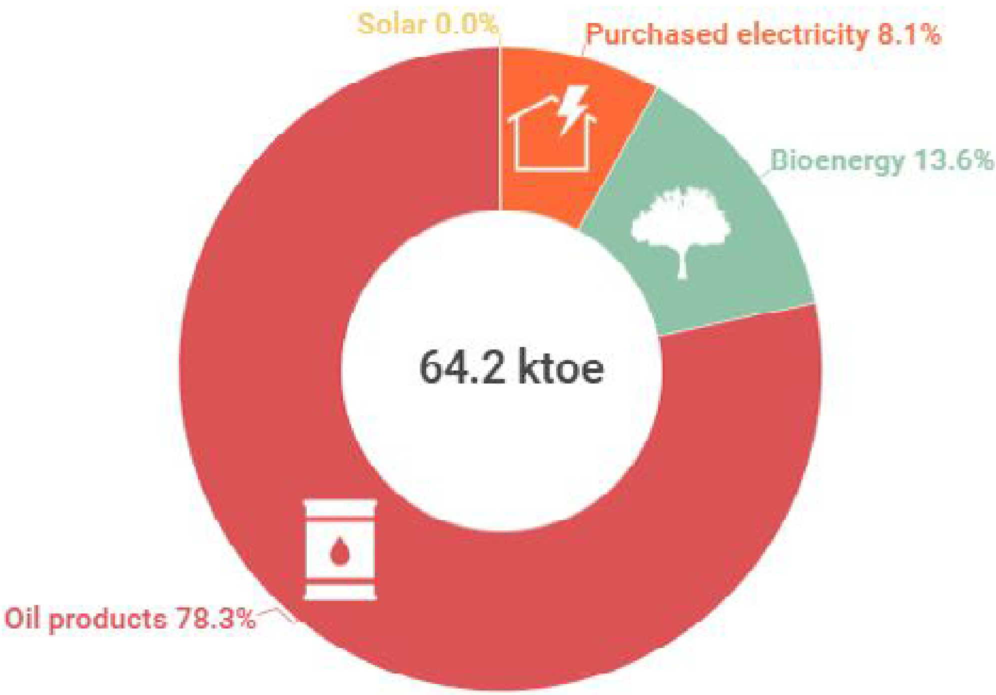
6 National data compiled by Dr. Orlando Balderama and his team with reference to publicly available sources.

7 Based on actual national data for 2019-2020, provided by the Philippines Department of Energy. See https://www.foi.gov.ph/requests/aglzfmVmb2ktcGhyHQsSB0NvbnRlbnQiEERPRS02MDg5OTkyMDk2OTQM

renewable, but the electric cooperatives in the region are being supplied by coal power plants from another region, within the Competitive Selection Process mechanism. These coal power plants and Eastern Samar local electric cooperatives entered into Power Supply Agreements (PSA) which would be valid for up to 25 years. Consequently, the percentage share of renewable electricity considers the share of the central grid, which was estimated as 48.4 per cent in 2020.[8] Other usage of renewable energy includes a small amount of biofuel consumption in the transport sector. The current blend of biofuel in the Philippines is 2 per cent for biodiesel and 10 per cent for bioethanol (DOE, 2021a).

The energy intensity in 2020 was calculated as 6 MJ/US$2017. Figure 4 shows the total primary energy supply (TPES) breakdown by fuel type in 2020, which was 64.2 ktoe, to the same as TFEC, as local electricity generation was minimal. Ormoc is connected to the Visayas grid, importing almost all (~100 per cent) of its electricity required from the central grid. A small amount of electricity was supplied through the installations of 255 units solar PV within the city boundary, with an estimated generation in 2020 at 139 GWh. The energy supply mix was bioenergy (biomass and biofuel) 13.6 per cent, oil products 78.3 per cent, purchased electricity 8.1 per cent and solar energy 0.02 per cent.

Figure 4. Total primary energy supply by fuel type in 2020



The GHG emissions in 2020 are estimated to have been 164.2 ktCO_2-e. The emissions from the residential sector were from the use of LPG and kerosene in household cooking. The transport emissions were from direct fuel combustions in internal combustion engines. In the LEAP analysis, emissions related to electricity usage are estimated separately. The grid emission factor considered for the base year 2020 is 0.461 tCO2/MWh. This is the average of the combined margin emission factors for the Visayas grid, 2015-2017 (DOE, 2021b).

8 Based on DOE's 2021 Power Statistics, gross generation per grid, by plant type.

2.2.2. National energy policies, plans, strategies, and institutions

Ormoc's energy sector development is guided by several national and local policies. These policies have been used as guiding references for the NEXSTEP modelling, to better understand the city's context and to provide recommendations in adherence to the national Government's overarching direction. Where applicable, the 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 Philippine Energy Plan, 2020-2040 and the Philippine Development Plan, 2017-2022** have set out ambitions to provide access to basic electricity for all Filipinos by 2022.
- **The Philippine Energy Plan, 2020-2040.** The power sector development in the Philippines will evolve over time, with increasing RE penetration. This should also result in a reduced grid emission factor throughout the analysis period. The Philippine Energy Plan, 2020-2040 stipulates two scenarios for the national power sector – these are the Reference Scenario (REF) and the Clean Energy Scenario (CES). NEXSTEP utilized the projected electricity generation of CES scenario in projecting the emission factor for 2030. The author's estimated emission factor in 2030 is 0.3 tCO2/MWh. DOE is targeting an increase in the current biodiesel share, from 2 per cent by volume to 5 per cent starting in 2022. DOE is also targeting a 10 per cent penetration rate of electric vehicles for road transport (motorcycles, cars, jeepneys) by 2040.
- **Solar and RE technologies in buildings (Department Circular, 2020-12-26).** The recently issued department circular mandates the use of solar PV and other RE technologies in new and existing buildings. This applies to buildings with electrical loads of at least 112.5 kilovolt-ampere or with a total gross floor area of at least 10,000 square metres. Similar to the above, NEXSTEP assumes that the new and existing buildings do not meet the implementation requirements.
- **The Philippines' Nationally Determined Contribution (NDC).** The Philippines intends to reduce its GHG emissions unconditionally by 2.71 per cent from the BAU baseline by 2030. The conditional target is 72.29 per cent from the BAU baseline by 2030, subject to adequate and enhanced access to technology development and transfer, financial resources and capacity-building support. The given targets are representing the Philippines ambition for the sectors of agriculture, waste, industry, transport and energy. Unfortunately, there is no specific reduction target for each sector.
- **The Minimum Energy Performance Standards (MEPS) and/or energy labelling standards** have been introduced for various household appliances, covering window-type air-conditioners (since 1993) and split-type room air-conditioners (since 2000), refrigerators and freezers (since 1999, applicable to sizes between 142-227 litres), compact fluorescent lamps (CFL), linear fluorescent lamps (LFL), and ballasts and circular fluorescent lamps (Hernandez, 2005). As MEPS for household appliances were introduced between 1993 and 2010, NEXSTEP assumes that existing appliances have already conformed to the minimum energy performance standards set out by DOE, where applicable. Hence, no additional potential savings are to be achieved.
- **The Philippines Green Building Code (GB Code)** was launched in 2015 and is applied to all new construction and/or alteration of buildings with a minimum total gross floor area (TGFA), as shown in table 1 (PGBI, 2016). NEXSTEP assumes that the new and old buildings in Ormoc do not meet the minimum TGFA, hence the mandatory building code does not apply to buildings in Ormoc.

Table 1. Minimum TGFA for different building types to comply with the Philippines Green building Codei

Building type	Minimum total gross floor area (TGFA)
Residential condominium	20,000
Hotel/resort	10,000
Educational school	10,000
Institutional hospital	10,000
Business office	10,000
Mercantile mall	15,000
Mixed occupancy	10,000

2.2.3. Local energy resources and potentials

In addition to geothermal power, there is a need to develop other renewable energy resources in the Metro Ormoc area to further raise the level of energy or improve the quality of power for local consumption as well as to allow export to the national grid. Currently, the country's national grid is experiencing power reserves deficiencies (EDCOP, 2020).

In terms of renewable energy, the region offers considerable potential for developing renewable energy sources, such as solar PV and hydropower. Other sources of energy include wind, biomass, biogas and biofuel. However, grid connectivity is still necessary for RE generation capacity. Therefore, a good power source combination is required.

In considering the increase in waste generation in the county, the Department of Environment and Natural Resources (DENR) is promoting the waste-to-energy (WTE) technologies to help address the nationwide problem on waste. Even though the technology might produce emissions that pollute the air and are harmful to health, this can be overcome with filters for trapping pollutants. The host LGU will ensure that the plan to establish and/or utilize the WTE facility is integrated in its approved 10-year solid waste management plan consistent with the provisions of the Republic Act No. 9003. According to this Act, the host LGU is allowed to implement clustering and/or form partnerships with the private sector (EDCOP, 2020) in establishing construction and operation of a WTE facility.

Table 2 presents a strength, weaknesses, opportunities and threats (SWOT) analysis of renewable energy resources in Ormoc.

Table 2. SWOT analysis of renewable energy resources in Ormoc

	Strengths	Weaknesses	Opportunites	Threats
Solar energy	- Abundant resource availability - Potential to deliver sustainable energy (electricity)	- Land conversion issue - Lack of financial mechanism - Grid instability	- Huge potential to meet the supply and demand gap - Reduction in GHG emissions	- High upfront capital cost
Wind energy	- Available resource	- Lack of feasibility study - Grid instability	- Reduction in GHG emissions	- High capital cost
Hydro energy	- Endowed with enormous water resources	- Seasonal variability	- Potential for micro-scale hydropower	- Disturbance in biodiversity
Biomass energy	- Availability of energy crops - Huge agricultural areas	- Lack of knowledge and competence - Limited application	- Opportunity to retrofit old thermal power plant	- Difficult to establish a suitable energy market
Geothermal energy	- Already established technology		- The key player in the current market - Environmentally-friendly	- High capital cost

3. Modelling assumptions


8.10
3.93
7.10
9.03
0.66
0.31
4.80
8.21
9.03
6.40
1.89
0.21

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

3.1. Scenario definitions

NEXSTEP is designed for scenario analysis, using the LEAP modelling system to enable energy specialists to model energy system evolution based on current energy policies. The baseline year 2020 was chosen, as it is the most recent year with sufficient data information for modelling. In the NEXSTEP model for Ormoc, four scenarios have been modelled. These include three core scenarios: (a) business-as-usual (BAU) scenario; (b) current policy scenario (CPS); and (c) sustainable energy transition (SET) scenario. In addition, one ambitious scenario has been developed – a towards net zero by 2050 scenario.

3.1.1. BAU scenario

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

3.1.2. Current policies scenario

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

3.1.3. SET scenario

The SET scenario builds on the current policy settings to provide recommendations for aligning Ormoc's energy transition pathway with the SDG7 targets. Energy efficiency improvement has been modelled in alignment with the global energy intensity improvement rate, while the renewable energy share has substantially increased with a higher energy efficiency and projected increase in the share of renewable electricity of the grid supply.

3.1.4. Ambitious scenario

Like the SDG scenario, the ambitious scenario aims to achieve the SDG 7 targets. In addition, these scenarios also look to increasing the socio-economic and environmental benefits for the city from raising its ambition beyond just achieving the SDG 7 targets, such as by further improving its energy efficiency beyond the SDG 7.3 target.

Further analysis shows that there are ample opportunities for Ormoc to raise its ambition beyond just achieving the SDG 7 targets. More can be done from a whole-economy perspective for Ormoc to decarbonize its energy system and achieve a higher energy efficiency improvement rate. For example, additional energy efficiency measures can substantially increase energy savings and reduce fuel imports. This is discussed further in section 6.

3.2. Assumptions

The energy demand is estimated by using the activity level and energy intensity in the LEAP model. The demand outlook throughout the NEXSTEP analysis period is influenced by factors such as annual population growth and annual GDP growth. The assumptions used in the NEXSTEP modelling are further detailed in Annex II, while table 3 provides a summary of key modelling assumptions for the three main scenarios (i.e., BAU, CPS and SDG scenarios).

Table 3. Important factors, targets and assumptions used in NEXSTEP modelling

Parameters	Business as usual scenario	Current policy scenario	Sustainable Energy Transition scenario
Economic growth	US$ 446.2 million in 2020, assumed growth rate of 6 per cent per annum.		
Population growth	230,998 in 2020, assumed growth rate of 1.5 per cent per annum.		
Commercial floor space	0.32 million square metres in 2030, assumed growth as GDP.		
Transport activity	Transport activities in 2020: 0.88 billion passenger-kilometres and 1.43 billion tonne-kilometres, with assumed growth as GDP per capita		
Industrial activity	GDP contribution in 2020: US$ 8.9 million; assumed growth as GDP		
Residential activity	The appliance ownership for electrical appliances is projected to grow at a rate like the growth in GDP per capita.		
Access to clean cooking fuels	Similar share as 2020 value since no policies are being implemented to improve clean cooking access		100 per cent clean cooking access rate through the promotion of LPG stoves and electric stoves.
Energy efficiency	Additional energy efficiency measures not applied	Improvement based on current policies	Global improvement in energy intensity adopted
Power plant	Based on 2020 existing RE installation within the city boundaries. Purchased electricity from the central grid is assumed to have the same fuel mix throughout the period.	Based on 2020 existing RE installation within the city boundaries. The purchased (grid) electricity mix in 2030 references the projected generation mix in the reference (CES) scenario in the Philippine Energy Plan 2020-2040.	

4. Energy transition outlook in the current policy scenario

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

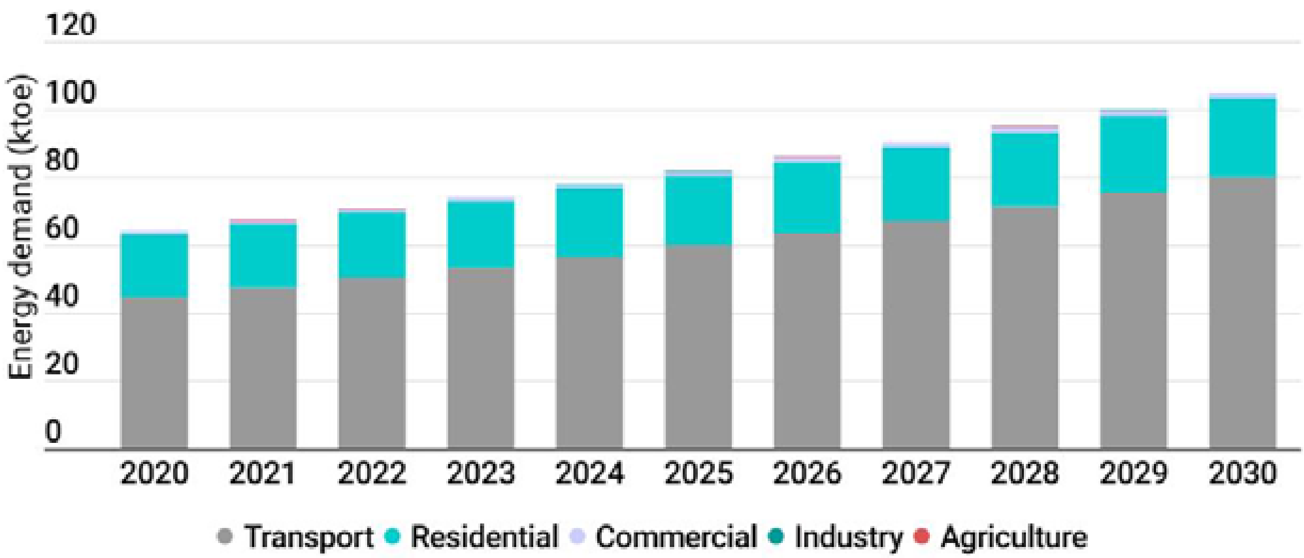
4.1. Demand

The CP scenario considers policy measures that have come into force or already have a concrete implementation timeline within the analysis period.[9] Otherwise, the energy intensities from different demand sectors are assumed constant throughout the analysis period, with demand growth as detailed in table 3. The following policies have been considered.

- **Energy efficiency:** As noted in the Philippine Energy Plan, DOE is targeting an increase in the current biodiesel share, from 2 per cent by volume to 5 per cent starting in 2022. DOE is also targeting a 10 per cent penetration rate of electric vehicles for road transport (motorcycles, cars, jeepneys) by 2040.
- **Power generation:** The electricity required to fulfil the demand in Ormoc is almost exclusively purchased from the grid, as local generation units are limited. Currently, installation of RE power capacity in governmental buildings is still in the planning stage. However, without further information on future installed capacity, the NEXSTEP analysis projects the existing capacity of 99.45 kW solar PV with an annual estimated generation of 139 MWh throughout the analysis period in CPS. The remaining demand is expected to be fulfilled with central grid electricity from the Visayas grid.

Figure 5 shows the forecast of TFEC by sector under the CP scenario.

Figure 5. Energy demand outlook in the CP scenario, 2020-2030



Under the current policy setting, the demand for total final energy is expected to increase from 64.2 ktoe in 2020 to 102.8 ktoe in 2030, an average annual growth rate 4.8 per cent. The 2.3 ktoe reduction in energy demand compared to the BAU scenario is due to the adoption of energy efficiency measures in the transport sectors. In 2030, the transport sector consumption will still be by far the largest at 75.7 per cent, followed by the residential sector at 22.6 per cent, the commercial sector at 1.6 per cent, the industrial sector at 0.1 per cent and the agricultural sector at 0.1 per cent. The sectoral energy efficiency measures are described further below.

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

4.1.1. Transport sector

Under the current policy setting, the transport sector will continue to dominate Ormoc's TFEC, with a 75.7 per cent share in 2030. The transport sector will consume 77.8 ktoe, an annual growth of 5.7 per cent, up from 44.7 ktoe in 2020. Ormoc's transport sector consists of land's passenger transport and freight transport. Among the passengers' vehicle categories in 2030, private cars will consume 37 ktoe, followed by motorcycles at 15.3 ktoe and buses at 0.3 ktoe. Freight trucks will consume 25.3 ktoe.

Under the current policy setting, the Government of the Philippines has a plan to increase the current biodiesel share and raise the penetration rate of electric vehicles. If the government of Ormoc implements the same measures, these will save a total of 2.3 ktoe. Table 4 shows energy efficiency measures in the transport sector.

Table 4. Energy efficiency measures – CP scenario compared with BAU scenario by 2030

Sector	Measure	2030	
		Energy demand reduction (ktoe)	GHG emission reduction ($ktCO_2$-e)
Transport	An increase in the current biodiesel share to 5 per cent starting in 2022.	0.21	1.11
Transport	A 10 per cent penetration rate of electric vehicles for road transport (motorcycles, cars, jeepneys) by 2040.	2.10	10.92
Total		**2.31**	**12.03**

4.1.2. Residential sector

The residential sector will consume 23.2 ktoe, an annual growth of 2.3 per cent, up from 18.5 ktoe in 2020. In terms of fuel, biomass will be the main energy source at just around 36.6 per cent, followed by oil products at 34.7 per cent and electricity at 28.7 per cent. Biomass and oil products are used mainly for cooking purposes. Electricity will be used mainly for air-conditioning (28.3 per cent) and refrigeration (26.4 per cent) while the remaining will be used for lighting, televisions, electric fans, washing machines, water pumps etc.

4.1.3. Industrial sector

In the CPS, the industrial sector will consume only 0.12 ktoe in 2030, an annual growth of 6 per cent, up from 0.07 ktoe in 2020. Within the industrial sector, 50 per cent of energy consumption will be consumed by machinery and transport equipment category. The wood and wood products category will account for 25 per cent of industrial energy use while the remaining will be used by food and beverages as well as other processing industries.

4.1.4. Commercial sector

Total energy consumption in the commercial sector (including government buildings) under the CPS will increase from 0.9 ktoe in 2020, at an average annual growth of 6 per cent, to 1.6 ktoe in 2030. Private offices will account a total of 34 per cent of the energy demand, followed by government buildings (16.3 per cent) and worship centres (15 per cent). Educational institutions and shopping malls will account for 11.3 per cent and 9.1 per cent of commercial's energy demand, respectively. The remaining share will be used by hotels and hospitals.

4.1.5. Agricultural sector

The energy demand from the agriculture sector was relatively insignificant. The energy demand is expected to increase from 0.04 ktoe in 2020 to 0.08 ktoe in 2030. The increase in energy demand stems from the increasing need for water pumping and agricultural machinery to increase crop productivity. The energy demand from agricultural machinery (i.e., harvesters, rotovators and tractors) is projected to grow at an annual rate of 5.5 per cent, as productivity increases.

4.2. Power sector

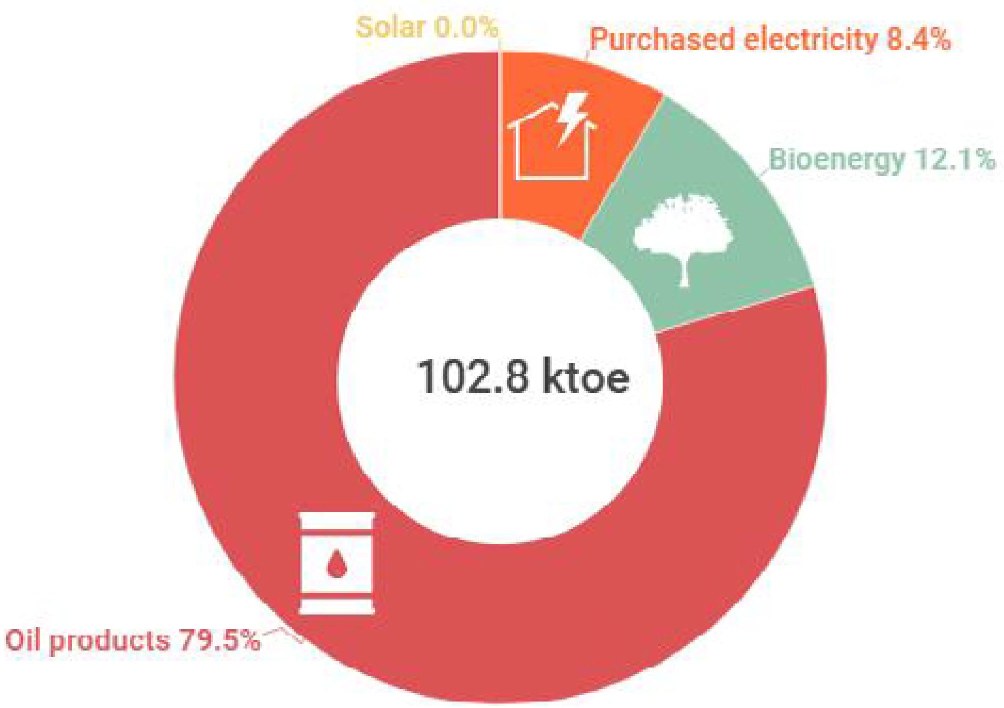
The 2030 demand for electricity in the current policy scenario is projected to be 101.1 gigawatt-hours (GWh), increasing from 60.7 GWh in 2020. The demand will be the highest in the residential sector at 77.5 GWh (76.6 per cent) followed by the commercial sector at 18.5 GWh (18.3 per cent) and the industry sector at 1.4 GWh (1.4 per cent). If the city government increases the adoption rate of electric vehicles to 10 per cent, around 3.7 GWh of electricity will be required by the transport sector.

The electricity required to fulfil the demand in Ormoc is almost exclusively purchased from the grid, as local generation units are limited. Currently, installation of RE power capacity in governmental buildings is still in the planning stage. However, without further information on future installed capacity, the NEXSTEP analysis projects the existing capacity of 99.45 kW solar PV with an annual estimated generation of 139 MWh throughout the analysis period in CPS. The remaining demand is expected to be fulfilled with central grid electricity from the Visayas grid.

4.3. Supply

In the current policy scenario, the TPES is forecast to increase from 64.2 ktoe in 2020 to 102.8 ktoe in 2030. As shown in figure 6, oil products are the dominating fuel supply, followed by bioenergy and grid electricity.

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



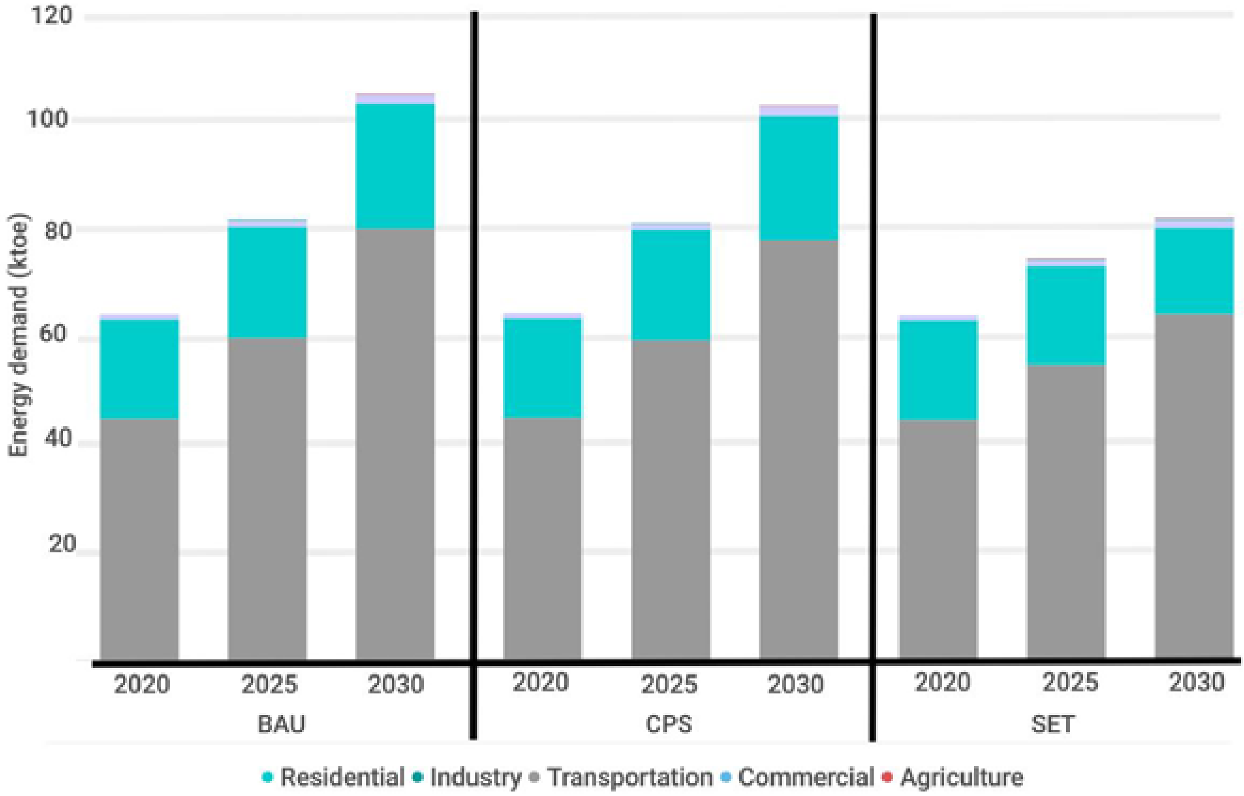
5. SET scenario – sustainable energy transition pathway for the City of Ormoc

Subnational and national efforts are both imperative to achieving the 2030 Agenda for Sustainable Development and Paris Agreement on climate change. In particular, cities around the world contribute around 75 per cent of global anthropogenic emissions and represent about 75 per cent of global energy demand (REN21, 2021). This chapter provides details of the SET scenario, exploring how economy-wide efforts may improve the energy and climate sustainability of the City of Ormoc. It starts with the energy demand forecast and then discusses the energy sector in relation to the SDG 7 targets.

5.1. SET energy demand outlook

In the SET scenario, TFEC increases at a much slower pace than CPS, from 64.2 ktoe in 2020 to 82.3 ktoe in 2030. The reduction of 20.5 ktoe in TFEC in this scenario, compared with the CPS, is due to the improvement in energy efficiency across the demand sectors. The proposed energy efficiency interventions are further described in subsection 5.2.4. In 2030, the transport sector will still have the largest share of TFEC at 64.5 ktoe (78.4 per cent), followed by the residential sector at 16 ktoe (19.4 per cent), the commercial sector at 1.6 ktoe (1.9 per cent), the industry sector at 0.1 ktoe (0.2 per cent) and the agricultural sector at 0.08 ktoe (0.1 per cent). Figure 7 shows TFEC by scenarios in 2030.

Figure 7. Comparison of energy demand between scenarios



5.2. SDG 7 targets

5.2.1. SDG 7.1.1 – Access to electricity

The electrification rate in Ormoc was already 100 per cent in 2020. Table 5 shows the progress of access to electricity in the city.

Table 5. Assessment of access to electricity

Existing policy	NEXSTEP analysis – gaps and recommendations
The Philippine Energy Plan, 2020-2040 and the Philippine Development Plan, 2017-2022 have set out ambitions to provide access to basic electricity for all Filipinos by 2022.	Ormoc had achieved universal access to electricity by 2020

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

Accelerated effort is required to achieve universal access to clean cooking. As of 2020, 15 per cent of households relied on polluting cooking technologies, including traditional biomass stoves and kerosene stoves. WHO has warned about the severity of health impacts arising from the exposure to kerosene and traditional use of biomass for cooking, and is encouraging policymakers to adopt measures to address this challenge. Women and children disproportionately bear the greatest health burden from indoor air pollution as they spend more time exposed to harmful smoke from polluting stoves and fuels. The NEXSTEP analysis proposes the use of electric cooking stoves as the most appropriate technology in filling in the gap due to their cost-effectiveness, zero air pollution and minimal maintenance compared to the more commonly used LPG stove.

However, the operation of electric cooking stoves requires substantial power supply capacity that may not be met by households connected to mini-grid or solar home systems. In that case, the LPG stove is the most appropriate technology.

Box 1 provides a summary of cost analysis and qualitative analysis of the pros and cons of different clean cooking technologies, in supporting the adoption of electric cooking stoves and LPG stoves as the most appropriate technologies.

Box 1. Cost and qualitative analysis of clean cooking technologies

Table 6 summarizes the annualized cost and annual fuel cost of the different cooking technologies in the context of Ormoc. Annex III summarises the cost and technical assumptions used in the economic analysis.

Table 6. Annualized cost of cooking technologies

Technology	Annualized cost
Electric cooking stove	US$ 107
Improved cooking stove (ICS)	US$ 28
LPG stove	US$ 119

While ICS is estimated to have a lower annualised cost than electric cooking stoves, concerns have been raised by various studies of their suitability as a long-term clean cooking solution for the general population, particularly the urban population. A short qualitative analysis on the pros and cons of the different clean cooking technologies is detailed below.

(a) Electric cookstoves

Electric cooking technology is classed as Level 5 in the World Bank 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 use electromagnetic energy to directly heat pots and pans and can be up to 90 per cent efficient.

(b) Improved cooking stoves

Studies suggest that ICS programmes often have low adoption rates due to inconvenience of use, preference for traditional cooking stoves, and the need for frequent maintenance and repairs. ICS programmes initially require strong advocacy to promote adoption, after which they require ongoing follow-up, monitoring, training, maintenance and repairs in order to facilitate continuing usage (ESCAP, 2021b). In addition, based on the WHO guidelines for emission rates for clean cooking, only certain types of ICS technology comply, particularly when considering that cooking stove emissions in the field are often higher than they are in the laboratory settings used for testing.

(c) LPG cooking stoves

LPG cooking stoves generate lower indoor air pollution compared with 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 with traditional cooking stoves. However, the LPG stove is estimated to have a higher cost than the electric cookstove, as shown in table 6.

Table 7 summarises the gap assessment and recommendations to address the clean cooking in Ormoc.

Table 7. Assessment of access to clean cooking

Existing policy	NEXSTEP analysis – gaps and recommendations
Not available.	**Gap:** Without any policy intervention, the NEXSTEP analysis projects that Ormoc may only reach an 85 per cent clean cooking access rate similar to the share in 2020. **SDG scenario:** The NEXSTEP analysis suggests bridging the remaining gap with a combination of electric cooking stoves and LPG cooking stoves as the most appropriate clean cooking solution.

5.2.3. SDG 7.2 – Renewable energy

SDG 7.2 does not have a quantitative target but requires a substantial increase in the renewable energy share in TFEC. The RE share in TFEC for Ormoc is determined by using the required improvement in energy efficiency as a constraint, for which NEXSTEP considers the alignment of Ormoc's annual average energy efficiency improvement with the suggested global improvement rate of 3 per cent per annum (UNSD, 2021) (detailed further in subsection 5.2.4). The RE share in TFEC also considers the increase in RE percentage in the grid electricity mix.

The share of renewable energy in TFEC in 2030 will be 9.3 per cent by 2030 in the current policy scenario (figure 8). This increases from just 6.2 per cent in 2020. The increase is mainly driven by two factors:

(a) The projected increase in RE share of the grid electricity in Visayas, from 48.4 per cent in 2020[10] to 66.9 per cent in 2030, based on the estimates from CES scenario in the Philippine Energy Plan 2020-2040;

(b) Increased biodiesel usage in the transport sector.

In the SET scenario, the renewable energy share in TFEC is projected to increase to 15.6 per cent by 2030. This is a result of further reduction of energy demand due to energy efficiency measures in the demand sectors (see subsection 5.2.4), and increased use of grid electricity (in the transport sector) which has a relatively high share of RE generation. Table 8 provides an assessment of renewable energy share in TFEC.

Figure 8. Renewable energy in TPES and TFEC, 2030

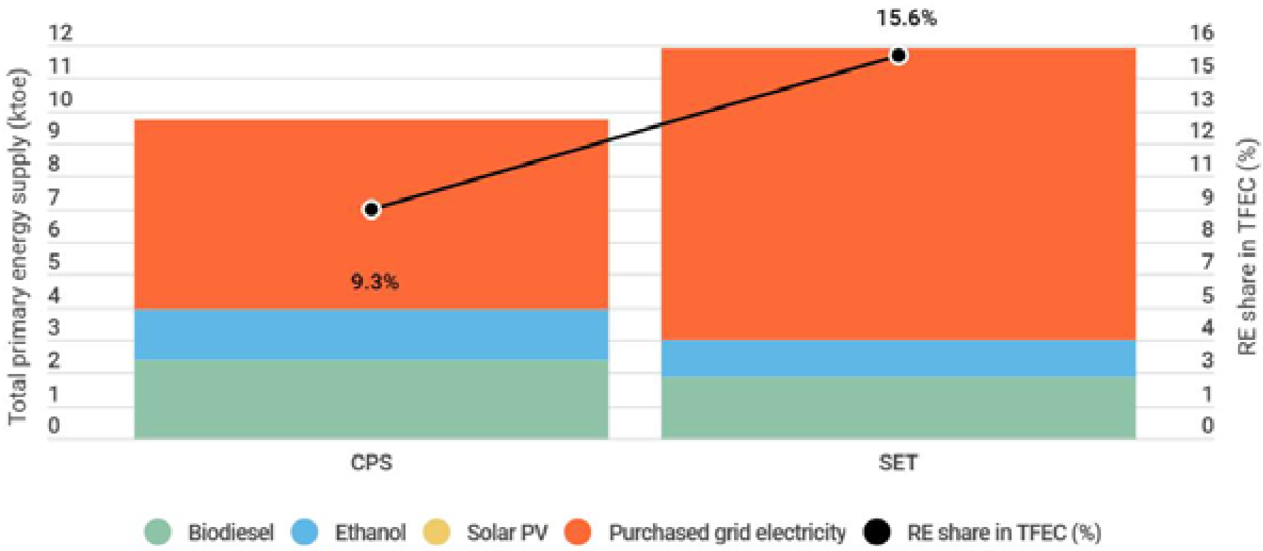


Table 8. Assessment of renewable energy share in TFEC

Existing policy	NEXSTEP analysis – gaps and recommendations
The Philippine Energy Plan, 2020-2040. The power sector development in the Philippines will evolve over time, with increasing RE penetration. This should also result in a reduced grid emission factor throughout the analysis period. The Philippine Energy Plan, 2020-2040, stipulates two scenarios for the national power sector, i.e., the Reference Scenario (REF) and the Clean Energy Scenario (CES). NEXSTEP utilized the projected electricity generation of CES scenario in projecting the emission factor for 2030. The author's estimated emission factor in 2030 is 0.3 tCO2/MWh. DOE is targeting an increase in the current biodiesel share, from 2 per cent by volume to 5 per cent, starting in 2022.	**CP scenario** The renewable share in TFEC is projected to be 9.3 per cent in the CP scenario due to the increase of planned renewable power capacities and biodiesel share. **SDG scenario** The inefficient traditional biomass cooking and heating stoves are phased out with electric cooking stoves and LPG stoves. The renewable energy share in TFEC is projected to be 15.6 per cent in 2030. This increase also results from the improvement in energy efficiency.

10 Based on the DOE 2020 Power Statistics, gross generation per grid, by plant type.

5.2.4. SDG 7.3 – Energy efficiency

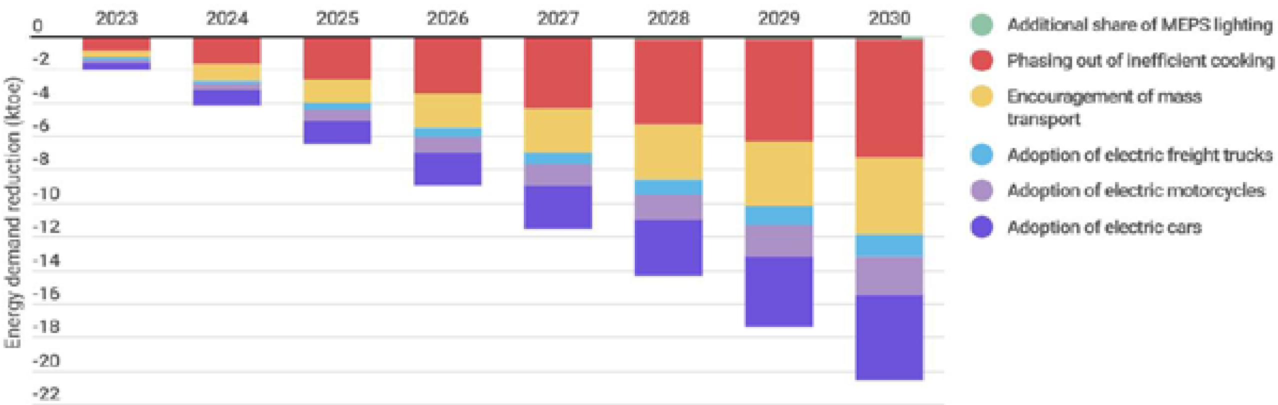
The primary energy intensity, a proxy for the measurement of energy efficiency improvement, is calculated as 5.39 MJ/US$$_{2017}$ in 2030 under the current policy scenario, which corresponds to an annual rate of improvement of 1.1 per cent. The primary energy intensity is further reduced to 4.31 MJ/US$$_{2017}$ in the SET scenario by 2030, made possible through the proposed economy-wide energy efficiency improvement measures. This corresponds to an average annual rate of improvement of 3.3 per cent, on a par with the suggested global improvement rate of 3.2 per cent (UNSD, 2021). Table 9 presents an assessment of energy intensity in the City of Ormoc.

Table 9. **Assessment of energy intensity**

Existing policy	NEXSTEP analysis – Gaps and recommendations
The Philippine Energy Plan, 2020-2040. DOE is targeting a 10 per cent penetration rate of electric vehicles for road transport (motorcycles, cars, jeepneys) by 2040.	**Gap(s):** It is projected that under the CP scenario, the energy intensity will be 5.39 MJ/USD$_{2017}$ in 2030. **SDG scenario:** The energy intensity is further reduced to 4.31 MJ/USD$_{2017}$ in 2030 or 3.3 per cent EE improvement rate, which exceeds the global energy efficiency improvement target. Achievement of the target requires phasing out inefficient cooking technologies, encouragement of mass transport, and increasing the adoption of EV to 20 per cent to realise an additional energy demand reduction of 20.5 ktoe in 2030, compared with the CP scenarios.

Figure 9 shows the energy savings that may be achieved through the implementation of energy efficiency measures across the demand sectors, compared with the CPS. The transport sector is the largest energy consuming sector in Ormoc; it can also be expected to have the largest contribution (13.3 ktoe in 2030), through the increased adoption of electric vehicles in multiple transport subcategories as well as encouragement of public transport. Energy demand reduction can also be realised through the phasing out of inefficient technologies in residential households.

Figure 9. **Additional energy saving measures under the SET scenario compared to the CP scenario**



Further details of the energy efficiency measures and their impacts are provided below.

(a) Transport sector

The current share of electric vehicles in the existing fleet is zero. However, the promotion of electric vehicles is an effective way to reduce demand consumption in the transport sector as well as GHG emissions. In the SET scenario, NEXSTEP proposes that the uptake of electric vehicles can be promoted across the different vehicle categories, reaching a considerable share of the transport fleet by 2030. In addition, the city government should encourage the utilization of public transportation in order to increase the passenger-kilometre of buses by 10 per cent. Further details and the estimated annual savings are shown in table 10.

Table 10. Energy efficiency measure applied and estimated cumulative savings between 2023 and 2030 (relative to CPS) in the transport sector

Subcategory	Energy efficiency measures	Energy demand reduction (ktoe)	GHG emission reduction (ktCO_2-e)
Freight trucks	Encouraging the adoption of electric freight trucks, reaching a share of 20 per cent by 2030.	5.4	58.8
Private passenger cars	Encouraging the adoption of electric passenger cars, reaching a share of 20 per cent by 2030	20.0	68.4
Motorcycles	Encouraging the adoption of electric motorcycles, reaching a share of 20 per cent by 2030	9.0	26.5
Public transport	Encouraging the use of public transportation (buses), increasing the passenger kilometres by 10 per cent by 2030.	19.3	53.3
Total		**53.7**	**207.0**

An increase in market penetration of electric vehicles is required to reach the targeted shares by 2030. For example, the annual sales[11] of electric motorcycles, passenger cars and trucks should slowly pick up from the current zero per cent to reach 50 per cent by 2028.

(b) Residential sector

Energy demand reduction can also be realised in the residential sector, particularly through achieving a 100 per cent access rate to clean cooking technologies. As inefficient cooking practices are gradually replaced by electric cooking stoves and LPG stoves usage, substantial energy savings can be expected. In addition, the use of more efficient household appliances (e.g., LED lighting) provides energy saving opportunities. Table 11 presents a summary of energy efficiency measures in the residential sector.

11 Electric vehicle sales rate is defined as the proportion of the number of electric vehicles compared to the total sales of vehicles in the area. Meanwhile, the electric vehicle penetration rate indicates the proportion of the number of electric vehicles compared to the total on-the-road vehicle in the area

Table 11. Energy efficiency measures applied and the cumulative savings in 2030 in the residential sector

Household appliance	Energy efficiency measures	Energy demand reduction (ktoe)	GHG emission reduction ($ktCO_2$-e)*
LED Lighting	Phasing out of compact fluorescent lamps (CFL) with LED lighting	0.8	2.4
Cooking	Achieving 100 per cent clean cooking access rate through induction electric cooking stoves and LPG stoves	30.5	2.5
Total		**31.3**	**5.0**

* GHG emission reduction for electrical appliances is calculated using the grid emission factor 0.298 kg CO_2-e/kWh.

5.3. Energy supply outlook

Under the SET scenario, the total primary energy supply is estimated to be 82.3 ktoe by 2030, a 20.5 ktoe reduction compared with the CP scenario. The phasing out of traditional biomass for cooking will reduce biomass supply by 8.5 ktoe. The remaining reduction comes from oil products due to additional energy efficiency improvements in the transport sector.

The demand for electricity in 2030 is projected to be 154.4 GWh in the SET scenario, an increase of 53.3 GWh compared with the CPS. An increase in electricity demand by the transport sector can be expected as it has more electric vehicles. The electricity demand in the residential sector will be 76.7 GWh, while in the transport, commercial and industry sectors it will be 57.8 GWh, 18.5 GWh and 1.4 GWh, respectively. The existing solar PV capacity in the city is an approximate annual generation of 0.1 GWh. The remaining demand will be fulfilled by grid electricity from Visayas, assuming that there is no other additional RE capacity within the city.

5.4. Nationally determined contribution targets

The energy sector emissions, from the combustion of fossil fuel, are calculated based on IPCC Tier 1 emission factors assigned in the LEAP model and expressed in terms of 100-year global warming potential (GWP) values. For the combustion of biomass and biomass products, the carbon emissions are not attributed to the energy sector, but are accounted for in the agriculture, forest and land-use change (AFOLU)[12] as per the accounting system suggested by IPCC. Nevertheless, the emissions of other GHGs, such as methane and nitrous oxide, are included in the total emissions in the energy sector.

Under the CPS, total emissions are expected to grow from 164.2 $ktCO_2$-e in 2020 to 260.5 $ktCO_2$-e in 2030. This corresponds to a 16.5 $ktCO_2$-e (6 per cent) reduction compared to the BAU scenario meeting the unconditional nationally determined contribution (NDC) target of 2.71 per cent. The decrease in GHG emissions, relative to the BAU scenario, is due to the higher RE share in electricity supply.

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

In the SET scenario, total emissions are expected to grow to 214.5 $ktCO_2$-e by 2030. This corresponds to a 62.6 $ktCO_2$-e (or a 22.6 per cent) reduction compared to the BAU scenario, which exceeds the unconditional NDC target in the energy sector. The additional decrease in GHG emissions compared with the CP scenario is due to measures discussed in the previous section. Figure 10 shows additional emissions reduction under the SET scenario, compared with the CP scenario. Figure 11 summarizes the SDG 7 indicators from the three different main scenarios.

Figure 10. Additional emission reduction measures under the SET scenario

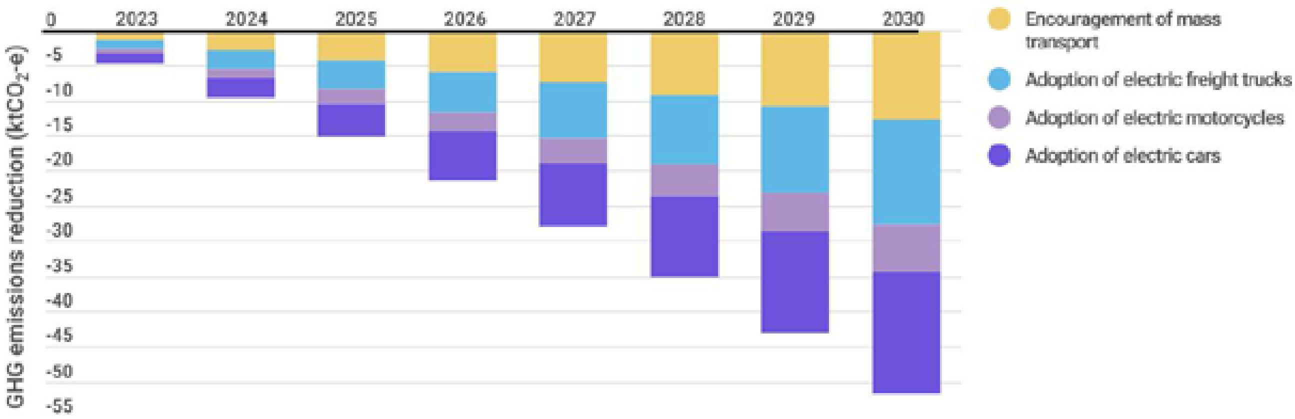
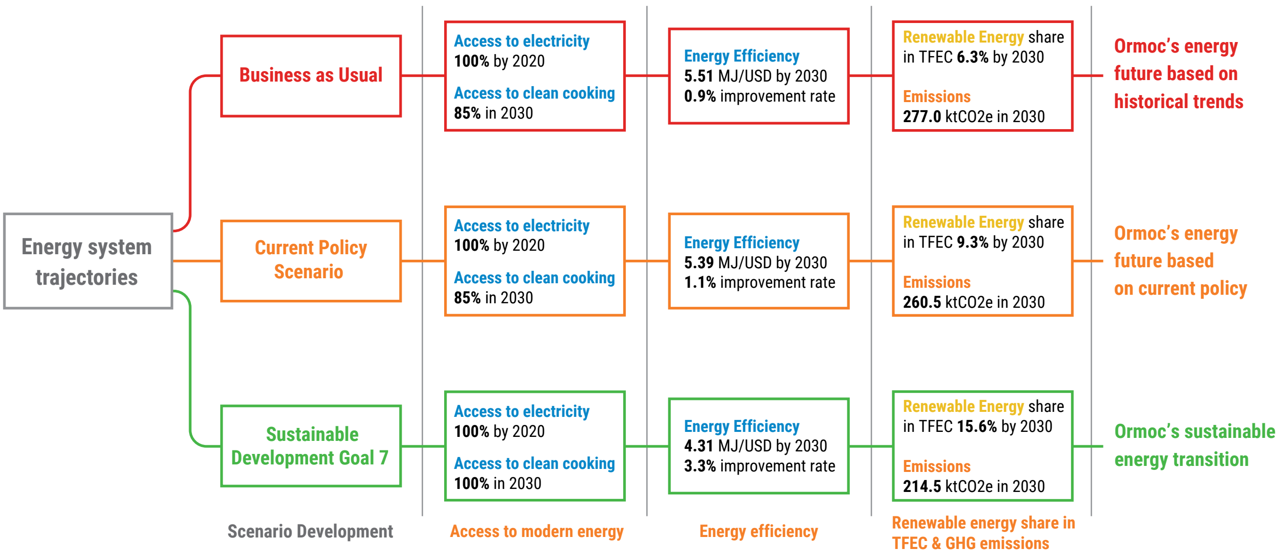


Figure 11. Summary of SDG 7 indicators for different main scenarios



6. Moving towards a net zero society with climate ambitious pathways

The SET scenario sets out various strategies for facilitating an economy-wide, energy-efficiency improvement in alignment with the global goal as well as appropriate technology options in advancing modern energy access in the City of Ormoc. These allow a GHG emissions reduction and an increase in the renewable energy share in TFEC. However, the City of Ormoc could consider more climate ambitious pathways, moving towards a net zero society.

Substantial energy demand and emission reduction have been achieved in the SET scenario through energy-efficiency improvement measures. These measures have allowed an energy demand reduction of 20.5 ktoe and emission reduction of 46 ktCO_2-e, relative to CPS. This corresponds to a 22.6 per cent reduction from the BAU scenario. With an increasing number of countries and cities pledging net zero emissions by 2050, the Towards Net Zero (TNZ) scenario has been developed to explore how Ormoc can raise its ambitions in moving towards net zero in its power supply as well as its energy system as a whole.

Around three-quarters of current greenhouse gas emissions globally come from the energy sector. Although this sector might have a critical role in avertin the worst impact of climate change, a significant challenge cannot be avoided. Limiting the temperature rise to 1.5^0 C requires a climate mitigation effort on an unprecedented scale and speed in order to reduce GHG emissions by about 45 per cent from 2010 levels by 2030, reaching net zero around 2050 (IPCC, 2018). Failing to act on the most pressing issue of this generation may lead to a catastrophic impact on human livelihoods.

In addition, COP26 in Glasgow has created momentum and called for transitioning towards net zero. This scenario examines the potential for Ormoc to achieve net zero by 2050. The rationale for the choice of a longer timeframe for this scenario is to allow the non-electric energy consumers, e.g., direct fuel combustion in the transport sectors, gradually transition to a fully electric system. As this scenario builds upon the previously discussed SET scenario, electricity in Ormoc is assumed to become carbon-free by 2030.

6.1. Demand sector strategy

The energy system of Ormoc is well-positioned for an accelerated de-carbonization effort as some required net zero technologies in decarbonizing its energy system are readily available in the Philippines, i.e., electric cooking stoves, electric vehicles and renewable power technologies. Building on the SET scenario, the TNZ 2050 scenario explores how the city can transition its demand side towards decarbonisation of its whole economy. There are two different timeframes for the implementation of multiple renewable energy and energy efficiency measures. These are discussed below.

6.1.1. Present until 2030

The total energy demand is expected to increase from 64.2 ktoe in 2020 to 73.5 ktoe in 2030, a reduction of about 8.8 ktoe relative to the SET scenario. The transport sector consumption will remain the largest at 76.1 per cent, followed by the residential sector at 21.4 per cent, the commercial sector at 2.1 per cent, the industry sector at 0.2 per cent and the agriculture sector at 0.1 per cent.

The energy demand reduction mainly stems from increased ambition in transport electrification. In the transport sector, NEXSTEP suggests the increase of electric vehicle sales to 100 per cent, starting from 2030 to reach a 100 per cent penetration rate by 2050. In the residential sector, NEXSTEP suggests the adoption of the electric cooking stove to reach at least 23 per cent of all households by 2030 from 8 per cent in 2020.

While not quantitatively assessed in this scenario due to the lack of data availability, future use of electric-powered and solar-powered agricultural machineries can be pursued, allowing further reduction in energy demand and GHG emissions. With the decreasing cost of solar panels and batteries, sustainable farm production through widespread use of non-diesel-powered machineries can become cost-effective. Table 12 summarises proposed measures and related energy savings and emissions reduction in the TNZ scenario compared to the SET scenario.

Table 12. Proposed measures and their respective cumulative energy savings and GHG emission reduction in 2030, TNZ scenario compared to SET

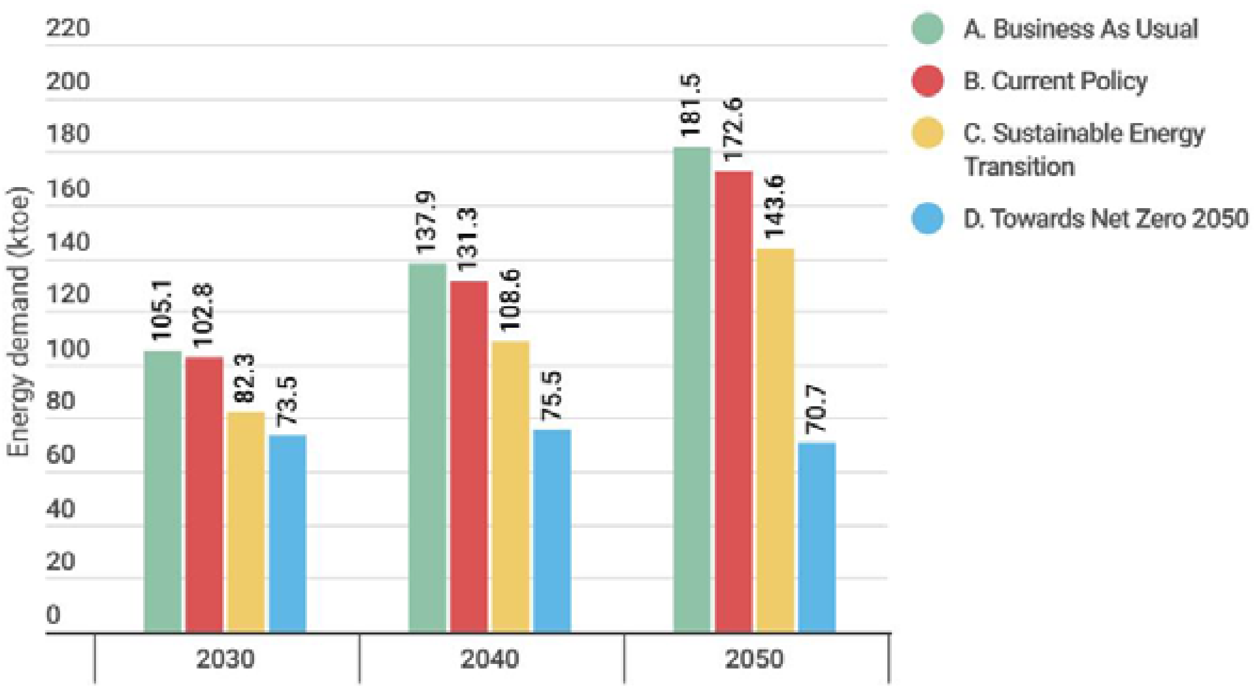
Subcategory	Measures	Energy demand reduction (ktoe)	GHG emission reduction ($ktCO_2$-e)
Transport			
Freight trucks	The market sales of electric vehicles should be 100 per cent starting from 2030.	3.7	40.3
Private passenger cars		16.2	55.4
Motorcycles		14.6	42.8
Buses		0.2	4.4
Total		**34.6**	**142.8**
Residential			
Residential cooking	Increase the adoption of electric cooking stove to 23 per cent of households	1.0	8.8
Agriculture			
Irrigation system	Replacement of diesel water pumps with solar irrigation system	0.3	0.9

6.1.2. Beyond 2030

For the measures implemented beyond 2030, NEXSTEP suggests the utilization of 100 per cent electric cooking stoves by 2050 to achieve net zero in the residential sector. The adoption of 100 per cent e-mobility is also critical to decarbonise the transport sector.

While this scenario requires an additional 56.4 ktoe (655 GWh) of electricity, compared with the BAU scenario it requires the least amount of energy among all scenarios by 2050, as shown in figure 12. Energy demand in this scenario in 2050 is 110.8 ktoe less than the BAU scenario, 101.8 ktoe less than the CPS and 72.9 ktoe less than the SET scenarios. Further implementation of energy efficiency would help to reduce this electricity demand.

Figure 12. Energy demand comparison among all scenarios



6.2. Supply sector strategy

The electricity demand in 2030 under the TNZ scenario is projected to be 213.8 GWh. Ormoc currently purchases almost all of its required electricity from the Visayas grid. Significant challenges exist for the city in increasing the share of renewable energy in purchased electricity as the city currently does not have any control over how the electricity is produced on the Visayas grid. Nevertheless, there are a few pathways that the city could explore in order to achieve a net-zero carbon power supply objective. These four pathways are explained below:

a) Promotion of agricultural waste-to-energy generation

As already noted, Ormoc has an active agricultural sector with nearly 54 per cent of its land being utilized for agriculture, of which the agricultural residues could possibly be used for electricity generation or other forms of energy generation. NEXSTEP's preliminary resource potential estimation found that the available agricultural waste may allow up to 0.33 MW of power generation (box 2). A formal feasibility study should be conducted to investigate its biomass resource potential as well as the business case for agricultural waste-to energy facilities.

b) Rooftop solar PV installation for new and existing buildings

Incentivising rooftop solar PV installation will provide two benefits to the city by reducing (i) the financial burden on the city for establishing its own solar PV system, and (ii) offsetting the land-use requirement from ground-mounted PV. As noted by IEEFA (2018), rooftop solar PV costs range between PHP 2.50 per kWh (US$ 0.052 per kWh; without financing expenses) and PHP 5.30 per kWh (US$ 0.11 per kWh) with financing expenses). By comparison, the average retail electricity tariff in the Philippines is around US$ 0.185 per kWh where the current rate in Ormoc is around US$ 0.21 per KWh. This provides a substantial financial gain for solar PV owners. Table 13 illustrates the financial saving that can be gain by increasing the solar rooftop by 50 per cent. It seems that Ormoc might save around US$ 5.5 million in 2025 and around US$ 10.7 million in 2030. Assuming a power generation potential of 4 kWh per square metre per day (IEEFA, 2018), the required rooftop area to increase the generation from solar rooftop by 50 per cent is around 73,202 m^2. However, ground-mounted solar PV on vacant lands within the city boundaries can also be considered.

Table 13. Comparison of costs for different modes of electricity purchase and estimated savings for selected years

Supply	2025	2030
Electricity demand (GWh)	42.5	65.5
Cost		
Cost of purchase 50% renewable energy from solar rooftop (million US$)	2.3	3.6
Cost of purchase from grid (million US$)	6.0	9.2
Total cost at 50% solar rooftop mix (million US$)	8.3	12.8
Saving		
Cost of purchase without increasing local RE generation (million US$)	11.9	18.3
Saving for switching to solar rooftop (million US$)	3.6	5.6

c) Establishing power purchase agreements

The city can enter into a special renewable energy power purchase agreement (PPA) with interested suppliers who are located along the Visayas grid. In turn, the supplier will supply Ormoc with an agreed RE share of electricity at an agreed price. However, this may not allow the city to take advantage of the lower generation costs available, such as through renewable energy auctions.

d) Lowering cost through renewable energy auctions

A more workable solution and the recent policy instrument is the renewable energy auction. This approach is likely to substantially decrease the cost of electricity supply through competitive pricing bidding and, therefore, return a greater net benefit. See box 5 for further details on renewable energy auctions.

Box 2. Agricultural waste potential in Ormoc

Ormoc has an active agricultural sector, specifically in rice and corn production. The total area of cultivation land consists of 4,987 hectares for rice cultivation and 965 hectares for corn production. Other food crops include sugarcane and coconuts with a total cultivation land of 9,896 hectares. Several studies have suggested the potential use of agricultural waste (i.e., rice husks and corn cobs) for energy-use purposes – for example, in electricity generation. Preliminary resource potential analysis by NEXSTEP suggests that the agricultural waste potential for electricity generation is around 331 kW, as detailed below. Table 14 shows electricity generation potential for different residue types.

Table 14. Electricity generation potential for different residue types in Ormoc

Residue type	Electricity generation potential
Rice husks	300 kW
Corn cobs	31 kW

(a) Rice husks

The agricultural waste associated with rice production consists of rice husks and rice straw. Rice straw is most effectively used if it is incorporated in fields to maintain soil organic matter levels and to enhance nitrogen fixation, making rice husks the only viable feedstock for bioenergy applications (Ang and Blanco, 2017). The annual rice yield is around 17,457 tonnes, which yields approximately 3,491 tonnes of rice husks upon milling.[13] This assumes that the rice husks make up 20 per cent of the total grain weight. The realistic potential is dependent on factors such as recovery efficiency and availability of biomass for energy, of which final availability is estimated to be about 2,315 tonnes.[14] Considering an estimated biomass feedstock requirement of 8,150 tonne/MW (table 14), (Ang and Blanco, 2017), the electricity generation potential stands at 300 kW.

(b) Corn cob

The cultivation area for corn production is 965 hectares, with a total yield of approximately 1,475 tonnes per annum. While maize stalks are abundant, harvesting of maize stalks for bioenergy application is considered unsustainable in the tropical regions due to concerns such as soil erosion as well as the depletion of nutrients and organic matter in the soil. Corn cobs are, however, a viable residue for bioenergy application, as they make up about 27 per cent of the total grain weight and have recovery efficiency ranges between 40 per cent and 80 per cent. The recovery efficiency is higher during the dry season (50 per cent to 80 per cent) and low during the wet season (40 per cent to 50 per cent) (Ang and Blanco, 2017). Assuming an average recovery efficiency of 50 per cent, the amount of corn cobs available for bioenergy application is approximately 199 tonnes/year. This corresponds to an estimated electricity generation potential of 31 kW.[15]

6.3. Emission outlook

Decarbonising the whole economy would be beneficial to the country since it would significantly reduce GHG emissions in 2030 (compared to the BAU scenario) by 116.7 ktCO_2-e (figure 13). Therefore, economy-wide emission reduction will be around 42.1 per cent compared to BAU. Moreover, transitioning to a fully renewable energy-based power system would be more cost-effective in the long term than relying on fossil fuel-based power generation.

13 Data from local consultant

14 Both the recovery efficiency (0.91*0.90) and availability of biomass for energy (0.81) are based on estimates provided in table 8 of Ang and Blanco, 2017. The recovery efficiency is a typical estimate for the Philippines and is dependent on two factors – 3 per cent of the total rice production is used for seed, while another 6 per cent is used for livestock feed and other purposes. The recovery efficiency is again lowered due to the use of "*kiskisan*" – a small village rice mill which does not produce rice hull. Such a milling method is responsible for 10 per cent of all rice produced in the Philippines.

15 Based on an estimated biomass feedstock requirement of 6,378 tonne/MW in table 4 of Ang and Blanco, 2017.

Figure 13. GHG emission comparison in Ormoc in the BAU, CPS, SDG and TNZ scenarios

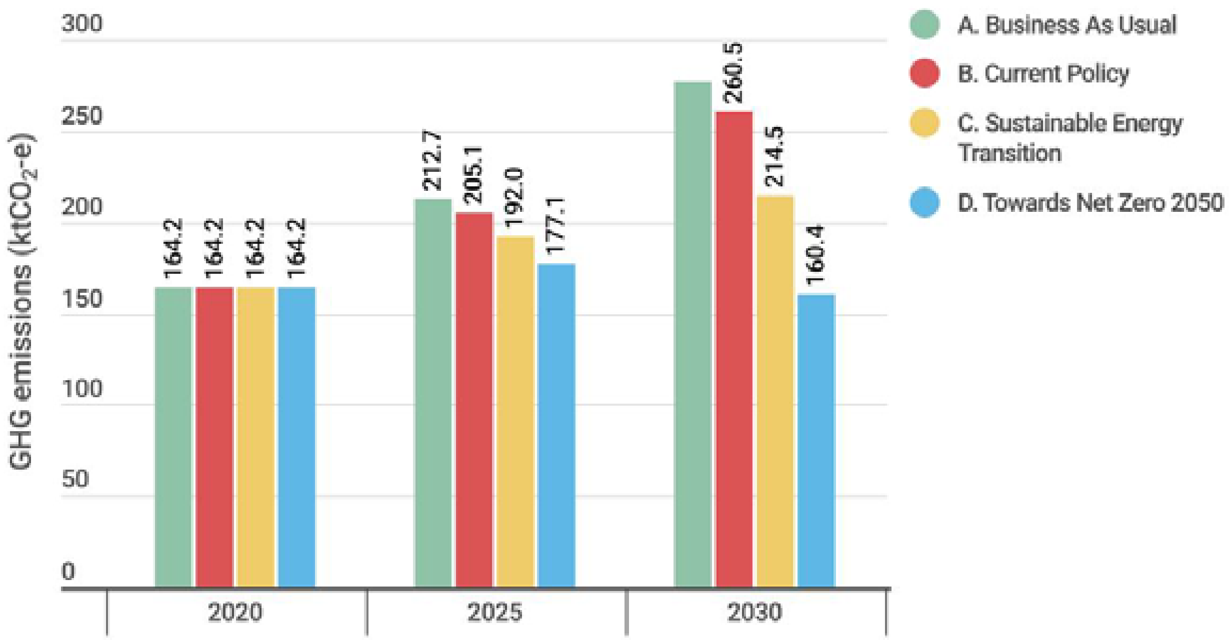
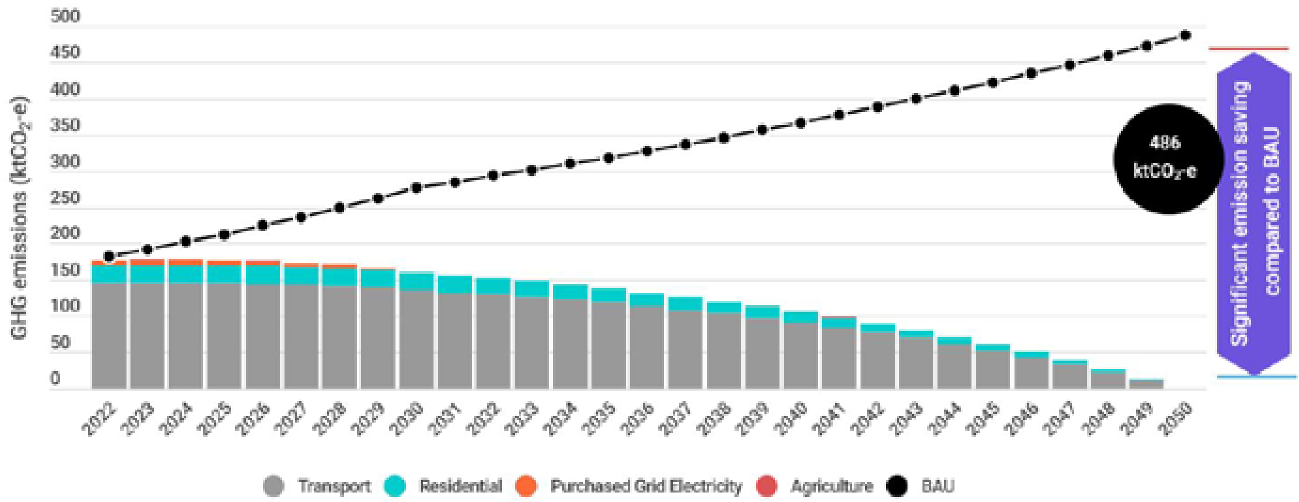


Figure 14 illustrates the GHG emissions in the demand sector under the BAU and TNZ scenarios by 2050. It appears that the emissions will increase by almost three times to 486.4 ktCO$_2$-e in 2050 under the BAU scenario if no significant measures are implemented during this period. However, under the TNZ scenario, the emissions will reach zero in 2050. A very small amount of residual emission is due to certain limitations in fully decarbonizing the machineries in agriculture sectors. Therefore, carbon sinks, such as reforestation or forest management, or other carbon capture technologies should be considered for absorbing the remaining carbon emissions.

Figure 14. GHG emission in Ormoc, 2022-2050, by sector in the TNZ scenario



7. Policy recommendations

7.1. Scenario evaluation

The current policy, SET and the ambitious scenarios have been evaluated and ranked, using the Multi-Criteria Decision Analysis (MCDA) tool, with a set of 12 criteria and weights assigned to each criterion (table 15). While the criteria and weights have been selected based on expert judgement, ideally the process should use a stakeholder consultation. If deemed necessary, this step can be repeated, using the NEXSTEP tool in consultation with stakeholders where the participants may want to change weights of each criterion. The following factors have been considered to assume comparative weights across the set of criteria, where the total weight needs to be 100 per cent:

(a) Universal access to electricity to be achieved;

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

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

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

(e) The emissions trajectory will need to align with the unconditional NDC target. Where possible, the conditional target should be achieved if it is economically viable;

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

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

Table 15. Criteria with assigned weights for MCDA

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

Table 16 shows the summary of results obtained through this evaluation process. The scenario recommendation suggests that the ambitious scenario, "Towards Net Zero by 2050" scenario, is the highest-ranked energy transition pathway for Ormoc.

Table 16. Scenario ranking based on MCDA

Scenarios	Weighted scores	Rank
Towards Net Zero 2050	51.0	1
SDG scenario	32.2	2
Current policy scenario	8.6	3
Business-as-usual scenario	0	4

Based on the above analysis, this Road Map recommends that Ormoc consider the adoption of the scenario "Towards Net Zero by 2050".

7.2. 7.2.Policy actions for sustainable energy transition and moving towards net zero

7.2.1. Electric cooking stoves and liquified petroleum gas stoves provide a sustainable solution with multifold benefits

Access to clean cooking fuels and technologies generally lacks attention from the policymakers. In turn, the inaction in closing the gap has led to substantial premature deaths due to household air pollution caused by unclean cooking practices. Nearly one-sixth of Ormoc's population relies on the use of traditional biomass stoves and kerosene stoves. Positive benefits that can arise from the adoption of clean cooking technologies include fuel savings (as evidenced in the SET scenario), less time spent on cooking and less use of cooking fuels, and reduced health risks from indoor air pollution.

NEXSTEP proposes that initiatives should be launched by providing electric cooking stoves as a long-term clean technology substitute. LPG stoves are a strong contender; however, electric cooking stoves are more cost-effective and cleaner in terms of household indoor air pollution. In addition, the use of electric cooking stoves paves the way towards net zero emissions when the electricity supply is decarbonized. LPG stoves may, however, be promoted to households that lack sufficient power supply capacity, i.e., households utilizing decentralised renewable energy systems. It will cost the city government around US$ 1.1 million to distribute electric cooking stoves towards 10,478 households and another US$ 0.8 million to distribute LPG stoves to 6,934 households.

7.2.2. Transport electrification and mass transport should be pursued

It is critical for the city government to reduce the energy demand in the transport sector. Mass transportation must be promoted to reduce the passenger-km by private vehicles. The number of buses must be increased by almost four times, from 20 buses to 75 buses, to increase the passenger kilometres of a bus by 10 per cent in 2030. Total energy saving potential through this measure between 2023 and 2030 will be 19.3 ktoe with 53.5 $ktCO_2$-e of emission reduction. In addition, the Government may consider the promotion of active transport as a complementing strategy to reduce the passenger kilometres of private vehicles. The implementation might refer to the following policy guidelines or recommendations to substantiate this proposed strategy:

- DOH-DOTr-DILG-DPWH Joint Administrative Order No. 2020-0001 on the proper use and promotion of active transport during and after the COVID-19 Pandemic[16];
- DILG Memorandum Circular No. 2020-100 on the establishment of a network of cycling lanes and walking paths in the LGUs; i
- DPWH Department Order No. 88, Series of 2020 on standards for bicycle-operating spaces and classification of bicycle facilities along our roadways;[17] and
- Regional Development Council VIII Resolution No. 71, 2022 on enacting local ordinances promoting active mobility transport.

16 https://ulap.net.ph/ulap-news/advisories/543-doh-dotr-dilg-dpwh-joint-administrative-order-jao-no-2020-0001.html

17 https://www.dpwh.gov.ph/dpwh/sites/default/files/issuances/DO_88_s2020.pdf

Box 3. Mobility with bicycles for a smart city

The concept of smart mobility is the underpinning principle of a sustainable city, and non-motorised mobility such as cycling is one of the key features of a smart mobility. The use of bicycles as a mode of city transport is gaining increasing popularity – not only in Europe and the United States but also in Asia. The benefits of cycling in cities are far-reaching:

- Bicycles use less space on the road than cars, and increased cycle use with modal change from cars can lead to less congestion. Also, parked cycles use less space than parked cars and free up valuable space in the city environment;
- Bicycles do not cause any pollution or emissions, while most other engine driven transport modes do – for example, PM, NOx and CO_2;
- Cycling is a more affordable transport mode than a car.
- Regular physical activity reduces the risk of diabetes, some types of cancer, obesity and many other diseases;
- Cycling makes a city a more pleasant place to live. A healthier, safer, and a less polluted city makes it more liveable. People who commute by bicycle are healthier and more productive. A study of 30,604 people in Copenhagen revealed that those who travel to work by bicycle had a 40 per cent lower risk of death over the course of the study than those who did not. Also, bike commuters had fewer days of sick leave each year than others.

The need to introduce and encourage cycling in Asian cities is more important given the severe traffic congestion on roads that waste time and fuel, and reduce overall productivity. Some cities in Asia are gearing up to increase cycling in a bid to improve mobility and reduce local air pollution. Seoul has a long cycling route running through the heart of the city. There are paths alongside both sides of the Han River, with a total length of more than 100 km, and paved bicycle pathways that light up at night. The Housing and Urban Affairs Ministry of India has launched an India Cycle4Change Challenge, where in the first phase, 10 cities will be selected and will receive technical support from the central government to create extensive cycling networks and supporting infrastructure (SCCI 2020).

Cities need to develop cycling strategies and mobilise investment in creating a cycling infrastructure as well as incentives to encourage cycling. While formulating cycle plans, it is important that cyclists are recognised as essential aspects of city planning and design and treated.

Transition to a clean energy sector will also require a shift from fossil fuel-powered transport to efficiently EVs powered by electricity supply that is increasing renewable energy based. Vigorous adoption of electric vehicles would reduce the demand for oil products, hence reducing Ormoc's reliance on petroleum fuel. Another advantage of EVs is their ability to absorb excess renewable energy. With specialised networks and large numbers of EVs plugged into the grid at any one time, there is the possibility to use the combined stationary battery capacity as an element of load levelling. At the same time, it can contribute to climate mitigation and improve local air quality. An adoption rate of 20 per cent for passenger cars, motorcycles and freight trucks by 2030 has the potential to save energy cumulatively by 34.4 ktoe and reduce emissions by 153.7 $ktCO_2$-e under the SET scenario between 2023 and 2030. The interventions might also be prioritized on e-jeepneys and solar-powered vehicles under the DOTr's Public Utility Vehicle Modernization Programme.

The Republic Act No. 11697, or the Electric Vehicle Industry Development Act which promotes innovation in the field of clean energy and sustainable transportation might provide incentive for the electric vehicle owners. Under the Comprehensive Roadmap for the Electric Vehicle Industry (CREVI), battery electric vehicle (BEV) owners are entitled to a 30 per cent discount on the motor vehicle users charge (MVUC), while hybrid owners get a 15 per cent discount. BEV and hybrid users will have the registration process expedited for them. These discounts will also apply to EV and hybrid inspection fees for the first eight years of this Act's effectiveness. Box 4 discusses the global progress of electric vehicles.

Box 4. Electric vehicles gain global interest

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

Despite supply chain bottlenecks and the ongoing COVID-19 pandemic, electric car sales hit a new high in 2021. Sales nearly doubled to 6.6 million, representing a world sales share of approximately 9 per cent compared to 2020, increasing the total number of electric vehicles on the road to 16.5 million. In 2021, the sales share of electric vehicles 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 electric vehicles were sold in the United States, doubling their market share to 4.5 per cent. Electric car sales increased more than twice as much in emerging nations, although they are still relatively small (IEA, 2022).

7.2.3. Pursuance of a high share of renewables in the power sector through cost-effective pathways

Renewable capacity has increased significantly across the globe amid climate change concerns. The decarbonization of the power sector is generally regarded as the low-hanging fruit, as the cost of renewable power technologies decreased rapidly during the past decade. Decarbonizing the electricity supply provides a quick decarbonization pathway to reaching a substantial GHG emissions reduction, while providing financial benefits. NEXSTEP proposes four different pathways that may be considered in decarbonizing the electricity supply, as described in subsection 6.2. A combination of these four pathways can also be adopted.

The stakeholders can utilize their local agricultural waste for energy generation. Such initiatives may come in two forms of arrangement, to be considered by the city government. First, the city government may opt to self-invest and self-govern the biomass facility. This may, however, require huge investment and operational responsibilities. A better solution would be to attract potential investors to establishing such facilities, while contributing positively to the city's economy and providing job opportunities. A power purchase agreement can be set up with the respective suppliers, requiring a supply to the city with a higher share of renewable electricity at an agreed price. On the other hand, citizen initiatives in setting up rooftop installations on both new and existing buildings should be promoted. For example, the city government is providing a tax incentive to small businesses that establish a minimum of 3 kW of RE systems, in the form of a 10 per cent discount from their gross sales for their corresponding business taxes in the city. The outcome of the initiative should be closely monitored to make sure that it aligns with the city's aspirations.

Renewable energy auctions may, however, be the best and cheapest option, whereby contracts and agreements are awarded through competitive bidding. The Department of Energy of the Philippines planned to launch a 2,000 MW renewable energy auction around mid-2021 (Rivera, 2020). While the renewable energy auction mechanism and its associated standards are set at the national level, the City of Ormoc can work with the Government to implement RE auctions at the city level. Box 5 explains further the renewable energy auction in detail.

Box 5. Mechanism of a renewable energy auction

A renewable energy auction, also known as a "demand auction" or "procurement auction", is essentially a call for tenders to procure a certain capacity or generation of renewables-based electricity. The auction participants submit a bid with a price per unit of electricity at which they are able to realise the project. The winner is selected on the basis of the price and other criteria, and a power purchase agreement is signed. The auctions have the ability to achieve deployment of renewable electricity in a well-planned, cost-efficient and transparent manner. Most importantly, it makes the achievement of targets more precise than would be possible by other means, such as a Feed-in-Tariff (FiT). Auctions are flexible and they allow the Government to combine and tailor different design elements to meet deployment and development objectives. Unlike a FiT, where the Government decides on a price, auctions are an effective means of discovering the price appropriate to the industry, which is the key to attracting private sector investment. In addition, an auction provides greater certainty about future projects, and is a fair and transparent procurement process. However, the administrative and logistic costs associated with auctions are very high unless multiple auctions are undertaken at regular intervals.

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

- **Auction demand.** A Government needs to clearly indicate the scale or size of each auction, the preferred technology (technology neutral or a specific technology), auction frequency, and the upper and lower limits of projects size and price;
- **Pre-qualification.** A strict or high pre-qualification for bidders will leave out the smaller entities, while a relaxed pre-qualification may undermine the quality of the project and increase the administrative costs. Governments need to make a trade-off, depending on the project size and other development objectives;
- **Selection criteria.** Commonly two selection criteria are used: (a) the lowest bid where only the lowest bidder will win; and (b) lowest bids plus other objectives where, in addition to the price, other objectives such as local content and jobs are taken into consideration;
- **Payment modalities.** The pay-as-bid model is good for minimizing the cost; however, the marginal cost payment model, where the same price (selected based on the highest cost winner) is paid to all winners is also practised;
- **Penalties for non-compliance.** There could be cases where the developer either delays the project or fails to complete it. To avoid such cases, penalties should be in place. There are two modes of penalty. In the monetary penalty, money will be deducted from bidder's "bond" or the price of energy will be reduced for a delayed completion. A form of non-monetary penalty can be the exclusion of the bidder from future auctions.

7.2.4. Moving towards net zero carbon

Efforts from all levels and sectors are imperative in the emissions race to net zero. Cities can play a significant role, as around the world they contribute around 75 per cent of global anthropogenic emissions and represent about 75 per cent of global energy demand (REN21, 2021). As of April 2021, more than 700 cities in 53 countries had committed to a net zero target by 2050, with a medium target of halving emissions by 2030 (C40 Cities, 2021). The energy system of Ormoc is well-positioned for an accelerated decarbonization effort, as the required net-zero technologies in decarbonizing its energy systems are readily available and mature – i.e., electric vehicles, electric cooking stoves, solar irrigation systems and renewable power technologies.

As detailed in chapter 6, a decarbonized electricity supply is required to complement the rapid adoption of electricity-based technologies, such as electric vehicles and electric cooking stoves. Further studies should be conducted to identify possible challenges to the electricity grid resulting from a high electricity load and a high level of RE penetration. Possible mitigating solutions may be required, such as integrated energy storage, demand side management and smart ICT solutions in managing the possible burden that large-scale demand electrification may place on the electricity grid.

8. Conclusion and the way forward

The 2030 Agenda for Sustainable Development and the Paris Agreement provide a common goal of achieving sustainability and climate objectives. While achieving the SDG 7 targets is principally a national effort, it requires combined contributions from stakeholders at various levels, such as subnational jurisdictions and cities. Ormoc is an active advocate for localizing SDGs by various initiatives and programmes benefiting its citizens. Ormoc and ESCAP have collaborated in the development of a Sustainable Energy Transition Road Map, which aims to inform the city about sustainable energy transition pathways tailored to its local context.

Ormoc is best recognised for its environmental initiatives and agricultural-centric economy. The GDP of Ormoc is projected to grow at 6 per cent per annum, while the population is expected to increase by 1.5 per cent each year. Under the current policy settings, Ormoc may fall short of achieving universal clean cooking access. The overall energy demand is projected to rise by an annual average rate of 4.8 per cent, to 102.8 ktoe. GHG emission is projected to be 260.5 ktCO_2-e, a reduction of 16.5 ktCO_2-e, compared to the baseline.

The SET scenario proposes an energy transition pathway that strategically allows Ormoc to close its existing gaps in clean cooking access. It also suggests several energy efficiency opportunities that would lead to energy savings and GHG emission reduction. Qualitative and quantitative analyses have suggested that electric cooking stoves may be the best way forward in closing the clean cooking gap. However, clean cooking technology selection between electric cooking stoves and LPG stoves should be done based on the power supply capacity of households. Closing the clean cooking gap will also provide a substantial energy demand reduction by phasing out polluting, inefficient cooking technologies (i.e., traditional biomass stoves and kerosene stoves).

The transport sector provides the greatest sustainable energy potential. The promotion of electric vehicles in multiple vehicle subcategories as well as an increase in public transport encouragement are estimated to provide a total energy savings of 13.3 ktoe only in 2030. At the household level, energy savings can be realised through the adoption of more efficient appliances, specifically by switching to LED lighting. With the proposed measures, the final energy demand and GHG emissions in the SET scenario are projected to be 82.3 ktoe and 214.5 ktCO_2-e, respectively.

Climate change is one of the most pressing issues of this century, requiring rapid and widespread climate mitigation from all sectors. Ormoc may play its part by raising its climate efforts through decarbonizing its electricity supply and whole economy, as explored in the most ambitious Towards Net Zero scenario. More can be done with co-operation from its citizens to adopt more electricity-based technologies, i.e., electric vehicles and electric cooking stoves. The penetration of electric vehicles and electric cooking stoves must be 100 per cent to achieve a net zero carbon target. However, strong institutional support is imperative in supporting a successful energy transition and sustainable development. The scenario requires an additional 655 GWh of electricity by 2050 to fulfil the increasing electricity demand. The city could undertake several pathways in decarbonizing its electricity supply to support the achievement of net zero target, with renewable energy auctions standing out as the cheapest option.

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Annexes

I. National Expert SDG 7 tool for energy planning methodology

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

Annex table 1. Targets and indicators for SDG 7

Target	Indicators	2020	2030
7.1. By 2030, ensure universal access to affordable, reliable and modern energy services.	7.1.1. Proportion of population with access to electricity.	100%	100%
	7.1.2. Proportion of population with primary reliance on clean fuels and technology for cooking.	85%	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.	6.2% (excluding traditional biomass)	15.6%
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.	6.0 MJ/US$ (2017) PPP	4.3 MJ/US$ (2017) PPP

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, and 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.

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

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.

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

II. Key assumptions for NEXSTEP energy modelling

(a) General parameters

Annex table 2. GDP, PPP and growth rate

Parameter	Value
GDP (2020)	446.2 million
Growth rate	6%

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

Parameter	Value
Population (2020)	230,998
Population growth rate	1.5%
Number of households (2020)	56,054
Household size (constant throughout the analysis period)	4.1

(b) Demand-side assumptions

(i) Industry

- There are four industry subcategories in Ormoc:(1) food and beverages; (2) machinery and transportation equipment; (3) wood and wood products; and (4)other processing industry. The fuel consumption data (exclusively electricity consumption) are shown in annex table 4.
- The industrial GDP is assumed to grow at an annual rate of 6 per cent, similar to the GDP growth rate. The energy intensity is assumed constant throughout the analysis period in the absence of energy efficiency interventions.

Annex table 4. Fuel consumption by industry subcategories in 2020

Industry subcategory	Electricity consumption in 2020 (toe)	Consumption share
Food and beverages	10	15%
Machinery and transportation equipment	34	50%
Wood and wood products	17	25%
Other processing industry	7	10%

(ii) Transportation

- Land transport sector consumption is estimated using the vehicle statistics, load factor, annual travel mileage and estimated fuel economy, as shown in annex table 5. 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.
- Transport activities in 2020 are estimated to have been 0.88 billion passenger-kilometres (0.08 billion-km when considering only public transport) and 1.43 billion tonne-kilometres. The growth in both passenger transport and freight transport activities is assumed as growing at the same rate as the population, i.e., 1.5 per cent per annum.

Annex table 5. Transport sector floorspace baseline assumptions

Passenger transport	No. of vehicles	Annual mileage (km)	Load factor (pass-km/veh-km)	Fuel consumption	% share of passenger-km
Passenger car	2,159 (gasoline) 6,477 (diesel)	24,000	2.5	8.5 km/l 8.3 km/l	59%
Motorcycle	19,498 (gasoline)	9,000	1.6	15 km/l	32%
Bus	20 (gasoline)	80,000	50	8.5 km/l	9%
Freight transport	**No. of vehicles**	**Annual mileage (km)**	**Load factor (tonne-km/veh-km)**	**Fuel consumption**	**% share of tonne-km**
Freight truck	2,326 (diesel)	56,000	11	8 km/l	100%

(iii) Commercial sector

- The total annual energy consumption in the commercial sector was 0.88 ktoe in 2020. It is projected to grow at an annual rate of 6 per cent, similar to the GDP growth rate in the BAU scenario.
- The commercial sector is further differentiated into four categories and the energy consumption by categories are as shown in annex table 6.

Annex table 6. Commercial sector fuel consumption in 2020

Category	Floor space in 2020 (million m^2)	Electricity intensity (kWh/m^2)	Consumption in 2020 (ktoe)
Private office	0.050	70	0.30
Government building	0.052	32	0.14
Shopping mall	0.083	11	0.08
Hotel	0.027	29	0.07
Hospital	0.034	21	0.06
University	0.052	22	0.10
Religious temple	0.019	80	0.13

(iv) Residential

- The residential households achieved a 100 per cent electricity access rate and an overall clean cooking rate of 85 per cent in 2020. The breakdown is shown in annex table 7.

Annex table 7. **Cooking distribution in households**

Stove type	Energy intensity (GJ/household)	Share
LPG stove	6.67	77%
Electric stove	5.57	8%
Biomass stove*	39.02	14%
Kerosene stove*	3.66	1%

* *These are unclean fuel/technology.*

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

Annex table 8. **Residential appliance baseline assumptions**

Appliance	Electricity intensity (kWh/HH/year)	Ownership
Lighting	96.6	100%
Air-conditioner	414.0	50%
Refrigerator	386.4	75%
Television	69.0	100%
Electric fan	110.4	100%
Water pump	124.2	25%
Iron	69.0	80%
Washing machine	110.4	90%

(v) Other sectors

- The energy demand of the agricultural sector is associated with irrigation and the use of agricultural machinery. The energy demand (under the BAU scenario) is expected to rise at an annual growth rate of 6 per cent, similar to the GDP growth rate. The energy demand breakdown for 2020 is shown in in annex table 9.

Annex table 9. Consumption by agricultural sector in 2020

Category	Energy demand in 2020 (toe)	Description
Irrigation (total: 30 toe)		
Diesel water pumps – large	30	37 water pumps consuming 888 litres of diesel annually per pump
Agricultural machinery (total: 13 toe)		
Tractors	8	
Rotovators	5	

III. 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 (annex table 10). The calculation assumes an annual cooking thermal energy requirement of 3,840 MJ per household (Putti and others, 2015). In addition, a discount rate of 5.37 per cent is assumed.

Annex table 10. Technology and cost data for clean cooking technologies

Technologies	Efficiency[18] (%)	Lifetime[19] (years)	Stove cost (US$)	Variable O&M[20] (US$/year)	Fuel cost (US$)
ICS	35	4	35	10	0.03 per kg
LPG stove	56	7	56	10	1.49 per kg
Electric stove	84	15	40	10	0.164 per kWh

IV. Summary results for the scenarios

	BAU scenario 2030	CPS scenario 2030	SET scenario 2030	TNZ Scenario 2030	TNZ Scenario 2050
Universal access to electricity	100%	100%	100%	100%	100%
Universal access to clean cooking	85%	85%	100%, via electric cooking stoves	100%, via electric cooking stoves	100%, via electric cooking stoves
Energy efficiency	5.51 MJ/US$	5.39 MJ/US$	4.31 MJ/US$	3.85 MJ/US$	2.05 MJ/US$
Renewable energy share in TFEC	6.3%	9.3%	15.6%	28.4%	100%
GHG emissions	277 ktCO_2-e	260.5 ktCO_2-e	214.5 ktCO_2-e	160.4 ktCO_2-e	0 ktCO_2-e

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

19 Sources: ICS – own estimation, LPG stove – (Clean Cooking Alliance, 2021), electric stove – (IEA, 2012).

20 Variable O&M is based on own assumptions