100% RENEWABLES ROADMAP

West Nusa Tenggara, Indonesia

ICLEI Local Governments for Sustainability

100% RENEWABLES CITIES & REGIONS ROADMAP

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This 100% Renewables Roadmap for West Nusa Tenggara Province, Indonesia is the culmination of the work under the 100% Renewables Cities and Regions Roadmap project. It represents the final outcome of an extensive consultation process, beginning with securing political commitment and engaging relevant stakeholders, and progressing through data collection and energy systems modelling to provide a feasible pathway towards 100% renewable energy use. This roadmap document outlines the local strategies, implementation mechanisms and recommendations for the local government to realize this vision.

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ABOUT THE 100% RENEWABLES CITIES AND REGIONS ROADMAP PROJECT

The 100% Renewables Cities and Regions Roadmap project facilitates the energy transition by raising local awareness on renewable energy sources, showcasing how local and national governments can create coordinated enabling frameworks and policies, exploring access to public and private sector finance, and building local renewable energy projects to address electricity, heating, and cooling. The project is implemented by ICLEI and funded by the German Federal Ministry for Economic Affairs and Climate Action (BMWK) through the International Climate Initiative (IKI).

ABOUT ICLEI – LOCAL GOVERNMENTS FOR SUSTAINABILITY

ICLEI – Local Governments for Sustainability is a global network working with more than 2,500 local and regional governments committed to sustainable urban development. Active in 125+ countries, ICLEI influences sustainability policy and drives local action for low emission, nature-based, equitable, resilient and circular development. ICLEI's Members and team of experts work together through peer exchange, partnerships and capacity building to create systemic change for urban sustainability.

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EXECUTIVE SUMMARY

Like most of Indonesia, West Nusa Tenggara (WNT) Province is heavily dependent on fossil fuel, with the main sources of energy being oil, gas, and coal in particular.. This is a threat to energy security as it's highly dependent on other regions, but also negatively impacts the environment due to the production of high levels of GHG emissions and other pollutants. The share of renewable energy is still relatively small, but this region has significant potential for renewable energy sources such as geothermal, hydro, wind, solar, municipal waste, biomass, and biogas across its region.

Since 2019, ICLEI Indonesia has supported the implementation of the 100% Renewables Cities and Regions Roadmap (100% RE) project in WNT Province . The project aims to assist West Nusa Tenggara in accelerating the achievement of renewable energy targets, energy efficiency, and electrification ratios, by formulating a strategy or 'roadmap' that leads it towards 100% renewable energy use in its territory.

The roadmaps produced as part of the 100% Renewables Cities and Regions Roadmap project were developed according to a multi-step and inclusive methodology that sought input from a range of stakeholders including experts, local government officials, government agencies, civil society, private sector, and academics. As per the methodology, participants begin by identifying key priorities through the 100% Renewables building blocks. They follow this by a serious game exercise that allows for innovative solutions to pressing issues facing the local sustainable energy transition, and this exercise can be revisited for validation as the roadmap is further developed. Participants then identify local strategies for each priority sector, i.e. pillars, as well as corresponding actions and implementation mechanisms, which are laid out in terms of their justification, responsibility, supporting policies and technologies, potential financing sources, as well as any associated risks and their mitigation.

At the regional level, WNT has a commitment to target net zero emissions by 2050. The formulation of the vision and mission to realize 100% RE in WNT in 2050 was also conducted using a participatory approach that involved stakeholders from various

sectors. The formulation of the vision further refers to the results of the energy modeling conducted by Fraunhofer ISE in 2021, which states that West Nusa Tenggara has the potential to realize the target of 100% renewable energy by 2050 in all sectors.

To develop the 100% RE scenario in WNT, Fraunhofer ISE modeled its energy system using the software KomMod. All relevant energy indicators (demand, supply, population, economy, etc.) were projected to 2050 under different demand scenarios. Renewable energy potential was calculated based on GIS data, statistical data, and secondary studies in WNT as well as in the rest of Indonesia where no WNT-specific data existed. All input data assessments were conducted for both Lombok and Sumbawa islands separately.

Ten different scenarios were calculated by varying three different features for the 100% RE scenario: biomass and biogas fuel price, energy demand, and a coupling of the energy systems of the two islands versus a separated modeling for both. In addition, a business-as-usual (BAU) scenario allowed for the comparison of costs and carbon dioxide emissions. Based on the discussion with the local government unit, the main scenario chosen was coupled energy system, mean energy demand, and low fuel price. This scenario uses low fuel prices, medium energy demand (3.49 times the base year demand) and is considered a coupled energy system between Lombok Island and Sumbawa Island. The merging of the Lombok and Sumbawa Island energy system is beneficial due to economic benefits, improved energy supply security, and a more even distribution of wind and solar PV generation.

In the electricity sector, WNT is quite dependent on diesel generation with 94-unit gensets with a total of 168 MW installed capacity, covering almost 30% of the total electricity generation in WNT. The dependence on fossil fuels is also a supply chain issue for WNT given its geography, which consists of small and scattered islands, as well as larger islands such as Sumbawa that are elongated and not well connected. Diesel is considered easy to transport to these locations, however generating power from it can be expensive and unreliable.

Based on the data from the Annual Report of the Energy and Mineral Resources Agency of WNT in 2022, the electrification ratio of villages reached 100% in 2018 for its 1,143 villages, where 1,138 villages/urban areas received electricity from the State

Electricity Company (PLN) and the remaining 5 villages are supplied by non-PLN sources, mainly using electricity from micro hydropower plants (PLTMH). The electrification ratio in WNT stands at around 99.98%. However, this ratio does not account for the quality of supply that should ideally be universal, adequate, affordable, and also reliable in accordance with the Sustainable Development Goals (SDGs).

The transportation sector has the largest energy demand in WNT—42% of the total. Of transportation's total energy demand, 89% is for land transportation, 8% for water transportation, and 3% for air transportation. In 2019, energy demand in the transportation sector reached around 3.1 million barrels of oil equivalent (BOE) in 2019. Gasoline is the most consumed fuel with 2.1 million BOE, followed by diesel with 923,000 BOE and heavy fuel oil with 87,000 BOE. Demand continues to grow with greater vehicle ownership.

The household sector is the largest consumer of electricity in West Nusa Tenggara, accounting for 65% of the total 2,149 GWh consumed in 2020[1], with a total of 1,509,537 household customers. Based on the 2021–2030 Electricity Supply Business Plan (RUPTL), electricity sales in WNT have continued to increase with the addition of electricity customers with an average growth of 11% per year since 2011. This shows a strong electrification effort throughout WNT and positive economic growth. Further growth in electricity use in households is expected due to an increase in the use of air conditioners, electric transport, and electric stoves.

The industrial sector has considerable potential for energy savings according to the Minister of Energy and Mineral Resources (MEMR)[2], ranging from 5–26%. In WNT, the industrial sector is dominated by medium and small industries. Electricity consumption from this sector only amounted to 154 GWh in 2020, or only 7% of the total electricity consumption in WNT[3]. In 2023, the WNT government encouraged industrialization programs with a downstream strategy to form a local industrial ecosystem. Thus, industrialization will increase added value and trigger economic growth, leading to more energy (and electricity) use. The WNT government's priority industrial sectors include food, upstream agro-industry, machinery industry, transportation equipment

[1] PLN, 2021.
[2] MEMR, 2020.
[3] PLN, 2021.

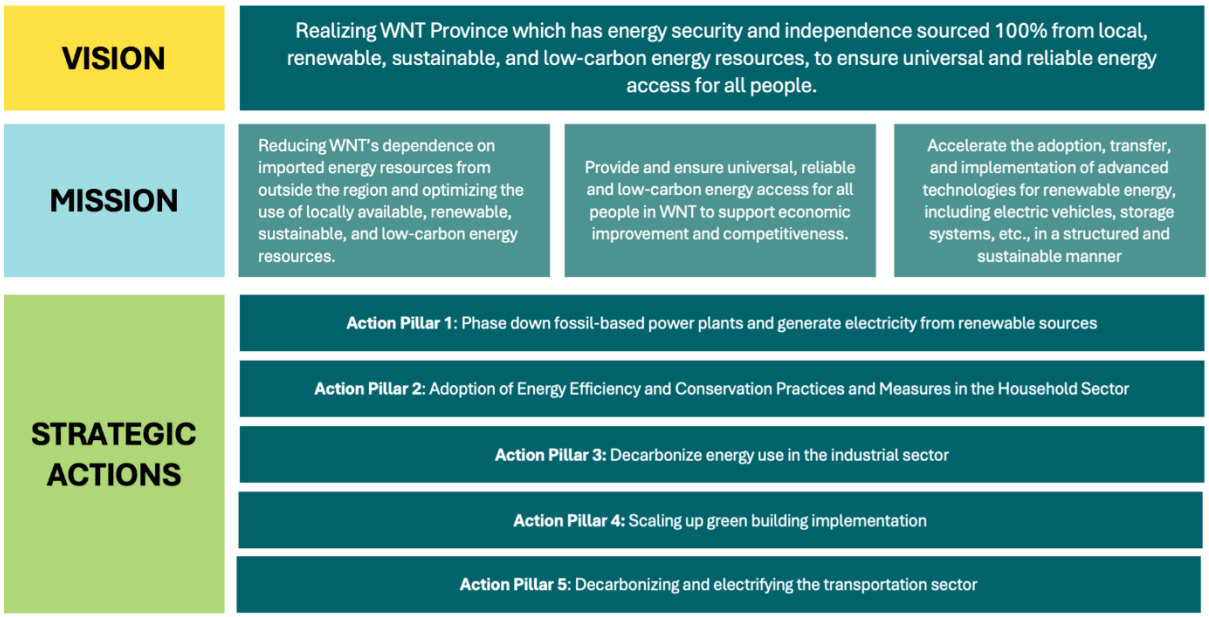
and renewable energy, mining, chemical industry, pharmaceuticals, cosmetics and medical devices sectors. Although energy consumption in the industrial sector in WNT is not too large at present, with further growth it is bound to grow, making energy management efforts critical to WNT's energy transition and goals.

The commercial sector and government buildings are the second largest consumers of electricity in West Nusa Tenggara, accounting for 21% of total electricity consumption in 2020.[4] Based on a study from MEMR and BPPT in 2020 on several Indonesian cities, the largest energy consumption comes from the use of air conditioning (with an average portion of over 60%).

This roadmap also highlights regulations in all sectors, ranging from central government, president regulation, ministries regulation, and regional level policies and regulations in WNT Province. Related to the energy sector, in 2019, West Nusa Tenggara established its National Energy General Plan (RUED) through Perda No. 3/2019. It contains the direction of energy management in the province, including the regional vision for the energy sector, energy availability to meet regional needs, and energy development priorities.

In this roadmap, the strategic action framework is guided by the overall vision, mission, and interim targets, determined through iterative participatory processes with concerned stakeholders and informed empirically by modeling exercises. Similarly, the action pillars, and the corresponding programs, projects, and activities (PAPs) were formulated through consultations with the representatives of important stakeholder groups in the province. Strategic actions are designed to maximize the RE potential of the province in line with the vision and mission, while making them inclusive measures where citizens also have a role to play. These are guided by the action pillars. Each of the pillars details the corresponding objectives, indicators, actions and other supporting requirements. The summary of vision, mission, and strategic actions in the roadmap can be found below:

[4] PLN, 2021.



In addition to strategic actions that developed, the investment strategies and financial innovations are also discussed in this roadmap. The framework of infrastructure funding, which includes renewable energy, can be divided into two broad groups: (i) the public/government funding through the modality of government budget or APBN (national budget) (and APBD (regional budget)) and (ii) the non-public funding or non-APBN/APBD. The government funding that is allocated through the APBN comes from tax revenues and grants, foreign loans, domestic loans, and the issuance of state securities (such as government bonds), whereas non-public/government funding includes financing from banking, non-bank financial institutions, capital markets (stocks and bonds), foreign funds, and others. Aside from that, there is Public Private Partnership (PPP), which is a collaborative arrangement to bring aboard the combination of government/public funding (via APBN/APBD) and business/private sector investment. The collaboration between public and private sector accelerates achieving national development goals through the involvement of private investment/business entities in the provision of public infrastructure. In addition, it is envisaged that each party's skills and assets (resources) can be leveraged collaboratively to offer the services and/or facilities required by the public. Furthermore, it offers rewards to each party as well as commensurate risks. The sections that follow explain each type of financial mechanism and instruments that have the potential to be optimized to achieve 100% renewables in WNT by 2050.

To achieve a 100% renewable energy mix by 2050, strategic and integrated policies are necessary.

Identified guiding principles to underpin the various actions include:

- Clearly set a renewable energy mix target that is gradual and measurable;
- Develop regulations and policies that support the development and utilization of renewable energy, including tax incentives and reductions for businesses that invest in this sector;
- Provide access to the information and technology for business and general public;
- Secure the distribution network to ensure the reliability and continuity of renewable energy integration;
- Establish partnerships and dialogues for relevant stakeholders; and
- Utilize and synergize the various types of financing mechanism.

This roadmap also presents the recommendations that need to be addressed on the identified challenges. To ensure energy supply security, multiple energy sources should be utilized, with solar PV being prominent but needing integration with other sources or storage systems. Detailed studies are necessary to determine the suitability of specific sites and technologies, such as wind farms or renewable fuels for industrial processes. Early stakeholder engagement and transparent policies are essential for the sustainable deployment of renewable technologies, helping to mitigate initial resistance. Emphasizing energy efficiency and conservation is crucial for reducing system costs and environmental impact. In transportation, public transport and ride-sharing can reduce car ownership and improve efficiency. Proximity to demand centers is important for using excess heat from CHP or electrolyzers. Finally, the costs of the energy transition require partnerships and strategic resource utilization to achieve energy and climate goals successfully.

INTRODUCTION

Indonesia is heavily dependent on fossil fuels, with the main sources of energy being oil, gas, and coal in particular. Not only does this dependence pose a threat to *energy security,* but it also creates adverse impacts on the environment due to the high level of greenhouse gas (GHG) emissions and other pollutants.

The share of electricity generation based on renewable energy (RE) is relatively minimal. In response to this, the Government of Indonesia (GoI) set a target of increasing the share of renewables in the nation's primary energy mix to 23% by 2025[5]. Further, in its recently submitted Enhanced Nationally Determined Contribution (NDC) to the United Nations Framework Convention on Climate Change (UNFCCC) in 2022, the GoI communicated its target to reduce its GHG emissions by 31.89% against a business-as-usual scenario by 2030. The GoI intends to increase this target to 43.20% subject to the availability of international support for finance, technology transfer and development, and capacity building. The forestry and energy sectors dominate the GHG emission reduction target with a reduction of 314 $GtCO_2$-eq and 497 $GtCO_2$-eq respectively in the *unconditional* scenario. In support of the commitment of the national government, subnational governments are also taking the lead. The West Nusa Tenggara Provincial Government conveyed its commitment towards Net Zero Emissions by 2050 during the 26th UNFCCC Conference of the Parties (COP26) in Glasgow.

To support this effort, the Ministry of Energy and Mineral Resources (MEMR) through the Directorate of Geothermal, Directorate General of New Renewable Energy and Energy Conservation (EBTKE) collaborated with the ICLEI - Local Governments for Sustainability to implement the *100% Renewables Cities and Regions Roadmap* (100% RE) project in West Nusa Tenggara (WNT). Funded by the German Federal Ministry for Economic Affairs and Climate Action (BMWK) through the International Climate Initiative (IKI), the project works closely with the WNT Provincial Government and other relevant community stakeholders.

The project aims to assist West Nusa Tenggara in accelerating the achievement of renewable energy targets, energy efficiency, and electrification ratios, by formulating a strategy or 'roadmap' leading it towards 100% renewable energy use in its territory. The experience of West Nusa Tenggara is also meant to serve as a model for replicating renewable energy development efforts in other provinces in Indonesia. Building on project activities and following extensive consultations with key stakeholders from local governments, private

[5] Government Regulation (**"PP"**) No. 79/2014 concerning National Energy Policy (**"KEN"**)

companies, CSOs/NGOs, communities, academia and research institutions, the **100% Renewables Roadmap for West Nusa Tenggara** ("roadmap") was developed.

The roadmap outlines local strategies and actions for West Nusa Tenggara to achieve its 100% renewable energy goal by 2050, by:

- Determining sector-wise action plans and strategies towards 100% RE in the household, commercial, industrial, transportation and electricity sectors;
- Providing guidance on technical steps for 100% RE use in WNT;
- Identifying institutional mechanisms, collaboration, and funding for the development and management of 100% RE in WNT; and
- Providing actionable policy recommendations to support actions and strategies towards 100% RE in WNT.

Chapter 1 of the roadmap provides an overview of WNT's regional context, including its baseline energy and economic conditions. **Chapter 2** outlines the roadmap development process, including the main scenario, as well as certain implementation challenges. **Chapter 3** outlines the key priorities and actions that WNT can take to realize its 100% renewables vision. **Chapter 4** provides an overview of the financing and funding sources available for WNT to implement various actions. **Chapter 5** summarizes certain local policy recommendations that can enable the implementation of the roadmap.

CHAPTER 1: WEST NUSA TENGGARA OVERVIEW

1.1 Profile of West Nusa Tenggara

This section provides baseline information about the province of West Nusa Tenggara, including its geographic setting, governance structure, demographics, economy, social services, environmental conditions, and energy access. A summary of this information is presented in Table 1 below.

Table 1: General Information on WNT Province[6]

Geography	
Province name	West Nusa Tenggara
Geographical position	8° 10' - 9° 5' N and 115° 46' - 119° 5' E
Government	
Capital city	Mataram, Lombok
Area	The province covers an area of 20,124.48 square kilometers, with Sumbawa Island making up two-thirds of the province.
Number of districts/cities	WNT has two municipalities and eight regencies spread across two main islands. These include Mataram City, West Lombok, Central Lombok, East Lombok, and North Lombok on Lombok Island, and Bima City, Sumbawa, Dompu, West Sumbawa and Bima on Sumbawa Island.
Economy & demographics	
Population	5,070,385 people of which 51.5% are female and 48.5% are male (2019)
Population density	252 inhabitants per square kilometer
Number of households	1,407,554 households, with an average of 3.6 members per household
Main economic activities	Agriculture, forestry, and fisheries; mining and quarrying; wholesale and retail trade; construction
Energy access	
Electrification ratio	99.98% (2022)[7]

[6]ICLEI Indonesia, 2020. *Initial Status Report of Deep-Dive Region: West Nusa Tenggara Province*, Published by ICLEI, Jakarta, Indonesia.

[7] WNT One Data Portal, 2022. Electricity Coverage (Electrification Ratio), accessed via https://data.ntbprov.go.id/dataset/cakupan-listrik-rasio-elektrifikasi

Villages with electricity	100% (since 2018)[8]
Electricity consumption	2,359 GWh (2022) or 465 kWh/capita
Main energy source	Electricity is sourced from diesel, steam, and a small amount of gas and renewable energy, including hydropower.

1.1.1 Geographic setting

West Nusa Tenggara is one of 38 provinces in Indonesia, located between 8° 10'-9° 5' S and 115° 46'-119° 5' E. The province is divided into two major islands – Lombok in the west and Sumbawa in the east. Sumbawa Island comprises two-thirds of the land area of the province. However, Lombok Island comprises the majority of the province's population and is home to the province's capital, Mataram City. The northern area of the island is mountainous while the southern and western sides are dry and arid lands. Selong City has the highest altitude of 166 meters above sea level while Taliwang has the lowest altitude of 11 meters above sea level[9]. The island province is surrounded by around 380 smaller islands and is bordered by the Java Sea and the Flores Sea in the north, by the Indian Ocean in the south, by the Sape Strait in the east, and by the Lombok Strait in the west (Figure 1-1).

Source: Google Maps satellite imagery (2022).

Figure 1: West Nusa Tenggara Province, Indonesia

[8]Annual report DEMR 2023, accessed via https://desdm.ntbprov.go.id/dokumen_file/LAPORAN%20TAHUNAN%20DINAS%20ESDM%20TAHUN%202022%20TTD.pdf

[9] Regional Planning Agency, 2013. West Nusa Tenggara in Figures 2013, accessed via https://bappeda.WNTprov.go.id/wp-content/uploads/2013/09/dda2013-09-babi1.pdf

1.1.2 Energy governance structure

The government of WNT Province is led by the Governor and Deputy Governor. In the 2019–2023 period, WNT Province was led by Governor Zulkieflimansyah and his deputy Sitti Rohmi Dajalilah. Through WNT Provincial Regional Regulation (Perda) No. 11/2016 on "the Establishment and Structure of WNT Provincial Regional Apparatus", the WNT Government established its Regional Apparatus, one of which is the Energy and Mineral Resources of West Nusa Tenggara Office. The office has several work units managed by the Energy and Mineral Resources Agency of WNT, namely electricity, minerals and coal, geology and groundwater, and energy.

The agency has the following functions in the field of energy and mineral resources:

- Formulation of technical policies on government affairs
- Guidance and implementation of government affairs tasks
- Controlling the implementation of government affairs tasks
- Implementation of other tasks assigned by the Governor in accordance with the duties and functions of the Energy and Mineral Resources Agency Service

The management of the electricity sector is carried out by the government-owned electricity supply company PT Perusahaan Listrik Negara (**"PLN"**) Unit Induk Wilayah (**"UIW"**) WNT.

1.1.3 Demographic aspects

Administratively, WNT is divided into eight regencies, two cities, 117 sub-districts, and 1,143 villages. The total population of WNT is 5,473,700 people, 48.8% of whom are male and 51.5% female. The annual population growth rate in 2022 was 1.64%. Although its area is only about 24% of the province's area, Lombok is home to around 4.5 million people (over 80% of WNT's population). Mataram City is the most densely populated settlement in WNT, while Sumbawa Regency is the least densely populated.[10] Table A1 (Appendix) shows the administrative areas of the regencies/cities and their population density.

1.1.4 Economic aspects

In general, economic activity in WNT during 2018–2020 was driven by four main sectors including agriculture, forestry, and fisheries; mining and quarrying; wholesale and retail trade; and construction. The province experienced a slowdown of around 3.03% year-on-year

[10] Central Bureau of Statistics (BPS), 2023. West Nusa Tenggara Province in Figures 2023, accessed through https://ntb.bps.go.id/publication/2023/02/28/4be8aa62e831b61d13521816/provinsi-nusa-tenggara-barat-dalam-angka-2023.html

attributed to the impacts of the COVID-19 pandemic. However, according to Bank Indonesia NTB, WNT was expected to grow by 6.95% in 2022, an increase compared to 2021, mainly attributed to a rebound from the effects of the pandemic. However, WNT also experienced an increase in the open unemployment rate (TPT). As a consequence, as of September 2020, the poverty rate was recorded at 14.23%, up 0.35% from the end of the same quarter in 2019.

1.1.5 Climate and environment

According to the data by the Meteorology, Climatology and Geophysics Agency (BMKG), the maximum temperature of West Nusa Tenggara ranges between 29°C and 34°C, while the minimum temperature ranges between 17°C and 22.6°C. The highest temperatures typically occur in October while the lowest temperatures are usually recorded in June. Space cooling is therefore a critical need, demand for which is expected to grow. West Nusa Tenggara has relatively high humidity which ranges between 77% and 85%. The average wind speed reaches 4–7 knots with maximum wind speeds reaching 26 knots. The average annual rainfall varies between 100 mm and 450 mm from November to March (rainy season) and 0 mm to 100 mm from April to October (dry season).

West Nusa Tenggara experiences both geological and hydrometeorological threats. Most of the province is prone to natural disasters due to its position within the Pacific Ring of Fire. Lombok Island is a seismically active area. There are three active Type A volcanoes within West Nusa Tenggara. Hydrometeorological disasters that commonly occur in West Nusa Tenggara include floods caused by high-intensity rainfall, which then become manmade disasters due to poor drainage infrastructure and planning, such as populated low-lying riverbanks. Some areas that are at risk of flooding include East Lombok (Sambelia and Sembalun sub-districts), West Lombok, Mataram City, South Central Lombok, Taliwang Sub-district KSB, Sumbawa Besar City, Dompu, and Bima. High-intensity rainfall can also cause landslides in some areas of the province.

In terms of environmental issues, the Environmental Management Performance Document (DIKPLH) of West Nusa Tenggara 2019 reported that the province faces three critical environmental challenges: land conversion, decline in water quality and quantity, and increased waste generation.[11] In the past decade, the provincial government has promoted corn farming as means to achieve food security. While this program drastically increased corn production, it also led to the large-scale conversion of forests into corn production areas, leading to land degradation and damaging natural ecosystems. The agricultural sector is the largest contributor to greenhouse gas (GHG) emissions in WNT, followed by the energy sector.

[11] https://dislhk.ntbprov.go.id/wp-content/uploads/2022/09/IKPLHD-2022-1-1.pdf

As of 2018, the remaining critical land area in the province is approximately 657 km^2 of which about 481 km^2 are forestry areas. The water quality index of the province decreased by about 40% in 2018. In 2018, only 20% of the total waste generated by the province was disposed of in landfills. To address this problem, the provincial government launched its Zero Waste Program, which aims to reduce waste generation by 30% and increase waste treatment by up to 70% by 2023.

1.1.6 Energy access

Electricity in the province is mainly supplied by the State Electricity Company (PLN), which relies heavily on coal and diesel power plants. There is no electricity import or export in the region. In 2022, the province consumed 2,359 GWh or 465 kWh/capita of electricity, with the household sector consuming the most. Based on the data from the Annual Report of the Energy and Mineral Resources Agency of WNT in 2022[12], the electrification ratio of villages reached 100% in 2018 for its 1,143 villages. Among them, 1,138 villages or urban areas received electricity from PLN. The remaining five villages, all located in the Sumbawa Regency, are supplied by non-PLN sources mainly using electricity from micro hydropower plants (PLTMH). They are situated in the mountains where the PLN electricity network has not been able to reach due to various constraints.

The electrification ratio[13] in WNT stands at around 99.98% (see Table A2 in the Appendix). However, this ratio does not account for the quality of supply. All WNT communities should ideally obtain electricity that is *universal*, *adequate*, *affordable,* and also *reliable* in accordance with the Sustainable Development Goals (SDGs). In this context, households that are not served by PLN but have been classified as electrified are generally still powered by energy-efficient solar lamps (LTSHE), small-scale diesel generators (that face fuel transportation barriers), and other non-PLN electricity sources such as mini- or micro-hydro (relatively less reliable).

1.1.7 Stakeholders

Stakeholder engagement is crucial in pursuing the goal of 100% renewable energy in West Nusa Tenggara. As such, public and private stakeholders that were key in the formulation and implementation of the roadmap were mapped. This section presents the list of key stakeholders and the recommended nature of their engagement on RE planning and development. The stakeholders are grouped into the following categories of responsibilities: **policy advisors, policy formulation, technical implementation,** and **enabling actors.**

[12] https://desdm.ntbprov.go.id/dokumen_file/LAPORAN%20TAHUNAN%20DINAS%20ESDM%20TAHUN%202022%20TTD.pdf
[13] The ratio between the number of households with an electricity connection and the total number of households

Policy advisors are government entities that were tasked with providing guidance and input to policies and regulation relevant to advancing renewable energy development in the province. They were also tasked with advising on the transition strategies that can be pursued by the roadmap, and for providing strategic guidance on the direction of implementation of the 100% RE Project.

Members of policy advisors group
• National Energy Council • Directorate of New and Renewable Energy and Energy Conservation, Ministry of Energy and Mineral Resources (MEMR) • Directorate of Energy Conservation, MEMR • Directorate General of Electricity, MEMR • Directorate of Synchronization of Local Government Affairs, Ministry of Home Affairs • National Focal Point of UNFCCC Indonesia, Ministry of Environment and Forestry • Ministry of State Planning (Bappenas) • Ministry of Industry • Ministry of Cooperatives and SMEs • Ministry of Tourism • Ministry of Transportation • State Electricity Company (PLN)

Policy formulation groups are government entities responsible for periodic reviews of existing policies, regulations, and other instrumentalities that govern renewable energy developments, including the 100% RE Roadmap. They were also tasked with identifying and prioritizing strategies that are to be incorporated in the roadmap.

Members of policy formulation group
• West Nusa Tenggara Provincial Secretary • Governor's Expert Team • Head of the Regional Development Planning Agency (Bappeda) • Head of the Environment and Forestry Agency • Head of the Public Works and Spatial Agency • Head of the Small and Medium Enterprise Cooperative Agency • Head of the Industry Agency • Head of the Agriculture and Plantation Agency • Head of the Transportation Agency

- Head of the Tourism Agency
- Head of the West Nusa Tenggara Central Bureau of Statistics
- Head of the Marine and Fisheries Agency
- Head of the Regional Revenue Management Agency
- Head of the Housing and Settlements Agency

The **technical implementation group** was tasked with providing the information and data required to generate the energy models that informed the roadmap. They were also responsible for the development of strategies and action plans including the identification and financing of RE and EE projects characterized in the roadmap.

Members of the technical implementation group
• Head of Energy Division, DEMR • Head of New Renewable Energy (NRE) Development Section, DEMR • Functional Staff Planner of West Nusa Tenggara Bappeda • Head of Natural Resources and Environment Sub-division, Sumbawa Regency Bappeda • Head of Natural Resources and Environment Sub-division, Mataram City Bappeda

Enabling actors are representatives from the private sector as well as CSO/NGOs, community groups, and interest groups. They were tasked with providing supplemental data and information for the energy models and the regional energy profile. They also provided inputs to the 100% RE Roadmap to ensure the inclusivity of the process as well as for achieving a holistic view for implementation, such as grid readiness, energy storage systems, and available private funding schemes. They are also responsible for continuing advocacy and promotion of renewable energy in the region.

Members of the enabling actors group	
SOE/Private sector • State Electricity Company – West Nusa Tenggara Regional Unit • PT Pertamina (Persero) • PT Sarana Multi Infrastruktur (Persero)	**CSO/NGOs, community groups, and interest groups** • Danish Energy Agency • Yayasan Rumah Energi • Indonesian Renewable Energy Society (METI) • DDOROCARE Community • HIVOS

	• The Community of Paman SAM, Narmada • West Nusa Tenggara Conception

1.2 West Nusa Tenggara's initial status

1.2.1 Status of the energy sector in WNT

The Government of Indonesia has made a commitment to achieve 23% renewable energy in the national energy mix by 2025 as outlined in the KEN and the RUEN (National Energy Plan). In addition, PT PLN (Persero) prepares the General Plan for Electricity Supply (RUPTL) [14] every period as the basis for electricity planning in Indonesia. Under the RUEN, the Provincial Government is mandated to develop the Provincial Regional Energy Plan (RUED-P), which includes energy planning and outlines the implementation plan of the RUEN that is cross-sectoral to achieve the RUEN targets at the national level. The WNT Provincial Government has prepared and ratified the RUED document through Regional Regulation (Perda) No. 3/2019.

1.2.1.1 Electricity supply

Dependence on fossil fuel generation

Electricity generation in West Nusa Tenggara is quite dependent on diesel generation. WNT still relies on 94-unit gensets with a total installed capacity of 168 MW, covering almost 30% of the total generating capacity in WNT. In Lombok, there are 19 units owned by PLN with a capacity of 82 MW and 4 other rental units with a total capacity of 40 MW. Meanwhile in Sumbawa (Tambora) there are 66 units of PLTD with a total capacity of 32 MW owned by PLN, and 5 rental units with a total capacity of 14 MW (see Table A3 in the Appendix). Electricity generation is managed both by PLN and private business entities, i.e. *independent power producers (IPPs)*.

The dependence on fossil fuels is also a *supply chain* issue for WNT given its geography, which consists of small and scattered islands, as well as larger islands such as Sumbawa that are elongated and not well connected. Diesel is considered easy to transport to these locations, however generating power from it can be expensive and unreliable. The dominance of diesel generation has implications for the cost of electricity generation (BPP) in WNT, which tends to be expensive in the range of Rp 1,700–1,800 per kWh, or around 67–80% more expensive than the average national BPP for the Lombok and Tambora systems (see Figure A1 in the

[14] PT PLN (Persero), 2021. General Plan for Electricity Supply 2021-2030, accessed through https://web.pln.co.id/statics/uploads/2021/10/ruptl-2021-2030.pdf

Appendix). In addition, both coal and gas need to be imported from quite far outside WNT (for example, Kalimantan and Sumatra). For gas in particular, limited regasification and pipeline infrastructure is another challenge.

Electricity grid system

At the distribution level, the reliability of the electricity network system in WNT varies greatly between large cities, rural areas and remote islands. In general, the existing electricity distribution network in WNT still relies on the 20 kV Medium Voltage Network (MVC) which generally uses open air lines and is quite long, resulting in high voltage drop rates. These lines are also prone to damage from trees, resulting in sub-par service. While small islands have power plants connected through the 20 kV network, some are directly connected to the 220 V low voltage network. Further details are available in the Appendix (see Figure A2 and A3).

Electricity in rural, remote, and island areas

Electricity access in rural and remote areas is generally assessed by the electrification ratio and the percentage of electrified villages. With high ratios for both—an electrification ratio of 99.98% and an electrified village ratio of 100%—electricity access is not a pressing concern in WNT, however ensuring reliable and adequate supply remains a challenge. The government aims to reach an electrification ratio of 100%. **Table 1.4** shows data on WNT's electrification ratio as of the second half of 2022.

1.2.1.2 Energy consumption

Transportation sector

The transportation sector in WNT consists of 4-wheeled vehicles (cars, freight trucks, and buses) and 2-wheeled vehicles (see Figure A4 in the Appendix). Most 4-wheelers operate in and around Mataram City[15], implying that activities in the capital city dominate peoples' activity in WNT in 2023. There were 209,000 4-wheelers in WNT in 2021 and 1.96 million motorcycles.

The transportation sector has the largest energy demand in WNT—42% of the total (Figure 2). Of the total transportation energy demand, 89% is for land transportation, followed by 8% for water transportation, and 3% for air transportation. In 2019, energy demand in the transportation sector reached around 3.1 million barrels of oil equivalent (SBM) in 2019. Gasoline is the most consumed fuel with 2.1 million SBM, followed by diesel with 923,000 SBM and heavy fuel oil with 87,000 SBM. Demand continues to grow with greater vehicle ownership.

[15] http://rc.korlantas.polri.go.id:8900/eri2017/laprekappolres.php?kdpolda=21&poldanya=NUSA%20TENGGARA%20BARAT

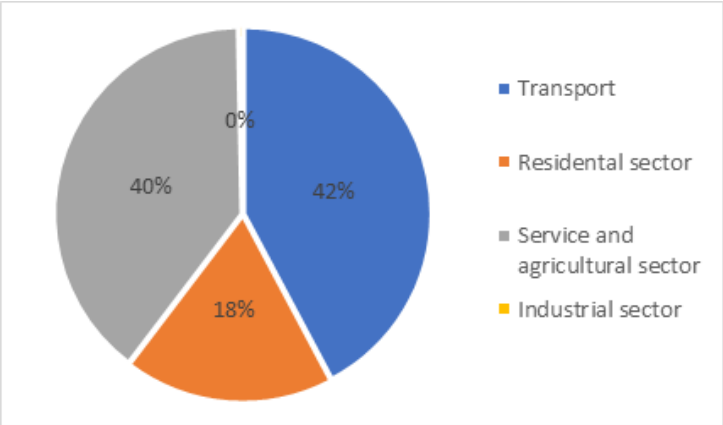


Figure 2: WNT Energy Consumption in 2019 by sector

Household sector

The household or residential sector is the largest consumer of electricity in West Nusa Tenggara, accounting for 65% of the total 2,149 GWh consumed in 2020[16], with a total of 1,509,537 household customers. Based on the 2021–2030 RUPTL, electricity sales in WNT have continued to increase with the addition of electricity customers with an average growth of 11% per year since 2011. This shows a strong electrification effort throughout WNT and positive economic growth. Further growth in electricity use in households is expected due to an increase in the use of air conditioners, electric transport, and electric stoves.

Various energy policies have been adopted by the government to target energy use in the household sector, including setting minimum energy performance standards (MEPS) on a number of household electrical appliances. The MEMR (2018) stated that the potential for energy savings in the household sector is estimated at 10-35%. Further data on appliance ownership by Indonesian households is available in Table A4 of the Appendix.

The government has also promoted the use of rooftop solar in the household sector. The current policies applicable to the household sector are shown in Table 2.

[16] PLN, 2021

Table 2: Current energy policies in the household sector

Regulation	Content
Government Regulation No. 79 of 2014	One of the national targets for the provision and utilization of primary and final energy is the achievement of electricity utilization per capita in 2025 of 2,500 kWh/capita and in 2050 of 7,000 kWh/capita.
Government Regulation No. 33 of 2023	Households are encouraged to utilize energy-efficient appliances, and also, the community is expected to play a role in energy conservation efforts by adopting energy-saving technologies, practicing energy conservation, using public transportation, and enhancing awareness of energy efficiency in both workplaces and households.
Minister of Energy and Mineral Resources Regulation No. 14 of 2021	Minimum Energy Performance Standard (MEPS) for household electrical appliances: *fluorescent* lamps, air conditioners, fans, refrigerators, rice cookers, and televisions
National Movement for One Million Solar Roofs (GNSSA)[17]	Declaration by Ministry of Energy and Mineral Resources, Ministry of Industry, BPPT, METI, various solar consortiums and associations, etc. One of the objectives is to encourage the growth of the solar industry in Indonesia and accelerate the development of rooftop solar power plants.

Industrial sector

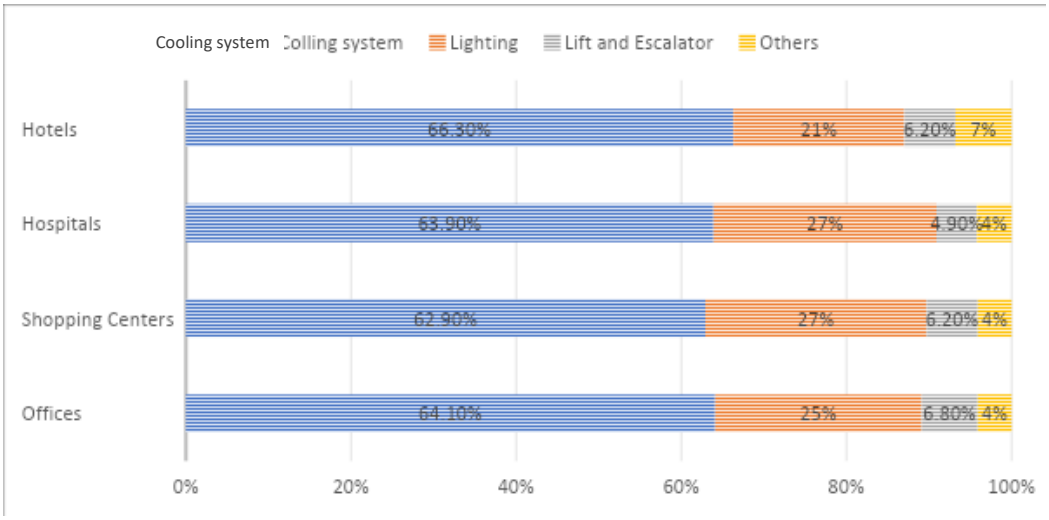
The industrial sector has considerable potential for energy savings according to the MEMR (2020), ranging from 5–26% . In WNT, the industrial sector is dominated by medium and small industries. Electricity consumption from this sector only amounted to 154 GWh in 2020, or only 7% of the total electricity consumption in WNT.[18] In 2023, the WNT government encouraged industrialization programs with a downstream strategy to form a local industrial ecosystem. Thus, industrialization will increase added value and trigger economic growth, leading to more energy (and electricity) use. The WNT government's priority industrial sectors include food, upstream agro-industry, machinery industry, transportation equipment and renewable energy, mining, chemical industry, pharmaceuticals, cosmetics and medical devices sectors.

[17] https://ebtke.esdm.go.id/post/2020/09/28/2643/harga.makin.kompetitif.pemerintah.optimis.wujudkan.satu.juta.surya.atap
[18] PLN, 2021.

Although energy consumption in the industrial sector in WNT is not too large at present, with further growth it is bound to grow, making energy management efforts critical to WNT's energy transition and goals.

Building/commercial sector

The commercial sector and government buildings are the second largest consumers of electricity in West Nusa Tenggara, accounting for 21% of total electricity consumption in 2020.[19] Based on a study from MEMR and BPPT (2020) on several Indonesian cities, the largest energy consumption comes from the use of air conditioning, with an average portion of over 60% (see Figure 3).



Source: ESDM and BPPT, 2020

Figure 3: Typology of energy consumption in the building/commercial sector in Indonesia

1.2.2 Energy sector policy and regulation

Indonesia already has a fairly progressive renewable energy development policy, as evidenced by the availability of regulatory tools from the central to the local government level. In addition, there are also various supporting policies in the building, transportation, industrial, and household sectors.

1.2.2.1 National-level policies and regulations

[19] PLN, 2021

There are two primary laws governing the energy sector in Indonesia: Law on Energy No. 30/2007, and Law on Electricity No. 30/2009. The Law on Energy No. 30/2007 regulates the provision of energy in a sustainable manner, requiring the government at all levels to utilize renewable energy resources where applicable. This law set the foundation for the formulation of the National Energy Policy (KEN) Government Regulation No. 79/2014, which set the target of achieving 23% renewable energy in the national energy mix by 2025 and 31% by 2030. This was followed by the implementation of the National Energy Plan (RUEN) Presidential Regulation No. 22/2017 which created a National Energy Management Plan to meet these targets. It also mandates regional governments to create their respective Regional Energy Plans (RUED-P) that feed into the Regional Medium-Term Development Plans (RPJMD) and the National Medium-Term Development Plan (RPJMN).

The Law on Electricity No. 30/2009 regulates electricity supply in Indonesia. It regulates the application of regional tariffs that apply to certain business areas and controls the use of electric power networks for telecommunications, multimedia, and informatics. This law also provides the basis for the National Electricity Plan (RUKN) MEMR Regulation that informs PLN's Electricity Supply Business Plan (RUPTL) MEMR Regulation and the Regional Electricity Plan (RUKD) Governor Regulation. The RUEN also informs the formulation of the RUKN. Relationships between regulations in the energy planning framework at the national level to the regional level is presented in Figure 4.

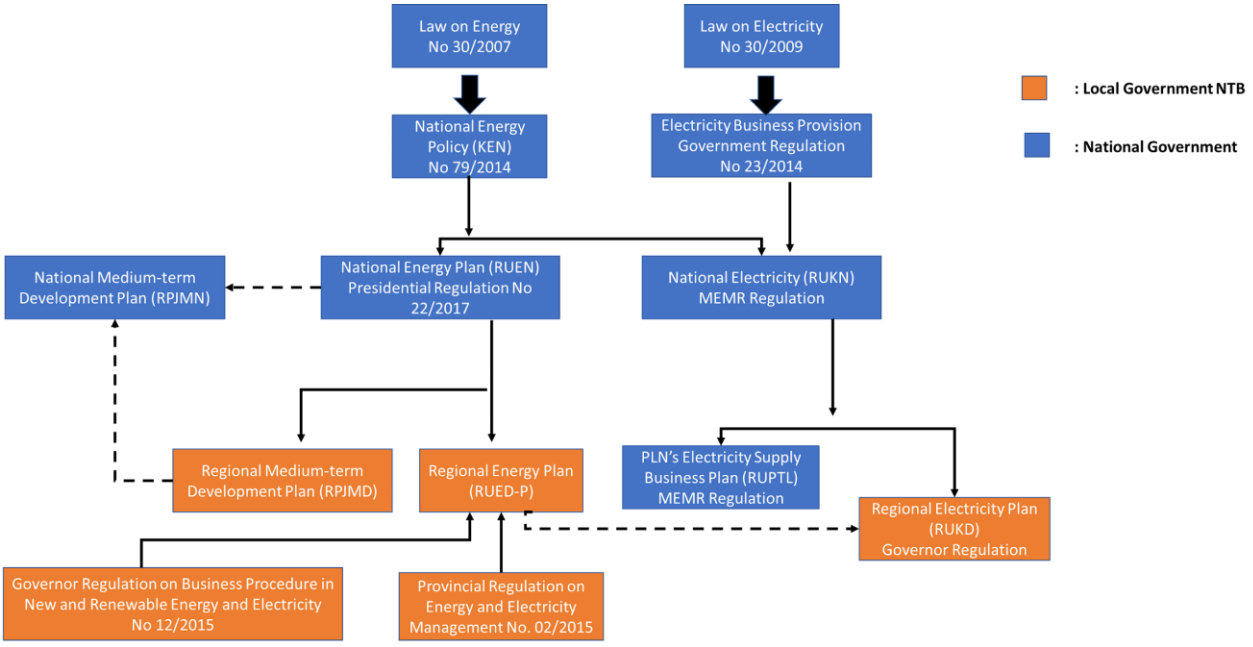


Figure 4: Energy policy framework in Indonesia

Table 3 below further lists and describes relevant general and sectoral policies associated with the energy sector in Indonesia:

Table 3: Indonesia's existing energy sector policy and regulatory framework

Ministry/Agency	Regulation name	Brief description
Central Government	Law No. 30/2007 on Energy	• Regulates the provision and utilization of energy in a sustainable manner. • Requires the central government and local governments to utilize new renewable energy in accordance with their authority.
Central Government	Law No. 30/2009 on Electricity	• Regulates the production and distribution of electricity. • Regulates the application of regional tariffs that are limited to a certain business area. • Regulates the utilization of electric power networks for telecommunication, multimedia, and informatics purposes.
Central Government	Law No. 1/2022 on Financial Relations between the Central and Local Governments	This covers the exemption of renewable energy-based vehicles from taxes and transfer fees.
Central Government	Government Regulation No. 33/2023 on Energy Conservation	This covers the implementation of energy conservation, incentives and disincentives, data and

Ministry/Agency	Regulation name	Brief description
		information, guidance and supervision on energy conservation practices.
Central Government	Government Regulation No. 79/2014 on National Energy Policy	This sets a target of achieving 23% renewable energy in the national energy mix by 2025 and 31% by 2030.
Central Government	Government Regulation No. 14/2015 on the National Industrial Development Master Plan (RIPIN) 2015-2035	This encourages the use of new and renewable energy in industrial processes.
Central Government	Government Regulation No. 29/2018 on Industrial Empowerment	The implementation of Green Industry Standards can gradually be applied on a mandatory basis covering raw materials, auxiliary materials, energy, production processes, products, business management, and waste management.
Central Government	Government Regulation No. 16/2021 on Building	This covers the implementation of the obligation to meet green building criteria for both new and existing buildings.
Central Government	Government Regulation No. 74/2021 on Motor Vehicles subject to Luxury Goods Sales Tax	This covers a 0% tax incentive on PPnBM (Luxury Goods Sales Tax) for electric vehicles.
President	Presidential Regulation No. 22/2017 on RUEN	This is a national-level energy management plan that is the

Ministry/Agency	Regulation name	Brief description
		elaboration and implementation plan of the National Energy Policy to achieve a renewable energy mix of 23% by 2025 and 30% by 2050.
President	Presidential Regulation No. 112/2022 on the Acceleration of Renewable Energy Development for Electricity Supply	This covers determining the price of electricity from various renewable energy sources, accelerating the operational termination of coal-fired power plants (PLTU) and prohibiting the construction of new coal-fired power plants.
Minister of Public Works and Housing (**"PUPR"**)	Ministerial Regulation (**"Permen"**) PUPR No. 02/2015 on Green Building	This covers green building principles; types of buildings that meet green building requirements; green building requirements; certification; incentives for green building implementation; and role of the community.
Minister of Environment (**"LH"**)	Permen LH No. 4/2009 concerning Thresholds for Exhaust Gas Emissions of New Type Motor Vehicles	This sets the maximum limit of polluting substances or materials that may be emitted directly from the exhaust pipes of new-type motor vehicles.
	Minister of Environment Regulation No. 20/2017 on Quality Standards for Exhaust Gas Emissions of	This sets the maximum limit of polluting substances or materials that may be emitted directly from the exhaust pipe

Ministry/Agency	Regulation name	Brief description
	New Type Motor Vehicles Category M, N, and O	of motorized vehicles with four or more wheels.
Minister of Energy and Mineral Resources	Minister of Energy and Mineral Resources Regulation No. 50/2017 and its amendments concerning Utilization of Renewable Energy Sources for Electricity Supply	This regulates the determination of tariffs and mechanisms for the procurement of renewable power plants.
	Minister of Energy and Mineral Resources Regulation No. 13/2020 concerning the Provision of Electric Charging Infrastructure for Battery-based Electric Motorized Vehicles	This regulates the electricity charging infrastructure for battery-based electric motor vehicles, including battery recharging and exchange facilities, as well as private electricity installations and SPKLUs.
	Minister of Energy and Mineral Resources Regulation No. 14/2021 concerning the Application of Minimum Energy Performance Standards for Energy Utilizing Equipment	This covers the implementation of *Minimum Energy Performance Standard* (MEPS) for household electrical appliances including fluorescent lamps, and air conditioners.
Minister of Transportation	Minister of Transportation Regulation No. 65/2020 on the Conversion of Motorcycles with Fuel Motor Drives to Battery-based Electric Motors	This regulates the organization of conversion of conventional fuel motors to electric motors, including conversion workshops, conversion certification, etc.
President	Presidential Regulation No. 112/2022 on Accelerating the Development of	This regulates the preparation of a business plan for the supply of electricity (RUPTL),

Ministry/Agency	Regulation name	Brief description
	Renewable Energy for Electricity Supply	the preparation of a roadmap to accelerate the end of the PLTU operational period, the implementation of power purchases, and government support in efforts to accelerate the development of renewable energy. This regulation generally replaces the Minister of Energy and Mineral Resources Regulation No. 50/2017.

1.2.2.2 Regional level policies and regulations

As mentioned above, provincial governments are required to translate the RUEN into RUED with respect to their local contexts. The RUED sets the province's energy mix target, including renewable energy, by 2025 and 2050. Cities and districts are expected to implement these provisions.

In 2019, West Nusa Tenggara established its RUED through Perda No. 3/2019. It contains the direction of energy management in the province, including the regional vision for the energy sector, energy availability to meet regional needs, and energy development priorities. Article 7 of the RUED states that it can be used as a reference in formulating the Regional Development Plan, Regional Electricity Plan, and Regional Budget. It can also be used as a guideline by local governments in formulating their Strategic Plans and by communities that wish to participate in energy developments. Article 13 of RUED states that the provincial government, through the Governor, can enter into cooperation with other provinces, third parties, and international organizations in the implementation of the RUED.

Considering the above, the RUED offers a clear entry point for WNT's 100% RE Roadmap, particularly in enhancing and advancing the existing renewable energy targets in both the RUED and RUEN. West Nusa Tenggara's provincial government has also enacted additional regulations that support the implementation of the RUED such as the Energy and Electricity

Management, Procedures for Business Licensing in the Field of New and Renewable Energy and Electricity, and the Regional Electricity General Plan.

1.2.3 Renewable energy potential in WNT

The WNT region has a high potential for renewable energy, with sources such as solar, wind, hydro, geothermal, waste and biomass available for further development. Estimates of the renewable energy potential in WNT were developed to feed into the 100% RE scenarios modelled by Fraunhofer ISE. The summary of the potential, which serves as the foundation for the 100% energy modeling, is outlined below in Table 4:

Table 4: Potential of various renewable energy sources in WNT

RE Potentials (**MW**)	**Lombok**	**Sumbawa**	**RE potentials**	**Lombok**	**Sumbawa**
Installable solar PV	18,274	16,258	Geothermal (MW)	70	75
Installable wind	2,793	2,485	Municipal waste (GWh)	3,126	1,355
Installable rooftop solar	4,224	1,591	Corn waste biogas (GWh)	501	2210
Run-of-river hydropower	8.91	4.82	Rice husk and straw biogas (GWh)	4381	31064
Reservoir hydropower	79.25	119.5	Biogas from Kelapa (GWh)	58	12

Source: ICLEI Local Governments for Sustainability (2022). 100% Renewables - Roadmap for Cities and Regions : Energy System Modelling Result for West Nusa Tenggara, Indonesia

Some sources raise certain concerns. For example, the geothermal potential in WNT may not be substantial, but it appears that the government is making efforts to maximize its utilization to support the expansion of renewable energy in the Lombok and Tambora (Sumbawa) grids. Theoretically, various types of biomass energy sources exist in West Nusa Tenggara. However, only the biomass potentials of agricultural residues and livestock residues were considered in this report. Forest cover is present in both Lombok and Sumbawa islands. However, since

wood is also used for other purposes, it was not considered as a fuel option in this report. Agriculture is an important sector in the province and the major crops produced include corn, coconut, and rice. Therefore, only agricultural residues were considered for estimating biogas potential. Lastly, livestock manure is also widely available and can be used for biogas production.

Based on the existing conditions of the regional energy sector, there are at least four RE development opportunities which are further described in the subsections that follow:

- Optimization of local RE potential to replace PLTD and PLTU generation. In this context, geothermal has great potential as *baseload power* in WNT to replace PLTU.
- Optimization of local RE potential such as solar energy for direct use including rooftop solar power plants in government buildings and public buildings, public street lighting, housing,etc.
- Transformation of the transportation sector with the development of mass transportation such as *Bus Rapid Transit* (BRT) and *railways* for tourist areas, development of *electric* vehicles starting from official vehicles and tourist area transportation, as well as hydrogen fuel based vehicles such as buses.
- Reduction in dependence on LPG and kerosene for cooking, with government programs for the conversion of LPG stoves to electric and induction stoves, and/or agricultural residue-based biomethane gas cylinder programs to replace LPG.

1.2.4 Strengths, weaknesses, opportunities, and threats

A SWOT analysis aims to identify both internal and external factors that can support the implementation of a certain project. The 100% RE project team led a series of workshops and meetings in support of this goal. Table 5 below presents the main strengths, weaknesses, opportunities, and threats (SWOT) identified during these sessions.

Table 5: SWOT Analysis of 100% RE in WNT

Strengths: • Renewable energy resources, particularly solar, wind, geothermal, water and biomass • Strong commitment from both the central and provincial government • Commitment from the mining industry in Indonesia to contribute to the energy transition • Abundance of natural resources available • Strong cooperation between institutions and stakeholders • Good collaboration and coordination between district areas • Availability of local knowledge and expertise in energy efficiency and solar PV energy • Strategic potential for tourism development and entrepreneurial initiatives • Robust regulations for regional and institutional general energy plans	Opportunities: • Creation of new job opportunities related to RE and EE at the local level, with corresponding skills development • Availability of grants and grant assistance for renewable energy infrastructure development and energy efficiency from foreign countries/institutions • Improvement and development of the regional economy • Technical support from ICLEI and collaboration with other parties • Enhancement of local capacity related to the energy transition • Access to national and international financing options • Further integration of renewable energy into urban planning • Harmonization of regional plans, regional roadmaps and national plans
Weaknesses: • Lack of responsible energy consumption habits and culture • Limited funding sources due to low regional fiscal capacity at the local level • Shortage of qualified human resources with technical expertise to access new renewable energy development funds • Inadequate support for facilities and infrastructure required for RE development • Limited involvement of provincial strategic actors in the energy transition • Insufficient technology and innovation to optimize regional renewable energy potential • Limited authority of the local government in the energy sector • Absence of integration of energy efficiency applications with urban planning • Lack of harmonization in planning documents among the National Government, Regional Government, and National Electricity Center (PLN)	Threats: · • Presence of fossil fuel subsidies and low oil prices • Discontinuation of RE and EE promotion policies and projects at the national level • Interruption or changes in energy transition policies or projects due to leadership changes at either national or regional level • Long dry seasons followed by rainy seasons with high rainfall can affect the electricity production from solar PV and hydro power plants • Floods potentially damage renewable energy infrastructures • WNT is vulnerable to earthquakes or tsunamis that potentially damage renewable energy installations such as wind turbines, solar farms, etc.

CHAPTER 2: NAVIGATING THE COURSE FOR 100% RENEWABLE ENERGY IN WNT

2.1 Roadmap principles, vision, and mission

This 100% Renewables Roadmap was developed to support West Nusa Tenggara's move towards 100% RE by 2050. In the preparation of this roadmap, the principles of energy efficiency and conservation were put forward to improve energy demand management in the household, industrial, building and transportation sectors.

The roadmap was developed by considering the proposals of every stakeholder in a proactive bottom-up, participatory, and collaborative manner based on the vision and mission of the Governor of WNT.

The formulation of the vision and mission to realize 100% RE in WNT in 2050 used a participatory approach by involving stakeholders from various sectors. The formulation of the vision also refers to the results of the energy modeling conducted by Fraunhofer ISE in 2021, which states that West Nusa Tenggara has the potential to realize the target of 100% renewable energy by 2050 in all sectors.

The 100% RE Roadmap for WNT was prepared for the period 2025–2050, using short-term targets every five years. The medium-term target in this roadmap is the phase out of coal-fired power plants and the achievement of 50% of the energy mix in WNT in 2035.

2.1.1 Vision

Vision 2050
Realizing the vision of a WNT Province which has energy security and independence sourced 100% from local, renewable, sustainable, and low-carbon energy resources, to ensure universal and reliable energy access for all people.
Intermediate milestone(s)/interim targets
• Achieving an electrification ratio based on PLN electricity connections for households in WNT of 100% by 2025 (for urban areas) and no later than 2030 (for remote areas and outer islands) with reliable quality, available 24 hours/day, and has a minimal level of disruption or interruption of availability (low SAIDI and SAIFI). • 50% of the renewable energy mix in WNT's electricity system by 2035 is based on solar, wind, geothermal, biomass *co-firing,* and hydro.

2.1.2 Mission

There are several missions to realize the vision of the 100% RE Roadmap in WNT:

- Reduce WNT's dependence on imported energy resources from outside the region and optimizing the use of locally available, renewable, sustainable, and low-carbon energy resources.
- Accelerate the adoption, transfer, and implementation of *advanced* technologies for renewable energy, including electric vehicles, storage systems, etc., in a structured and sustainable manner.
- Provide and ensureg universal, reliable and low-carbon energy access for all people in WNT to support economic improvement and competitiveness.

2.2 Pathways to 100% renewables by 2050

2.2.1 Overall process

Once the political commitment was secured and teams were identified to proceed with the planning of the roadmap, the next phases of the roadmap development process involved data collection related to energy and the socioeconomic situation in order to inform the energy systems modelling. The process of roadmap development is outlined in Figure 5 below:

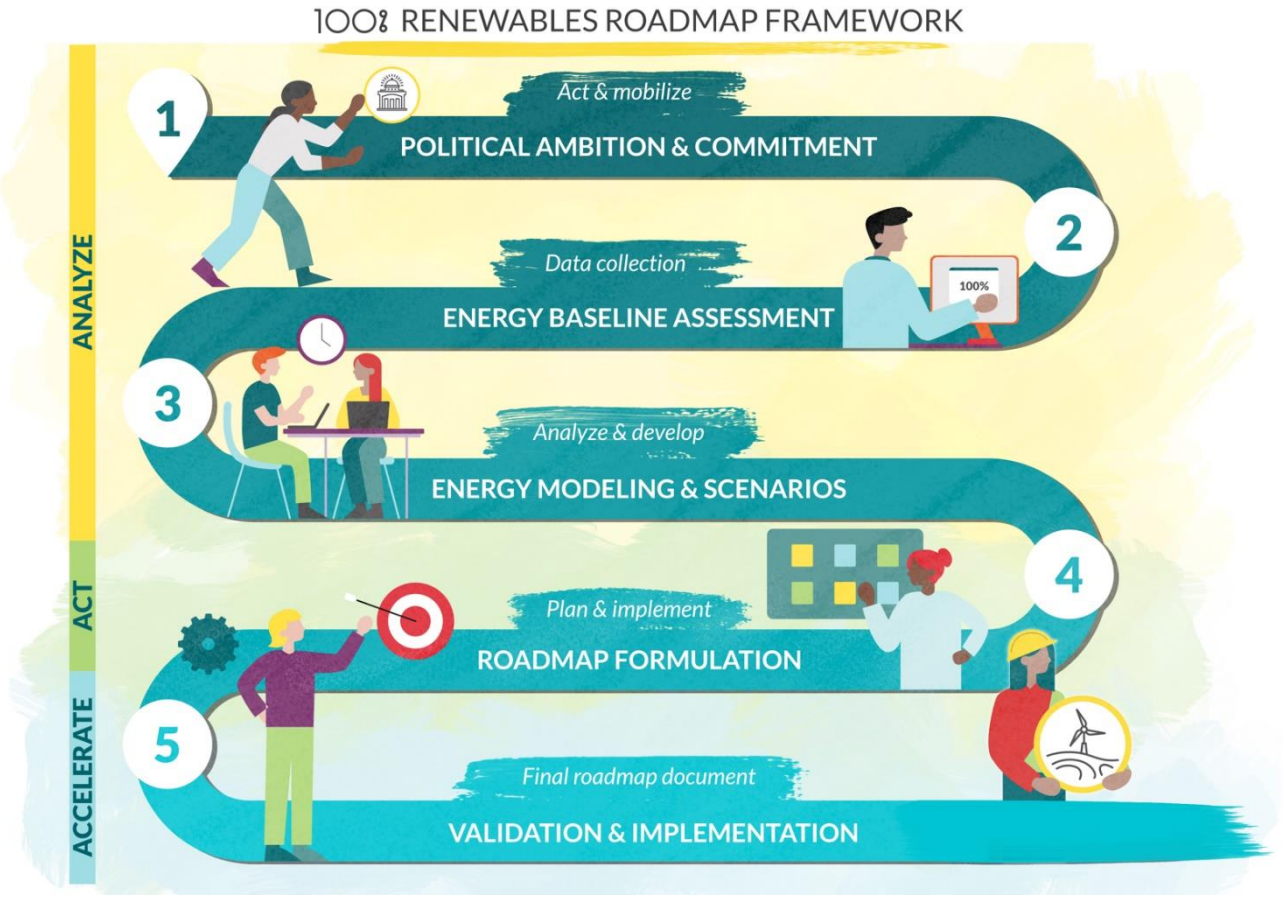


Figure 5: The 100% Renewables Cities and Regions Roadmap Framework

2.2.2 Energy systems modeling

To develop the 100% RE scenario in WNT, Fraunhofer ISE modeled its energy system using the software KomMod. All relevant energy indicators (demand, supply, population, economy, etc.) were projected to 2050 under different demand scenarios. Renewable energy potential was calculated based on GIS data, statistical data, and secondary studies in WNT as well as in the rest of Indonesia where no WNT-specific data existed. All input data assessments were conducted for both Lombok and Sumbawa islands separately.

Ten different scenarios were calculated by varying three different features for the 100% RE scenarios: biomass and biogas fuel price, energy demand, and a coupling of the energy systems of the two islands versus a separated modeling for both. In addition, a business-as-usual (BAU) scenario allowed for the comparison of costs and carbon dioxide emissions. Based on the discussion with the local government unit, the main scenario chosen was ***coupled energy system, mean energy demand, low fuel price***. This scenario uses low fuel prices,

medium energy demand (3.49 times the base year demand) and considered a coupled energy system between Lombok Island and Sumbawa Island.

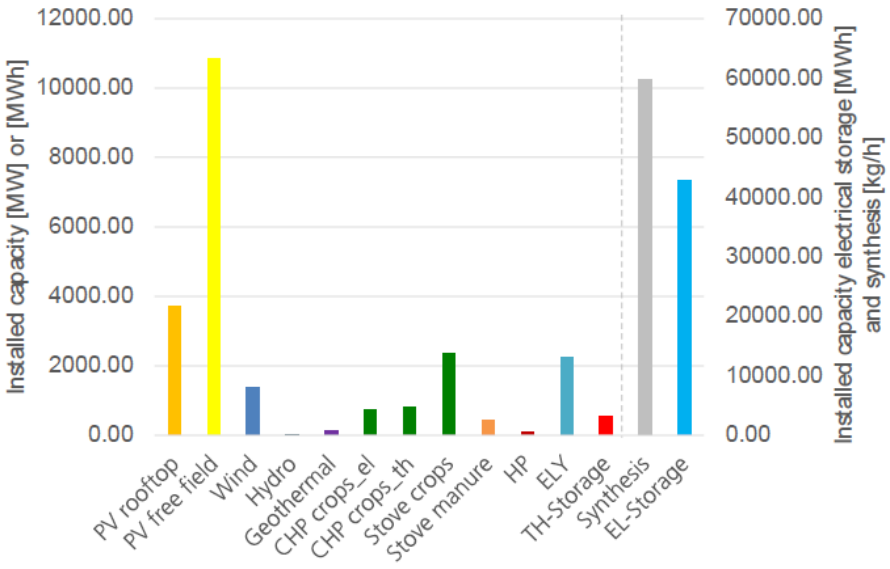


Figure 6: Installed capacities of various RE technologies in the lead scenario

The total electricity demand to be covered in this scenario is **18,507 GWh**. This electricity demand consists of: (i) electricity demand for cooling, (ii) demand for EVs, hydrogen and synthetic fuels, (iii) electric cooking and (iv) electrification of heating and fuel. The largest electricity supplier is photovoltaic with 69%; of that, free field photovoltaic has the larger share with 51%. The second-largest supplier is combined heat and power plants (CHPs) using biogas from crops with 18%, while wind power plants cover 10%. Only minor electricity amounts are supplied by geothermal and hydropower plants, although their potential is fully used.[20]

Heating demand is split across (i) industrial and commercial use, including for CO_2 sequestration for the process of methanization and (ii) cooking demand. For the former, this totals **9,755 GWh**, and is largely met with CHPs using biogas, waste heat from electrolysis, and heat pumps. For the latter, the total demand of **5,087 GWh** and is met with biogas predominantly from crops, with some share of manure. Electric cooking is not feasible in a situation with low fuel prices, as per the modeling results.

[20] ICLEI Local Governments for Sustainability (2022). 100% Renewables - Roadmap for Cities and Regions: Energy System Modelling Result for West Nusa Tenggara, Indonesia link : https://renewablesroadmap.iclei.org/resource/west-nusa-tenggara-energy-modelling-report/

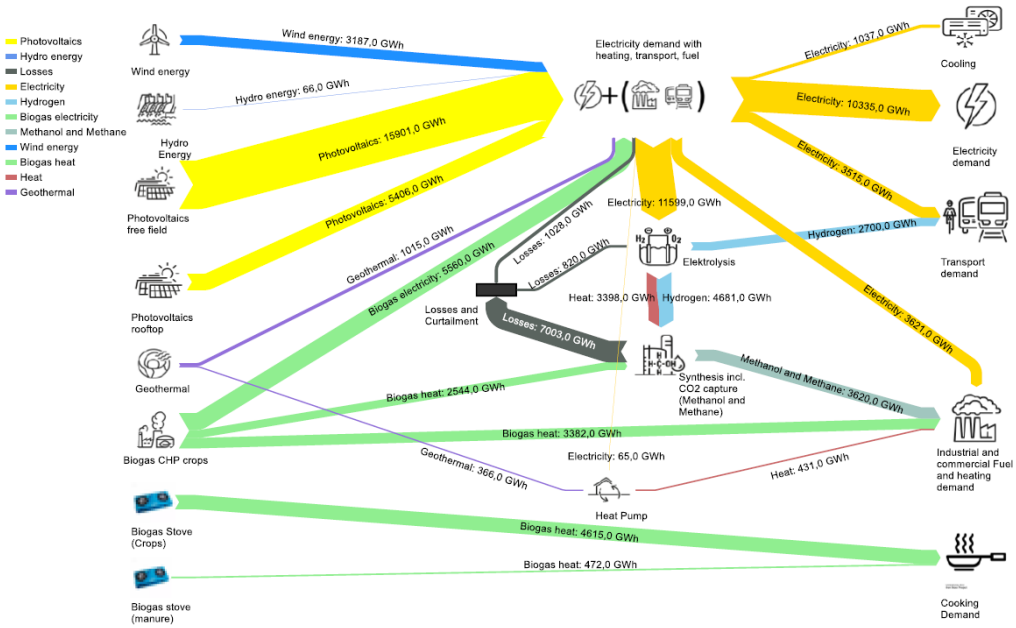


Figure 7: Sankey diagram showing 100% renewable energy use in West Nusa Tenggara in 2050

The merging of the Lombok and Sumbawa Island energy systems is beneficial for several reasons:

- economic benefits;
- improved *energy supply security;* and
- a more even distribution of wind and solar PV power generation.

In either case, 100% RE is economically cheaper than the BAU scenario, where most of the energy demand is still covered by fossil fuels. Modeling results show that the BAU scenario is 32% more expensive and has 4.5 times higher carbon dioxide emissions (from fuel combustion), for the same energy demand.

Energy efficiency should be improved across all sectors to *decouple* energy demand and economic growth in the long run. Government programs and regulation can encourage energy efficiency improvements in the household, commercial, and industrial sectors. In the transportation sector, promotion and expansion of other public and active modes of transportation as well as EV uptake can help.

Considering that energy demand will grow in the future, and that the currently installed fossil power plants will eventually reach the end of their useful life, new renewable energy-based power plants should be installed in the following years. In the early years, this would be PV and biogas CHPs; later wind and solar PV must be installed until 100% RE is met by 2050.

2.2.3 Serious game methodology

Stakeholder engagement has been a consistent part of the roadmap development process. As a specific participatory tool for gathering stakeholders' input, ICLEI designed the **Sustainable Energy Transition Strategy (SETS)** 'serious game' with the aim of bringing together stakeholders to address the various challenges involved in the energy transition.[21]

The purpose of the workshop was to discuss challenges identified by each stakeholder in an interactive manner. Through the game, stakeholders stepped into other people's shoes, differing from their day-to-day role. This opportunity allowed them to express out-of-the box opinions and think from different perspectives. Various stakeholders attended the meeting on July 25th, 2023, including WNT officials from various agencies such as the Energy Agency, Industry, Public Works and Housing, Transportation Agency, Agriculture and Plantations Department, Bappeda and Statistics Agency, etc. Representatives from various sectors,

[21] For further information on the game, please see here.

including PT PLN, private industry, BUMD, academics (from universities and vocational schools) and NGOs attended the forum and actively contributed their insights.

Figure 8: Key stakeholders participate in the serious game (SETS) activity on July 25, 2023 in WNT Province

The workshop started by assigning roles to the participants—there were 14 roles representing various national, regional and municipal stakeholders and actors in the energy system. The purpose of the discussion was to formulate a collective strategy to achieve the 100% renewable energy target by 2050 in all sectors. Individual approaches were developed first, depending on the stakeholder's unique interests, followed by a round of consensus-seeking for the scenario and technologies involved.

The discussion began by identifying renewable sources that could be utilized and marking them on a map of WNT Province. Referring to the WNT energy demand in 2050 and available energy resources, the participants opened discussions by deciding on technologies to fulfill WNT's energy demand. Discussions were held to agree on each technology in each sector among participants and determine where the funding would come from and which actors were critical to this effort.

Figure 9: Participants were assigned certain roles in the serious game (SETS) activity

Some insights and strategies that surfaced during the workshop that were incorporated into the roadmap and associated recommendations were as follows:

- Mobilize rural communities to adopt renewable energy sources by utilizing biogas from livestock and agricultural waste. This can reduce energy costs of electricity and cooking.
- Village funds can be used for energy purposes and to ensure equitable access to electricity services through discounts and subsidies.
- Conduct public awareness campaigns about environmental issues, clean energy, and the potential of renewable energy resources in the province. Private sector, through their corporate social responsibility arms, can be tapped for this, especially to reach younger sections of the population.
- City residents need to be trained on renewable energy, waste separation, various technologies, and their impacts on the environment.
- Sumbawa Island of WNT has dry, unproductive land. Training communities in energy cultivation is needed so they can help provide feedstock for the island's co-firing power plant.
- In terms of industry, the main factor for profit is stability, and the government must be able to ensure it through consistent and unchanging policies to ensure a sustainable energy sector. Likewise, the government must also ensure the sustainability of foreign players in the energy sector.
- Prioritize the employment of locals in renewable energy projects in WNT through strategies such as knowledge transfer and capacity building.

In the end, the majority of stakeholders recognized the need for the energy transition to encompass various technologies such as electrolysis, electric vehicles, and the extensive integration of renewable energy into the PT PLN grids. Most stakeholders actively support renewable energy and acknowledge that, given limited national and regional capabilities, alternative funding is essential. Private funding often ensures efficient and expedited project implementation, fostering innovation in achieving goals and ensuring sustainability. Nevertheless, a share of government funding is still necessary to enhance ownership of these initiatives.

CHAPTER 3: LOCAL STRATEGIES AND IMPLEMENTATION MECHANISMS

The roadmaps produced as part of the 100% Renewables Cities and Regions Roadmap project were developed according to a multi-step and inclusive methodology that sought input from a range of stakeholders including experts, local government officials, government agencies, civil society, private sector, and academics. As per the methodology shown in Figure 6, participants began by identifying key priorities through the 100% Renewables building blocks. They followed this by a serious game exercise that allows for innovative solutions to pressing issues facing the local sustainable energy transition, and this exercise can be revisited for validation as the roadmap is further developed. Participants then identified local strategies for each priority sector i.e. pillars, as well as corresponding actions and implementation mechanisms, which are laid out in terms of their justification, responsibility, supporting policies and technologies, potential financing sources, as well as any associated risks and their mitigation.

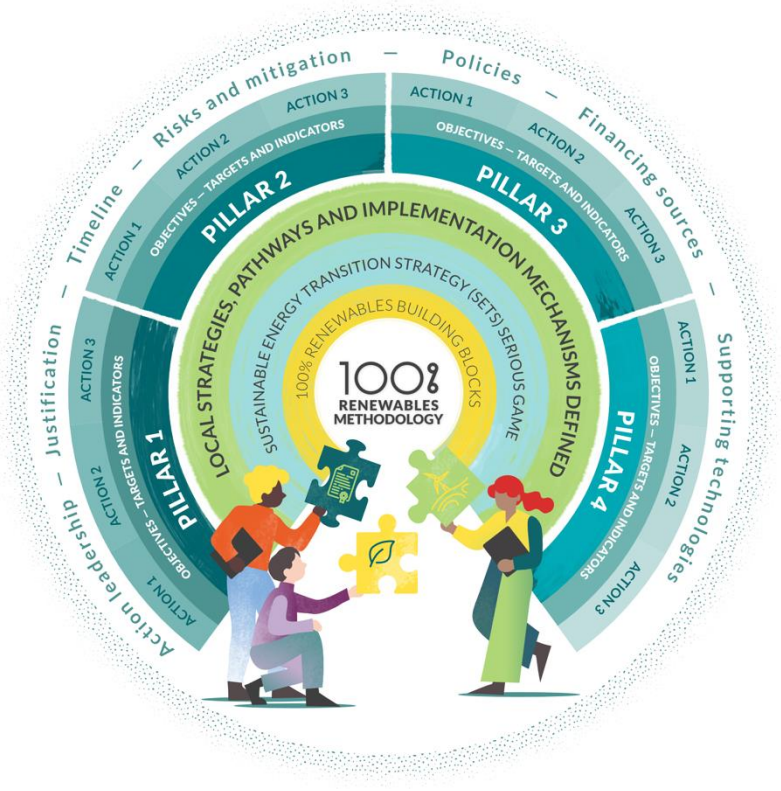


Figure 10: The 100% Renewables methodology

In West Nusa Tenggara's case, the strategic action framework (Figure 7) of the roadmap is guided by the overall **vision**, **mission**, and **interim targets**, determined through iterative

participatory processes with the concerned stakeholders and informed empirically by the modeling exercises. Similarly, the action pillars, and the corresponding programs, projects, and activities (PAPs) were formulated through consultations with the representatives of important stakeholder groups in the province.

Strategic actions are designed to maximize the RE potential of the province in line with the vision and mission, while making them inclusive measures where citizens also have a role to play. These are guided by the action pillars. Each of the pillars are described in the sections below, detailing the corresponding objectives, indicators, actions and other supporting requirements.

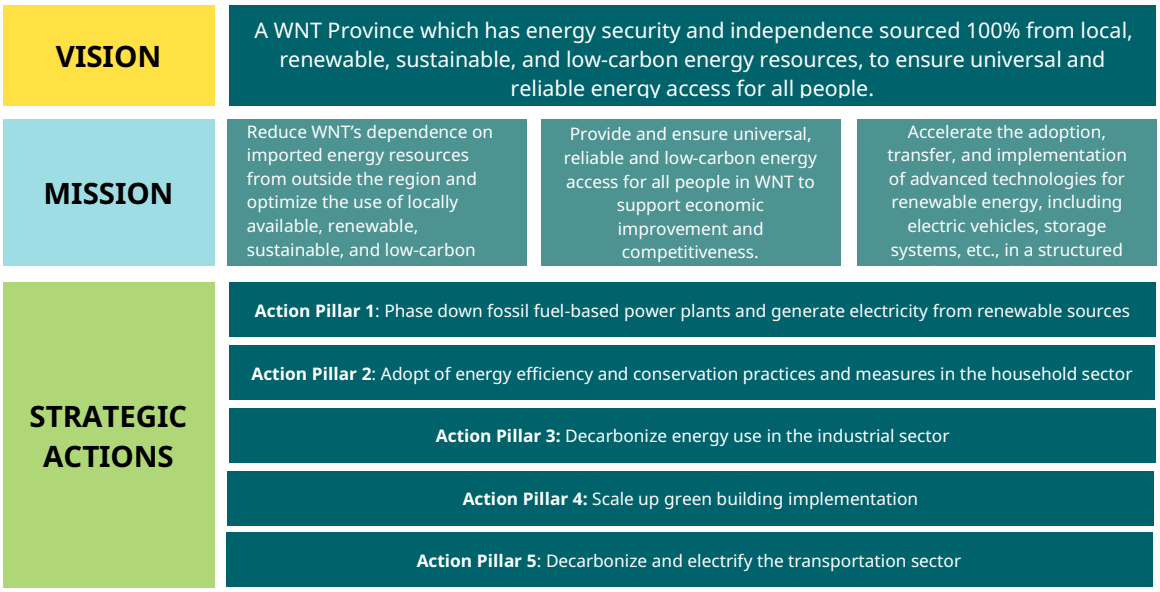


Figure 11: Strategic action framework of the WNT's 100% Renewable Energy Roadmap

The action pillars and their corresponding actions will now be laid out in the following sections of the roadmap. They lay out a vision for the transformation of West Nusa Tenggara's energy system from one predominantly based on fossil fuels, to one that relies on renewable energy sources and technologies.

3.1 Action Pillar 1: Phasing down fossil fuel-based power plants and generate electricity from renewable sources

Objective	Realizing the transformation and decarbonization of the electricity sector through the development of renewable energy
Outcome	Electrification is one of the major pillars for decarbonizing our energy systems. However, it must be ensured that this electricity is coming from renewable energy sources to make this possible. The main intention here is to move away from fossil fuel-based generation and adopt a wide range of renewable energy technologies, along with energy efficiency, to meet the province's energy needs.
Alignment with Sustainable Development Goals	
Action 1	Increase electrification ratio rate and household electricity connection
Action 2	Retire coal-fired power plants and implement biomass co-firing
Action 3	Retire diesel power plants by 2030
Action 4	Develop centralized solar PV and distributed rooftop solar PV
Action 5	Develop and directly utilize geothermal power plants
Action 6	Develop wind farms
Action 7	Develop hydropower (including mini hydro/MHP)
Action 8	Develop integrated municipal waste-to-energy power plant facilities under PPPs

Success factors

3.1.1.1 Regulation

Create a favorable investment environment

A favorable investment environment facilitates the deployment of resources for the further development of renewable energy technologies. Financial incentives and regulatory support such as PPP frameworks, tax breaks, subsidies, and guarantees incentivize companies and help reduce investment risks. Reduced risk perceptions and strategic financial support can help attract investment.

- A *robust regulatory framework for public-private partnerships* (PPP) in the renewable energy sector can spur the development of such types of projects. This framework should provide clear guidelines and procedures for PPP-based RE projects, as well-designed projects are likely to make the partnership itself successful. The framework should also provide for project selection, procurement, contract management, transparent and accountable decision-making processes, and mechanisms for resolving disputes.

Establish electricity and energy markets

Governments can establish electricity and energy markets with tariff structures that are efficient and promote overall electricity system health. However, these are deep structural reforms that must balance affordability concerns with maintaining economic competitiveness. Alternatively, targeted subsidy programs can provide financial assistance to households that cannot afford the full cost of electricity connections or consumption, thereby ensuring inclusivity and reducing financial barriers.

- *Net metering* policies allow solar energy system owners to receive credit for excess electricity generated by their system and fed back into the grid. The availability and structure of net metering policies can have a significant impact on the economic viability of solar energy projects, particularly decentralized rooftop solar projects.
- The regulatory framework could provide attractive and predictable renewable energy tariffs that offer a sufficient return on investment. Such methods have been used successfully in the early stages of RE deployment; however, their necessity with falling RE costs needs to be investigated further. This can include *fixed tariffs, feed-in tariffs*, or other incentive mechanisms that provide a stable and predictable revenue stream. Reverse auctions can also be implemented to produce a productive tender process with the most reliable and economical tariff. For waste-to-energy projects, tipping fee payment schemes could be required.

Conduct a strategic study around retirement of fossil fuel plants

Existing fossil fuel plants are productive assets, thus retiring them before their end-of-life ideally requires supporting regulations and compensation or funding. A strategic study is needed, including technical, legal, and financial aspects, as well as the implementation of the procurement of replacement plants, depending on the context. An energy balance study is required to ensure the adequate supply against demand during the transition of fossil fuels to low-carbon fuels and early plant retirement.

Smooth the permitting process

Permitting and regulatory requirements can vary depending on the location and type of the RE project. This can include environmental and land-use regulations, building codes, and interconnection standards. Governments should conduct reviews in consultation with industry actors and citizens to identify blockages and smooth the permitting process, while minimizing negative impacts.

- The regulatory framework should include robust *environmental and social safeguards* to ensure that RE projects are developed in a sustainable and responsible manner. This can include requirements for environmental impact assessments, stakeholder engagement, and mitigation measures for potential environmental and social impacts.

3.1.1.2 Technology and research

Conduct local research

Local research is needed to develop and improve energy generation technologies so that they can operate in Indonesia's particular geography and climate. This can apply to different solar panel technologies and their suitability to local contexts, as well as energy storage technologies and appropriate sites. Finding innovative uses of existing fossil fuel assets can be investigated, depending on local needs. Developing of a local value chain for expertise, materials processing, and manufactured goods can also be investigated.

Promote innovative business models

Innovative business models such as pay-as-you-go (PAYG) schemes can be promoted, especially in rural areas, for electricity access. These can be supported with information and awareness campaigns for communities.

3.1.1.3 Governance

Prioritize rural electrification

Governments should establish policies that prioritize rural electrification as a national goal including provisions for off-grid solutions, mini-grids, and decentralized energy systems. In addition, a well-established and structured coordination between the local and central government is needed regarding the regulation of the electricity tariff subsidy mechanism in mini-grids. This has been regulated in MEMR Regulation No. 38/2016 but is not running optimally.

Mobilize funding and financial resources

Governance should include mechanisms to mobilize funding and financial resources for rural electrification. Public finance can be deployed strategically to reduce investment risks for electrification projects—allocating budgetary funds, securing development assistance, leveraging innovative business models and PPP. Financing mechanisms, such as green funds, bonds, loans, or grants, can also be established to support the transition.

Strengthen institutional coordination

Effective governance requires strong institutional coordination among government agencies, regulatory bodies, and relevant stakeholders. Creating bodies that can oversee progress for specific goals could facilitate implementation.

Promote active engagement and participation of stakeholders

Governance should promote active engagement and participation of stakeholders, including rural communities, local authorities, private sector entities, civil society organizations, and development partners along the decision-making process. It is necessary to involve the private sector such as when it comes to replacing fossil fuels with RE plants.

Strengthen local capabilities

Governance should focus on capacity building and technical assistance to strengthen local capabilities. This involves providing training and support to local technicians, community leaders, and entrepreneurs in areas such as system maintenance, operation, entrepreneurship, and management. Financial, managerial, and legal skills such as being able to manage and implement PPP-based projects should not be neglected.

Use robust monitoring and evaluation mechanisms

Effective governance requires robust monitoring and evaluation mechanisms to assess the progress, impact, and effectiveness of rural electrification programs. In the event of private involvement, clear guidelines must be issued for reporting requirements.

3.1.1.4 Infrastructure

Ensure smooth functioning of the grid

The smooth functioning of the grid and overall energy system is critical. Adequate studies, planning and digital technologies can assist in this.

- Accurate **forecasting** of renewable energy generation is critical for grid operators to balance supply and demand and ensure grid stability. Advanced forecasting techniques, such as machine learning algorithms and advanced weather forecasting models along with ground measurement techniques, can improve the accuracy of renewable energy forecasting and help to reduce grid variability.
- **Investment** in energy storage systems, grid management and control systems, predictive analytics and forecasting are some techniques/solutions used for grid stabilizing depending on the scale of solar PV integration. Smart grid technologies are also important to reduce losses and handle two-way flows, as well as demand response systems. Adequate connection of RE plants to the grid should also be ensured.

Conduct detailed studies of local conditions

The design and engineering of RE systems will vary depending on the specific location and conditions in the area. Factors such as wind and weather conditions, topography, and local regulations can all affect the design and engineering of RE systems. Detailed studies should be conducted, and there should be adequate investment in data collection and capabilities. The implementation of RE such as geothermal development in direct use, such as hot spring tourism areas, with local BUMDs and socialization and education can reduce the potential for community rejection of geothermal power plant development.

Construct access roads

Access roads and other transportation forms are required to transport equipment, personnel, and materials to the RE site. The construction of access roads is critical to ensure that construction goes smoothly and that maintenance and repairs can be carried out.

Segregate waste at source

Waste sorting allows for the segregation of different types of waste at the source or upstream, before it reaches the waste-to-energy facilities. By segregating waste at the source, the overall quality of the waste stream can be improved, making it more suitable for different waste treatment processes and use in energy projects if needed.

Benefits

3.1.2.1 Environmental benefits

- Renewable energy sources **emit far fewer greenhouse gases and other pollutants** than fossil fuels, resulting in reduced impacts on climate change and the immediate environment. There are some exceptions such as biofuels, however, their impacts are reduced overall. This can also lead to improved air quality, particularly indoors, and lead to associated health and welfare benefits.

- **Reduced water usage and stress** as solar and wind power do not require water for generation/cooling. Some technologies such as mini hydro power can help in flood control and water management as well, with reduced environmental impacts.

- Clean energy sources, if planned properly, can reduce the impact of energy generation on **natural environments and biodiversity**. They can be planned in a way that reduces the fragmentation of natural habitats.

- For backup systems such as diesel generators, replacing them with solar and storage technologies can reduce **noise pollution** as well.

- Renewables may need more **land** than the equivalent fossil fuel plants, however they can be situated in a way that minimizes the impacts on nature. For example, rooftop solar PV systems do not require additional land to be developed. Municipal waste-to-energy projects divert waste from landfills, reducing the amount of space needed for landfills and improving overall waste management.

3.1.1.2 Socioeconomic benefits

- **Improved quality of life** through improved lighting, refrigeration for food storage, and access to information and communication technologies. Enhanced educational opportunities such as the ability to study after dark or to access online learning resources.

- **Better health outcomes** through reduced pollutants and enabling the delivery of decentralized health services.

- **Increased economic opportunities** through expansion of business activity and operating hours, as well as the services sector and associated value chain.

Decentralized generation and backup systems can help to improve the reliability of the power system, reducing the risk of power outages and associated economic losses, helping to attract industrial and commercial investments. Biomass co-firing can for example provide new revenue streams for farmers and foresters, supporting rural economic development. The installation of rooftop solar PV systems can increase property values for homeowners and businesses, which can provide a return on investment and stimulate economic activity in the area.

- **Expanding access to electricity** through clean energy can help to reduce energy poverty and improve social equity, particularly in rural and low-income areas.

- Clean energy technologies can reduce wholesale electricity costs, leading to **cost savings** down the line. Households and businesses also save on fuel costs.

- Investing in clean energy can help to **reduce dependence on imported fossil fuels** and attract international finance. Some projects can generate carbon credits, which can be sold on the global carbon market to companies seeking to offset their carbon emissions and attract further finance and create a supporting service sector.

- Municipal or community-owned projects can **generate revenue for the community**, to be invested locally.

Targets and indicators

In realizing the objectives of the roadmap, there are several main targets, medium-term targets, and indicators set in the electricity sector, as follows:

Table 6: Targets and indicators in electricity sector

Target	Medium-term target	Indicator	Share
The realization and guarantee of equal and adequate access to electricity for all households in WNT	To achieve an electrification ratio based on PLN electricity connections for households in WNT of 100% by 2025 (for urban areas) and no later than 2030 (for remote areas and outer islands) with reliable quality, available 24 hours per day, and which has a minimal level of disruption or interruption of availability (low SAIDI and SAIFI)	Percentage of households with PLN electric grid connections and households with decentralized systems and served by IPPs by 2025	100% of households in WNT should have access to reliable electricity from the PLN electric grid, from IPPs and from their own decentralized systems by 2025 (for urban areas) and by 2030 (for remote areas and outer islands).
		By still considering renewable energy supply and energy efficiency measures, achieving the minimum level of electricity consumption in WNT should be in line with the national average electricity consumption beginning in 2030.	The average electricity consumption of the people of WNT should increase to reach the same level as the national average electricity consumption beginning in 2030.

Target	Medium-term target	Indicator	Share
Decarbonize the electricity generation system in WNT to 100% renewable energy by 2050.	50% of the renewable energy mix in WNT's electricity system by 2035 should be based on solar, wind, geothermal, biomass *co-firing,* and hydro.	Percentage of renewable energy mix in the electricity generation system in WNT	• 100% renewable energy mix in WNT's electricity system by 2050. • Phase out all diesel generation by 2030. • Phase out all steam/coal power plants by 2050 or implement 100% biomass by 2040. • Prospecting undersea transmission/ interconnection between Lombok and Sumbawa Islands in 2050.
		Shutdown of diesel-based power plants by 2030 and steam/coal power plants by 2050, so that all power generation is based on renewable energy	

The following is an explanation of the indicators for achieving the roadmap targets in the energy sector:

Table 7: Explanation of indicators in electricity sector

Indicator	Definition		
	Description	Calculation method	Period
Percentage of households with PLN connection by 2025 (for urban areas) and by 2030 (for remote areas and outer islands)	Calculate the percentage of households that have been connected to PLN electricity and its power class in urban areas (Lombok, Sumbawa), rural areas, as well as remote areas and outer islands.	The calculation of the number of households connected to PLN electricity divided by the total number of households in WNT, can be categorized based on the area where they live.	2025–2050
Percentage of households with off-grid electricity connections (non-PLN)	Some households have electricity connections but not through PLN or the grid.	Calculate the total number of households, of which those have access to electricity from off-grid i.e. non-PLN sources such as local mini-grids.	2025–2030
Electricity consumption in WNT to be in line with the national average electricity consumption	Calculating the electricity consumption per capita of the community, where an increase in electricity consumption close to national average	Per capita electricity consumption is calculated by dividing the total gigawatt-hours of electricity consumed by electricity	2030–2035

Indicator	Definition		
	Description	Calculation method	Period
	indicates that the socioeconomic conditions of the community are close to developed countries.[22]	customers on 31 December of a year, as determined by the authority, by the population of the province on 31 December of that year.	
Percentage of renewable energy mix in the electricity generation system in WNT	Calculating the mix of electricity generation composition (GWh) in WNT based on the type of power plant (RE and non-RE).	The ratio between RE and non-RE (fossil energy) mix of all electricity generated in an electricity system in a given year	2025, 2035, 2050
Shutdown of diesel-based power plants by 2030 and steam/coal power plants by 2050, so that all power generation is based on renewable energy	Ensure that no electricity is generated from diesel by 2030 and coal by 2050.	Calculate the electricity mix of diesel and coal, which are assumed to be 0% in 2030 and 2050 respectively.	2030–2050

[22] https://www.sciencedirect.com/science/article/pii/S0973082616301892

Action 1.1: Increase electrification ratio rate and household electricity connection

Justification	Increasing access to electricity for communities in West Nusa Tenggara is critical to be able to decarbonize end uses through renewable energy, particularly those that are still heavily reliant on fossil and other polluting fuels such as cooking and transportation.
Implementation strategy	• Identify the condition (status), challenges, and roadmap for achieving household electricity access in WNT (on Lombok Island, Sumbawa Island, and outer islands) by involving stakeholders including PT PLN and village officials. • Develop community electrification program indicators (beyond electrification ratio) as well as strategies and plans to achieve them, incorporating small and medium enterprises that might use diesel generators as backup. • Develop a subsidy program for electricity connections for the poor, utilizing various forms of financing including national and own sources. • Establish cooperation between the WNT Provincial Government and industries and companies related to the optimization of Corporate Social Responsibility (CSR) funds to subsidize the electricity connection costs of poor households (RTM) and subsidized connections (max. 900VA-RTM) with prepaid token connections or pay-as-you-go (PAYG). • Develop a mini-grid based electricity program, involving the private sector where necessary. This might optimize the public private partnership (PPP) business model with government support to leverage private investment in electricity access, particularly at the village or larger scale.
Supporting technology	• **Renewable power generation:** This includes solar PV, wind turbines, biomass, hydropower, etc. for generating clean energy. • **Energy storage systems** (like lithium-ion batteries): Used to store excess energy and for grid balancing. • **Pumped hydro storage:** This could also be explored depending on the water resources, design, and topography, etc. • **Smart grid technologies:** These are needed for efficient management and distribution of electricity, and includes smart metering and demand response management.

	• **Microgrids:** These are needed for localized distribution of electricity and to improve reliability and resilience of the power system.
Are there policy linkages at different levels?	• Minister of Energy and Mineral Resources Regulation No. 38/2016 on the Acceleration of Electrification in Undeveloped Rural Areas, Remote Areas, Border Areas, and Small Populated Islands. • Presidential Regulation No. 22/2017 on the National Energy General Plan. • Presidential Regulation No. 112/2022 on the Acceleration of Renewable Energy Development for Electricity Supply.
Timeline	The electrification of all households in WNT through reliable PLN or off-grid connections with 24-hour supply can be achieved by 2025, or by 2030 at the latest.
Possible sources of financing	• State-budget, both central (APBN) and local government budget (APBD) • PLN's budget or investment • Private investment in electricity is carried out by non-government or private parties through a mini-grid concept, including through public-private partnerships • Corporate social responsibility (CSR) funds for household electricity connection expansion • International climate funds, multilateral development banks, and international program support on energy access
Risks associated with implementation of the action	The estimated risks include high initial investment costs, technology risks, and operation and maintenance costs, and potential issues of changing entrenched behavioral patterns. However, the economic feasibility can be increased by various incentives, subsidies, and favorable policies. In the long run, clean energy solutions can provide a more stable and predictable source of energy, reducing reliance on fossil fuels and mitigating the environmental impacts of electricity generation.
Definition of initiative leadership	• PLN Regional PLN (PLN UIW NTB) • Department Agency of Energy and Mineral Resources (DEMR), WNT Province Agency of WNT • Ministry of Energy and Mineral Resources (MEMR)

Action 1.2: Retire coal-fired power plants and implement biomass co-firing

Justification	Retiring coal power is a very effective way to reduce greenhouse gas emissions, but simultaneously requires an increase in renewable energy supply—using biomass for co-firing technology can provide a way to address both simultaneously.

• **Implementation strategy**	• Starting in 2025, the implementation of the biomass residue co-firing system at the coal-fired power plants (CFPPs) in Lombok (CFPP Jeranjang) and Sumbawa (CFPP Sumbawa Barat) can be as follows, with the composition ratio of biomass residue and coal as follows (based on same energy output)
	  ◦ 20% biomass, 80% coal by 2025.
	  ◦ 60% biomass, 40% coal by 2030.
	  ◦ 80% biomass, 20% coal by 2035, up to 100% biomass use by 2040, or sooner depending on the readiness of the system and supply chain of biomass feedstock.
	• The biomass feedstock shall optimize the WNT agriculture and forestry industry residues.
	• Co-firing is carried out in parallel and gradually with the development of baseload renewables power plants such as geothermal power plants.
	• Coal-fired plant retirements are carried out in reference to the feasibility of the plant's lifespan.

Supporting technology	Retrofitting coal-fired boilers for biomass co-firing (if required), includes: • **Boiler modifications:** The existing coal-fired boiler may need to be modified to enable co-firing with biomass, such as the installation of new burners or modifications to the existing burners to accommodate biomass. • **Fuel storage and handling systems**: The existing coal handling and storage systems may need to be modified or replaced to handle biomass feedstocks. • **Biomass handling and preparation systems**: New systems may need to be installed to handle and prepare the biomass feedstocks for co-firing. • **Air and flue gas systems**: The air and flue gas systems may need to be modified to accommodate biomass co-firing, such as the installation of new air and flue gas treatment systems.

	• **Control and monitoring systems**: New control and monitoring systems will need to be installed to monitor and regulate the co-firing process.
Are there policy linkages at different levels?	• Indonesia's Law No. 16/2016 on the Ratification of the Paris Agreement. As part of this law, Indonesia has submitted an Enhanced Nationally Determined Contribution (NDC) in 2022, which includes co-firing in its mitigation actions. • Presidential Regulation No. 112/2022 on the Acceleration of Renewable Energy Development for Electricity Supply. • The Central Government's policy planning in achieving Net Zero Emissions in 2060, one of which includes the preparation of a co-firing roadmap to the retirement of coal-fired plants in Indonesia.

Timeline	• 2022–2025
	  ◦ Study and mapping of biomass supply chain for co-firing purposes including (i) identification of biomass sources (e.g., wood pellets, rice husks, corn stover, etc.); (ii) preparation of biomass supply business model; and (iii) development of energy forest in collaboration with the Environmental Agency and Energy and Mineral Resources Agency of WNT and involvement of regionally owned enterprises.
	  ◦ Preparation and trial implementation of co-firing the CFPPs in WNT in cooperation with PLN, and identifying barriers encountered along the way and possible solutions.
	  ◦ Retrofitting of CFPP's mechanical and electrical equipment where possible.
	• 2025: Gradual implementation of co-firing of power plants with biomass, with an increase in the percentage of biomass composition to 80-100% in 2035-2040, and so on.

Possible sources of financing	• State budget • Private investment in the context of preparing and developing energy forests and strengthening the biomass supply chain in WNT. • Investment of business entities in the context of joint venture and operation of co-firing technology in existing CFPPs. • PLN's budget for retrofitting CFPPs and diversifying coal feedstock into biomass. • Donor grants and international climate funds, and international development agencies in the preparation of related studies.

Estimated risks associated with implementation of the action	• Biomass and its **low-carbon status** is often contested, and so detailed studies should be conducted to understand its lifecycle emissions and whether it is a suitable energy source to achieve net-zero goals. • The availability and **quality of biomass** feedstock can be uncertain and variable, which can affect the cost and efficiency of co-firing. Ensuring a reliable and consistent supply of biomass feedstock may require additional investments in feedstock management and storage. Feedstock management should include protection and storage with an early warning system for climate-related risks, such as floods, to allow for timely response and mitigation. • Given that coal and biomass may not have the same **energy density**, planning should take this into account and assess whether energy demand can be met or whether additional generation is required. • Biomass, such as wood pellets or agricultural residues, needs to be **sourced and collected** from various locations. Supply chains covering transportation and logistics from the sources to the CFPP sites could be part of new risks to the shifts. • Biomass co-firing requires **modifications** to existing coal-fired power plants, which can involve technological challenges and risks, such as compatibility issues and reduced performance. Ensuring proper design, testing, and commissioning of the co-firing systems can mitigate these risks. • Co-firing biomass with coal can produce different types and levels of **emissions** than coal-fired power plants, which may require additional investments in emission control systems to meet regulatory requirements and ensure good air quality. • Implementing biomass co-firing can require **significant investments** in infrastructure, technology, and feedstock, which can affect the economic viability of the power plant. Careful planning and analysis of the costs and benefits of co-firing, including the potential for carbon credits and other incentives, can help ensure the economic viability of the project. Subsidies may be needed to support local manufactures in producing feedstock. • Implementing biomass co-firing requires **compliance with safety regulations** and environmental laws. Ensuring that the co-firing systems and procedures are designed and operated safely, and that the emissions meet regulatory standards, is critical to reducing risks and maintaining regulatory compliance. • The phasing-out policy from coal-fired power generation can meet with **resistance** from the coal industry, including workers and communities that rely on coal production for their livelihoods. In addition, changes in political leadership, policy priorities, or political instability can create uncertainty

	around the regulatory environment, which can increase the risk of investment in renewable energy projects, including biomass co-firing. • **Natural disasters** are unavoidable, but robust disaster risk insurance policies can help mitigate the economic fallout from potential damage or loss caused.
Definition of initiative leadership	• Agriculture and Plantation Agency • Energy and Mineral Resources Agency • PLN • Department of Environment and Forestry, WNT Province

Action 1.3: Retire diesel power plants by 2030

Justification	Similar to coal, retiring diesel plants is also necessary due to their inefficiencies and emissions, as well as replacing them with renewable energy sources.
Implementation strategy	Stop the operation of diesel power plants in WNT by 2030 to reduce electricity generation costs and dependence on diesel. The implementation of this action starts from the main city or island area and then targets the outer island areas of diesel users where alternatives may not be so readily available. In parallel, develop replacement plants such as solar, wind, hydro, geothermal, and batteries, also carried out through both PLN and IPP schemes.
Supporting technology	Substitute power plants such as solar power and batteries (for outer island areas), and where feasible, wind, geothermal, and hydropower plants.
Policy linkage	• Presidential Regulation No. 112 of 2022 on the Acceleration of Renewable Energy Development for Electricity Supply.
Are there policy linkages at different levels?	• The central government's policy to achieve Net Zero Emissions by 2060 includes de-dieselization or diesel replacement.

Timeline	• **2022–2025**
	  ◦ Mapping of areas and diesel fleet units to be replaced based on priority scale, for example starting from diesel with low to medium capacity factor and plant age.
	  ◦ Preparation of studies and plans for diesel fleet replacement generation options, procurement e.g. through IPP schemes for the scale of WNT Province, as well as cost analysis.
	• **2025–2027**: IPP procurement or tendering for the replacement of diesel.
	• **2028–2030**: Construction of replacement plants and gradual commissioning.
	• **2030**: All diesel fleets in WNT have ceased operation and are replaced by renewable energy plants.

Possible sources of financing	• PLN budget and state funding assistance (if required) in study or assessment preparation and procurement efforts. • Donor grants and international agencies in the preparation of related studies. • Investment of business entities (IPPs) in the provision of replacement generation.
Estimated risks associated with implementation of the action	• Techno-economic risks related to the lifecycle of solar and batteries as well as the economics of the project, for example, the price offered by the private or business entity turns out to be too expensive in the absence of revised subsidies or tariffs. • Low private sector involvement in the diesel-replacement business sector in WNT due to unattractive business model and investment returns. • The shift away from fossil fuels can result in job losses in associated industries, creating adverse impacts particularly in areas that are heavily reliant on these industries. In addition, the transition to renewable energy sources may require workers with different skills than those in the fossil fuel industry. Workers in the fossil fuel industry may need to be retrained or reskilled to work in the renewable energy sector, which can create challenges and require investment in workforce development.
Definition of initiative leadership	• PLN • Ministry of Energy and Mineral Resources

Action 1.4: Develop free-field and rooftop solar PV

Justification	Solar photovoltaic technology has the benefit of being deployable in large configurations or in a decentralized manner—both are crucial to optimize the use of land and decarbonize the electricity supply.
Implementation strategy	• Development of both ground-mounted and floating centralized solar power plants, which can be done with PPPs and reverse auction schemes in collaboration with the Ministry of Energy and Mineral Resources, Ministry of Public Works, and PLN. This includes the development of hybrid power plants (solar and batteries) to replace diesel power plants in remote areas and outer islands in WNT. • Development of rooftop solar power plant in the commercial and industrial sectors on a voluntary basis with the encouragement of public policies, such as green industry standards and incentive or disincentive mechanisms. • Development of rooftop solar in the household or residential sector on a voluntary basis with public policy encouragement including mandatory rooftop solar PV for the luxury housing segment, land and building tax relief or incentives for rooftop solar users, etc. • Development of rooftop solar for government and public buildings sector (including hospitals, schools, government buildings), such as under a PPP scheme to ensure economies of scale of investment. • The development of solar power plants with direct-use schemes, such as solar cold storage and solar street lighting, can be carried out under a business entity investment scheme and/or PPP. • Development of supporting infrastructure, including control systems, including SCADA, balancing storage or battery systems, and implementation of network impact studies and intermittent RE penetration.
Supporting technology	• PV solar system and battery technology • Control systems, including SCADA • Implementation of network impact and RE penetration studies • Retrofitting and updating distribution network systems, substations, and transformers in anticipation of RE penetration
Are there policy linkages at different levels?	• Presidential Regulation No. 112/2022 on the Acceleration of Renewable Energy Development for Electricity Supply. • Central Government target in achieving Net Zero Emission by 2060.
Timeline	• Utility-scale solar and rooftop solar PV in public buildings • **2022–2024:** Development of PPP procurement schemes for rooftop and ground mounted or floating solar power plants, solar power

	plants for public street lighting, and solar power plants in public buildings.[23] • **2024–2030**: Periodic PPP procurement or tendering parallel to plant construction and operation. • **2030–2035**: 100% of government buildings and public buildings in Mataram should have rooftop solar PV installed; 30–35% of government buildings and public buildings in Sumbawa (especially district capitals such as Taliwang, Sumbawa Besar, Bima and Dompu) should have rooftop solar PV installed. • **2035–2040**: 50–100% of government buildings and public buildings in Sumbawa (especially district capitals such as Taliwang, Sumbawa Besar, Bima, and Dompu) should have rooftop solar PV installed. • **2025–2030**: the public street lighting system in Mataram should be using solar power, gradually also in the Sumbawa region starting from the district capital and district and provincial roads. • Rooftop solar PV for residential and commercial/industrial buildings • **2022–2025**: Development of policy framework and incentive or disincentive schemes in coordination with stakeholders at central and regional levels, including PLN. • **2025**: Commencement of social campaign of the use of rooftop solar PV in the residential and industrial sectors on a voluntary basis. • **2025**: Implementation of incentive and disincentive policies for residential and industrial sectors related to the use of rooftop solar PV and the declaration of the achievement of annual targets for rooftop solar PV installed capacity. • **2035**: 100% of eligible households in Mataram city and surrounding areas should have installed rooftop solar, 30–35% of households in Sumbawa (especially district capitals such as Taliwang, Sumbawa Besar, Bima, and Dompu) should have installed rooftop solar. • **2035-2050**: 50–100% of households in Sumbawa (especially district capitals such as Taliwang, Sumbawa Besar, Bima and Dompu) should have installed rooftop solar.
Possible sources of financing	• PLN budget and government funding assistance (if required) in study or assessment preparation and procurement efforts • Donor grants and international agencies in the preparation of related studies, including multilateral development banks (MDBs)

[23] An example is the 8 MW Bintang Bano solar power plant, which is in the preparation stage.

	• Investment of business entities in the framework of developing solar power plants in public buildings, government buildings, public street lighting, through the PPP scheme. • Local tax and land-building tax fiscal incentives for rooftop solar power users
Estimated risks associated with implementation of the action	• The development of large-scale centralized solar PV systems may require **significant land use**, which can impact natural habitats and ecosystems. • The integration of distributed rooftop solar PV systems into the electricity grid may require significant infrastructure investments and planning and could pose challenges for **system stability and reliability**. • Solar PV systems may be subject to **technical challenges**, such as shading, weather, and temperature variations, which can affect system performance and output. • The development of solar PV systems may be subject to **financial risks and uncertainties**, including changes in government policies, fluctuations in energy prices, and changes in demand. • The installation and operation of solar PV systems may pose **safety and security risks**, such as fire hazards, electrical shock, and potential theft or vandalism. • The **cost risks** arising from replacing energy sources that are still economical with new RE-based generation require proper study and planning.
Definition of initiative leadership	• PLN • MEMR, Department of Energy and Mineral Resources WNT Province

Action 1.5: Develop and directly utilize geothermal power plants

Justification	Geothermal energy is a promising source of consistent renewable energy and that can serve as a baseload, helping to reduce dependence on fossil fuels. Indonesia has high potential for geothermal energy, but its feasibility will depend on local geographies.
Description	• Encourage the involvement of business entities, both state-owned and private, in the development of geothermal energy in WNT (indirect utilization). • Conduct engagement campaigns to educate communities on the real benefits and risks of geothermal developments to mitigate potential community resistance.

	• Conduct geothermal development in direct use as a tourism destination by collaborating between regional enterprise and the community so that it can provide direct added value to the community. • Offer incentives to the geothermal sector, especially at the exploration stage, to reduce investment costs and risks. • Develop supporting infrastructure such as access roads to potential geothermal locations to reduce investment costs, aligned with existing plans. • Initiate cooperation with the Ministry of Finance and Ministry of Energy and Mineral Resources regarding opportunities for government drilling and resource assessment.
Supporting technology	• **Geothermal drilling technology**: Necessary to drill into the Earth's surface to reach the temperatures needed to generate electricity or provide direct heat. • **Heat exchangers:** Used to transfer heat from geothermal fluids to a secondary fluid, which can then be used to heat buildings or generate electricity. • **Pumps and turbines**: These are used to circulate the geothermal fluids through the system and to generate electricity. • **Power conversion technology**: This technology is necessary to convert the heat energy from geothermal fluids into electricity. • **Monitoring and control systems**: These systems are used to monitor the temperature, pressure, and flow of the geothermal fluids and to control the operation of the system to optimize performance and prevent damage. • **Infrastructure**: This includes pipelines, power transmission lines, and other necessary infrastructure to transport the geothermal fluids and electricity to end-users. • **Reservoir management technology**: This includes technologies for monitoring and modeling the geothermal reservoir to optimize performance and to prevent depletion of the resource. • **Binary cycle power plants**: These power plants can be used to generate electricity using low-temperature geothermal resources that are not hot enough to generate steam directly. For the direct use of geothermal, some potential utilization and required technologies are:

	• **Geothermal for agriculture and crop drying**: This means the development of geothermal greenhouses that are heated using geothermal energy. Geothermal heat is used to warm the soil and the air inside the greenhouse, providing an ideal growing environment for crops. • **Aquaculture technology**: This includes technologies for designing and managing aquaculture systems that are optimized for geothermal heating, such as recirculating aquaculture systems. • **Spa and tourism facilities**: These facilities can be developed around hot springs or other geothermal resources to provide health and wellness services to visitors. • **Food processing and drying**: Geothermal resources can be used for food processing and drying, such as drying fruits or vegetables to prevent spoilage.
Are there policy linkages at different levels?	• Law No. 21/2014 concerning geothermal for direct and indirect use • GR No. 28/2016 concerning Production Bonuses • GR No. 7/2017 concerning Geothermal for Indirect Utilization • Presidential Regulation No. 112/2022 on the Acceleration of Renewable Energy Development for Electricity Supply • Minister of Finance Regulation No. 80/2022 concerning Support for Geothermal Development Through the Use of Geothermal Sector Infrastructure Financing funds in the Company (Persero) PT Sarana Multi Infrastruktur • Central government policy in achieving Net Zero Emissions by 2060

Timeline	• **2024–2030:**
	  • Conducting geothermal development studies in the WNT region, consisting of mapping, resource assessments, and feasibility studies; these can be conducted under the MEMR cooperation program.
	• **2024–2030:**
	  • Implementation of geothermal development in direct use in collaboration with regional enterprises.
	  • Initiate the implementation of government drilling and/or other government exploration programs with the MEMR, PLN, Ministry of Finance, and PT SMI regarding options in geothermal areas in WNT, including Sembalun, East Lombok and Hu'u-Daha, East Sumbawa.

	• Commence socialization and education for the surrounding community regarding geothermal utilization. • Formulation of local tax incentive policies for geothermal development. • **2025–2030:** • Construction of access roads and supporting infrastructure to geothermal areas through regional budgets and/or regional loans, in alignment with existing plans. • Government drilling is expected to be completed by 2030. • Implementation of auction for the development of geothermal areas resulting from government drilling. • **2030–2035:** • Development of a geothermal power project in WNT in the Sembalun and Hu'u-Daha working areas, operational target in 2035.[24]
Possible sources of financing	• Local budgets and technical assistance from donors and international organizations to develop related studies. • Geothermal Sector Infrastructure Financing Fund (PISP) and the state budget in the implementation of government drilling. • APBD, regional loans, and/or BUMD investments and business partners in the context of tourism development and direct use. • Investment of business entities through the IPP scheme. • Local tax and land-building tax fiscal incentives.
Estimated risks associated with implementation of the action	• **Unfavorable economics** of geothermal electricity tariffs can make geothermal investment in WNT less attractive for businesses. • The **risk of community rejection** of geothermal power plants due to a lack of understanding of the urgency and impact of geothermal development.
Definition of initiative leadership	• PLN • Ministry of Energy and Mineral Resources • Energy and Mineral Resources Agency • Ministry of Finance, Directorate General of Financial Risk Management that is responsible for the geothermal exploration funds

[24] Hu'u is targeted to become a baseload plant in the eastern part of Sumbawa, while Sembalun is expected to replace WNT's electricity supply dependence on coal and diesel plants scattered in Lombok.

Action 1.6: Develop wind farms

Justification	Being an island province, WNT has a high wind energy potential, including offshore and onshore—however, detailed studies are required for site suitability.
Implementation strategy	This strategy covers wind farm development from resource assessment to operation by introducing PPP-based reverse auctions in cooperation with the MEMR and PLN. Project development can be a complex undertaking, involving several stages which overlap between general PPP project preparation and structuring and the wind farm project development itself.
Supporting technology	• **Resource assessment and monitoring technologies:** These technologies are used to accurately measure the wind resource potential in a certain location. They include meteorological towers, remote sensing devices (such as LIDAR or SODAR), and numerical modeling tools that simulate wind behavior. Wind monitoring technologies are used to continuously measure wind speed and direction at the site of the wind farm, and can include anemometers, wind vanes, and other weather sensors. • **Wind turbine technologies**: There are several types of wind turbines available, including horizontal-axis and vertical-axis turbines, with varying rotor diameters, hub heights, and generator capacities. The selection of the appropriate turbine technology will depend on factors including the wind resource potential, site conditions, and regulatory requirements. • **Electrical infrastructure technologies**: Electrical infrastructure technologies are used to transmit and distribute the electricity generated by the wind farm. These technologies include transformers, inverters, switchgear, transmission lines, and other components of the electrical grid. The selection of the appropriate electrical infrastructure technology will depend on factors including the capacity of the wind farm, the distance to the grid connection point, and the regulatory requirements for grid connection. • In addition to these three main categories, **advanced control systems, energy storage systems, and predictive maintenance tools** are extremely useful. They help increase the efficiency and reliability of the wind farm, reduce operational costs, and extend the lifespan of the wind turbines.
Timeline	• **2022–2025**: Finalization of the wind farm development study in WNT by the MEMR and PLN, donor support can help the study formulation. • **2025–2030**: Installation and operation of scattered met-mast towers spread across WNT in near-shores and high topographical zones, in

	collaboration between the local government, airport operators, the MEMR, and the local meteorological agency. • **2025–2035**: The development of wind power plant schemes of business entities or IPPs is spread across the WNT region, both onshore and offshore.
Possible sources of financing	• Government funding • Local budgets and technical assistance from donors and international organizations to develop related studies • Business entity or private sector investment • Donor funding from international organizations or MDBs to fund initial site assessment studies
Estimated risks associated with implement ation of the action	• The profitability of wind farms depends on market conditions, such as electricity prices, demand, and regulatory policies. Changes in market conditions can affect the revenue and profitability of wind farm projects. • Wind turbines and associated equipment are complex and can be subject to technological failures. Technical risks can include equipment failure, inadequate design, or lack of maintenance. • Most wind turbine system components are imported from other countries, and there is a lack of local experts in this field, making maintenance or further indigenous R&D difficult. • Wind farms can have environmental impacts, including impacts on wildlife, and habitats. Projects can face challenges related to environmental assessments, permits, and public opinion. • Wind farm projects can require significant upfront capital costs and can have long payback periods. Financing risks can include uncertainty around revenue streams, interest rates, and the availability of funding. • Wind farm projects can be subject to changes in government policies, regulations, or incentives. Changes in policies or regulations can affect the profitability and viability of wind farm projects. • Wind farm projects can be complex and require effective project management to ensure that projects are completed on time, within budget, and to the required quality standards.
Definition of initiative leadership	• PLN • MEMR • Energy and Mineral Resources Agency • Land and Spatial Planning Agency • Agency of Regional Planning

Action 1.7: Develop hydropower

Justification	Hydropower has a role to play in electricity decarbonization, particularly micro and mini hydropower sources that minimize environmental impacts and provide other valuable water management possibilities.
Implementation strategy	The resources for hydropower development in WNT are not abundant considering the relatively dry climate (compared to Java Island). Therefore, the development of large hydropower would perhaps not be feasible. Instead, the hydropower development in WNT can be focused on smaller-scale projects such as distributed mini or small hydropower (<10 MW). There are several projects that have been built and operated as run-of-river projects. Mini hydropower project development can also optimize the use of existing and planned multifunction water storage or reservoirs in WNT. The involvement of the private sector and business entities is required. In addition, it is recommended for the local government, energy and mineral, public works, and meteorological agencies to improve the quantity and quality of the hydrological and meteorological data as a basis for the project's technical study.
Supporting technology	• **Mini hydropower technology system**: Turbines and generators are the key components of any hydropower system, and the selection of appropriate technologies is essential to ensure optimal energy production and efficiency. For mini hydropower systems, smaller turbines and generators may be used. Depending on the site characteristics and water resources availability, the turbine type can be a Pelton, Kaplan, or Francis turbine. • **Control systems**: Required to monitor and regulate the operation of the hydropower system. This includes the sensors, data acquisition systems, and control software. • **Penstocks and intake structures:** Used to transport water from the storage or reservoir to the turbine. The design and construction of penstocks and intake structures require a sound

	understanding of site conditions, water flow rates, and other factors.

Timeline	• **2022–2025**:
	  • Identification and preparation of several PPP projects for the development of mini hydro at multifunctional dams in WNT, including Bintang Bano Hydropower Plant, etc., in cooperation with the Ministry of Public Works, PLN, MEMR, and the local government.
	  • Identification of run-of-river MHP potential in WNT by the local government (the energy agency).
	• **2025–2030**: Implementation of mini hydropower development on all multifunctional dams in WNT.

Possible sources of financing	• State budgets, central and local government • Technical assistance from donors and international organizations to develop related studies • Private sector investment
Estimated risks associated with implementation of the action	• Mini hydropower projects can be capital intensive and may require **significant upfront investment** (around USD 2–2.5 million per MW). There is a risk of cost overruns, and unforeseen expenses during construction or operation that can impact the project's financial viability. • Mini hydropower projects are often located in remote areas with **limited access to infrastructure and skilled labor**, which can create technical risks during construction and operations. • **Technical risks** can include issues with equipment performance, water flow, and sedimentation. • Mini hydropower projects can have an impact on the environment, including changes to water flow and sedimentation, and the potential for habitat disruption or loss. **Environmental risks** can also include potential impacts on fish and wildlife, and the loss of recreational activities such as fishing and boating. • Mini hydropower projects can impact local communities and indigenous people, **potentially leading to social conflicts, land issues, and displacement**. • Mini hydropower projects may require various permits and approvals, and regulatory requirements can vary by country and region. **Regulatory risks** can result in delays in permitting and

	approval processes, changes in regulations or policies that impact the project's viability, and potential legal challenges. Considerations related to water rights and usage may apply.
Definition of initiative leadership	• Energy and Mineral Resources Agency • Public Works, river management units • Spatial Agency

Action 1.8: Develop integrated municipal waste-to-energy power plant facilities under PPPs

Justification	Using waste to generate electricity is a pathway to manage waste and find alternatives to fossil fuels—however, it is better placed as a transition fuel.
Implementation strategy	Prepare a structured plan for the design of a Public Private Partnership (PPP) scheme in the development of a regional waste disposal and final processing site on Lombok Island integrated with a *waste-to-energy (WTE)* power plant. This includes the following: • Preparation of a feasibility study, including the government's budget to compensate for waste management services. • Identification of supply chains and waste transport capabilities between districts and cities, etc. • Implementation and strengthening of the cooperation and coordination between level government districts in Lombok in the development of the regional MSW management and waste-to-energy project. • The implementation of the Lombok regional waste-to-energy facility under PPP basis will occur in 2025 and operate before 2030. • However, the implementation of WTE as a long-term solution has to follow detailed study and assessment. WTE is one of the ways to manage the waste problem in the region, nevertheless the most important thing is to improve the waste management system first.
Supporting technology	• **Waste handling and pre-processing systems:** Designed to sort, shred, and process incoming waste before it is fed into the waste-to-energy process. This can include conveyor belts, shredders, and magnetic separators. • **Combustion technologies:** Municipal waste-to-energy plants typically use mass-burn or refuse-derived fuel (RDF) combustion technologies to burn waste and generate steam, which is used to produce electricity. This can include moving grate, fluidized bed, and rotary kiln systems. • **Flue gas treatment systems:** Reduce emissions from the waste-to-energy process, such as particulate matter, heavy metals, and

	acid gases. This can include electrostatic precipitators, fabric filters, scrubbers, and selective catalytic reduction (SCR) systems.
	• **Energy recovery and steam turbine systems:** Recover the heat from the combustion process and convert it into electricity. This includes steam turbine generators, heat recovery steam generators (HRSGs), and condensers.
	• **Ash handling and disposal systems:** Handle and dispose of the ash that is generated by the combustion process. This can include dry or wet ash handling systems and landfill or recycling facilities.
	• **Control and automation systems:** Monitor and control the waste-to-energy process, including the combustion process, flue gas treatment, and energy recovery. This can include distributed control systems (DCS), programmable logic controllers (PLCs), and supervisory control and data acquisition (SCADA) systems.
	• Non-combustion technologies:
	  • **Mechanical-biological treatment (MBT)/anaerobic digestion:** A type of waste processing facility that combines sorting with a form of biological treatment such as composting or anaerobic digestion. MBT plants are designed to process mixed household waste as well as commercial and industrial waste. In addition to the separation of dry recyclables from the incoming waste stream, the plant can be designed to produce an energy-rich Refuse Derived Fuel (RDF) or Solid Recovered Fuel (SRF) (which meets standards) making it suitable for use in a range of thermal processes.
	  • **Landfill gasification:** Uses the methane produced by decomposing organic waste in landfills to generate energy. The technology involves excavating the waste from the landfill, sorting and treating it to remove non-combustible materials, and then gasifying the remaining organic waste to produce a synthetic gas (syngas) that can be used to generate electricity or heat.

Timeline	• **2022–2025**: Finalization of the study on the development of municipal solid waste to energy in WNT, including the preparation of PPP projects and TPPAS land acquisition.

	• **2025**: Implementation of PPP auctions until an implementing entity is found. • **2025–2030**: Construction of waste-to-energy plant in WNT and its operation.
Possible sources of financing	• State budget, local government, for payment of waste service fees • State budget, central government; this consists of the Ministry of Public Works investment to provide land and basic infrastructure for waste landfills and the Ministry of Environment special subsidy for the tipping fee of waste services • Central government assistance through the Ministry of Finance for study preparation or Project Development Facility • Local budgets and technical assistance from donors and international organizations to develop related studies • Private sector investment
Estimated risks associated with implementation of the action	• Municipal waste-to-energy projects can produce **emissions and waste products** that can have environmental impacts if not properly managed. • Waste-to-energy projects can face **opposition from local communities** concerned about potential environmental and health impacts. • Waste-to-energy projects can be **complex to design, build, and operate**, and can face technical challenges related to the nature and variability of the waste feedstock. Typically, there are two types of potential technology: mass-burning or anaerobic digestion to produce RDF. However, mass-burning is considered to be more effective in order to reduce the amount of unmanaged waste. • Waste-to-energy projects can require multiple permits and approvals from different levels of government and can face **regulatory challenges** related to environmental and health standards. • Waste-to-energy projects can be capital intensive and **may require significant upfront investment**. Project developers may also face **financial risks** related to fluctuations in energy prices, waste disposal fees, and other factors that can affect project economics.

	• As private finance waste-to-energy projects have to be compensated by the local government under a long-term contract payment for services, the **limited ability of the budget** is one of the risks. This is potentially exacerbated by low public willingness to pay for waste services. • Waste-to-energy projects are complex and **require significant operational expertise** to run efficiently and safely. • **Waste streams may not be adequately sorted** to make them suitable as a fuel, particularly in areas where the sector is largely informal.
Definition of initiative leadership	• Department of Environment and Forestry • Agency of Energy and Mineral Resources • Ministry of Finance, the PPP Unit • Ministry of Environment and Forestry • Ministry of Public Works cq. Directorate General of Housing and Settlements

3.2 Action Pillar 2: Adoption of energy efficiency and conservation practices and measures in the household sector[25]

Objective	Achieving a sustainable household sector with the use of environmentally friendly, energy-efficient, and emission-free technologies and the development of circular economy concepts. Households are the largest energy consumers in WNT, so this sector plays a significant role in regional energy demand projections.
Outcomes	1. Achieving energy efficiency or savings in the household sector. 2. Realizing energy diversification and conversion starting from the household sector, including encouraging the use of rooftop solar power plants in residential areas. 3. Promoting the use of modern cooking technologies such as electric stoves for households in WNT.
Alignment with Sustainable Development Goals	
Action 1	Create rooftop solar incentives for household sector
Action 2	Develop a rooftop solar obligation for luxury houses and apartments
Action 3	Implement a modern cooking conversion pilot project
Action 4	Disseminate energy-efficient electrical equipment knowledge and information

[25] Energy conservation is a systematic, planned, and integrated effort to preserve domestic energy resources and improve their utilization efficiency ; Energy Resource Conservation is the management of energy resources that ensures their utilization and availability while preserving and enhancing their quality, value, and diversity ; Energy Efficiency is the effort to use energy wisely and efficiently while prioritizing safety, security, comfort, and productivity (Government Regulation No 33 of 2023)

Success factors

3.2.1.1 Regulation

Implement a comprehensive net metering policy

- Implement a comprehensive net metering policy that allows residential rooftop solar owners to feed surplus electricity into the grid and receive credits or compensation for the energy exported.
- Define clear rules and procedures for net metering applications, installation, metering, and billing processes.
- Ensure that net metering arrangements are fair and beneficial to homeowners, with a reasonable credit or compensation mechanism for exported energy.

Streamline interconnection procedures

- Streamline interconnection procedures for residential rooftop solar systems, making it easier and more cost-effective for homeowners to connect their systems to the grid.
- Develop clear technical guidelines and standards for interconnection for safety and efficiency.

Introduce tax and duty exemptions or reductions on solar equipment

- Introduce tax and duty exemptions or reductions on solar equipment, including solar panels, inverters, and associated components, to lower the overall system costs.
- This also involves robust incentive mechanism for rooftop solar use e.g., capex subsidy, tax relief.

Invest in consumer protection

- Invest in consumer protection to address grievances and ensure transparency in contracts, warranties, and performance guarantees provided by solar system providers.

Ensure quality and performance

- Implement mechanisms to ensure the quality and performance of rooftop solar systems and other RE technologies.
- Establish certification processes for installers and for solar equipment to ensure adherence to technical standards. Conduct regular inspections and monitoring to verify compliance and maintain system integrity.

- Establishing a local network and value chain of certified maintenance and repair services for rooftop solar systems and stove technologies, for example, can greatly enhance consumer confidence.

Implement mechanisms for monitoring and enforcing compliance

- Implement mechanisms for monitoring and enforcing compliance with energy standards and mandates.
- Define penalties or consequences for non-compliance, including fines, sanctions, or permit revocation.
- Regularly assess and audit installed systems.

3.2.1.2 Technology and research

Continue research and development

- Continue research and development in the field of renewable energy technologies.
- Energy-efficient electrical equipment can help to improve performance and reduce the cost of these technologies, making them more accessible.
- Facilitating the transfer of technology from research and development institutions to manufacturers and consumers can help to accelerate the adoption of energy-efficient electrical equipment.
- Of particular relevance to WNT's and Indonesia's context more broadly, research into electric and biogas **stoves** (especially user-friendly designs), more efficient **solar PV** systems, scalable **energy storage** solutions**, smart grid** management technologies, **remote monitoring** and maintenance (for example, for decentralized mini-grids), smoother **building integration** of RE technologies, **grid interconnection**, **economic and financial modeling**, and **environmental and social impacts** across the technology lifecycle.
- Demonstration projects can be used to showcase the benefits of energy-efficient electrical equipment to citizens, providing them with first-hand experience of the technology and its advantages.
- Research efforts should focus on understanding **consumer behavior**, preferences, and barriers to the adoption of various RE technologies such as rooftop solar. This includes conducting surveys, interviews, and behavioral studies to identify factors influencing decision-making and develop effective strategies for awareness and education campaigns. Study market trends, consumer preferences, and economic models to develop targeted policies and regulations and assess their effectiveness.

- **Financial incentives design** study is an essential component of promoting technology adoption. It involves examining various financial mechanisms and designing effective incentive structures to make rooftop solar installations financially attractive for homeowners.

3.2.1.3 Governance

Implement public education and awareness campaigns

- Public education and awareness campaigns can help homeowners understand the benefits of solar PV rooftop development and other technologies such as cookstoves, including the long-term savings on electricity bills and the positive environmental impact.
- Engage in extensive public consultation and stakeholder engagement processes to gather input, address concerns, and build consensus.

Establish mechanisms for knowledge and information dissemination

- Awareness campaigns, workshops, and training programs help to enhance understanding and promote informed decision-making by the broader public.

Ensure regular monitoring and evaluation of policies and programs

- This can help to identify areas for improvement, assess the effectiveness of policies and programs, and ensure that resources are being allocated in an efficient and effective manner.

Ensure transparency and accountability

- These are important to ensure that policies and programs related to the dissemination of energy-efficient electrical equipment knowledge and information are effective and efficient, and that resources are allocated in a fair and equitable manner.

Foster coordination and collaboration among relevant government agencies

- These include energy departments, urban planning departments, tax authorities, and utility companies, to streamline processes, resolve conflicts, and ensure smooth implementation of RE programs.

Encourage stakeholder engagement throughout the regulatory development process

- Seek input from property developers, industry experts, utility companies, consumer advocacy groups, and other relevant stakeholders to ensure a balanced and effective regulatory framework.

Obtain strong political support of political leaders and public officials

- This support is critical in driving policy, regulation and funding as well as ensuring its success.

Consider energy performance contracting

- Energy performance contracting can be used to finance the implementation of energy-efficient electrical equipment in public buildings and facilities, providing a model for citizens to follow.

3.2.1.4 Infrastructure

Ensure availability of a wide range of energy-efficient electrical equipment

- The availability of a wide range of energy-efficient electrical equipment that is affordable and of good quality is crucial to support the adoption of these technologies by citizens.
- Developing a robust supply chain for energy-efficient electrical equipment, including distribution and retail channels, can help to ensure that citizens have access to these technologies.

Upgrade electricity connection capacity

- The upgrading of electricity connection capacity at the household level is a crucial infrastructure requirement for the successful implementation of a modern electric cooking program, particularly for accommodating the increased electricity load from electric stoves.
- This involves retrofitting the beyond meters electrical installation to ensure it can handle the additional power demand such as wiring and cabling, electrical panel upgrade, and safety-related measures.
- A robust grid infrastructure, compensation mechanisms for self-generation, digital tools and monitoring, etc. are critical factors to enable this expansion.

Upgrade power grid infrastructure, transformers, control systems, and forecasting systems, as well as other electricity system supporters

- This upgrading is required in anticipation of the massive integration of rooftop solar power plants and the additional electric load from EV charging, cooking, etc.

Benefits

3.2.2.1 Environmental benefits

- Renewable technologies such as solar PV and wind **do not emit greenhouse gases** or other pollutants, resulting in reduced air pollution and climate impact.

- Rooftop solar panels can be used in conjunction with energy management systems, such as battery storage systems, to improve **energy efficiency and reliability** for households, and reduce the amount of electricity generated from the grid that is wasted.

- Conventional power plants require large amounts of **water** for cooling. Rooftop solar panels do not require any water and thus can help to conserve this scarce resource.

- Traditional cooking stoves that use wood or charcoal can contribute to deforestation, as trees are cut down to provide fuel. Modern cooking stoves that use biogas or electricity can **reduce deforestation** by decreasing the demand for wood and charcoal.

- Biogas-based agriculture and livestock waste stoves can use organic waste to produce biogas, **reducing the amount of waste** that ends up in landfills or is burned.

3.2.2.2 Socioeconomic benefits

- By reducing **energy costs** and increasing energy security, incentives for rooftop solar or cleaner stoves can improve the quality of life for households and increase their economic well-being due to reduced fuel costs, an alternative source of electricity, lighting, more time for other income-generating activities, etc.

- Reduced **health impacts** and costs from lower indoor air pollution levels, particularly for women and children. Traditional cooking stoves can also pose fire and burn hazards. Some modern cooking stoves can eliminate the need for open flames, reducing the risk of fire and burns.

- Installation of rooftop solar panels, for example, can increase the **value of a property** by improving energy efficiency and reducing energy costs.

- By generating their own electricity, households can reduce their dependence on the grid and increase their **energy security** and reduce fuel costs. This can also have implications for national energy security due to the reduced dependence on imported LPG.

- The installation of rooftop solar panels and clean cookstoves can create **new job opportunities** and a local value chain, which can stimulate local economic growth and opportunities.

- Households that generate **excess electricity** can sell it back to the grid, providing a source of additional income.

- Traditional cooking stoves can be **time consuming** to operate, requiring frequent refueling and maintenance. Modern cooking stoves such as electric stoves are easier to operate, requiring less time and effort to cook meals, making time for other educational or economic opportunities. In many households, women and girls are responsible for cooking, so this benefit has particular relevance for them.

- Increased demand for modern cooking stoves can **drive innovation and growth** in the manufacturing sector. This can lead to new job opportunities and increased economic activity. Greater use of biogas-based agriculture and livestock waste can create new markets for agricultural producers, particularly smallholder farmers, providing a new source of income for rural communities.

Targets and indicators

The targets in the household sector are embodied in several medium-term targets and indicators as follows:

Table 8: Targets and Indicators in household sector

Target	Medium-term target	Indicator	Mix
To achieve energy efficiency and conservation in the household sector	By 2035, there should be a 10% decrease in peak load in the household sector compared to 2025 actual load and its growth without intervention of energy efficiency and conservation.	Percentage decrease in energy consumption of the household sector from year to year, indicating the implementation of energy efficiency	There should be energy savings in the household sector or a 25% reduction in peak load in the household sector in 2050 compared to the projected increase in peak load under a business-as-usual scenario in WNT in 2025.
To increase use of rooftop solar PV in residential areas, which will help realize energy diversification and conversion goals	• By 2035, the penetration or use of rooftop solar PV in the household sector of Mataram City and its surroundings should be 50%. • For households in the Sumbawa region (especially district capitals such as Taliwang, Sumbawa Besar, Bima, and Dompu), rooftop	Percentage of residential buildings in WNT that use rooftop solar PV[26]	The use of rooftop solar power in the household sector has reached the following: • >50% in Mataram City by 2035. • >50% in district capitals in Sumbawa (especially district capitals such as Taliwang, Sumbawa Besar, Bima and Dompu) in the period 2035-2050.

[26] According to Law no. 4 of 1992 concerning Housing and Settlements, a house is a building that functions as a residence or a means of fostering a family.

Target	Medium-term target	Indicator	Mix
	solar PV penetration is 30-35%.		
To develop modern cooking for households in WNT using biogas and/or electric stoves	By 2030-2035, the use of biogas and electric stoves in the WNT household sector should be 25%.	Percentage of households using biogas and electric stoves	50% of households in WNT should use biogas and electric stoves in 2050, with >50% of households in Mataram city already using biogas and electric stoves. This is in line with the use of rooftop solar PV which can be a *prosumer* energy source for electricity load growth through electric stoves.

All of the indicators above are then defined and the calculation method is formed as follows:

Table 9: Explanation of indicators in household sector

Indicator	Definition		
	Description	Calculation method	Period
Percentage decrease in energy consumption of the household sector from year to year, indicating the implementation of energy efficiency and conservation	Observe and quantify the impact on the projected trend of decreasing peak load of PLN electricity consumption in the household sector in line with the implementation of energy-efficient technologies and equipment such as *heating, ventilation, and air-conditioning* (HVAC) components and energy-efficient lighting in the household sector.	• Growth in electricity use including peak load in the household sector on an annual basis. • The calculation can be done using annual electricity consumption data in the household sector from PLN.	2025–2050

Indicator	Definition		
	Description	Calculation method	Period
Percentage of household buildings in WNT that use rooftop solar PV	Calculate the number of household buildings in WNT that have installed rooftop solar PV to reduce energy consumption from PT PLN electricity and at the same time increase the renewable energy mix in WNT.	• Compare the number of household buildings in WNT that have used rooftop solar PV with the total number of household buildings in WNT. • The calculation can be done by using data on the number of household buildings that apply for permits to install rooftop solar power plants to PLN.	

Action 2.1: Create rooftop solar incentives for household sector

Justification	Rooftop solar technology can be scaled up rapidly to deploy emission-free electricity, without the need for land as existing buildings can be used.
Implementation strategy	This comprehensive policy program aims to drive the widespread adoption of rooftop solar systems in the household sector of West Nusa Tenggara (WNT) by providing substantial financial incentives, regulation, and facilitating net metering. Through an innovative subsidy or grant scheme, households will receive significant financial assistance, with priority given to low-income and remote communities to promote inclusivity. Additionally, a results-based subsidy mechanism will reward households based on actual energy generation. The net-metering framework will enable households to export excess electricity to the grid, ensuring fair compensation and encouraging more households to invest in rooftop solar.[27] Streamlined administrative processes, standardized guidelines, and public awareness campaigns will empower households to adopt rooftop solar PV systems with confidence, while strategic collaborations with financial institutions will offer accessible financing options to overcome upfront cost barriers. This multi-faceted approach will progress in this sector. Governments and private sector organizations can provide financing options, such as loans and leases, to help households cover the costs of installing rooftop solar panels.[28]
Supporting technology	• **Solar photovoltaic (PV) equipment**: This includes solar PV systems, solar charge controllers, battery systems, and import-export kWh meters. • **Solar PV system design and monitoring tools**: To design and monitor rooftop solar systems, tools such as solar site analysis tools, system design software, and monitoring systems are required. • **Energy management Systems:** Inverters, charge controllers, and battery storage systems are required to ensure that households can effectively store and use the electricity generated by their rooftop solar panels.

[27] Reportedly the government will revise the regulation by eliminating the net metering scheme. It remains unclear how this will impact the solar sector in Indonesia, nonetheless it can be assumed that since the net metering would no longer be available (thereby not reducing electricity bills from rooftop solar users), this likely will make rooftop solar less attractive for the household sector.

[28] In early 2022, the Government of Indonesia, through the Ministry of Energy and Mineral Resources in collaboration with the UNDP, has launched an incentive program initiative for rooftop solar PV called the Sustainable Energy Fund (SEF). The program implementation ended in late 2022 and is awaiting further continuation and funding commitment support.

	• **Internet of Things (IoT) devices:** Smart meters, etc. can be used to track the generation and use of electricity by households, and to facilitate the implementation of net metering policies. • **Payment systems:** Electronic payment platforms and mobile wallets are required to facilitate the transfer of credits or payments for excess electricity generated by households and fed back into the grid. • **Data management systems:** For example, cloud-based platforms are required to store and manage data related to the generation and use of electricity by households, and to support the implementation of various incentives and financing options.
Are there policy linkages at different levels?	• Minister of Energy and Mineral Resources Regulation Number 26/2021 concerning the Use of Rooftop Solar Power Plant Systems by PLN Consumers. Through this regulation, people could pay cheaper electricity bills through the application of electricity "export-import" with PLN. However, reportedly the government is set to revise the regulation by eliminating the net metering scheme. • Until now, there has been no policy regarding rooftop solar PV incentives in the form of a special regulatory formulation.

Timeline	**2025–2030** for the combination of implementation of capex subsidy, tax exemption, and net metering policies, with illustrative details as follows.
	• **2024:** Launch the rooftop solar incentive program in WNT; set the initial subsidy amount at a competitive level to stimulate early adoption and establish an application process and eligibility criteria for households.
	  ○ As a seed fund, donors/climate funds can complement the state budget. Building and land tax exemption can also be introduced for rooftop solar users.
	  ○ A robust and attractive net metering policy is required. It is worth it to also create awareness campaigns to educate households about the benefits of rooftop solar.
	• **2025:** Continue promoting the rooftop solar incentive program through public awareness campaigns.
	  ○ Implement a gradual decrease of subsidy for rooftop solar under first come first serve basis.
	  ○ Allocate a budget and target to install around 100 MW rooftop solar capacity in residential sector across WNT.
	• **2026–2030:** Evaluate the progress of rooftop solar installations in WNT.

	○ Adjust and lower the subsidy amount, enhance the application and approval process to streamline and expedite the implementation.
Possible sources of financing	• State budget, in terms of subsidy or tax reliefs • Funds from donor agencies/philanthropy • Household investment • Bank financing system for rooftop solar power plant ownership (credit for rooftop solar power plant ownership), etc.
Estimated risks associated with implementation of the action	• If the **incentives are not sufficiently attractive** it may discourage households from participating. • Challenges in the **distribution** of rooftop solar incentives can hinder their effectiveness. If the incentives are not effectively communicated to households or if the distribution process is complex and burdensome, it can deter potential participants. Streamlining the application and distribution process, ensuring transparency, and providing user-friendly information can help overcome these challenges. • **Inconsistent or unclear regulations** on rooftop solar installations and net metering can pose risks. Utility resistance to net metering, which allows households to sell excess electricity back to the grid, can limit the financial benefits and make rooftop solar less attractive. Ensuring clear and supportive regulations, addressing utility resistance, and promoting net metering policies are essential for the success of rooftop solar programs. • **Inadequate consumer protection** measures can be a risk for households participating in rooftop solar programs. This includes issues related to misleading sales practices, poor-quality installations, or insufficient warranty and maintenance support. Implementing robust consumer protection regulations, quality standards, and accreditation systems can address these risks and provide confidence to households. • **High upfront costs** and limited availability of affordable loans or financing programs can make it challenging for households to invest in rooftop solar systems. Implementing financial mechanisms such as low-interest loans, green financing programs, or third-party ownership models can help to overcome this barrier. • The implementation of fiscal incentives has the potential to cause a decrease in local tax revenues, so an alternative **fiscal strengthening**

	strategy is needed. Cooperation with donor agencies such as UNDP in the context of SEF[29] can be a good example for the development of fiscal neutral incentives.
Definition of initiative leadership	• Agency of Energy and Mineral Resources • Ministry of Energy and Mineral Resources • PLN • Responsible agency on revenue management, including tax formulation

[29] https://www.undp.org/indonesia/projects/hibah-sustainable-energy-fund-sef-insentif-plts-atap

Action 2.2: Develop a rooftop solar obligation for luxury houses and apartments

Justification	This action intends to encourage the development of rooftop solar panels in high-end properties, whose owners are more able to afford such investments. The success of this initiative can bring down costs and make it feasible for households at large.
Implementation strategy	• Establish regulations that make it mandatory for luxury houses and apartments to install rooftop solar systems as a requirement for obtaining building permits. • Define the minimum capacity or percentage of rooftop area that must be dedicated to solar installations. • Develop technical standards and guidelines for the design, installation, and maintenance of rooftop solar systems in luxury properties. These standards should ensure safety, efficiency, and proper integration with the existing infrastructure. • To overcome resistance, one approach could be to offer incentives such as tax exemptions or rebates to those who install rooftop solar panels. The scheme could also be linked with the building permit for new housing and apartment buildings construction. This would provide a financial incentive for luxury homeowners and apartment dwellers to invest. • Another way to encourage development would be through awareness campaigns about the benefits of rooftop solar panels. • Finally, it may also be helpful to involve the luxury real estate industry in the push for rooftop solar panels. This could be achieved by working with real estate agents, developers, and builders to incorporate rooftop solar panels into the design of new luxury properties. This would help to make rooftop solar panels a more attractive and desirable feature for high-end buyers and encourage more widespread adoption.
Supporting technology	• **Solar Photovoltaic (PV) equipment:** This would include a solar PV system, inverter, solar charge controller and battery system (if needed), mounting system/racking, import-export kWh meter. • **Solar Photovoltaic (PV) System Design and Monitoring Tools:** To design and monitor rooftop solar systems, tools such as solar site analysis tools, system design software, and monitoring systems are required.
Are there policy linkages at	• Presidential Regulation No. 22/2017 of the National Energy General Plan (RUEN) states that luxury houses, housing complexes, and apartments that use more than 2200 VA are required to install solar

different levels?	panels on at least 25% of their roof area through the Building Construction Permit (IMB). • Ministry of Energy and Mineral Resources Regulation No. 26/2021 sets out the net metering policy.

Timeline	• **2023–2028:** Development and introduction of the policy proposal and guideline for the rooftop solar obligation for luxury houses and apartments, outlining the requirement for new luxury houses and apartments to install rooftop solar systems.
	  ○ Engage with luxury property developers and stakeholders to discuss the benefits and implementation process of the rooftop solar obligation.
	  ○ Conduct public consultations and awareness campaigns to educate luxury property owners, developers, and residents about the benefits of rooftop solar and the obligations under the new policy.
	• **2025–2030**: Gradually implement the rooftop solar obligation as a requirement for obtaining building permits for new luxury houses and apartments.
	  ○ Establish a certification and verification process to ensure compliance with the rooftop solar obligation, including periodic inspections and system performance monitoring.
	  ○ Provide financial incentives and support mechanisms to facilitate the adoption of rooftop solar for luxury properties, such as grants, tax incentives, and streamlined financing options.
	• **2031–2035**: Monitor the progress and compliance of luxury houses and apartments in meeting the rooftop solar obligation.
	  ○ Continue to refine and update the regulation based on feedback and lessons learned from the initial implementation phase.
	  ○ Strengthen monitoring and enforcement mechanisms to ensure ongoing compliance with the rooftop solar obligation.
	  ○ Conduct regular assessments of the policy's impact on renewable energy adoption, energy independence, and environmental sustainability.

Possible sources of financing	• Self-funding by the housing developer • Financing of financial institutions both retail to the public and corporately to housing and apartment developers • Investment by third parties (e.g. solar power plant developers) in leasing schemes for housing developers
Estimated risks associated with implementation of the action	• Some apartment developers and homeowners may be **resistant** to the rooftop solar obligation due to concerns about increased construction costs or perceived aesthetic impacts on luxury properties, resulting in delays, legal disputes, or non-compliance. Early engagement is critical. • The **upfront costs** of installing rooftop solar systems can be a significant barrier for luxury property owners, especially for large-scale installations required in apartment buildings. The financial burden may deter adoption unless attractive financial incentives, such as grants, subsidies, or tax incentives, are provided to alleviate the upfront costs. • Implementing a robust and attractive **net metering** policy is crucial to incentivize luxury property owners to install rooftop solar. However, challenges may arise in establishing fair net metering rates and ensuring smooth integration with the existing grid infrastructure. • Developing and **enforcing regulations** for the rooftop solar obligation can be complex, requiring coordination among multiple government agencies, utility providers, and stakeholders. Delays or confusion in the regulatory process may hinder the timely implementation and compliance of the obligation. • Luxury houses and apartments often have unique architectural designs, limited rooftop space, or structural limitations that may pose challenges for installing rooftop solar systems. Ensuring that the installations are **seamlessly integrated** into the luxury properties while meeting technical requirements can be a complex task. • **Ensuring proper maintenance** and monitoring of rooftop solar systems in luxury houses and apartments is crucial for optimal performance and longevity. Inadequate maintenance practices or system malfunctions may result in suboptimal energy generation and reduced financial benefits for property owners.

Definition of initiative leadership	• Agency of Energy and Mineral Resources • Ministry of Energy and Mineral Resources • PLN • Ministry of Public Works cq. Agency of Settlements and Housing

Action 2.3: Implement a modern cooking conversion pilot project

Justification	Many households still use traditional or fossil fuels for cooking, which have negative impacts on climate change as well as pollution—switching to electric or other low-carbon clean cooking options, such as biogas, can help tackle both.
Implementation strategy	Households that still use LPG should be encouraged to switch to cleaner and more sustainable alternatives such as electric or biogas stoves. The development of pilot projects is important, particularly for electric stoves. Implementation must also consider various aspects, especially the impact on electricity costs incurred by users in the household sector and behavioral adaptations required. The policy program includes the following key elements: • **Biogas conversion pilot project**: The program initiates a pilot project to promote the use of biogas as a clean cooking fuel. The project involves identifying suitable sites for biogas plants, educating households and communities about biogas production and usage, and providing support for the installation of biogas digesters and cooking appliances. • **Electric stove conversion:** Encourages households to switch from traditional cooking methods to electric stoves. The program provides incentives and support for households to purchase electric stoves, including financial assistance, subsidies, and access to affordable financing options. • **Awareness and education campaign:** Conducts a comprehensive awareness and education campaign to inform households and communities about the benefits of modern cooking technologies. This includes raising awareness about the health hazards of traditional cooking methods, promoting the environmental advantages of clean cooking, and providing information on the availability and benefits of biogas and electric stoves. • **Capacity building and training:** This includes training on the installation, operation, and maintenance of biogas digesters and electric stoves. Additionally, the program supports the development of local technicians and entrepreneurs who can provide such services. • **Research and development**: The program encourages research and development activities to explore innovative and sustainable

	solutions for modern cooking. This includes researching improved biogas production techniques, enhancing the efficiency of electric stoves, and investigating new cooking technologies that utilize renewable energy sources. • **Monitoring and evaluation**: The program establishes a monitoring and evaluation framework to assess the progress and impact of the pilot projects. This involves tracking the adoption of biogas and electric stoves, measuring the reduction in emissions and indoor air pollution, and evaluating the socioeconomic benefits for households and communities. • **Scaling-up and replication:** Based on the success of the pilot projects, the program aims to scale up the adoption of modern cooking technologies across West Nusa Tenggara. This involves expanding the availability and accessibility of biogas and electric cooking solutions, strengthening partnerships with relevant stakeholders, and integrating modern cooking practices into broader energy and sustainability initiatives.
Supporting technology	**Biogas** • **Biogas digesters:** These are essential devices that convert organic waste, such as animal manure, crop residues, or kitchen waste, into biogas through a process called anaerobic digestion. Various types of digesters are available, including fixed-dome, floating-drum, and plug-flow digesters. • **Gas storage and distribution**: Biogas needs to be stored and distributed efficiently. This can be done through gas storage systems, such as gas holders or gas tanks, which store the biogas produced by the digester. A distribution network consisting of pipes or hoses transports the biogas from the storage to the cooking stoves. • **Biogas stoves:** Biogas stoves are designed to burn biogas cleanly and effectively, providing a reliable and convenient cooking solution. • **Gas quality testing:** Gas quality testing devices, such as gas analyzers or gas sensors, help determine the composition of the biogas, including the percentage of methane, carbon dioxide, and other impurities. This information can guide adjustments to the digester operation and gas treatment processes, and ensure optimal functioning. • **Biogas appliances and accessories:** These may include biogas lamps, biogas water heaters, biogas refrigerators, and biogas

	electricity generators. The availability of these appliances can significantly impact the overall benefits of the biogas stove development program. • **Monitoring and evaluation systems**: This may involve the use of data loggers, energy meters, or remote monitoring systems to track biogas production, gas consumption, and stove usage. Regular monitoring and evaluation provide insights for program improvement and can help ensure long-term success. **Electric stoves:** • **Electric stove models:** These include coil stoves, smooth-top stoves, induction stoves, and electric ovens. All of them utilize electrical energy to generate heat for cooking. The choice of electric stove models depends on factors such as affordability, efficiency, safety, and cooking requirements. • **Energy efficiency measures:** Technologies such as energy-efficient heating elements, smart controls, and improved insulation can enhance the efficiency of electric stoves, thereby reducing energy costs and environmental impact. • **Electricity metering and billing systems**: Smart metering technologies enable real-time monitoring, remote reading, and precise billing, facilitating efficient energy management and customer engagement. • **Electrical safety measures:** Electrical safety is paramount when using electric stoves. Safety technologies such as circuit breakers, ground fault circuit interrupters (GFCIs), and residual current devices (RCDs) help protect against shocks and prevent electrical hazards. Promoting safety education and compliance with electrical codes and regulations is also important. • **Demand management and load balancing**: These technologies ensure a balanced distribution of electricity during peak demand periods, minimizing strain on the grid and enhancing system reliability.
Are there policy linkages at different levels?	• The Enhanced NDC of Indonesia includes mitigation actions in the energy sector, which include induction electric stoves. The target for this action is to have 18,170,000 electric stoves adopted by 2030. • For the uptake of biogas stoves in rural communities, there are some initiatives through the BiRU (Biogas Rumah) program undertaken by

	an civil society organization of Yayasan Rumah Energi and HiVOS (Yayasan Humanis dan Inovasi Sosial).[30]
Timeline	**2025–2030**, and possible extension for 5 years to 2035 for piloting some projects across WNT, with details: • **2025–2027:** ○ Launch awareness campaigns to educate communities about the benefits of modern cooking technologies. ○ Conduct feasibility studies to identify suitable pilot locations. ○ Begin consultations with stakeholders, including households, communities, local authorities, and relevant organizations, to gather input and build support for the program. ○ Select pilot sites for the biogas and electric stove conversion projects based on feasibility studies and stakeholder consultations. ○ Initiate training programs for local technicians and entrepreneurs on biogas and electric stove operation and safety. ○ Install biogas digesters and electric stoves in select households and monitor to assess performance and user satisfaction. • **2027–2030:** ○ Expand the pilot projects to additional households and communities. ○ Conduct comprehensive market assessments to understand the demand and market potential in WNT. ○ Collect and monitor data on energy consumption, emissions reduction, indoor air quality, and user feedback to evaluate effectiveness. ○ Identify any challenges or barriers encountered during the pilot phase and make necessary adjustments. ○ Review the results and lessons learned from the pilot projects to refine the program's design and address any identified issues. ○ Develop best-practice guidelines and standards for the installation, operation, and maintenance of biogas digesters and electric stoves.

[30] The program has developed biogas projects targeting those communities that still rely on kerosene and firewood under cooperative schemes in various areas particularly in Eastern Indonesia.

	○ Strengthen partnerships with local governments, financial institutions, and manufacturers to secure funding and support. • **Beyond 2030**: ○ Begin preparation for the commercial implementation phase, including the development of a detailed implementation plan, resource allocation, and regulatory frameworks.
Possible sources of financing	• State budget, both local and central government, includes provisions for fiscal incentives • Private sector support, including technology suppliers in pilot projects • Involvement of PLN in the electric stove pilot project • Crowdfunding, donor funding, philanthropy for the biogas stove project in rural communities, as well as under community cooperative schemes
Estimated risks associated with implementation of the action	• Some households and communities may be **resistant to transitioning** away from traditional cooking methods to modern cooking technologies. Therefore, they must be consulted from the early stages. • The initial cost of biogas digesters and electric stoves may pose a financial challenge for some households. The **affordability of these technologies**, needs to be addressed through financial incentives and accessible financing options. • The successful implementation of biogas and electric cooking systems relies on the **availability of skilled technicians and service providers**. The limited number of trained professionals and the need for ongoing technical support and maintenance could present a challenge during the scaling-up phase. • Ensuring the **quality and safety of biogas digesters and electric stoves** is crucial for user satisfaction and long-term sustainability. Poor quality products, inadequate installation practices, and insufficient safety measures could lead to operational issues, safety hazards, and a loss of confidence among users. • The **availability of appropriate infrastructure**, such as access to electricity and waste management systems, is essential for the effective implementation of biogas digesters. In areas with limited infrastructure development, additional investment and coordination may be required to overcome these limitations.

	• **Lack of knowledge and awareness** about the benefits, availability, and functioning of biogas and electric cooking technologies could hinder their widespread adoption. Comprehensive information dissemination and awareness campaigns are necessary to address this challenge. • The **absence of supportive policies and regulations**, including net metering arrangements, quality standards, and financial incentives, can impede the implementation of the modern cooking program. Clear and favorable policies need to be in place to encourage participation and create an enabling environment for the transition to modern cooking technologies.
Definition of initiative leadership	• Agency of Energy and Mineral Resources • PLN • Civil society organizations

Action 2.4: Disseminate energy-efficient electrical equipment knowledge and information

Justification	Drawing on national-level efficiency standards, WNT can spread awareness about the cost savings and benefits of more efficient equipment and appliances to encourage adoption in its territory.
Implementation strategy	• The dissemination of energy efficient electrical equipment knowledge and information can promote the adoption and use of energy-efficient electrical appliances, such as inverter air conditioners, refrigerators, and LED lights, in households and buildings in West Nusa Tenggara. • The program focuses on raising awareness about the benefits of energy-efficient equipment, as well as offering energy management training for households and housing/building managers. • The provincial government can lead by example by opting for more efficient options for lighting, cooling, etc. in its facilities.
Are there policy linkages at different levels?	• Government Regulation No. 16/2021 on Building • Government Regulation No. 33/2023 on Energy Conservation • ESDM Ministerial Regulation No. 14/2021 concerning Implementation of Minimum Energy Performance Standards for Energy Utilizing Equipment • Ministry of Public Works Regulation No. 2/2015 on Green Building • Ministry of Public Works Regulation No. 9/2021 on Sustainable Construction • Ministry of Public Works Regulation No. 21/2021 concerning Green Building Performance Assessment • This action is also supported by the preparation of WNT green-building regulations (Pergub or Perda). It should be noted that this action does not only involve the household sector, but the commercial and building sectors in general.
Timeline	**2025–2030:** • Launch a comprehensive awareness campaign through various media channels to promote energy-efficient equipment (brochures, ads, etc.). • Begin implementing energy labeling and standards for appliances to guide consumers in making informed choices. • Conduct energy management training programs for households and housing/building managers.

	• Strengthen collaboration with retailers and manufacturers to ensure the availability and accessibility of energy-efficient appliances in the market. • Enhance partnerships with local retail associations to provide exclusive discounts and promotions for energy-efficient appliances. • Conduct an extensive review of the program's effectiveness and gather feedback from stakeholders. • Use the collected data to further refine the program and identify new opportunities for knowledge dissemination. • Establish a monitoring and evaluation framework to track energy savings, consumer adoption rates, and overall program impact. • Review procurement guidelines for WNT's own facilities to opt for more energy-efficient appliances and equipment
Possible sources of financing	• State budget, both central and local government • International agency cooperation, such as the CLASP program, through technical assistance • Private financing support
Estimated risks associated with implementation of the action	• **Incorrect or misleading information** about energy-efficient electrical equipment can be disseminated, which can lead to confusion and mistrust. • People may be **resistant to changing their behaviors or purchasing new equipment**, even if it is more energy efficient. • There may be limited impact if people do not have the **financial means** to purchase or install the equipment, or if the **equipment is not readily available**.
Definition of initiative leadership	• Ministry of Energy and Mineral Resources • Agency of Energy and Mineral Resources

3.3 Action Pillar 3: Industry decarbonization

Objective	Helping local industries meet green industry standards to increase their competitiveness and encourage sustainable economic growth.
Outcomes	In the industrial sector, the objectives to be achieved under the roadmap are to encourage green industry development and certification. The program will be constructed in accordance with the green industry policy and standards by the Ministry of Industry (MoI) in Indonesia. Referring to the MoI as mentioned in the MoI Regulation No. 51/M-IND/PER/6/2015 on Guidelines for Setting Green Industry Standards and the Law No. 3/2014 on Industry, a green industry is an industry that in its production process prioritizes efficiency and effectiveness in the use of resources in a sustainable manner so as to be able to align industrial development with the preservation of environmental functions and to provide benefits to society.
SDGs	
Action 1	Provide technical assistance with green industry standardization
Action 2	Provide financial support for industrial energy efficiency
Action 3	Achieve zero fossil fuel use in the industrial sector

Success factors

3.3.1.1 Regulation

Align regional and national regulation

- A clear regulatory framework can provide the necessary guidance and incentives for the industrial sector to transition to more sustainable energy sources.

Streamline permitting and licensing

- Streamlined and efficient permitting and licensing procedures can help accelerate the deployment of hydrogen and other industrial infrastructure and facilities.
- Regular inspections and compliance checks can ensure adherence to safety standards throughout the project lifecycle.

Draw on insights from data

- Drawing insights from data to tailor approaches and monitor progress can go a long way.
- Regulations may require industrial energy users to report on their energy use, emissions, and other environmental impacts, and to monitor and report on their progress.

Develop and enforce specific safety standards and regulations

- Specific safety standards and regulations should be developed and enforced for the production, storage, transportation, and utilization of hydrogen in industrial processes.
- These standards should address aspects such as equipment design, handling procedures, storage facilities, and emergency response protocols.
- Close collaboration between regulatory bodies, industry stakeholders, and research institutions can ensure that safety standards are up-to-date and effective.

Implement monitoring infrastructure to assess and track environmental impacts

- Implement monitoring infrastructure to assess and track the environmental impacts of industrial activities.
- This includes air quality monitoring stations, water quality monitoring systems, and other environmental sensors to ensure compliance with sustainability goals and regulatory standards.

Establish a robust monitoring, reporting, and verification system

- This is needed to track the progress of the transition to zero fossil fuel use and hydrogen research in the industrial sector.
- Regular reporting on key indicators, such as energy consumption, emissions reduction, and research outcomes, can provide valuable feedback and inform policy adjustments if necessary.

3.3.1.2 Infrastructure

Establish a robust infrastructure for renewable energy generation

- This includes solar farms, wind farms, and biomass facilities. These infrastructures will provide clean and sustainable energy sources to power industrial processes, reducing reliance on fossil fuels.

Enhance the electrical grid infrastructure

- Enhance the electrical grid infrastructure to accommodate the integration of RE sources and hydrogen technologies.
- This includes upgrading transmission and distribution systems, implementing smart grid technologies, and developing energy storage solutions to balance intermittent renewable energy generation and ensure a reliable energy supply.

3.3.1.3 Technology and research

Allocate funds for research and development

- Allocating funds for research and development (R&D) activities related to hydrogen and other industrial technologies will support their advancement and readiness.
- Establishing partnerships between academia, research institutions, and industry players can foster collaborative R&D efforts, leading to the development of innovative solutions, improved safety protocols, and cost-effective applications of hydrogen in industrial processes.

Encourage technology demonstration projects

- Encouraging technology demonstration projects can showcase the viability and benefits of hydrogen technologies in real-world industrial settings.
- These projects can involve pilot installations, collaborations between industry and research institutions, and knowledge-sharing platforms.
- Successful demonstration projects can build confidence, generate data on performance and safety, and encourage wider adoption of hydrogen technologies.

Create platforms for collaboration and knowledge exchange

- Creating platforms for collaboration and knowledge exchange among industry stakeholders, government agencies, research institutions, and international partners can accelerate the adoption of hydrogen and other zero-fossil-fuel technologies.
- These platforms can facilitate the sharing of best practices, lessons learned, and technological advancements, fostering a supportive ecosystem for the transition to zero fossil fuel use.
- Foster international collaboration and partnerships to benefit from global expertise, knowledge, and resources in hydrogen research.

3.3.1.4 Governance

Foster coordination and collaboration

- Foster coordination and collaboration among relevant government agencies, departments, and ministries responsible for energy, industry, environment, and research.
- Effective interagency coordination ensures a coherent and integrated approach to policy development, implementation, and enforcement.

Develop and enforce regulations and standards

- Develop and enforce regulations and standards specific to zero fossil fuel technologies, including hydrogen.
- These regulations should cover safety protocols, technology standards, permits, licensing, and quality control to ensure the safe and efficient adoption of new technologies.
- Regular updates and amendments to regulations should be considered to keep pace with evolving technologies and industry best practices.

Build capacity and skills

- Develop and implement programs for capacity building and skills development related to zero fossil fuel technologies and hydrogen research.
- This includes training programs, workshops, and educational initiatives to enhance the technical capabilities of professionals, researchers, and workers in the industrial sector.
- Capacity building efforts should also focus on promoting gender equality and inclusivity in the workforce.

Consider creating energy management awards

- Consider the application of non-fiscal incentives such as awards for the implementation of energy management in industry.

Benefits

3.3.2.1 Environmental benefits

- The **socialization** of green industry and energy-efficient equipment is expected to increase the awareness of industrial facility managers to apply the principles of environmentally friendly green industry.

- Providing incentives and disincentives will encourage the **growth of green industries** in WNT and will contribute to reducing emissions from the industrial sector.

- By eliminating fossil fuel use in the industrial sector, WNT can significantly **reduce its carbon footprint** as well as improve air quality due to reduced emissions.

- By eliminating fossil fuel use, the industrial sector can **reduce the demand for water-intensive extraction** and minimizing the risk of water pollution from fossil fuel operations.

- Fossil fuel extraction and use are associated with various environmental risks, including oil spills, accidents at extraction sites, and the release of toxic chemicals. By transitioning to renewable energy sources, WNT can **mitigate these risks**.

- Embracing zero fossil fuel use promotes sustainable development and **fosters a green economy**. WNT can create new job opportunities, stimulate economic growth, attract green investments, and establish itself as a leader in sustainable industrial practices for the long-term.

3.3.2.2 Socioeconomic benefits

- Widespread dissemination activities throughout the community can encourage an **increase in the number of green industries** in WNT.

- **Improved public health** due to reduced emissions from the shift away from fossil fuels.

- The shift towards renewable energy technologies and infrastructure **creates new job opportunities and stimulates economic growth**. The development, installation, and maintenance of renewable energy systems require skilled labor, local supply chains, and a local workforce.

- Shifting towards renewable energy sources can lead to **long-term cost savings** for industries due to reduced operational costs.

- Embracing zero fossil fuel use can **attract domestic and international investments** as investors are increasingly interested in projects aligned with sustainable development goals.

- Reducing dependence on imported fossil fuels **improves energy security and resilience**, decreasing WNT's vulnerability to price fluctuations and supply disruptions.

Targets and indicators

Table 10: Targets and indicators in industry sector

Target	Medium-term target	Indicator	Share
To implement green industry standardization in the industrial sector in WNT, including the implementation of energy management and savings	In the period 2025-2030, the targets are as follows: • More than 10 industrial companies in WNT should be categorized as green industries referring to the government (Ministry of Industry) • To achieve energy consumption savings, including electricity and gas, in the WNT industrial sector of 15% compared to 2025 with business-as-usual growth	• Number of companies/industries in WNT that are categorized as green industries • Percentage of savings (decrease) in energy consumption, including electricity (from PLN network) in the industrial sector in 2050 compared to 2025 conditions	• By 2050, all industries in WNT (100%), especially large and medium industries should be categorized as green industries, including implementing energy management and savings. • By 2050, achieve energy savings or conservation, both in the form of electricity (from the PLN network) and gas in WNT of 50% compared to 2025 conditions.
Rooftop solar for industrial buildings	By 2035, 50% of industrial buildings, especially those categorized as *energy intensive* (including the medium, large, and mining	Percentage of industrial buildings in WNT that use rooftop solar PV	75% of all industrial buildings in WNT should be operating rooftop solar by 2050. Specific oversight will be deployed by the local government where

Target	Medium-term target	Indicator	Share
	manufacturing sectors) should have rooftop solar PV.		mandatory rooftop solar installation will be one of the requirements for permit extension and green industry certification.
Zero fossil fuel use in the industrial sector in WNT	By 2035, 50% of LPG-based heating and energy sources in the industrial sector should have been replaced by biogas/bio-CNG, biomass residues, and other forms such as hydrogen and synthetic fuels.	Percentage decrease in LPG use and increase in biogas/bio-CNG penetration, hydrogen utilization, and use of biomass residues in the industrial sector in WNT	By 2050, 100% of industries in WNT should use bio-CNG/biogas, residual biomass, hydrogen, synthetic fuels, and no more LPG.

The following is an explanation of the indicators for achieving the roadmap targets in the energy sector:

Table 11: Explanation of the indicators in the industry sector

Indicator	Definition		
	Description	Calculation method	Period
Number of companies/industries in WNT that are categorized as green industries	Calculate the number of companies categorized as green industry based on government regulations or any other benchmarks internationally available; an established coordination with the Ministry of Industry is required.	Calculate the number of industries/companies categorized as green industries	2025-2050
Percentage of energy conservation or savings achieved in the industrial sector compared to the condition in 2025	Calculate the trend of energy consumption (including electricity from the PLN network) in the industrial sector as a result of energy savings obtained from the implementation of green industry as well as the installation of *energy-efficient* equipment such as *high-efficient* HVAC and energy-efficient lighting in the industrial sector.	Compare the difference in average energy consumption in the industrial sector in 2025 to the average energy consumption in 2050. The calculation can be done by using annual electricity consumption data in the industrial sector from PLN.	2025 - 2050
Percentage of industrial buildings including factories in WNT that use rooftop solar PV	Calculate the number of industries in WNT that have installed rooftop solar power plants to reduce PLN electricity consumption and at the	Compare the number of industries in WNT that have used rooftop solar PV to the total number of industries in WNT.	2025 - 2050

	same time increase the renewable energy mix.		
Percentage of industries in WNT that use biogas and biomass residues for boilers	Count the number of industries in WNT that have used biogas and/or biomass boilers to replace LPG. In addition, also count the number of industries that have utilized non-LPG and non-coal boilers (can be through capex investment or long-term contract with a third party).	Compare the number of industries in WNT that use biogas to the total number of industries in WNT.	2025 - 2050

Action 3.1: Provide technical assistance with green industry standardization

Justification	Green industry standards are currently voluntary, with 17 types of industry standards launched for implementation by the Ministry of Industry. The government plans to selectively make these standards compulsory. WNT has potential to be a pilot region for the extensive implementation of the green industry standard.
Implementation strategy	A "green industry" is an industry that prioritizes the sustainable use of resources in the production process to balance industrial development with their environmental and waste impact, including circularity principles. Examples include the use of environmentally friendly raw materials or processes, the application of the 3R concept (reduce, reuse, recycle), and in a broad sense saving energy in the manufacturing process and using environmentally friendly or low carbon technologies (such as renewables, biogas, processing waste into fuel, carbon capture and storage, etc.). This also can be elaborated as a part of ISO 140001 certification on environmental management. One of the elements in green industry is energy management and conservation, including through the application of SNI ISO 5001 regarding energy management. Based on Government Regulation No. 33/2023 on Energy Conservation, energy users of at least 4,000 TOE are required to carry out energy management, namely appointing an energy manager, preparing an energy conservation program, conducting regular energy audits and implementing recommendations, and reporting progress annually to the government. According to the Ministry of Industry, the Green Industry Standard is a reference for industry players to develop a consensus related to raw materials, auxiliary materials, energy, production processes, products, business management, waste management and/or other aspects that aim to realize a green industry. In this roadmap, the application of green industry standards including SNI ISO 50001 will start in the form of socialization to relevant industry players, training/technical assistance, and the application of these standards for industries starting with large industries. The implementation of the actions and strategies will start from the large industry group that refers to the Regulation of the Minister of Industry No. 64/M-IND/PER/7/2016 on the Number of Workers and Investment Value for Industrial Business Clarification. This is because

	large industries in WNT tend to be limited in number and are classified as having intensive energy consumption patterns so that policy implementation and monitoring for the initial stage will be easier, controlled, but contribute significantly to energy conservation efforts. In short, this action means to disseminate information and spread awareness about green industry, including ISO 140001 and ISO 50001 energy management training for industrial facility managers, and its implementation based on local government policies. The WNT Provincial Government also needs to compile technical information on energy-efficient equipment in the industrial sector.
Supporting technology	• **Expert instructor:** Certified in energy management and circular economy • **Energy-saving technologies**: High-efficiency boilers, condensing economizer, green chiller, waste heat recovery, energy-efficient lighting, ceiling fans, and rooftop solar panels
Are there policy linkages at different levels?	• Government Regulation No. 14/2015 on the National Industrial Development Master Plan (RIPIN) 2015-2035 • Government Regulation No. 29/2018 on Industrial Empowerment • Government Regulation No. 33/2023 on Energy Conservation

Timeline	**2024–2050**
	• **2024:**
	  ◦ Programmatic approach and policy preparation and development
	  ◦ This includes knowledge dissemination, campaign, socialization, and the initiation of ISO 14001 and ISO 50001 training and certification.
	• **2024–2030:**
	  ◦ Continued information dissemination efforts with advanced ISO 14001 and ISO 50001 training and workshops for industrial facility managers to enhance their understanding and implementation of energy management systems.
	  ◦ This also involves customized training and capacity building for specific industrial sectors to address their unique energy management challenges and empower industrial facility managers with the necessary skills and knowledge to drive sustainable practices.

	• In these years, an increased collaboration with industry associations, experts, and other stakeholders to expand the reach and impact of the green industry initiatives. • The partnerships are also enhanced with educational institutions and research organizations to promote research and innovation in energy-efficient technologies. • The strengthening of cooperation with the Ministry of Industry is also expected to enforce and monitor compliance with green industry policies, providing support and guidance to industrial facilities. In parallel, evaluation of the progress and impact of the implemented initiatives, followed by the preparation of reports highlighting achievements and areas for improvement, shall be conducted. • **Beyond 2030:** • The WNT Provincial Government continues to prioritize green industry and energy management, with a focus on sustained implementation, monitoring, and evaluation.
Possible sources of financing	• Budget from the local and central government • Funds from donor agencies/philanthropy • Private financing for certified energy management training activities and investment (and/or retrofitting) of energy-efficient equipment for factory/industry use
Estimated risks associated with implementation of the action	• **Lack of awareness and interest** in the industrial sector to implement green industry principles due to the absence of sufficient incentives and disincentives, as well as dominant growth-oriented agenda. This transformation should ideally take place amidst a broader rebalancing of incentives away from fossil fuels towards renewable energy. • The cost (both economic and time) of energy management training participation may be considerable for some industries. Hence, there is a **possibility of low participation in training activities**. • The number of energy managers, engineers, technical personnel, and energy auditors is **limited**, so the possibility of getting qualified human resources is not easy and takes time. • **Energy audits are not usually cheap** when relying on third-party energy auditors, affecting their implementation.

	• The results of energy audits often recommend measures that **require large investments**, so often these recommendations are not implemented, enabling further pollution and continued use of unsustainable energy sources with certification providing justification for continued company patterns.
Definition of initiative leadership	• Ministry of Industry • Agency of Industry • Agency of Energy and Mineral Resources

Action 3.2: Provide financial support for industrial energy efficiency

Justification	The lack of knowledge within industries about the benefits of implementing energy efficiency, coupled with various challenges, can be addressed by providing support through financial mechanisms or incentives depending on industry capabilities.
Implementation strategy	Providing incentives for the implementation of energy conservation and retrofitting technologies to save energy is another form of encouragement for the implementation of environmentally friendly, low-emission, and energy-efficient industries. • For small industries, efforts to make energy savings are usually hindered by the cost of obtaining energy-efficient technology, so assistance in the form of **grants** is needed for small industries to carry out energy efficiency activities. • For large and medium industries, local governments need to provide **incentives** for industrial facility managers who have implemented energy management. These incentives can be in the form of fiscal incentives such as local tax relief, as well as non-fiscal incentives such as awards for facility managers who have implemented green industry standards including ISO 50001 energy management well. • In addition to incentives, to encourage the growth of green industries, local governments can also provide **disincentives** for industrial managers who do not implement energy management. The form of disincentives provided can also be fiscal and non-fiscal such as the application of additional taxes, etc.
Supporting technology	**Energy-saving technologies**: High-efficiency boiler, condensing economizer, green chiller, waste heat recovery, and energy-efficient lighting
Are there policy linkages at different levels?	• Government Regulation No. 33/2023 on Energy Conservation • ESDM Ministerial Regulation No. 14/2021 on Implementation of Minimum Energy Performance Standards for Energy Utilizing Equipment
Timeline	2025-2050
Possible sources of financing	• State budget, both central and local government • Private investment such as the energy services company (ESCO) or direct investment in energy efficiency equipment by the building or industry owners

	• Funding from donor agencies or philanthropy with a focus on energy management
Estimated risks associated with implementation of the action	• The **incentives provided are not enough to attract interest** from industry managers to encourage the implementation of energy management. • The **disincentives imposed are not enough to make industry managers comply** with green industry principles. • The application of fiscal taxes/disincentives may potentially **reduce industry competitiveness** or resistance from industry players. • There is a **weak incentive disbursement mechanism**. • **Monitoring to enforce disincentives** is often less effective. • Overreliance on grants leaves businesses **vulnerable to changes in donor environment** and international relations.
Definition of initiative leadership	• Agency of Industry • Agency of Local Development Planning

Action 3.3: Achieve zero fossil fuel use in the industrial sector

Justification	Decarbonizing industries is crucial for WNT in achieving the target of net-zero emissions by 2050 given their energy-intensive nature.
Implementation strategy	Achieving zero fossil fuel use in the industrial sector in West Nusa Tenggara (WNT) requires a multi-faceted approach. To successfully implement these measures, several factors need to be considered: • Firstly, technology adoption is crucial. The industrial sector in WNT would need to invest in and adopt the necessary technologies for biomass utilization, Bio-CNG production, hydrogen technology, and solar energy systems. This may require incentives, subsidies, and supportive policies from the government to encourage and facilitate the transition. • Secondly, investment matters should be taken into account. The transition to zero fossil fuel use would require financial resources to procure and install the required infrastructure and equipment. • Furthermore, capacity building and training programs can help educate and train the workforce in the utilization of new technologies and sustainable practices. This would ensure a smooth transition and create job opportunities in the renewable energy sector. Certain areas that are amenable to renewable energy integration include: • Replacing coal boilers with biomass derived from agricultural waste, which is abundant in the region, for industrial heating purposes. Some examples have been done in Indonesia such as in a food and beverages industry in East Java and Central Java31. • Substituting liquefied petroleum gas (LPG) with Bio-CNG, also known as renewable natural gas (RNG), produced from organic waste materials through a process called anaerobic digestion. This biogas primarily consists of methane, which is the main component of natural gas. • The industrial sector in WNT can also explore the use of hydrogen. Hydrogen is a versatile and clean energy carrier that can be produced from renewable sources through electrolysis. By incorporating hydrogen technology into industrial processes, such

[31] Catriana, E. (2020) Gandeng BECIS, Nestle Bangun Biomass Boilers di Pabriknya. Available at: https://money.kompas.com/read/2020/12/15/185402526/gandeng-becis-nestle-bangun-biomass-boilers-di-pabriknya. Authors: Elsa Catriana Editors: Ambaranie Nadia Kemala Movanita (Accessed: 03 July 2023).

	as fuel cells or hydrogen combustion, the sector can further reduce its reliance on fossil fuels and contribute to a greener and more sustainable energy system. • The implementation of rooftop solar panels in factories and industries can play a role in achieving zero fossil fuel use. Solar energy can offset the need for some amount of traditional fossil fuel-based power sources.

Supporting technology	• **Biomass conversion technologies**
	  • **Biomass boilers:** These are specialized boilers designed to efficiently burn biomass fuels, such as agricultural waste, rice husks, and wood waste, to produce steam or hot water for industrial processes.
	  • **Biomass gasification:** This is a thermochemical process that converts biomass into a synthetic gas (syngas) containing mainly hydrogen, carbon monoxide, and methane. Syngas can be further used for heat generation or converted into other valuable products.
	  • **Biomass and waste handling and processing equipment:** This includes equipment such as shredders, grinders, and conveyors that can handle and process different types of biomass and waste materials.
	  • **Fuel storage and handling systems:** These systems include silos, bins, and conveyors that can store and transport biomass and waste fuels to the boilers.
	
	• **Bio-CNG production technologies**:
	  • **Anaerobic digestion:** This biological process converts organic waste, such as agricultural residues, food waste, or wastewater sludge, into biogas through the action of anaerobic microorganisms. The biogas can then be upgraded and purified to produce Bio-CNG.
	  • **Biogas upgrading**: Biogas upgrading technologies, such as pressure swing adsorption (PSA) or water scrubbing, remove impurities, especially carbon dioxide (CO2), to meet the specifications of natural gas standards for use as Bio-CNG.
	  • **Compression and storage:** Technologies for compressing Bio-CNG to high pressures and storing it in suitable containers are necessary for its utilization as a fuel.
	
	• **Hydrogen infrastructure:**
	  • **Electrolysis**: Electrolysis technology uses electricity to split water into hydrogen and oxygen. This process can be powered by RE

	sources, such as solar or wind, to ensure the production of green hydrogen. • **Fuel cells**: Hydrogen fuel cells convert hydrogen into electricity and heat through an electrochemical reaction. They can be used as a clean power source for various industrial applications, such as backup power, material handling equipment, or vehicle propulsion. • **Rooftop solar technologies:** • **Solar panels:** Solar panels capture sunlight and convert it into electricity through the photovoltaic effect. These panels are typically made of silicon-based solar cells. • **Inverters**: Inverters convert the DC (direct current) electricity generated by solar panels into AC (alternating current) electricity suitable for industrial use or grid connection. • **Mounting systems**: Mounting systems are used to securely install solar panels on rooftops, optimizing their orientation and tilt for maximum energy generation. • **Energy management systems**: Energy management systems monitor and optimize the performance of solar systems, ensuring efficient energy production and integration with other energy sources and loads.
Are there policy linkages at different levels?	• Government Regulation No. 29/2018 on Industrial Empowerment • Government Regulation No. 33/2023 on Energy Conservation
Timeline	2025–2050, with details as follows: • **2025–2030**, focuses on low hanging fruit technology adoption towards the zero fossil fuel use in the WNT industrial sector. • **Awareness and planning**: The government of WNT initiates awareness campaigns and engages stakeholders to highlight the importance of transitioning to a zero fossil fuel future. Planning and policy development begin to set targets and create a roadmap for the industrial sector's decarbonization. • **Pilot projects**: Several pilot projects are launched to demonstrate the feasibility and benefits of renewable energy technologies. This includes the installation of rooftop solar systems in selected factories and industries, showcasing their potential for clean energy generation.

- **Biomass adoption**: Industrial facilities start adopting biomass boilers, utilizing agricultural waste, rice husks, and wood waste as an alternative to coal for heating purposes. Some industries also begin exploring the implementation of biomass gasification technologies.
- **Scaling up renewable energy**: The use of rooftop solar expands significantly across the industrial sector in WNT. More factories and industries install solar PV systems, taking advantage of the region's abundant sunlight. The government introduces supportive policies and incentives to accelerate the adoption of renewable energy technologies.
- **Energy efficiency and innovation**: Industries focus on energy efficiency measures, implementing advanced technologies and process optimization to minimize energy consumption. Continuous innovation and research drive the development of more sustainable industrial practices, further reducing environmental impact.

- **2030–2040:**
  - **Bio-CNG integration**: Adoption of Bio-CNG as a replacement for LPG gains traction. Anaerobic digestion facilities are established to convert organic waste into biogas, which is then upgraded to Bio-CNG quality. The infrastructure for Bio-CNG production, distribution, refueling stations, safety, and storage is developed to meet the growing demand.
  - **Hydrogen technology introduction**: The industrial sector starts exploring the integration of hydrogen technology. Electrolysis facilities are established to produce hydrogen from renewable energy sources, and initial applications such as hydrogen fuel cells for backup power or material handling equipment are introduced.

- **2040–2050:**
  - **Significant RE penetration**: The industrial sector in WNT achieves a high level of RE penetration. The majority of factories and industries rely on a combination of biomass, solar, and Bio-CNG for their energy needs, significantly reducing their dependence on fossil fuels.

	● **Advanced hydrogen applications**: Hydrogen technology becomes more mature and widely adopted in the industrial sector. Industries explore advanced applications such as hydrogen-based heating systems, hydrogen fuel cells for industrial processes, and hydrogen-powered vehicles for transportation within industrial complexes. ● **2050:** ● **Zero fossil fuel use**: The industrial sector in WNT successfully achieves zero fossil fuel use. All coal boilers have been replaced by biomass boilers, and LPG is entirely substituted with Bio-CNG. Industries have fully integrated rooftop solar systems, meeting a significant portion of their electricity demand through clean energy generation. Hydrogen technology is expected to become a mainstream energy solution, contributing to the decarbonization of various industrial processes.
Possible sources of financing	● State budget from WNT or the Government of Indonesia, particularly for derisking ● International climate funds such as the Green Climate Fund (GCF), the Global Environment Facility (GEF), or the Clean Development Mechanism (CDM) ● Private sector investments, which can be facilitated through favorable policies, tax incentives, and regulatory frameworks. Private financing for biomass conversion can also be done through steam supply and sales agreement. This type of contract and project structure has been implemented in several industrial factories in Java. ● Development banks and financial institutions such as the Asian Development Bank (ADB) or the World Bank ● Carbon pricing and carbon markets: Implementing carbon pricing mechanisms, such as carbon taxes or emissions trading systems, can generate revenue that can be directed towards funding RE projects. ● Energy efficiency financing: Energy efficiency measures can significantly contribute to reducing fossil fuel use in the industrial sector. Financial mechanisms, such as energy performance

	contracts, energy service companies (ESCOs), or green building financing, can provide upfront capital for energy efficiency upgrades, with the investment recovered through energy savings over time. • Relevant action: Providing positive publicity to attract beneficial contributions from individuals, organizations, or entities by providing awards, certificates, public announcements, or media coverage.
Estimated risks associated with implementation of the action	• The adoption of new technologies might require **infrastructure upgrades**, modifications to existing processes, and retraining the workforce and so will require proper planning, expertise, and adequate investment. Broad market acceptance must be created by building trust in safety and benefits of switching to biomass-and hydrogen-based technologies. • The **initial capital costs** associated with transitioning to zero fossil fuel use can be significant. Securing funding and ensuring the economic viability of these projects can be a challenge. Additionally, fluctuations in the costs of renewable energy technologies and fuel feedstocks, such as biomass or bio-CNG, can impact the long-term financial feasibility of these projects. • The **availability and reliability of feedstocks**, such as biomass and agricultural waste, may pose a risk. Changes in agricultural practices, weather patterns, or competing demands for feedstocks can impact availability and cost. Additionally, for technologies like bio-CNG, ensuring a consistent supply of organic waste materials may require efficient waste management systems and reliable feedstock sourcing. • Some of the technologies involved may still be in the **early stages** of development or commercialization. Ensuring their readiness and efficiency of will require rigorous testing, R&D efforts, and continuous improvement. • Implementing certain technologies, such as hydrogen, requires careful attention to **safety considerations**. Hydrogen is highly flammable and requires proper handling, storage, and transportation. • **Integrating variable RE generation into the grid may be challenging**, posing problems for balancing supply and demand, and ensuring grid stability and reliability. Proper grid

	infrastructure upgrades, energy storage solutions, and smart grid management systems are necessary to address these challenges. • **Inadequate or inconsistent regulatory and policy frameworks** can create uncertainties and challenges. Regulatory uncertainties may discourage investments and hinder the adoption of certain technologies. Industries require clear and supportive policies. • **Environmental impacts and sustainability**: While the transition to zero fossil fuel use is aimed at reducing environmental impacts, it is essential to carefully consider the potential environmental impacts associated with alternative technologies. For example, biomass sourcing should be done sustainably to avoid deforestation or overexploitation of resources. Additionally, the production and disposal of certain materials used in renewable technologies, such as solar panels or hydrogen production catalysts, may have their own environmental considerations that need to be managed properly.
Definition of initiative leadership	• Agency of Industry • Agency of Energy and Mineral Resources • Ministry of Energy • Ministry of Energy and Mineral Resources

3.4 Action Pillar 4: Green building implementation

Objective	To implement green building principles through the application of renewable energy and energy efficiency, targeting 25% energy savings in the commercial building sector by 2050.
Outcomes	The roadmap encourages commercial buildings in WNT to apply green building principles. There are various green building standards that can be adopted, including those from the Leadership in Energy and Environmental Design (LEED), Building Research Establishment Environmental Assessment Method (BREEAM), Green Mark, and Greenship. In general, green building refers to the design, construction, and operation of buildings with a focus on improving their environmental and health performance. The goal of green building standards is to create buildings that are energy efficient, environmentally sustainable, and healthy for the occupants. Green building typically considers a range of parameters, including: • Energy intensity: The amount of energy used by a building per unit of floor area or per capita, with the goal of reducing energy consumption and promoting the use of clean, renewable energy sources. • Water efficiency: The use of water-saving technologies and practices, such as low-flow fixtures, rainwater harvesting, and greywater reuse, to reduce water consumption and protect water resources. • Indoor environmental quality: The health and well-being of building occupants, including air quality, lighting, acoustics, and thermal comfort. • Materials and resources: The selection and use of materials that are environmentally friendly, sustainable, and non-toxic, and the reduction of waste and the use of recycled materials. • Site selection and land use: The impact of a building on the natural environment, including the protection of wildlife habitats and the reduction of land use and sprawl. • Innovation: The development and implementation of new, innovative technologies and practices that promote sustainability and environmental performance in the building sector.

	These parameters can guide the green building rating category that, along with other methodologies, are used to 1) evaluate the environmental performance of buildings, 2) guide the design and construction of new, sustainable buildings, and 3) guide the retrofitting of existing buildings. By considering these parameters, green building promotes the efficient use of resources and the reduction of environmental impact in the building sector. However, in this context, the roadmap focuses on meeting the energy efficiency aspects of buildings with the following objectives.
SDGs	
Action 1	Disseminate green building knowledge to commercial building managers
Action 2	Design and implement incentives and disincentives to encourage adoption of green building standards
Action 3	Mandate energy audits for government and commercial buildings
Action 4	Implement rooftop solar obligation for specific buildings

Success factors

3.4.1.1 Regulation

Obtain regular reports

Governments can require building owners and managers to regularly report on their energy use, energy conservation practices, and energy management programs. This information can be used to assess progress and tweak incentives.

Set standards for energy management

Governments can set standards for energy management and energy audits that building owners and managers must comply with. This can include minimum requirements for energy efficiency, energy conservation, and energy management practices.

Provide grant programs

Governments can provide grant programs to help building owners pay for the installation of rooftop solar panels and energy efficiency measures, including to stimulate the market in the early stages.

Run awareness campaigns

Governments can run awareness campaigns to educate building owners, the public, and industry professionals about the benefits of rooftop solar installations and the reasons behind the mandate.

3.4.1.2 Technology and research

Conduct research on sustainable building materials and construction methods

Research sustainable building materials and construction methods, such as the use of recycled materials and environmentally responsible manufacturing processes, can help building managers reduce the environmental impact of their buildings.

Assist managers to evaluate environmental performance

Advancements in building performance simulation and analysis tools, such as life cycle assessment and building energy modeling, can help building managers evaluate the environmental performance of their buildings and make informed decisions about upgrades and retrofits.

Keep up to date with data collection and analysis tools

Advancements in data collection and analysis tools, such as Internet of Things (IoT) devices and cloud-based data management platforms, can help building managers monitor and analyze building performance data in real-time and make informed decisions about building operations.

Conduct research on energy efficiency education

Research is needed to understand the most effective methods for educating building owners, managers, and the public about energy efficiency.

Conduct research on creating efficient buildings that interact with the grid

This is a useful way to optimize energy use and production.

3.4.1.3 Infrastructure

Assist managers in accessing resources on green building practices

Commercial building managers need access to comprehensive and up-to-date information and resources on green building practices, including guidelines, best practices, and case studies.

Use programs that certify and label green buildings

Programs that certify and label green buildings can help building managers demonstrate the environmental performance of their buildings and provide a useful tool for marketing and communication.

3.4.1.4 Governance

Collaborate with universities to become a knowledge hub

Collaborating with universities on green building-related activities can help the WNT government, through the Agency of Public Works, become a knowledge hub.

Collaborate across government agencies

Although central government resources may be beneficial, the agency in charge of asset and revenue management along with the technical agencies such as the Agency of Public Works and the Agency and Energy and Mineral Resources need to work together to develop regulations and oversee the implementation of incentives and assessments.

Support education and training programs

Governments can support education and training programs for building managers and professionals, helping to build capacity and knowledge of green building practices. Building managers may need technical assistance and support practices, including access to consultants, engineers, and other experts, and networking opportunities.

Set clear policies and regulations

Clear policies and regulations are necessary to define the requirements and expectations for green building practices, and to provide a framework for implementation and enforcement. This can include building codes, energy efficiency standards, and other regulations that promote sustainable building practices. Their implementation must be effective, transparent, and accountable.

Ensure effective implementation through enforcement mechanisms

Effective implementation is necessary. This can include the establishment of enforcement mechanisms, such as penalties for non-compliance, as well as incentives for meeting or exceeding performance targets.

Prioritize stakeholder engagement

Stakeholder engagement is necessary to ensure that the needs and perspectives of all parties involved in the building industry are taken into account, including building owners and managers, architects and engineers, contractors, and the public. This can

include the establishment of stakeholder working groups, public consultations, and other engagement mechanisms.

Make use of monitoring and evaluation systems

Monitoring and evaluation systems are necessary to track progress and assess the impact of green building policies and incentives, as well as to identify areas for improvement. This can include performance monitoring and reporting systems, benchmarking tools, and other data collection and analysis mechanisms.

Continuously seek to improve green building policies and incentives

Continuous improvement is necessary to ensure that green building policies and incentives are continuously refined and updated to reflect the latest best practices and changing circumstances. This can include regular reviews and updates to building codes and regulations, and ongoing stakeholder engagement and feedback.

Regulate third-party ownership arrangements

Third-party ownership arrangements, in which a separate company owns and operates the rooftop solar PV systems, must be regulated to ensure the fair treatment of all parties involved.

Benefits

3.4.2.1 Environmental benefits

- A key benefit is **reduced greenhouse gas emissions** and other pollutants due to use of RE technologies to replace fossil fuels.

- Improved efficiency can result in **fewer resources** consumed for the same output, and therefore lower costs and emissions.

- Green building standards often include measures to **conserve water**, such as low-flow plumbing fixtures and rainwater harvesting systems, which can help to reduce water use.

- Encouraging building owners and managers to adopt sustainable waste management practices, such as composting and recycling, can help to **reduce waste** and pollution and conserve resources. Knowledge of sustainable building materials and methods can

help managers make informed decisions about the materials used in their buildings, reducing the waste generated during construction and operation of the building.

3.4.2.2 Socioeconomic benefits

- The installation and maintenance of rooftop solar panels **can create new jobs** in the green economy, It requires a skilled technical workforce. Likewise, the operational and maintenance phases of rooftop solar require additional technical manpower.

- By generating their own electricity, commercial buildings can reduce their dependence on the electrical grid and **improve their energy reliability**.

- Rooftop solar panels can **increase the value of commercial buildings**, providing a financial benefit to owners and investors.

- By generating their own electricity, commercial buildings can reduce their energy bills and **realize cost savings** over time.

- Green building practices can help commercial building managers **differentiate their buildings in the marketplace**, attracting tenants and buyers looking for environmentally sustainable properties.

- Green building practices can improve indoor air quality, reduce exposure to toxic materials, and provide access to natural light, all of which can contribute to **improved health and well-being** of building occupants.

- Buildings designed and managed with green building practices in mind can provide **more comfortable environments** through improved temperature and lighting control, and better air quality.

Targets and indicators

There are two main targets in the building sector, including energy efficiency and energy conversion with the use of rooftop solar PV:

Table 12: Targets and indicators in the building sector

Target	Medium-term target	Indicator	Mix
Energy savings in the building and construction sector	To achieve 15% energy savings from 2025 conditions with green building by 2035.	Percentage of energy savings achieved in the building and construction sector compared to 2025 conditions	There should be 25% energy savings in the building and construction sector by 2050 from 2025 levels.
Use of rooftop solar power in commercial buildings.	The installation of rooftop solar should reach 50% in commercial buildings in Mataram City for the period 2035-2040. This will depend on the feasibility of rooftop solar installation e.g., availability of roofs, roof structure strength, irradiation, etc. Specific oversight will be deployed by the local government where rooftop solar installation will be one of the requirements for permit extension.	Percentage of commercial buildings in WNT that use rooftop solar	As many as 80% of all commercial buildings in WNT, including those on Sumbawa Island, should be using rooftop solar power, with the majority in the Mataram City area.

The following are indicators of the achievement of the above targets:

Table 13: Explanation of the indicators in building sector

Indicator	Definition		
	Description	Calculation method	Period
Percentage of energy savings achieved in the building sector compared to the condition in 2025	Calculate the energy saving results obtained from the implementation of green buildings as well as the installation of energy-efficient equipment such as high-efficiency HVAC and energy-efficient lighting in the building sector.	The energy savings from the implementation of green buildings can be calculated by comparing the energy consumption of a building before and after the green building measures have been implemented. This can be done using energy audits, monitoring and evaluation systems, and other tools.	2025–2050
Percentage of commercial buildings in WNT that use rooftop solar	Calculate the number of commercial buildings in WNT that have installed and operated rooftop solar to reduce energy consumption from PLN electricity and at the same time increased the	▪ Determine the total number of commercial buildings in the area: This can be done using data from government agencies, real estate databases, or other sources. ▪ Identify the number of commercial	2025–2050

Indicator	Definition		
	Description	Calculation method	Period
	renewable energy mix in WNT.	buildings with rooftop solar systems: This can be done through site inspections, data from solar installation companies, or other sources. ▪ Calculate the percentage: Divide the number of commercial buildings with rooftop solar systems by the total number of commercial buildings, and multiply by 100 to express the result as a percentage.	

Action 4.1: Disseminate green building knowledge to commercial building managers

Justification	Addressing the lack of awareness and knowledge in implementing green building practices within the commercial building sector involves directly targeting stakeholders and encouraging their active participation in initiatives to improve energy efficiency and energy conservation.
Implementation strategy	**Information dissemination** and socialization activities on the implementation of green building standards. This includes energy management training for commercial building managers as well as digitalization of building management systems. The WNT government also needs to compile technical information on green building derived from central government regulations.
Are there policy linkages at different levels?	• Government Regulation No.16/2021 on Building • Ministry of Public Works Regulation No. 02/2015 on Green Building • Ministry of Public Works Regulation No. 9/2021 - Guidelines for the Implementation of Sustainable Construction • Ministry of Public Works Regulation No.21/2021 concerning Green Building Performance Assessment • Government Regulation No. 33/2023 on Energy Conservation
Timeline	**2025–2050** The cooperation arrangement between the provincial government of WNT and various responsible agencies in energy, public works, and housing, shall formulate several strategies on enhancement of green building regulations for commercial building owners and managers. This will include consultations with other relevant stakeholders (e.g. academia and government) in WNT including the development of working groups, capacity building, and green building certification. However, it is worth noting that the implementation of green building obligations in the WNT shall be subject to the overall regulatory framework including incentives, disincentives, and other government supports.
Possible sources of financing	• State budget, both central and local government of WNT • Funds from donor agencies/philanthropy in terms of technical assistance and programmatic approach to green building knowledge dissemination to the stakeholders in the WNT • Private self-financing of certified energy management training activities

Estimated risks associated with implementation of the action	• There may be **upfront costs** associated with implementing green building practices, which can affect the likelihood of them being implemented without the right incentives. • Building managers may **lack the technical knowledge and capacity** required to effectively implement green building practices, which could result in suboptimal performance and missed opportunities. • The **regulations and standards** associated with green building certification can be **complex**, and building managers may struggle to understand and comply with them. • There may be **barriers to the widespread adoption** of green building practices, such as a lack of demand for green buildings or a lack of awareness of the benefits of green buildings.
Definition of initiative leadership	• Agency of Housing and Settlement • Ministry of Public Works in cooperation with the Ministry of Energy and Mineral Resources cq. the Directorate General of Renewable Energy and Energy Conservation and the Directorate of Energy Conservation.

Action 4.2: Design and implement incentives and disincentives to encourage adoption of green building standards

Justification	The limited adoption of green building standards in WNT highlights the necessity for supportive regulation and financial mechanisms, particularly for new building projects. This strategic approach aims to kickstart a broader adoption of green building practices in the region.

Implementation strategy	• To encourage the growth of green buildings, local governments need to provide incentives for commercial buildings to meet green building principles, such as:
	  • **Tax credits and rebates:** Governments may offer tax credits and rebates to organizations and companies that invest in green building practices and technologies, and moreover certification. This could be in the form of land and building tax exemption and other related taxes.
	  • **Recognition and awards:** Governments and non-profit organizations may offer recognition and awards to organizations and companies that have made significant contributions to the development of green building practices and technologies. This can be done in partnership with the green building certification agency.[32]

[32] As for a note, currently the Ministry of Energy and Mineral Resources has already implemented the Subroto Award, that also consists of some award nominations on energy efficiency.

	• **Grants:** Grants to support green building implementation can vary from the planning stage (e.g., grant to support the investment grade audit/IGA) or grants as part of investment subsidy. • **Building codes:** Governments can establish and enforce standards that promote green building practices, such as energy efficiency requirements, water conservation measures, and the use of sustainable materials. Requiring the use of energy-efficient electrical equipment in new construction or renovation projects or adding new requirements such as targets or mandatory energy audits, can also help. • **Green procurement:** The governments can set procurement policies that require government buildings to be constructed and maintained to green building standards, serving as an example and a catalyst for private sector adoption. • Conversely, to encourage the growth of green buildings, local governments can also provide disincentives for buildings that do not comply with green building rules in WNT, such as: • **Fines or penalties:** Governments may impose fines or penalties on building owners who fail to comply with green building standards or who use building technologies and practices that are deemed harmful to the environment. • **Denied building permits**: Governments may deny building permits to developers or building owners who do not meet green building standards, requiring them to make changes to their plans or to invest in energy-efficient or environmentally friendly technologies. • **Zoning restrictions:** Governments may impose zoning restrictions that limit the use of certain building technologies and practices in certain areas, such as the use of fossil fuels for heating and cooling.
Supporting technology	• **Building Information Modeling (BIM):** This is used to accurately model the energy consumption of buildings and evaluate their sustainability. • **Energy simulation software:** Used to predict energy use and identify areas where energy efficiency can be improved. • **Automated monitoring systems**: Used to track the performance of green buildings in real-time and ensure they meet the required standards. • **Smart grid technologies:** These enable the integration of renewable energy sources into the electrical grid and support the use of clean energy.

	• **Digital tracking and reporting systems:** These enable transparent and efficient tracking and reporting of green building certifications and incentives. • **GIS mapping:** Used to identify the locations of green buildings and assess their impact on the surrounding environment. • **Artificial Intelligence (AI) and machine learning:** Used to analyze data and identify patterns and trends in green building performance, helping to improve the design, construction, and operation of future green buildings. • **Renewable energy technologies:** These are necessary to support the transition to more sustainable and low-carbon buildings. This can include rooftop solar PV or integrated PV and storage systems, mini wind turbines, etc. • **Energy efficient building materials and products:** These are necessary to improve building performance and reduce energy consumption. This can include insulation materials, lighting, high-efficiency HVAC systems, etc.
Are there policy linkages at different levels?	• Government Regulation No.16/2021 on Building • Ministry of Public Works Regulation No. 02/2015 on Green Building • Ministry of Public Works Regulation No. 9/2021 concerning Guidelines for the Implementation of Sustainable Construction • Ministry of Public Works Regulation No. 21/2021 concerning Green Building Performance Assessment • Government Regulation No. 33/2023 on Energy Conservation
Timeline	**2025-2050** As derivative provisions to the existing central government regulations on green building, the mechanisms of incentives and disincentives shall have to be formulated and the required budget shall have to be allocated. The formulation of regulation is expected to be finalized within 2-3 years with the support of donors and development agencies.
Possible sources of financing	Fiscal incentive policies can be sourced from the local government budget or WNT Provincial Government budget, however due to potential financial constraints, the incentives also shall have to be allocated from the central government state budget, and as such the coordination between the Ministry of Public Works, Ministry of Energy and Mineral Resources, and the Ministry of Finance is crucial.
Estimated risks associated with implementa	• The **incentives** provided are **not enough to attract interest** from commercial building owners and managers to encourage the implementation of energy management. • The **disincentives** imposed are **not enough to make commercial building managers comply** with green building principles. • Weak **incentive disbursement** mechanism

tion of the action	• **Monitoring** to enforce disincentives is often less effective • **Cost** of building materials and refurbishments becomes beyond what building owners and managers can afford • **Local expertise does not keep pace** with speed of change in buildings necessary to meet goals
Definition of initiative leadership	• Agency of Housing and Settlement, • Ministry of Public Works in cooperation with the Ministry of Energy and Mineral Resources cq. the Directorate General of Renewable Energy and Energy Conservation and the Directorate of Energy Conservation.

Action 4.3: Mandate energy audits for government and commercial buildings

Justification	Energy audits are not currently mandatory, however focusing initially on energy-saving opportunities starting with government buildings and highly energy-intensive sectors such as commercial buildings can minimize energy waste, promote sustainability and increase economic benefits.
Implementation strategy	• Mandatory energy management reporting or energy audit policies typically require owners and managers of commercial buildings to regularly report energy usage data and implement energy-saving measures. • These policies aim to increase energy efficiency and reduce greenhouse gas emissions. To comply with these policies, building owners and managers may need to install energy monitoring systems, conduct energy audits, implement energy-saving technologies and practices, and regularly report energy consumption data to the relevant government agency such as the Agency of Public Works and the Agency of Energy and Mineral Resources. Building owners can also deploy certified energy audit consultants to conduct regular reporting. • Finally, it is expected that the recommendations based on energy audit results could be adopted by the building owners and managers. The common goal is to reduce energy waste and promote sustainability.
Supporting technology	As noted in Section 3.4.2, there are various technologies that can support and accelerate the implementation of mandatory energy management reporting for commercial building owners and managers. These technologies, when combined with energy-saving practices and regular energy reporting, can help building owners and managers to comply with mandatory energy management reporting policies and improve the energy efficiency of their buildings.
Are there policy linkages at different levels?	• Government Regulation No. 33/2023 on Energy Conservation • MEMR Regulation No. 14/2012 on Energy Management
Timeline	**2025–2050:** • The cooperation arrangement between the provincial government of WNT cq. the Agency of Energy and Mineral

	Resources and the Agency of Public Works and the Ministry of Energy and Mineral Resources cq. the Directorate of Energy Conservation and the Ministry of Public Works cq. the Directorate General of Housing and Settlements shall have to establish several strategies on the implementation of mandatory energy management and reporting. This is also in line with the provisions of energy audits as per the Government Regulation No. 33/2023 on Energy Conservation. • As a first step, the energy audits can begin with government buildings as the government should lead by example and best practice. • In addition, in the next few years, following the effectiveness of Government Regulation No. 33/2023, the central government cq., the Directorate of Energy Conservation, and MEMR will also have to build human capacity on energy conservation, including training on energy audit and energy management.
Possible sources of financing	• For public buildings such as government buildings and schools, the implementation of energy management can use the funding from the local government budget. • Alternative business models where the initial investment is paid back through energy and cost savings • For commercial buildings, energy management implementation uses private funding. • International support through grants and technical assistance can support Investment Grade Audit (IGA) activities.
Estimated risks associated with implementation of the measures	• Implementing energy management systems and conducting energy audits can be challenging, especially for building owners and managers with limited technical expertise. This can include **difficulties in understanding** energy-saving technologies and practices, or in interpreting the results of energy audits and identifying appropriate energy-saving measures. • Collecting and sharing energy consumption related data for auditing purposes could pose **privacy and security risks** if not adequately protected. • Energy management and energy audit reporting programs may require the collection and reporting of large amounts of data. Ensuring the **quality and relevance of this data** can be

	challenging, especially if building owners and managers are not familiar with the data collection and reporting requirements. • There may be **significant costs** associated with complying with mandatory energy management and energy audit reporting requirements, including the cost of training personnel, implementing energy management systems, and conducting energy audits. These costs may discourage building owners and managers from complying with the requirements, especially if they believe that the benefits of energy-efficient practices are not worth the investment. • Building owners and managers **may not be aware** of the benefits of energy-efficient practices, the available energy-saving technologies and practices, the regulatory requirements for energy management and energy audit reporting, or the potential for savings. This can result in a lack of participation. • The number of available energy managers, engineers, technical personnel, and energy auditors is limited, making it **difficult to find qualified human resources**. Limited human resources can also be an obstacle in reporting energy management to the WNT government.
Definition of initiative leadership	• Agency of Public Works • Agency of Energy and Mineral Resources

Action 4.4: Implement rooftop solar obligation for specific buildings

Justification	Although the regulation mandating the installation of rooftop solar for specific buildings exists, its implementation faces challenges, including the need to raise community awareness, provide accurate information and navigate the stages of implementation.
Implementation strategy	• This policy aims to target specific categories of buildings, including industries and factories, commercial buildings such as malls, shopping centers, and hotels, institutional and public buildings like hospitals, schools, and universities, as well as government-owned or public buildings. • The selection of these building types is based on their energy consumption levels. For industries and factories, the threshold is typically set at those consuming more than 4,000 TOE per year, as determined through energy audits i.e. energy-intensive establishments. • To ensure compliance with this obligation, local governments will have specific oversight responsibilities. One measure they will implement is making the installation of rooftop solar a requirement for permit extension. This means that building owners or operators will need to demonstrate that they have installed rooftop solar panels to obtain an extension for their permits or licenses. This requirement acts as a regulatory tool to encourage the adoption of solar energy systems and promote the overall deployment RE.
Supporting technology	• **Solar panels:** This is primary electricity generation technology. • **Inverters:** Used to convert the direct current (DC) generated by the panels into alternating current (AC) used by most electrical appliances and the grid. • **Battery storage systems:** Used to store excess energy for later use or for times when the sun is not shining. • **Smart grid technology:** This is needed to manage the flow of electricity from the panels to the grid and to the building's electrical system. • **Monitoring and control systems:** These are used to track energy generation, consumption, and storage, and to optimize the use of solar energy.

	• **Electrical and structural upgrades:** Needed to ensure the building's electrical system can handle the additional load from the solar panels and to reinforce the building's structure to support the weight of the panels.
Are there policy linkages at different levels?	• Presidential Regulation No. 22/2017 on General Energy Planning • Government Regulation No. 33/2023 on Energy Conservation • Government Regulation No.16/2021 on Building • Minister of Public Works Regulation No. 02/2015 on Green Building • Minister of Energy and Mineral Resources Regulation No. 26/2021 concerning Rooftop Solar Power Plants Connected to the Electricity Network of Holders of Electricity Supply Business Permits for the Public Interest
Timeline	• **2025–2050:** The targets of rooftop solar utilization in buildings, particularly public-owned buildings, should be stipulated under the Indonesia's General Energy Planning, which sets out a target of around 3 GW by 2025. The rooftop solar net metering regulation should also be provided under the MEMR Regulation No. 26/2021. However, the regulation is likely to face resistance from PLN citing grid stability and potential revenue losses. • **2023–2024**: Set up WNT regulation on mandatory solar, derived from other regulations. The local government should draft and finalize a policy that mandates rooftop solar installations for specific building categories (industries, commercial buildings, institutional and public buildings, and government-owned buildings). This formulation of regulation should also include public consultations and stakeholder engagements including PLN, solar developers, and building owners to gather feedback and address concerns. The policy should be officially announced and published, outlining the requirements and implementation timeline. • **2024-2025:** Regulation implementation. • **2024:** Awareness raising to inform building owners, operators, and the public about the obligation and its benefits, financial incentives, and compliance procedures through workshops, seminars, and training sessions.

	• **Beyond 2025**: Starting from this year, the local government should enforce the mandatory rooftop solar requirement as a prerequisite for permit extension. Building owners and operators must submit evidence of rooftop solar installations, such as documentation, permits, and inspection reports, to obtain permit extensions. Regular inspections and monitoring may be carried out to ensure compliance and proper functioning of the installed rooftop solar systems. • **Beyond 2025:** Continuous monitoring and evaluation in which the local government continues to monitor the implementation of the mandatory rooftop solar obligation for buildings in WNT. Feedback from building owners, operators, and the public is collected to assess the effectiveness and impact of the policy. Adjustments and improvements may be made based on the evaluation results to optimize the renewable energy deployment and address any challenges or issues that arise.
Possible sources of financing	• Self-financing by private sector commercial building managers • Financing by financial institutions to commercial building managers • Leasing or buying and selling of electricity between investors such as independent power producers/solar technology providers and commercial building managers
Estimated risks associated with implementation of the measures	• There may be **resistance** from the utility against rooftop solar and net metering due to the threat to its existing business model. • Building owners and managers might **not be aware** of the benefits of rooftop solar and the process of installation. Thus, public education can help build support for the initiative. • The **cost** of installing rooftop solar panels can be substantial for commercial building owners, who may need to bear the initial cost as well as maintenance expenses. In addition, the cost competitiveness in the short term is also challenging since electricity prices in Indonesia are subsidized. • There may be **technical challenges** involved in the installation of rooftop solar panels, such as compatibility with existing electrical systems, structural compatibility with the building, and regulatory requirements.

	• Building owners may **resist** mandatory rooftop solar installations due to the perceived cost and disruption to their operations. • Rooftop solar only generates electricity when the sun is shining, which may lead to an **inconsistent supply** and increase the need for energy storage. • Rooftop solar panels require ongoing **maintenance and repairs** to ensure they are functioning correctly and generating energy efficiently.
Definition of initiative leadership	• Agency of Housing and Settlement • Ministry of Public Works in cooperation with the Ministry of Energy and Mineral Resources cq. the Directorate General of Renewable Energy and Energy Conservation and the Directorate of Energy Conservation

3.5 Action Pillar 5: Decarbonizing and electrifying the transportation sector

Objective	Transport is a major energy-consuming sector. Decarbonizing it is critical, through electrification using renewable energy and modal shifting to less energy-intensive modes such as public transport.
Outcomes	Achievement of clean (zero emission) transportation through the development and integration of mass transit, electric vehicles, and hydrogen. Gradual adoption and implementation of electric vehicle and battery technology is expected to occur in WNT along with technological advancement, market growth, and declining investment costs.
SDGs	
Action 1	Implement a scrappage program
Action 2	Develop integrated Electric Zero Emission Bus Rapid Transit (E-ZEBRT)
Action 3	Implement tax incentives and subsidies for EVs
Action 4	Develop electric vehicle charging stations
Action 5	Prepare industry for fuel to electric vehicle conversion
Action 6	Promote hydrogen vehicles for public transport

Success factors

3.5.1.1 Regulation

Establish clear eligibility criteria

Any program should establish clear eligibility criteria for the types of vehicles that are eligible for incentives, whether tax incentives for EVs (e.g. 2- or 4-wheelers, up to a certain cost, etc.) or for scrappage programs (such as vehicle age, emissions levels, fuel efficiency).

Establish a system for monitoring and evaluation

The program should establish a system for monitoring and evaluation, including tracking the number of vehicles scrapped, the types of vehicles being scrapped, and the impact on emissions.

Integrate with other government initiatives

The program should be integrated with other government initiatives, such as renewable energy programs and policies, and public transportation initiatives, for a comprehensive strategy. Building codes can incorporate requirements for charging infrastructure on-site.

Establish a clear and supportive legal framework

This is essential for the successful development of renewable transportation, including the E-ZEBRT system, which clearly outlines the rights, obligations, and responsibilities of the government and private sector partners.

Create other regulations when appropriate

Other regulations may include restrictions or penalties on the import or sale of ICE vehicles to encourage the shift towards EVs. However, this must be done over a longer horizon when EV options are plentiful and affordable.

Create and adhere to supportive policies

Supportive environmental policies can encourage the adoption of sustainable transportation solutions, including the promotion of e-buses and the development of an E-ZEBRT system. Environmental policies must be adhered to for programs such as scrappage.

Recognize the value of land use policies

Adequate land use policies are also essential for the successful development of an E-ZEBRT system, including the provision of dedicated bus lanes and safe and accessible bus stops, as well as deploying charging and refueling infrastructure. Land use policies can also be used to designate scrapyard areas on barren or unproductive land.

Establish public procurement policies

Governments can establish public procurement policies to encourage the deployment of charging infrastructure in public spaces and to support the use of EVs by government fleets.

Foster a supportive regulatory environment

A supportive regulatory environment is essential to promote the deployment of hydrogen vehicles and hydrogen refueling infrastructure. This may include establishing standards and safety regulations for hydrogen vehicles and hydrogen refueling infrastructure, as well as providing incentives for the deployment of these technologies.

Set emission standards and regulations for ICE vehicles

The goal of these standards and regulations is reducing the overall emissions from the transportation sector. In addition, other disincentives for conventional vehicles should be considered e.g., gradual removal of a subsidized fuel price, restriction of the use and purchase of subsidized fuel prices for new generation (e.g. produced after year 2020) of conventional cars and with engines >1,500 CC, voiding of guarantee scheme for new cars if they use subsidized fuel with a low octane rate (e.g., <RON 92).

3.5.1.2 Technology and research

Invest in research and development to support the development of advanced technologies

The development of advanced technologies such as batteries with higher energy density, longer range, and lower cost will be crucial to support the widespread adoption of EVs. This also includes hydrogen fuel cell technologies. Governments can invest in research and development to support these.

Integrate smart grid technologies

The integration of smart grid technologies will be essential to manage the increased demand for electricity that will result from the widespread adoption of EVs, and to ensure that charging is conducted in a way that is consistent with the grid's capacity and reliability.

Invest in research and development to advance V2G technologies

Research and development is needed to advance **V2G technologies**, which allow EVs to act as distributed energy storage and provide grid support services, such as load balancing.

Implement Intelligent Transport Systems (ITS)

Intelligent transportation systems such as real-time bus tracking, smart ticketing systems, and traffic management systems, help to improve the efficiency and reliability of the public transport system at large, making it more attractive to passengers.

Develop a comprehensive network planning and management system

This includes a central database of charging stations and real-time information on their availability and usage, to support the growth of the EV market.

Promote the interoperability and compatibility of EV charging stations and charging equipment

This ensures that EV drivers can charge their vehicles anywhere.

Encourage partnerships

Encouraging partnerships between vocational schools, polytechnics, universities, and the electric vehicle industry can provide a skilled workforce to support the development and growth of the industry. Technical training and educational programs can support the development of the workforce with the necessary skills to perform conversions.

3.5.1.3 Infrastructure

Encourage partnerships with the private sector

This includes EV manufacturers, charging equipment suppliers, and energy companies, to accelerate the development and deployment of EV charging stations and reduce the risks and costs associated with charging infrastructure.

Prioritize a well-developed road infrastructure

A well-developed road infrastructure is essential for vehicles and the E-ZEBRT system to operate effectively, including the provision of dedicated bus lanes and safe and accessible bus stops.

Prioritize a reliable and sustainable power infrastructure

This is also critical for the success of zero-emissions vehicles.

Establish a robust IT infrastructure

This is necessary to support zero-emissions vehicle infrastructure, such as charging stations, an E-ZEBRT system, etc.

Ensure adequate maintenance and operations facilities

These are also essential for zero-emissions vehicles in public transportation.

3.5.1.4 Governance

Understand consumer behavior and willingness to switch to EVs

This understanding is crucial to implementing tax incentives and subsidies. This can include market research and surveys to determine the factors that influence consumer behavior, such as range anxiety, cost, and charging infrastructure.

Ensure clear and consistent communication

This can help educate citizens about the tax incentives available for EVs and encourage adoption.

Engage with key stakeholders

The government should engage with key stakeholders, including the automotive industry, EV manufacturers, and consumer organizations, to ensure that the implementation of tax incentives and subsidies is effective and meets the needs of all relevant parties.

Benefits

3.5.2.1 Environmental benefits

- A **reduction in greenhouse gas emissions** and other pollutants by moving away from fossil fuels to (ideally) renewables-based electric vehicles and hydrogen vehicles. This will result in **improved local air quality**, as transport emissions are a major contributor.

- EVs are typically more energy efficient than internal combustion engine vehicles, meaning that they can travel further on a given amount of energy. This can **reduce the overall demand for energy** (although electricity demand may increase), reducing costs and resource requirements.

- Improved air quality resulting from the conversion of vehicles to EVs can have a **positive impact on public health**, reducing the incidence of respiratory problems and other health conditions.

- EVs are much quieter than traditional gasoline-powered vehicles, leading to **decreased noise pollution**, particularly in urban areas.

3.5.2.2 Socioeconomic benefits

- **Decreased dependence on fossil fuels**, which can improve energy security due to a greater reliance on local sources of energy.

- Deploying EVs, a cleaner and more effective public transport system, and ride-share programs can **enhance the potential of eco-tourism** by providing more sustainable and environmentally friendly modes of transportation for tourists and residents.

- The deployment of zero-emissions vehicles and the associated charging infrastructure can **create new jobs locally, stimulate the local economy, and develop a value chain** for repairs and maintenance, vehicle conversion, etc. This can further attract investment from manufacturers and other ZEV industry actors.

- Over the long-term, **zero-emissions vehicles can be more cost-effective** than traditional gasoline-powered vehicles, as they generally have a lower fuel cost, a longer lifespan, and lower maintenance requirements.

- Public EV charging stations can generate revenue from fees for charging services and from the sale of electricity. This can provide a **new source of income** for governments and private businesses.

Targets and indicators

There is one main target aimed at the transportation sector in the roadmap, namely the realization of an emission-free transportation sector in WNT. The target is derived into medium-term targets and indicators of achievement as follows:

Table 14: Targets and indicators in the transportation sector

Target	Medium-term target	Indicator	Mix
WNT transportation roadmap development by the Agency of Transportation and the provincial government	To develop a transportation roadmap by 2030 to 2050 by optimizing a shift to non-fossil fuel transportation modalities in WNT, accounting for land use changes, new infrastructure, rates, etc.	By 2025, the first WNT transportation roadmap should be issued to the public. The roadmap shall be monitored, evaluated, and updated every five years.	

Target	Medium-term target	Indicator	Mix
Emission-free transport sector in WNT	To achieve the electrification of 30% of two-wheelers and three-wheelers in the city of Mataram by 2030 and 15% in surrounding Lombok Island. A gradual growth of 5% in every 10 years is expected; this follows the incentives of electric motorcycle and infrastructure development that attract the communities and markets to adopt e-motorcycles.	Percentage usage of two- and three-wheeled electric vehicles	More than 75% of two- and three-wheeled vehicles in the city of Mataram and the urban and tourism areas of Lombok Island should be electric vehicles by 2050.

	To achieve the electrification of 100% of local government operational four-wheelers and 15% of privately owned four-wheelers by 2030 with coverage of Mataram city.	The percentage of electric vehicle use for local government operational four-wheelers and privately owned four-wheelers	• 100% of the local government's operational four-wheel drive vehicles should be electric by 2050, in the city of Mataram, all of Lombok Island, and the district capitals in Sumbawa. • 50% of private four-wheeled vehicles should be electric by 2050, both in the city of Mataram, the whole island of Lombok, and the district capitals in Sumbawa. • Internal combustion engine-based vehicles (both cars and motorcycles) should be gradually limited from 2030 and restricted in the market by the year 2040, specifically on Lombok Island.

Target	Medium-term target	Indicator	Mix
	To develop an integrated Bus Rapid Transit (BRT) system in Lombok Island through a series of progress milestones. These milestones would mark significant steps in the planning, design, construction, and operation of the BRT system. By 2035, the BRT system should be commercially operated.	Milestones of integrated bus rapid transit development for tourism areas on Lombok Island such as: feasibility study and concept design, public consultation and stakeholder engagement, route planning and networks design, business model development including potential PPP scheme, financial close, infrastructure construction, BRT fleets procurement, testing, operational, and monitoring.	By 2050, the integrated BRT should be commercially operated and developed in terms of number of lanes, bus fleets, green bus fleets, and the use of a non-fossil fuel bus system.

Target	Medium-term target	Indicator	Mix
	Develop public EV charging stations spread over 10 areas in 2025-2030 (Mataram city), and 20 areas in 2030-2035 (Lombok Island)	Number of EV charging stations on Lombok Island	• The development of EV charging stations should be built across Lombok Island by 2050 following the demands. • EV charging stations should be built scattered in urban areas or regency capitals on Sumbawa Island by 2050 following the demands.
	Fuel 5% of bus vehicles and 10% of freight truck vehicles with hydrogen by 2030.	Percentage of hydrogen-based vehicle use in trucks and buses	• 50% of buses and 50% of trucks should be hydrogen fueled by 2050.

All indicators in the transport sector above are then defined and the calculation method is formed as follows:

Table 15: Explanation of indicators in the transportation sector

Indicator	Definition		
	Description	Calculation method	Period
Percentage usage of two- and three-wheeled electric vehicles	Vehicle license census through the data from the responsible agency for vehicles and vehicle-related taxes registration and management and the regional police bureau on the traffic management sector. This can also count the number of motorcycles and motor tricycles.	Compare the number of two- and three-wheelers that are electric vehicles with the total number of two- and three-wheelers in 2050.	2025-2050
Percentage use of electric vehicles: • Local government operational four-wheel drives • Privately owned four-wheelers and public vehicles • Electric buses for inner-city transport, including DAMRI	Vehicle license census through the data from the responsible agency for vehicles and vehicle-related taxes registration and management and the regional police bureau on the traffic management sector, conducting a census on the number of: • Electric-based government	• All four-wheeled government operational vehicles are electric vehicles. • Compare the number of private four-wheelers that are electric vehicles with the total number of four-wheelers in 2050.	2025-2050

Indicator	Definition		
	Description	Calculation method	Period
	operational vehicles • Four-wheeled private and public vehicles that are electric vehicles, including sedans, jeeps, minibuses, vans, and buses		
Number of EV charging spots on Lombok Island	Planning and development of EV charging stations across Lombok Island, calculation/counting the location	Develop charging stations based on a feasibility study (finance, technical aspects, business model including PPP), and targeting 100 EV charging stations built on Lombok and 50 in the urban area of Sumbawa Island.	2025-2050
Percentage of integrated bus rapid transit development progress (planning, FS, business model, funding, construction, and operation and maintenance) for tourism areas on Lombok Island	Progress of BRT roadmap in increasing connectivity of tourism areas on Lombok Island (counting the development progress: planning, feasibility study, business model, funding, construction, and operation and maintenance).	Calculate the progress percentage of the achievement of the BRT roadmap for Lombok Island.	2025-2050

Indicator	Definition		
	Description	Calculation method	Period
Percentage use of hydrogen-based trucks and buses.	Vehicle census on the number of hydrogen-fueled public and freight vehicles with more than four wheels, including buses, trucks, and mining vehicles.	Compare the number of hydrogen buses and trucks with the total number of buses and trucks in 2050.	2040-2050

Action 5.1: Implement a scrappage program

Justification	Facilitating the transition from old vehicles with intensive emissions to promoting the use of low carbon emission and electric vehicles.
Implementation strategy	• The vehicle scrappage program can be linked to the encouragement of electric vehicle use in the following ways: • **Targeting older vehicles**: The program could prioritize the removal of older, more polluting vehicles from the road by offering more generous incentives for those who trade in their vehicles for electric vehicles. Programs may include setting a maximum age limit for vehicles allowed to operate; and/or setting vehicle emission limits. • **Incentives for electric vehicle purchases:** The program could offer financial incentives, such as tax credits or rebates, for individuals who trade in their old, polluting vehicles for new electric vehicles. • The program could require or incentivize the installation of electric vehicle **charging infrastructure** as part of the trade-in process, making it easier for individuals to transition to electric vehicles. • The program could include **educational components** to raise awareness about the benefits of electric vehicles and the associated incentives, encouraging more individuals to make the switch. • The program could collaborate with automakers and dealerships to offer **discounts or special financing** options for electric vehicle purchases.
Supporting technology	• **Digital platforms:** A secure, user-friendly digital platform is needed to manage the scrappage program, process applications, and track trade-ins. • **Automated vehicle valuation systems:** Automated vehicle valuation systems can be used to determine the value of trade-in vehicles and ensure that incentives are distributed fairly. • **Scrapyards and recycling centers:** The program should have access to well-equipped scrapyards and recycling centers to process the trade-in vehicles and ensure environmentally responsible scrappage.

	• **Scrap processing equipment:** Scrap processing equipment, such as shredders and compactors, is necessary, as are transport vehicles such as trailers and storage containers. • **Electric vehicle charging infrastructure:** Access to a wide and reliable network of EV charging stations is necessary to support their adoption. • **Battery recycling technologies:** Battery recycling technologies are necessary to manage the end-of-life of electric vehicle batteries, ensuring that valuable materials are recovered and reused. • **Environmental control systems:** Scrap processing facilities should be equipped with systems to control emissions, such as dust control systems, and to manage and treat any waste generated during processing.
Policy linkage	• At the national level, regulations regarding motor vehicle emission thresholds are outlined by the Ministry of Environmental and Forestry Regulation No. 4/2009 concerning New Type of Motor Vehicle Exhaust Emission Threshold and No 20/2017 concerning Quality Standards for New Types of Motorized Vehicle Exhaust Emissions. • Government Regulation No. 74/2021 that sets out 0% VAT incentive for electric vehicles. • Presidential Regulation No. 55/2019 on the Acceleration of Battery Electric Vehicle Program for Road Transportation. • Minister of Finance Regulation No. 38/2023 that sets out subsidy for the purchase of electric vehicle.

Timeline	• **2025:**
	  ○ Launch a voluntary scrappage program for certain vehicles that are old, highly polluting, and contribute significantly to emissions. Provide incentives, such as financial incentives or tax credits, to encourage replacement with cleaner alternatives, including EVs.
	  ○ Implement measures to promote the adoption of EVs, such as offering purchase subsidies, reducing taxes or import duties on EVs, and expanding charging infrastructure. Launch awareness campaigns to educate the public about the benefits of EVs.

	• **2030:**
	  ○ Enhance the scrappage program by increasing the incentives for scrapping older vehicles and targeting specific vehicle categories that contribute the most to pollution and emissions. Expand the program's coverage to include commercial vehicles, buses, and taxis.
	  ○ Continue to expand the market for EVs by implementing more robust policies and incentives. Introduce stricter emission standards and regulations that encourage vehicle manufacturers to produce and market more electric models. Enhance charging infrastructure with the installation of fast-charging stations in key locations.
	• **2040:**
	  ○ Transition the scrappage program from a voluntary to a mandatory scheme. Enforce the retirement of older, high-emission vehicles, ensuring their replacement with cleaner alternatives, including EVs. Implement penalties or fines for non-compliance.
	• **2050:**
	  ○ Achieve a near-zero emission vehicle landscape with a majority of vehicles on the road being electric or other zero-emission alternatives. Phasing out internal combustion engine (ICE) vehicles becomes the norm, with a complete ban on new ICE vehicle sales. EV charging infrastructure is fully developed and integrated into the transportation network, ensuring convenient charging options for all EV owners.
	  ○ Experience significant improvements in air quality and reduced carbon emissions as a result of the widespread adoption of EVs.

Possible sources of financing	• State budget, particularly the central government with support from the local government, to finance the preparation and implementation of the scrappage program.

	• Private investment for the provision of emission testing equipment and scrappage sites. The program should have a strong network of dealerships to handle the trade-in process, ensure that vehicles are scrapped in an environmentally responsible manner, and provide information and support to program participants.
Estimated risks associated with implementation of the action	• The transition to a more sustainable transportation system **may face resistance from stakeholders**, such as automobile manufacturers and oil companies, who may view it as a threat to their current business models. • **Encouraging consumer adoption of EVs may be challenging**, particularly if there are concerns about range, charging infrastructure, and the higher upfront cost of EVs compared to traditional gasoline-powered vehicles. • The **general public may lack awareness of the benefits of EVs** and may be resistant to changing their transportation habits. • A scrappage program and the development of the necessary infrastructure for EVs can be costly, requiring **significant upfront investment**.
Definition of initiative leadership	• Agency of Transportation • Agency of Energy and Mineral Resources

Action 5.2: Develop integrated Electric Zero Emission Bus Rapid Transit (E-ZEBRT)

Justification	Electrifying public transport and making it more efficient can go a long way in improving its usage and shifting away from more energy-intensive and individual forms of transport.
Implementation strategy	The development of integrated Electric Zero Emission Bus Rapid Transit (E-ZEBRT) on Lombok Island aims to increase accessibility and connectivity while also boosting ecotourism. The project involves the deployment of electric buses as a mode of public transportation on the island. The E-ZEBRT system would provide a clean, efficient, and reliable mode of transportation for residents and tourists, reducing reliance on personal vehicles and reducing carbon emissions. The project also aims to support the development of ecotourism by improving connectivity between tourist destinations. More detailed analyses and studies will be needed to assess demand and feasibility.
Supporting technology	• **Electric buses:** The E-ZEBRT system will require a fleet of electric buses. • **Charging infrastructure:** The E-ZEBRT system will require a network of charging stations to ensure that the electric buses can be recharged quickly and efficiently. The charging infrastructure can be integrated with the grid or be standalone and powered by renewable energy. • **Smart transport systems:** A smart transport system can provide passengers with real-time information about bus schedules, arrival times, and route information for greater efficiency and user-friendliness. • **IT systems:** The E-ZEBRT system should be supported by robust IT systems, including a central control system, a customer information system, and a payment system, to manage operations and support customer interactions. • **Maintenance and repair systems:** This system should include preventative maintenance programs, a spare parts inventory, and a system for tracking and reporting maintenance activities.
Policy linkage	• Presidential Regulation No. 35/2018 on Public Private Partnership • Ministry of Transportation Regulation No. 58/2018 on PPP in the Transportation Sector

Timeline	• **2025–2027:**
	  ○ Initiate the planning process for the development of an integrated Electric Zero Emission Bus Rapid Transit (E-ZEBRT) system on Lombok Island.
	  ○ This includes conducting a comprehensive feasibility study to assess viability, potential routes, passenger demand, and infrastructure requirements for the E-ZEBRT system and engagement with relevant stakeholders.
	• **2026–2028:**
	  ○ Determine the appropriate business model for the E-ZEBRT system, considering public-private partnership (PPP) arrangements.
	  ○ Allocate the necessary state budget to support the project, ensuring financial viability. Identify potential investors and initiate discussions.
	• **2028–2029**:
	  ○ Finalize the selection of private investors through a competitive bidding process under the PPP scheme.
	  ○ Sign agreements and contracts with the selected investors.
	  ○ Ensure that the agreements address the necessary financial arrangements, performance targets, and risk-sharing mechanisms.
	• **2030-2035**:
	  ○ Begin construction of the necessary infrastructure including dedicated bus lanes, charging infrastructure, stations, and ITS.
	  ○ Progressively build and enhance the infrastructure over the designated corridors on Lombok Island.
	  ○ Procure the electric buses required, ensuring they meet the anticipated passenger demand and technological requirements.
	• **2035**: Ready for operation:
	  ○ Complete the construction of infrastructure and the acquisition of the E-ZEBRT fleet.
	  ○ Conduct operational testing and commissioning to ensure the readiness of the system for passenger service.
	  ○ Obtain necessary certifications and regulatory approvals.

	○ Officially launch the Integrated Electric Zero Emission Bus Rapid Transit system on Lombok Island, offering sustainable and efficient transportation options to the public. • **Beyond 2035**: Expansion and enhancement: ○ Continuously evaluate the performance and ridership of the E-ZEBRT system. ○ Identify opportunities for network expansion, integration with other modes of transportation, and improvement of passenger amenities. ○ Consider the adoption of advanced technologies to enhance the system's efficiency and passenger experience. ○ Monitor market trends and explore possibilities for expanding the E-ZEBRT system to cover additional routes and areas on Lombok Island.
Possible sources of financing	• Government funding: The Indonesian government could provide funding through various channels, such as the national budget, grants, and loans. • International development organizations: Organizations such as the World Bank, Asian Development Bank, and the United Nations Development Programme could provide funding for the project through loans, grants, and technical assistance. • Public-private partnerships (PPP): A PPP model could be used, where private companies partner with the government to finance, design, build, and operate the E-ZEBRT system. This model could leverage private sector financing, expertise, and innovation to support the development of the E-ZEBRT system. The private sector could provide funding for the project through investment in the form of equity or debt financing. This could include local and international investors, as well as the automotive and energy industries. Whereas the government side is responsible for the payment mechanism and long-term political and government guarantee to ensure the bankability of the project. • Carbon credits: The project could also generate revenue through the sale of carbon credits, as it would result in significant

	greenhouse gas emissions reductions compared to traditional transportation methods.
Estimated risks associated with implementation of the action	• The implementation of the E-ZEBRT system may be impacted by **technical challenges**, including issues related to the charging infrastructure, the electric buses, or the IT systems supporting the system. • The **financing** of the E-ZEBRT system, which is likely to rely on a combination of government funding and private investment, may be impacted by changes in economic conditions or fluctuations in the capital markets. • The success of the E-ZEBRT system will depend on the **demand** for public transportation on Lombok Island, which may be impacted by changes in the local economy, demographic trends, or tourist patterns. • The **operation and maintenance** of the E-ZEBRT system may be impacted by issues related to staffing, maintenance, and customer service, which could impact the reliability and efficiency of the system. • The development of the E-ZEBRT system may be impacted by changes in **regulations**, including those related to transportation, energy, and the environment, which could increase costs or impact the feasibility of the project. • **Political instability** or changes in government policies may impact the continuity and stability of the E-ZEBRT project. For example, changes in government leadership or political priorities may result in changes to the funding, regulation, or support for the project. • The success of the E-ZEBRT project will depend on the **acceptance and usage of the system** by the public, which may be impacted by factors such as convenience, reliability, and cost. The government may need to invest in public engagement and education initiatives to build support for the project. • The development of E-ZEBRT **may conflict with existing public transportation organization** (Organda); thus careful coordination and stakeholder engagement are essential.

Definition of initiative leadership	• Agency of Local Development Planning • Agency of Transportation

Action 5.3: Implement tax incentives and subsidies for EVs

Justification	Electric vehicles are considered expensive to adopt, and financial support will be needed for robust adoption across all segments, both for 2-wheelers and 4-wheelers.
Implementation strategy	A policy of tax exemption and incentives for electric vehicle (EV) purchases and the EV industry is a government incentive aimed at encouraging the adoption of EVs and promoting the development of the EV market. Under this policy, buyers of EVs may be exempt from paying certain taxes, such as sales tax or value-added tax, when purchasing an EV. The policy may also provide tax exemptions or waivers for the EV industry, including tax breaks for manufacturers and suppliers of EVs, as well as for charging infrastructure developers and operators, and conversion of ICE-based vehicles to EV. The goal of these tax exemptions and waivers is to reduce the cost of EVs for consumers and to provide financial support for the development of the EV industry. By making EVs more affordable and accessible, the policy aims to increase the adoption of EVs and promote the growth of the EV market. Additionally, the policy may encourage innovation in the EV industry and support the development of new technologies and charging infrastructure, battery processing, electric vehicle assembly, and electric vehicle engine conversion.
Policy linkage	• PP 74/2021 regulates the 0% VAT incentive for electric vehicles • Law 1/2022 exempts taxes and transfer duties for RE vehicles • Presidential Regulation No. 55/2019 on the Acceleration of Battery Electric Vehicle Program for Road Transportation • Presidential Regulation No. 55/2019 on the Acceleration of Battery Electric Vehicle Program for Road Transportation • Minister of Finance Regulation No. 38/2023 that sets out subsidy for the purchase of electric vehicle
Timeline	**2024 onwards:** • Implementation can start as policy instruments are in place. • Measures can be further strengthened based on progress and feedback.

	• Awareness campaigns can begin so people can begin taking advantage of the various support offers when purchasing new vehicles.
Possible sources of financing	State budget, central and local government
Estimated risks associated with implementation of the action	• There is a risk that only a **few people** will buy EVs, even with the incentives and subsidies. • Incentives **may encourage EVs instead of more efficient forms of transport** including public transport and active modes. • The fiscal and state **budget burden** of offering tax incentives and subsidies can be significant and may lead to limited availability and eligibility, potentially limiting their impact. • By offering tax incentives and subsidies for EV purchases, the government may **lose out on tax revenue** from traditional gasoline-powered vehicle sales.
Definition of initiative leadership	• Ministry of Finance • Local Development Planning Agency • Agency of Energy and Mineral Resources

Action 5.4: Develop electric vehicle charging stations

Justification	The uptake of EVs will be difficult without an adequate number of charging stations to fuel them, and so the two must go hand-in-hand. Stations can be grid-connected or standalone, powered by renewables.
Implementation strategy	Develop RE-based and non-RE-based public electric vehicle charging station locations in public spaces, such as on highways, at public parking facilities, and at government-owned buildings, commercial and tourism areas. Electric vehicles in this case can include 4-wheelers as well as more affordable e-scooters or e-bikes, which may have a wider reach and therefore improve the use case for charging stations.
Supporting technology	• **Charging equipment:** The charging equipment, including the charging points and the electrical distribution systems, must be designed and installed to meet the specific requirements of EVs, including compatibility with different vehicle models (including 2- or 4-wheelers), safety, and efficiency. • **Solar PV panels**: The most essential component for a renewable energy-based EV charging station is a solar PV system that converts sunlight into electricity. The size and capacity of the solar PV system will depend on the energy demand of the station and the availability of sunlight. • **Energy storage systems**: To ensure reliable and consistent charging, renewable energy-based EV charging stations often require energy storage systems, such as batteries or flow batteries. • **Monitoring and control systems**: Renewable energy-based EV charging stations also require monitoring and control systems to manage and optimize the operation of the charging equipment, energy storage systems, and solar PV panels. These systems can monitor energy consumption and production, control charging speed, and ensure safety and reliability. • **Grid connection**: If the charging station is connected to the grid, it may require additional technologies, such as inverters, to convert the direct current (DC) electricity generated by the solar PV panels into alternating current (AC) electricity that can be used by the EVs and the grid.

Policy linkage	• Presidential Regulation No. 55/2019 on the Acceleration of Battery Electric Vehicle Program for Road Transportation • MEMR Regulation No. 13/2020 concerning the Provision of Electric Charging Infrastructure for Battery-Based Electric Motor Vehicles

Timeline	• **2023–2025**:
	  ○ Conduct a comprehensive study to identify suitable locations for EV charging stations across Lombok Islands.
	  ○ Evaluate factors such as population density, existing vehicle usage (2- or 4-wheelers), hubs, commercial areas, and tourist destinations.
	  ○ Collaborate with local authorities and utility providers to assess the feasibility of infrastructure development.
	• **2024–2029**:
	  ○ Begin the installation of EV charging infrastructure at key locations, including urban centers, public parking lots, shopping centers, and tourist attractions.
	  ○ Focus on deploying a mix of charging station types, including Level 2 AC chargers for overnight charging and a few fast DC chargers for quick charging needs.
	  ○ Ensure the stations are strategically placed to provide convenient access.
	• **2030–2034**:
	  ○ Expand the EV charging network across Lombok Islands to increase accessibility and coverage.
	  ○ Install additional charging stations along major roads, highways, and rural areas to support longer-distance travel and promote EV adoption in different regions.
	  ○ Collaborate with private stakeholders and businesses to install charging stations at their premises, including hotels, resorts, and commercial complexes.
	• **2035–2040**:
	  ○ Upgrade the existing charging stations to support advanced charging technologies and higher charging speeds.

	○ Install more fast DC chargers to cater to the growing demand for quick charging. ○ Implement smart charging solutions that optimize energy usage, load balancing, and billing processes. ○ Consider innovative charging options which may become feasible in the future, such as wireless or inductive charging. • **Continuous**: ○ Monitor the EV charging network's performance and make necessary optimizations to meet evolving needs. ○ Evaluate the demand for additional charging stations in underserved areas and expand the network accordingly. ○ Embrace emerging technologies, such as ultra-fast charging and vehicle-to-grid integration, to enhance the functionality and sustainability of the charging infrastructure.
Possible sources of financing	• The government can provide funding for the development of EV charging stations directly or through **grants and subsidies**. This approach is commonly used to support the deployment of charging infrastructure in public spaces or along highways. • In a **PPP**, the government partners with private companies to finance, build, and operate EV charging stations. This can involve the government providing land or incentives and the private sector providing the capital and expertise to develop the charging network. • **Private companies** can also fund the development of EV charging stations, either through direct investment or by partnering with other companies. For example, a charging network operator may partner with a utility company to access its existing infrastructure, or with a car manufacturer to provide charging services for its vehicles. • It also should be considered that both PPP and private involvement can involve **partnering** with electric vehicle (EV) manufacturers, brands, or suppliers to increase technology access, adoption of EV, joint marketing, and promotion of EVs.

Estimated risks associated with implementation of the action	• There is a risk that **EV technology may become outdated** or be replaced by new advancements before the investment can be recouped. • The uptake of EVs and **the demand for charging infrastructure is subject to uncertainties**, and there is a risk that the market may not work as expected, leading to underutilization of charging stations and lower than expected returns on investment. This also includes business model and commercial feasibility risk. Making the infrastructure available to a wider cohort (2- or 4-wheelers) can help address this risk. • The development of EV charging infrastructure is subject to a **complex and ever-evolving regulatory environment**, including local and central government regulations. Changes in regulations could increase costs, delay deployment, or make investments uneconomic since the market is still at the very early stage in Indonesia. • The **development of EV charging infrastructure is capital-intensive**, and there is a risk that financing may not be available or that returns on investment may not be adequate to cover costs. • The **operation of charging stations involves a range of risks**, including the risk of equipment failures, power outages, and other operational disruptions. • The deployment of charging infrastructure may involve **environmental risks**, including risks associated with the use of land, the construction of charging stations, and the potential impact on local wildlife and habitats.
Definition of initiative leadership	• PLN • Local Development Planning Agency • Agency for Public Works and Spatial Development

Action 5.5: Prepare industries for electric vehicle conversion

Justification	The public perception about electric vehicles is that they are prohibitively expensive to buy. As an alternative, local governments can develop an industry to convert existing fuel/internal combustion engine (ICE) vehicles into electric vehicles, particularly 2-wheelers.
Implementation strategy	This strategy can begin with the conversion of motorcycle engines/two-wheelers, allowing for a more gradual transition from traditional gasoline vehicles to EVs[33]. This can be a cost-effective solution for countries with a high proportion of older vehicles on the road, including Indonesia. Government policies and incentives can provide tax credits, subsidies, and other financial incentives to encourage the transition to EVs. In addition, standards and regulations can be established to ensure the safety and reliability of converted vehicles. However, the conversion process is complex and requires significant technical knowledge and expertise, so the industry must be prepared to invest in research and development to improve conversion technologies and processes.
Supporting technology	• **Electric drivetrain components**: This includes electric motors, inverters, batteries, and other components necessary for the conversion to an EV. • **Vehicle design and engineering:** This involves the modification of existing vehicle designs to incorporate electric drivetrain components, as well as the development of new designs specifically for conversions. • **Manufacturing processes:** This includes the development of efficient and cost-effective manufacturing processes for converting vehicles to EVs, including welding, assembly, and testing processes. • **Battery management systems:** This includes the development of efficient and safe battery management systems to ensure that the battery packs in converted vehicles are safe and reliable.

[33] The conversion process involves replacing the traditional gasoline engine and fuel system of a vehicle with an electric motor and battery pack, resulting in an electric vehicle.

	• **Electrification and power electronics expertise:** This involves expertise in the design and integration of electrical systems in vehicles, as well as the development of efficient power electronics systems. • **Safety and certification:** This involves the development of safety and certification processes to ensure that converted vehicles meet relevant safety and regulatory standards.
Policy linkage	Minister of Transportation Regulation 65/2020 on the Conversion of Fuel Motors to Electric Motors

Timeline	• 2023 onwards:
	  ○ Introduce government incentives and subsidies to encourage industries to transition to EVs.
	  ○ Raise awareness among industrial players about the benefits of EV adoption, including reduced operating costs, environmental sustainability, and improved public image.
	  ○ Collaborate with industry associations and organizations to organize workshops, seminars, and information campaigns to educate businesses on the conversion process and its market potential, and available support.
	  ○ Collaborate with local universities, polytechnics, and vocational schools on conventional vehicle engine conversion technologies and learning.
	
	• **2025–2026**:
	  ○ Initiate pilot programs in selected industries to assess the feasibility of converting their fuel-based fleets to electric vehicles (EVs).
	  ○ Collaborate with industry stakeholders, EV manufacturers, and charging infrastructure providers to gather data, evaluate the technical and economic viability, and identify any potential challenges or requirements for the conversion process.
	
	• **2025–2035**:
	  ○ Invest in the development of charging infrastructure specifically tailored for industrial needs.

- Collaborate with charging infrastructure providers and businesses to strategically install charging stations at industrial sites, logistic hubs, and transportation depots.
- Prioritize high-capacity charging infrastructure to meet the energy demands of larger fleets and optimize charging times.

- **2025–2035**:
  - Fleet electrification means encourage industries to gradually replace their fuel-based fleets with EVs.
  - Offer financial incentives, tax breaks, and supportive regulations to facilitate fleet electrification.
  - Work closely with automotive manufacturers and fleet operators to ensure the availability and suitability of electric vehicle models for different industry requirements.
  - Facilitate the leasing or financing options to ease costs.

- **2025–2035**:
  - Foster collaboration among industries, EV manufacturers, and charging infrastructure providers to develop tailored solutions for specific industrial sectors.
  - Create platforms and networks to share best practices, experiences, and lessons learned from successful conversions.
  - Encourage supply chain integration to support the growth of EV adoption, including partnerships for battery recycling and renewable energy sourcing.

- **Beyond 2030**:
  - Monitor the progress of industry conversions and evaluate the effectiveness of implemented measures.
  - Conduct periodic assessments to identify emerging technologies, regulatory changes, and market trends that could impact the industry's transition to EVs.

	○ Provide ongoing support, technical assistance, and funding opportunities to ensure the sustained growth of EV adoption.
Possible sources of financing	• **Governments** can provide funding for the development of conversion technologies and processes, as well as provide incentives for EV adoption. • **Automobile manufacturers**, as well as other private investors, can provide financing for the development of conversion technologies and processes, as well as for the manufacture and sale of converted EVs. • **Venture capital** firms can provide funding for startups and small businesses involved in the conversion of vehicles to EVs.
Estimated risks associated with implementation of the action	• **Technological risks**, such as the lack of availability of critical components, battery technology limitations, and slow charging times. • **Market risks**, such as uncertainty in consumer demand and government support, competition from ICE vehicles, and potential changes in fuel prices. Slow adoption and growth of the electric vehicle market may cause this electric motor conversion industry to insufficiently develop. • **Regulatory risks**, including potential changes in government regulations, incentives, and subsidies. • **Financial risks**, such as high costs of converting to EV production, potential changes in consumer demand and subsidies, and high capital investments in EV technology. • **Infrastructure risks**, including the availability of charging stations and the lack of standardization in charging technologies. • **Supply chain risks**, such as the availability of raw materials, components, and other resources needed for EV production and charging infrastructure. Currently, WNT is not an industrial area, so the development of this kind of industry has more potential to be developed in Java.
Initiative leadership	• Ministry of Industry • Agency of Industry

Action 5.6: Promote hydrogen vehicles for public transport

CHAPTER 4: INVESTMENT STRATEGIES AND FINANCIAL INNOVATIONS

The framework of infrastructure funding, which includes renewable energy, can be divided into two broad groups: (i) the public or government funding through the modality of government budget or APBN (and APBD) and (ii) the non-public funding or non-APBN/APBD.

The government funding that is allocated through the APBN comes from tax revenues and grants, foreign loans, domestic loans, and the issuance of state securities (such as government bonds), whereas non-public or government funding includes financing from banking, non-bank financial institutions, capital markets (stocks and bonds), foreign funds, and others.

Aside from that, there is Public Private Partnership (PPP), which is a collaborative arrangement to bring aboard the combination of government/public funding (via APBN/APBD) and business or private sector investment. The public and private collaboration accelerates achieving national development goals through the involvement of private investment/business entities in the provision of public infrastructure. In addition, it is envisaged that each party's skills and assets (resources) can be leveraged collaboratively to offer the services and/or facilities required by the public. Furthermore, it offers rewards to each party as well as commensurate risks.

The sections that follow explain each type of financial mechanism and instruments that have the potential to be optimized in order to achieve 100% renewables in the WNT province of Indonesia by 2050.

4.1 State and local government budget

The government budget consists of the central government budget (known as the *Anggaran Penerimaan dan Belanja Negara* or APBN) and the local government budget (or known as the *Anggaran Penerimaan dan Belanja Daerah* or APBD), they are the basic modality and fiscal instrument of the government. Both APBN and APBD consist of how the government budget is funded or collected and spent, where one of the major allocations of APBN spending is in the form of transfers of central funds to local governments.

The funding of APBN come from taxes, non-tax state revenue (*Pendapatan Negara Bukan Pajak* or PNBP), and other financial instruments such as bonds, loans, and grants from within and outside the country originating from (1) bilateral and multilateral development financing institutions; (2) financial institutions (banks and non-banks); and (3) investors, both individuals and business entities. These funding sources have different characteristics, so their utilization needs to be adjusted to those characteristics.

- **Taxes**
  Taxes are state revenues originating from the public deriving from income tax, value-added tax, land and building tax, vehicle tax, excise, international trade tax, and other taxes. Taxes are used to finance government operations and investments. However, the low tax collection ratio hurts the government's capability to fund itself, for reasons of policy gaps and compliance gaps. The policy gap arises due to the reduced tax revenue and special tax provisions, such as tax incentives. The incentive is indeed needed to spur some specific emerging markets (for example renewables, EV, etc.) while at the same time it also sacrifices the tax-based revenue.

  One of the major issues in Indonesia is the underperformance of tax to Gross Domestic Product (GDP) ratio or tax ratio indicator. In 2020, the national tax ratio was only around 10.1%, lower than other neighboring countries such as the Vietnam (22.7%), Philippines (17.8%), and Thailand (16.5%).[34] The tax revenue gap also covers the issue of the large tax evasion potential. It includes public awareness and compliance to comply with taxes such as the upper-class of Indonesian people who tend to avoid paying taxes. Likewise, tax administration needs to improve the ease of payment, trust, reporting, tax-staff integrity, and access to tax information based on information technology.

- **Non-tax state revenue (PNBP)**
  Non-tax state revenue is state revenue outside of tax revenue, which includes revenue originating from the utilization of natural resources, services carried out by the government, management of state assets separated, management of State Property, management of funds and other state rights. PNBP is used to finance government operations and investment activities.

[34] https://www.oecd.org/tax/tax-policy/revenue-statistics-asia-and-pacific-thailand.pdf

- **Grants**

  Grants constitute state revenue in the form of foreign exchange, foreign exchange converted into rupiah, goods, services, and/or securities that do not need to be repaid, which can come from within or outside the country. Grants are used to support national development programs and disaster management as well as humanitarian aid.

- **Foreign loans**

  Foreign loans are state revenues that must be repaid under certain conditions, in the form of government debt bound by a loan agreement and not in the form of state securities. Foreign loans consist of cash loans and activity loans, originating from multilateral creditors, bilateral lenders, foreign private lenders, and guarantee institutions for export credit. Foreign loans can be used to finance APBN deficits and priority activities of ministries or agencies; manage the debt portfolio; forwarded to the local government and state-owned enterprise; and granted to local governments with a focus on financing economic and social infrastructure with technology transfer; international good practice and knowledge sharing; piloting projects that can be replicated with rupiah funding; and has high leverage.

On the spending side, this includes mainly the central government spending (including ministerials and government agencies' budgets) and transfer to the local government. There are several challenges facing APBN spending:

- Limited space for fiscal movement due to mandatory expenditures such as energy (electricity, LPG, gasoline) and social security subsidies, etc.
- Low efficiency and effectiveness of state spending
- Nonoptimal state expenditures for capital investment as reflected in the lower target realization, while subsidy spending is higher than the target
- The low tax collection or tax-to-GDP ratio

Similarly, with regards to the APBD, a review of the 2021 APBD found that local own-source revenues (PAD), on average, accounted for only 17% (mostly from local tax revenues) of total local government revenues. The 80% dominance of revenue generally relies on the transfer revenue component including transfer funds from the central government (e.g., General Allocation Funds and Special Allocation Funds), while the other 3% is other income. In terms of expenditure, the 2021 APBD study shows that around 69% of the expenditure allocation is used for operational expenditures (including employee salary expenditures, etc.) leaving a small portion for capital expenditure (including infrastructure) namely about 17% of the financing budget.

In terms of infrastructure, the national medium-term development plan for 2019-2024 has identified the funding requirement of Rp 6,500 trillion to build up Indonesia's infrastructure (including the energy sector). However, according to the government release, the APBN has limitations in financing national infrastructure development which can only cover 42% of the total infrastructure funding needs.[35] Besides direct spending, the government has also provided fiscal incentives to enterprises in the infrastructure industry (for example, the green infrastructure through fiscal incentives for renewable energy development). It is indeed essential for the government to spur clean energy investment through tax incentives.

The following are several sorts of relevant state taxes related to the advancement of renewable energy:

able 16: State taxes related to the advancement of renewable energy

Type of incentives	Prevailing regulations	Remarks
Tax allowances Tax allowance, or tax relief, is an incentive given in the form of a reduction in corporate income tax. The award is based on Government Regulation No. 78 of 2019 which regulates 166 specific business sectors and 17 specific business sectors located in certain areas that are entitled to income tax reduction. Investment in renewable energy power plants is included in the priority sector category, along with activities for utilizing geothermal energy, generating electricity from micro and mini hydro, and coal gasification. The technical regulations regarding tax allowances are stipulated in the	• Government Regulation No. 78/2019 • Minister of Finance Regulation No. 96/PMK.010/2020	• Deduction in net income of 30% of the total investment in the form of tangible fixed assets; charged for six years at 5% each per year • Accelerated depreciation and amortization • Income tax on dividends to foreign taxpayers is set at 30% or lower • Compensation for losses that are longer than 5 years but not more than 10 years

[35] https://www.cnnindonesia.com/ekonomi/20220708134350-532-818994/apbn-cuma-sanggup-biayai-42-persen-infrastruktur-hingga-2024

Type of incentives	Prevailing regulations	Remarks
Minister of Finance Regulation No. 96/PMK.010/2020 concerning Income Tax Facilities for Investment in Certain Business Fields and/or Certain Regions.		
Import facilities Additional fiscal facilities for renewables are levy relief on imported goods. Apart from being entitled to a tax allowance, renewables developers are also entitled to exemption from income tax due to imported goods, exemption from import duties, and VAT exemption for imported goods.	• Ministry of Finance (MoF) Regulation No.176/2009 jo. 188/2015 • MoF No. 66/2015	• Income tax for imported goods: Tax deduction for import machinery and equipment • VAT exemption: Exemption from the imposition of VAT on imports of machinery and equipment • Import duty exemption facility: Import duty exemption for the import of machinery and construction materials
Tax holidays Tax holidays give an opportunity for investors to get tax relief facilities for 5-20 years with a minimum investment of Rp 500 billion, and a maximum of 100% income tax deduction. There is also a mini tax holiday incentive in which investors can get five years of tax relief facilities with a minimum investment of Rp 100-500 billion, and a maximum of 50% income tax deduction.	• Minister of Finance Regulation Number 130/PMK.010/2020	

Related to the achievement of 100% renewables in WNT, the APBN and APBD constellation's sustainability and reliability to support this ambitious target are very limited. Therefore, the local government, especially the WNT Provincial Government, needs to explore possible and

potential financing options to close the gap in infrastructure and renewable energy financing needs.

Some options that can be considered to strengthen the APBD are as follows:

Table 17: Potential financing option to strengthen the APBD

Financing facilities	Brief description	Prevailing regulations	Challenges and opportunities
Local government loan facility	A state-owned enterprise (SEO) under the Ministry of Finance that enables loan schemes for infrastructure development; also known as *PT Sarana Multi Infrastruktur/PT SMI*[36]	Minister of Finance Regulation (PMK) No. 100/PMK.010/2009 concerning Infrastructure Financing Companies with eight operational sectors financeable by PT SMI	• O1: The company's mandate is to promote sustainability through SDGs and mitigating climate change. • O2: Concentrating on eight operational sectors namely, roads and bridges, transportation, oil and gas, telecommunications, waste management, electricity, irrigation, and drinking water supply.
Municipal bonds	One source of medium- and long-term regional loans that may only be issued on the domestic capital market and in rupiah	Minister of Finance Regulation Number 180/PMK.07/2015 of 2015 regarding Amendments to MoF Regulation Number 111/PMK.07/2012 on the Procedure	• C1: The regional bonds may only finance public sectors that (i) produce income and benefit the community and (ii) are related to the regional

[36] SMI (2021), https://ptsmi.co.id/cfind/source/files/digital-publication/panduan-inisiasi-pinjaman-daerah-2021.pdf.

		for the Issuance and Accountability of Regional Bonds	government's business. • C2: Generally overlooked due to unfamiliarity, credit rating issues, financial capacity, and the availability of other funding alternatives.
Two step foreign loans (PPLN)	Bilateral loans originated from development banks and international organizations (e.g., *Japan International Cooperation Agency* / JICA, *Asian Development Bank* / ADB, the World Bank, and bilateral loans from other countries).	Minister of Finance Regulation (PMK) No. 108/2016 jo. 108/2019 on Procedures for Domestic Loan Forwarding and Foreign Loan Forwarding to State-Owned Enterprises and Regional Governments	• O1: Loans are generally thematic, and support specific sectors agreed between creditor and debtor. • C1: Classified as a *sovereign* loan facility aimed at the country.

Apart from the APBN / APBD-based funding development model above, the national government has reviewed other policies to expand specific public funding sources for RE development including through *carbon taxes, surcharges* on electricity and fuel oil use, and *levies* on coal exports (see Table 18 below). This is not yet fully set to become a policy and is still in the study stage. However, in the future, these options for strengthening the state budget will be very dynamic and continue to roll out.

Table 18: Public funding alternatives

Instruments	Remarks
Carbon taxes	In addition to providing fiscal incentives, the government plans to impose a carbon tax on GHG emitters. In a carbon tax, the party that produces more emissions will pay a higher tax because the carbon tax rate is set per the amount of emissions produced. The imposition of a carbon tax will be a disincentive for economic activities that are not environmentally friendly due to a larger tax burden, and vice versa, and will be an incentive to encourage more environmentally friendly economic activities. Apart from being a source of state revenue, carbon taxes can also be used as a source of climate change funding through earmarking, including building green and resilient infrastructure, including renewables. The government compiled a carbon tax in 2021 through the Tax Harmonization Law originally to be implemented in April 2022. Initially, the carbon tax pilot cases will be conducted in the power sector. However, based on the government's statement in October 2022, the implementation of this carbon tax policy has been delayed again until 2025.[37]
Surcharges on fossil fuel use and limiting fossil fuel subsidy	A strategy of public funding collection for fuel use per liter was proposed and announced by the government in 2016. The fund was planned to be managed as an Energy Security Fund to construct lighting and electricity facilities in remote locations and to build strategic petroleum reserves. Other goals of the fund included subsidizing RE electricity rates and building RE infrastructure. However, the inadequate legal framework could not protect the recovery of these funds and this policy has been put on hold for an unforeseen period.[38] Limiting and eventually removing fossil fuel subsidies presents a strategic opportunity to redirect financial resources towards renewable energy projects. This initiative can foster the growth of the renewable energy sector by reallocating funds, incentivizing investments, fostering competitiveness, and advancing power grids.

[37] https://nasional.kontan.co.id/news/implementasikan-penerapan-pajak-karbon-mulai-berlaku-tahun-2025

[38] https://www.cnnindonesia.com/ekonomi/20160104184253-85-102101/jokowi-batalkan-rencana-pungutan-dana-ketahanan-energi

4.2 Public-private partnerships (PPPs)

The limited government budget (APBN/APBD) in infrastructure financing causes gaps in ensuring the availability of infrastructure services for the community as beneficiaries. To overcome this, the government can use alternative financing mechanisms by involving private investment through an umbrella cooperation agreement known as public-private partnership (PPP). Typically, PPP is a form of binding agreement between the public sector as the government contracting agency with the private sector or business entity to provide a public service facility for a longer time period (e.g. 10-20 years or more) ("PPP Agreement").

PPP is generally applied to infrastructure projects whose existence is important for improving the quality of life of the community but has a typical marginal economy or is not feasible enough to be developed on a *business-to-business* (B2B) basis, for example drinking water supply systems (SPAM), wastewater treatment plants (WWTP), satellites, hospitals, and the like. In order to increase investment feasibility, projects developed under the PPP scheme − especially solicited PPPs (based on the proposal or prioritization of the government's plan) − can obtain government support in the form of the Viability Gap Fund (VGF), government guarantee through PT Penjaminan Infrastruktur Indonesia (PII), and the Project Development Facility (PDF) which aims to provide technical assistance to the local government as the government contracting agency (depending on the project structure) in preparing and conducting PPP transactions.

On various occasions, PPP is often juxtaposed as an alternative to the direct use of APBN/APBD in infrastructure financing. Instead of direct use of APBN/APBD, where all risks of infrastructure provision are absorbed by the government with high *upfront costs*, PPP transfers some of the obligations and risks of infrastructure provision such as capital investment requirements, financing, design, as well as construction and operation risks during the agreement period to the private sector entities, who are better equipped to manage such risks. Therefore, PPPs present a framework that, while engaging the private sector, acknowledges the role of the government in ensuring that social obligations are met and necessary public investments are realized. Private sector engagement usually requires a reasonable rate of return on its investment as a prerequisite for PPP projects.

Furthermore, compensation from an investment in the availability of infrastructure services developed by business entities in a PPP will be made through a payment mechanism that is the right of the business entity. This ensures that the investment made has a decent and attractive

rate of return. The payment is obtained periodically by the business entity within a certain period during the implementation of the PPP agreement. There are several types of payment mechanisms, but briefly the payment mechanisms can be grouped into two categories, namely:

- **Retribution or *user charges*** where payment is collected by the business entity directly from users of the service (e.g., toll roads).
- ***Government pays*** where payment for the availability of infrastructure services is made by the government to the business entity under the condition that it meets the minimum service requirements in accordance with the PPP Agreement. This mechanism is generally applied if the PPP project does not generate a payment from the public or user, or the business model has a high level of default risk if applied using user charges.

Table 19: General legal umbrellas in the implementation of PPPs in Indonesia

Ref.	Regulations	Relevance to the project
Public-private partnership	• Presidential Regulation No. 38/2015 on Public Private Partnership for Infrastructure Development Ministry of National Development Planning/ National Development Planning Agency Regulation No. 4/ 2015 on Implementation Procedures of Public Private Partnership for Infrastructure Development as amended by Ministry of National Development Planning / National Development Planning Agency Regulation No 2/2020 on the Amendment of Ministry of National Development Planning Regulation No. 4/2015 on Implementation Procedures of Public Private Partnership for Infrastructure	• These are the basic regulations that regulate the implementation of PPP in Indonesia. • The LKPP Regulation No. 19/2015 covers steps and guidelines of procurement of (i) PPP preparation body/experts/consultants (that are not funded by grant / international organization, etc.) that are mandated to assist the GCA in project preparation and/or transaction of the project, and (ii) procurement IBE both in term of solicited and unsolicited PPP projects.

Ref.	Regulations	Relevance to the project
	Development ("Bappenas Regulation No. 4/2015 juncto Bappenas Regulation No. 2/2020") ● National Public Procurement Agency Regulation No. 19/2015 on Implementation Procedures of Procurement in Public Private Partnership for Infrastructure Development ("LKPP Regulation No. 19/2015")	
Availability payment	● Ministry of Finance Regulation No 260/PMK.08/2016 on Procedure for Payment of Service Availability on Public Private Partnership for Infrastructure Development ("MoF Regulation No. 260/2016"); and ● Ministry of Home Affairs Regulation No 96/2016 on Availability Payment on Public Private Partnership for Regional Infrastructure Development in ("MoHA Regulation No. 96/2016")	● The MoF Regulation No. 260/2016 sets out that availability payment is sourced from the government budget (APBN / APBD) where in this case GCA is the Budget User Authority. The AP budgeting shall be carried out periodically by Ministers/Head of Institutions/Head of Regions in every fiscal year following the payment obligations of GCA during the PPP agreement. The regulation also requires that in order to be entitled to AP, the selection of IBE in PPP must be done fairly, openly, and transparently. ● The MoHA No. 96/2016 regulates funding

Ref.	Regulations	Relevance to the project
		mechanisms for infrastructure development at the regional level. The regulation provides assurance for the private sector that their capital expenditure to build infrastructures will be repaid by the regional government through the regional budget on a yearly basis.
IIGF guarantee	• Presidential Regulation No 78/2010 on Infrastructure Guarantee in Public Private Partnership Implementation through Infrastructure Guarantee Facility ("PR No. 78/2010") • Ministry of Finance Regulation No. 260/PMK.011/2010 on Implementation Guide on Infrastructure Guarantee in Public Private Partnership as amended by Ministry of Finance Regulation No 8/PMK.08/2016 on Amendment of Ministry of Finance Regulation No 260/PMK.011/2010 on Implementation Guide of Infrastructure Guarantee in Public Private Partnership ("MoF Regulation No.	• The presidential decree regulates the mechanism to have the project being guaranteed by the Government of Indonesia through the Indonesia Infrastructure Guarantee Facility (IIGF). • The MoF No. 8/PMK.08/2016 regulates mechanism of availability payment (AP) for PPP projects, including planning and/or preparation for PPP projects with AP scheme. It also explains the provision of fiscal facility for PPP projects based on regulations.

Ref.	Regulations	Relevance to the project
	260/2010 juncto MoF Regulation No. 8/2016")	

The use of PPP schemes in the electricity sector and especially renewable energy in Indonesia is currently very limited. This is because the electricity sector is considered a common business model and has been classified as feasible to run B2B (for example, in the Independent Power Producer (IPP) scheme). However, there are still many potential PPP opportunities for renewable energy development, including in solar power plant infrastructure, solar-based public street lighting, public electric vehicle charging stations, waste management and waste-to-energy, mini-grid based village electricity, and others. Note that each of these infrastructure projects will have different characteristics and require tailored PPP preparation, so each PPP plan needs to be well-identified by the local government.

Some of the PPP focal points are:

- Directorate of Government Support Management and Infrastructure Financing
- Directorate General of Financing and Risk Management, Ministry of Finance
- Directorate General of Infrastructure Financing, Ministry of Public Housing Public Works
- PPP Joint Office led under the National Development Planning Agency or Bappenas
- PT Sarana Multi Infrastruktur (Persero)
- PT Penjaminan Infrastruktur Indonesia (Persero) or the Indonesia Infrastructure Guarantee Fund

Independent Power Producer (IPP) Scheme
PT PLN is open to business-to-business collaborations with private entities to invest, develop, and operate power generation projects. This framework is designed to encourage private sector engagement, attract investments, and foster the development of renewable energy in Indonesia's energy mix. The regulations governing this initiative are outlined in MEMR Regulation No 50/2017 concerning the utilization of renewable energy sources for electricity provision, as amended by Ministerial Regulation No 4/2020. This amendment specifies that PT PLN will procure electricity through direct appointments, considering location and capacity as outlined in PT PLN's Electricity Supply Business Plan (RUPTL). The procurement process follows the Power Purchase Agreement (PPA), a bilateral cooperation agreement that

delineates the terms of electricity purchase, including the agreed-upon tariff, duration, and other pertinent conditions.

In the sale of electricity based on the Own Generation Cost (BPP) formula, PT PLN has stipulated conditions for various renewable sources such as solar photovoltaic, wind power, biomass, biogas, and ocean energy. According to these conditions, the maximum purchase price for electricity is set at 85% of the generation cost of the power system.

Some aspects the local government must lead when planning and developing a PPP project are as follows:

- Have and prepare the capacity of regional government work units as PPP teams.
- Improve the local government staff knowledge and expertise related to PPP, project risk allocation, and aspects related to project technical and financial feasibility.
- Establish cooperation with international organizations regarding cooperation and *technical assistance* in the preparation of PPPs.
- Prepare a solid pipeline of PPP projects that are ready to be developed and consolidate the project *pipeline* in the PPP project list and the Regional Medium-Term Development Plan (RPJMD).
- Establish coordination and communication with PPP stakeholders, including legislative elements or the Regional House of Representatives regarding the planning of PPP projects and their budgeting in the APBD.

Table 20: Differences between the use of APBN/APBD for infrastructure capital expenditure and the implementation of PPP schemes

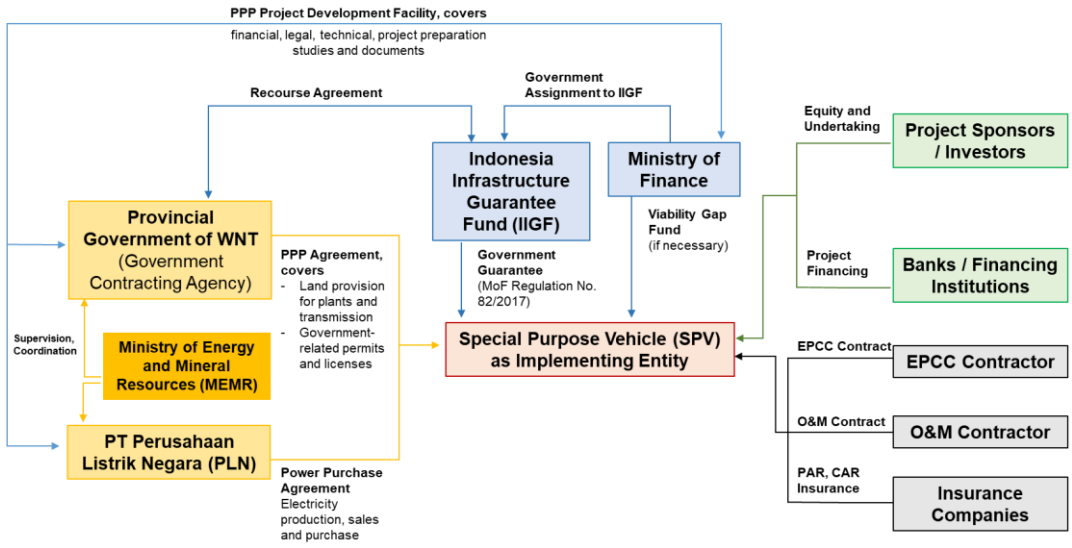
Aspects	APBN/APBD	PPP
Cooperation subject	Generally, in the form of capital expenditure by the government with payments to contractors	Government and business entities
Business entity scope of work	The selected contractor undertook the *Design and Build* work.	The selected business entity can carry out the work under the contract for *Design, Build, Finance, Operation, Maintenance, Transfer.*

Aspects	APBN/APBD	PPP
Government contribution or support	It can be in the form of general fiscal incentives to the contracting corporation or specifically in the form of incentives for exemption from import duties, etc. if imports are required.	May include: • Fiscal incentives, income tax and VAT tax exemptions (tax allowances), import/export duty exemptions. • Project Development Facility (PDF) • Viability Gap Fund • Government guarantee through IIGF • Availability payment • Land acquisition, by the State Asset Management Agency (LMAN)
Return on enterprise investment	None, as financing is fully covered by APBN/APBD where the Business Entity generally only acts as a contractor for the work.	May include: • User charge for a period in accordance with the PPP agreement • Availability payment for a period in accordance with the PPP agreement • Other forms in accordance with the PPP agreement as long as it does not conflict with applicable laws
Source of financing	APBN/APBD	• Commercial investment funds and generally loans or credits from banks to business entities to cover the construction cost and general capital expenditure • APBN/APBD as a source of availability-based payment
Operational mechanism	Depending on the contract, generally long-term operations are carried out by the government or local government work units or related agencies. However, if it is done by a business entity,	The business entity is fully responsible for project operations in accordance with the PPP agreement until it ends with the transfer of ownership.

Aspects	APBN/APBD	PPP
	there will generally be a separate contract outside the construction contract.	
Example	• The Ministry of Energy and Mineral Resources' Solar Energy Saving Lamp (LTSHE) program for communities in outermost regions that have not been electrified • The construction of solar and micro-hydro power plants for villages under the Energy Independent Village scheme, using a budget from the Ministry of Energy and Mineral Resources	Waste-to-energy projects, 2x30 MW power plant, water supply system (SPAM), etc.

Two potential schemes of PPP for renewable energy projects – namely a solar park and rooftop solar for government buildings – are outlined in Figure 12 below:

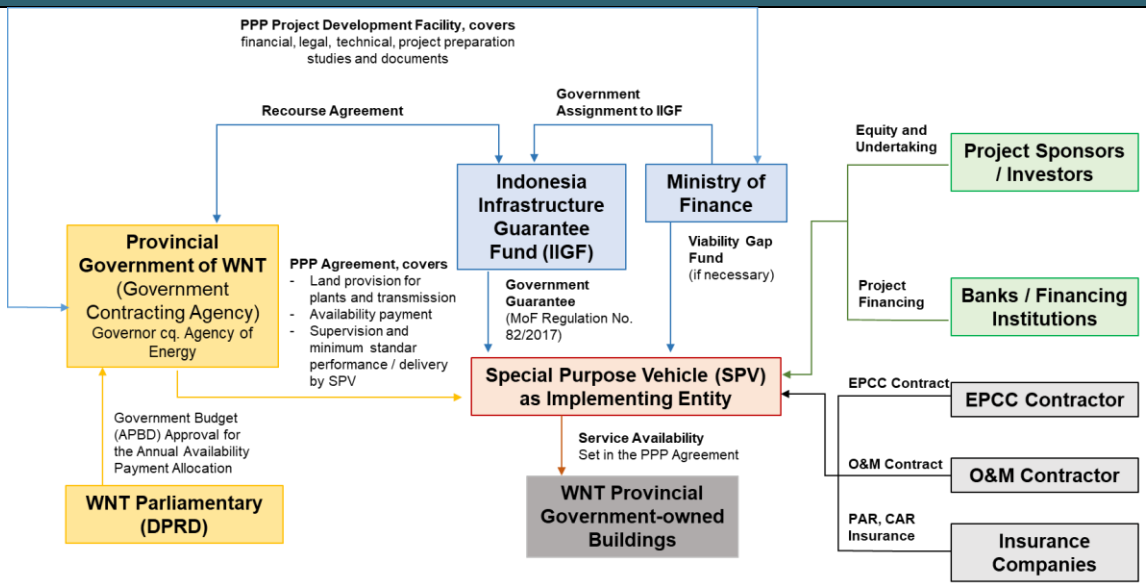
Potential PPP scheme in the development of a solar park in WNT



The above graphic shows prospective and potential project structures for a PPP-based solar park. However, as a disclaimer, this structure has to be further exercised

Potential PPP scheme in the development of a solar park in WNT
and is still not yet provenly workable particularly in terms of its alignment with legal and PPP regulatory framework. One of the challenges in the PPP-based solar park scheme in West Nusa Tenggara (WNT) and Indonesia in general, when involving the provincial government, is the existence of two government contracting agencies with different significant authorities, namely the provincial government and PLN. Thus a further exercise is required to develop an effective project structure and also risk-sharing allocation mechanisms. In the potential structure above, the WNT government can act as a government contracting agency (GCA) to handle the part of land provision, transmission, and licensing, while PT PLN - referring to the current state owner of the electricity sector - conducts a tender or reverse auction for the development of ground-mounted solar parks on a PPP basis. In the context of the Project Development Facility, bid preparation may also receive technical support, such as network potential and impact assessments, the creation of technical specifications and draft PPAs, etc. Batteries may also be required by technical specifications, which would have an impact on the electricity pricing determined by the auction. In terms of financial support, the Ministry of Finance may designate the Indonesia Infrastructure Guarantee Fund (IIGF) to cover the government-related risks associated in accordance with regulations. In addition, the PPP scheme can also be applied for the floating solar power plant on the inundation of dams in WNT such as Pandan Duri Dam, Bintang Bano, and Batu Bulan. The government contracting agency depends on who has ownership and authority over the use of the dam (for example, the Minister of Public Works). The concept of floating solar on dams is a solution to the risk of land availability for large-scale PLTS. As a note, the above case only illustrates the potential PPP implementation for the solar park. Further research is required to identify the details and applicability.

Potential PPP scheme in the development of rooftop solar for government buildings



PPP-based rooftop solar for government buildings could encourage private sector participation in the development of innovative solar projects. According to this plan, the Governor of WNT will serve as the government contracting agency (GCA), and the Provincial Energy and Mineral Resources Agency will act as GCA's delegation for the project. In the PPP-based rooftop solar project, the government will conduct the planning and preparation along with conducting business and feasibility studies, and an auction to obtain the private partner. The project can also access government guarantees by the IIGF. Under the terms of the PPP agreement with the GCA, the corporate entity will get compensation for its investment through a long-term availability payment (AP) contract.

Figure 12: Two potential PPP schemes for renewable energy projects

4.3 Banks and non-banking financial institutions

Funding renewable energy projects in West Nusa Tenggara Province, Indonesia, can be achieved through various sources and mechanisms. Banking and non-banking financial institutions (NBFIs) form a vital source of funding renewable and clean energy projects where loans or credit facilities from traditional banks to projects may cover up to 50% to 70% of capital expenditure. Here, businesses may secure different types of loans, such as term loans, working capital loans, or lines of credit. In addition to this, the NBFIs, which include entities like insurance companies, pension funds, hedge funds, and other financial intermediaries, may provide financing in the form of loans or investments to the energy projects. National and local

banks may also consider issuing green bonds or participating in the stock market through an initial public offering (IPO) to raise capital for renewable and clean energy projects. This approach involves engaging with investment banks and regulatory authorities. Moreover, foreign funds in the form of foreign direct investment (FDI), where a company from one country invests in another, or foreign portfolio investment (FPI), which involves investing in financial assets such as stocks and bonds, can be implemented by banks and authorised by the national financial regulatory authority of Indonesia.

Solar energy is one of the backbones to achieving 100% renewables in WNT in 2050. Therefore, attractive financing support for rooftop solar, especially in the household sector, is a crucial incentive for the community to use rooftop solar. Several banks of the Association of State-Owned Banks (Himbara) such as Bank Mandiri[39] , BRI[40] , and BNI[41] have provided a special financing facility in the form of instalments for commercial retail customers to install rooftop solar power systems. In addition, private banks such as UOB Bank through the U-Solar program have also developed similar facilities in collaboration with rooftop solar vendors.[42] To garner support in realizing a more substantial development of rooftop solar power systems in WNT, the regional government needs to coordinate with these investors, rooftop solar power providers, and banks.

As an enhanced incentive to encourage communities (including household) to install rooftop solar, the United Nations Development Programme (UNDP) Indonesia, in partnership with the MEMR, launched an incentive program for rooftop solar systems under a Sustainable Energy Fund (SEF) grant in February 2022 that tapped funding support from the Global Environment Facility (GEF). The program ended in early 2023 as it accomplished its milestones. In brief, this incentive aimed to encourage people to install rooftop solar systems, especially for the customers of state electricity utility PLN from households, businesses, and small and medium enterprises (SMEs), and social category (schools/educational buildings, hospitals, houses of worship). The SEF grant for rooftop solar systems was given based on a performance-based payment mechanism using e-vouchers. Applicants must pass a verification stage by meeting the requirements and criteria. Approved applications received incentives paid in a lump sum according to the e-voucher value via bank transfer to the applicant's account number.[43]

[39] https://wartaekonomi.co.id/read389726/bank-mandiri-dan-grup-sun-energy-teken-mou-green-financing-dan-perluas-pemanfaatan-sistem-plts-atap
[40] https://money.kompas.com/read/2021/01/22/063302126/bri-dan-len-industri-kerja-sama-untuk-pembiayaan-plts-atap
[41] https://m.bnizona.com/events/view/6691
[42] https://www.uobgroup.com/u-solar-id-en/index.page
[43] https://www.esdm.go.id/en/media-center/news-archives/energy-ministry-launches-sef-grant-for-rooftop-solar-systems

Project owners and developers from WNT may seek funding from international organizations and agencies that support renewable energy projects in developing countries. Organizations such as the Asian Development Bank (ADB) and the International Finance Corporation (IFC) may provide financial assistance. Secondly, collaborating with international organizations and non-governmental organizations (NGOs) that focus on sustainable development could be another way to source funding for projects, as these entities may provide grants, technical assistance, or facilitate partnerships. The WNT government, in collaboration with national government ministries, must investigate climate funds and initiatives that support projects aimed at mitigating climate change. The Green Climate Fund (GCF) is an example of an international fund that supports climate-related projects.

In addition, some project developers are beginning to explore the market of commercial and industrial (C&I) solar aiming at providing electricity-based solar systems for commercial and industrial buildings. Several start-up companies provide a zero-investment scheme for the C&I off-takers, and offer a long-term contract under a leasing agreement in which all the required investment including PV equipment are provided by the solar project developers. Although high risk, this is considered as a new innovative business scheme to expand the growth of solar in Indonesia.

4.4 Business-to-business (B2B) private and enterprise investment

B2B investments by both private and state-owned enterprises (SOEs) in the renewable energy sector include projects that are technically and commercially viable, such as the Independent Power Producer (IPP) scheme in the electricity sector. These private investment schemes involve investment capital funds and generally loans or financing from banks, both national and international, as lenders. Depending on the type of project, compensation for the investment is paid for example using a long-term payment contract such as a power purchase agreement (PPA). There are several precedents in WNT Province for this scheme, such as the construction of the Selong, Sengkol, and Pringgabaya solar power plants with a total capacity of about 20 MW financed by the Asian Development Bank - Private Sector Operation Development.

ADB and private support for solar PV development in WNT[44]
In 2017-2018, the ***Asian Development Bank*** (ADB) declared its investment in RE assets developed by Vena Energy, formerly Equis Energy, the largest independent producer of renewable electricity in Asia and the Pacific with an 11 GW portfolio in operation,

[44] https://www.adb.org/id/news/adb-finances-first-ever-utility-scale-solar-pv-plants-indonesia-160-million-renewables-deal

construction, and development. In total, ADB's USD 160 million investment will support the construction, operation, and maintenance of a portfolio of RE projects including 4 solar farms: a 21 MW solar farm in Likupang, North Sulawesi, and three units of ~7 MWp each (or about 5 MW inverter/AC capacity) located in Pringgabaya, Selong, and Sengkol in Lombok, WNT as well as a 72 MW wind farm in South Sulawesi. The solar farm and wind farm will supply energy to PT PLN, Indonesia's national electricity utility.

Several banks and non-bank financial institutions can provide financing to the private sector and business entities for infrastructure development, including the renewable energy sector. PT Sarana Multi Infrastruktur (SMI) is currently continuing to increase its financing portfolio in the RE sector through various types of facilities which are generally in the form of investment credit financing both conventionally and Sharia compliant. One of the RE project financing portfolios in WNT is the Sumbawa solar project with a capacity of 26 MWp which was built in the mining area owned by PT Amman Mineral Nusa Tenggara. PT SMI is also supported by funding from various international cooperation partners in SDG Indonesia One, a platform that aims to mobilize funding and technical support for infrastructure development in line with the Sustainable Development Goals.

Project owners and developers of renewable and clean energy projects in WNT may explore venture capital and private equity opportunities to attract investment from venture capital firms or private equity investors interested in renewable energy projects. These investors may provide funding in exchange for equity or returns on investment. Secondly, businesses can raise capital by issuing stocks (equity) or bonds (debt) in the capital markets. Investors purchase these securities, providing the company with funds. The stock market represents equity financing, while bonds represent debt financing. In addition to this, it is possible to collaborate with Energy Service Companies (ESCOs) for projects focused on energy efficiency and renewable energy. ESCOs may provide funding or operate on a shared savings or performance-based model. The WNT government could continue to work with the national government on policies and regulations to further support ESCO business.

4.5 Leveraging innovative financing

Financing is an important factor to support the achievement of 100% renewables. Funding renewable energy projects in West Nusa Tenggara involves a multifaceted approach that incorporates various financial mechanisms and instruments, and sustainability considerations. Public funds sourced from the government budget have many limitations around allocation, prioritization, and administration.

As a follow-up, it is necessary to mobilize investment funds for business entities and the private sector. However, the effectiveness of these investments will only be optimal if accompanied by supportive government policies. An independent study from the Climate Policy Initiative (2018)[45] provides insights and recommendations for optimizing public funds (APBN and APBD) to leverage greater private investment, including in the form of providing more attractive RE electricity buying and selling rates (including implementing competitive tenders to encourage healthy competition in RE development), development of blended finance and PPP instruments, as well as expansion of Government guarantee instruments in RE development.

In addition to existing funding sources, namely public funds and private funds or business entities, it is imperative to diversify the mode and source of funding that is further supported by innovation and digitization. Below are some financing concepts, strategies and instruments that not only have the potential to make achieving 100% renewables and net-zero emissions feasible and viable, but also speed up the transition at the local level:

- **Crowdfunding**: Crowdfunding platforms can be utilized to raise small amounts of money from a large number of people. This approach can engage local communities and individuals in supporting renewable energy projects and benefit from the initiative. Crowdfunding campaigns can highlight the social and environmental benefits of projects to attract a wider audience.
- **Renewable Energy Certificates (RECs)**: RECs represent the environmental attributes of renewable energy generation. Investors or project developers can sell or trade these certificates to individuals or organizations looking to offset their carbon footprint. Developers in West Nusa Tenggara can generate additional revenue from RECs for their renewable energy projects.
- **Carbon market financing**: Participation in carbon markets, such as cap-and-trade systems, allows organizations and project owners to buy and sell carbon credits. By reducing greenhouse gas emissions, renewable energy projects in West Nusa Tenggara could generate carbon credits that can be sold to entities seeking to offset their emissions.
- **Results-based financing (RBF)**: RBF involves paying for the actual outcomes of a project rather than the inputs. RBFs involve rewarding projects based on the achievement of predetermined results. In the context of renewable energy, RBFs could be structured to reward successful project development, energy generation, or emission reductions.

[45] https://www.climatepolicyinitiative.org/publication/energizing-renewables-in-indonesia-optimizing-public-finance-levers-to-drive-private-investment/

- **Environmental, social and governance (ESG) investing**: ESG investing involves considering environmental, social, and governance factors in investment decisions. Renewable energy project owners and developers in WNT with projects that demonstrate strong ESG credentials may attract investments from individuals, funds, or institutions looking to align their portfolios with sustainable and socially responsible initiatives.
- **Impact investments**: Impact investors seek financial returns alongside measurable social and environmental impacts. Funding from impact investors can be directed towards renewable energy projects in West Nusa Tenggara, emphasizing positive outcomes for the local community and the environment.
- **Social impact incentives**: Governments, international organizations, or philanthropic entities may offer incentives for projects that have a significant positive impact on society. These incentives could come in the form of grants, subsidies, or low-interest loans, encouraging the development of renewable energy infrastructure.

Diversifying funding sources reduces dependency on a single channel and enhances financial resilience. Innovation in financing models, such as green bonds or sustainability-linked loans, can attract investors. Digitization of financing processes can streamline transactions, reduce costs, and increase transparency. It is important to conduct thorough market research, engage with local stakeholders, and align projects with national and regional energy policies and goals. Additionally, establishing partnerships with local communities, government agencies, and international organizations can enhance the success and sustainability of renewable energy initiatives in the region.

Certainly, achieving the goal of 100% renewable energy in the WNT province by 2050 is an ambitious endeavor that calls for substantial effort. Combining various financing mechanisms, emphasizing environmental and social sustainability, and leveraging digital tools can create a robust and diversified funding strategy for renewable energy projects. Recognizing the complexities involved, it becomes evident that collaboration among stakeholders is essential for success. Embracing a positive perspective, the local government of WNT can play a pivotal role in orchestrating a harmonious multilevel governance approach.

In the journey towards a sustainable future, WNT's local government is poised to assume a more proactive stance. The upcoming years present an opportunity for the local government to pioneer progressive change by implementing encouraging financial policies, innovative mechanisms, and effective instruments. This transformative process will be tailored to the unique jurisdiction and authority of WNT.

The envisioned shift involves the introduction of initiatives such as a public-private partnership (PPP) scheme and the establishment of local government incentives. These initiatives will serve as catalysts for both retail and corporate participation in renewable energy projects. By doing so, the local government not only fosters a favorable investment climate but also accelerates the overall development of renewables in WNT.

In essence, this strategic push towards multilevel action and involving multiple levels of governments not only acknowledges the challenges but embraces them as opportunities for positive transformation. As WNT embarks on this journey, it sets the stage for a future where renewable energy is not just a goal but a thriving reality, fostering sustainable development and environmental well-being.

CHAPTER 5: SYNTHESIS AND FUTURE PROSPECTS

To achieve 100% renewable energy mix by 2050, strategic and integrated policies are necessary. Some guiding principles that should ideally underpin the various actions mentioned in the previous chapters include:

- Clearly set a renewable energy mix target that is gradual and measurable. This target can be achieved through the optimal development and utilization of renewable energy sources, such as solar, wind, hydro, and biomass.
- Develop regulations and policies that support the development and utilization of renewable energy, including tax incentives and reductions for businesses that invest in this sector.
- Provide access to the latest information and technology in the field of renewable energy for businesses and the general public, including through capacity building and education programs.
- Develop a reliable and integrated renewable energy distribution network to ensure the reliability and continuity of renewable energy supply throughout WNT.
- Establish partnerships and open dialogues with relevant parties, such as local governments, the private sector, and the public, to support the development and utilization of renewable energy in WNT.
- Utilize and synergize various types of financing mechanisms, including through APBN / APBD and PPPs.

5.1 Mapping the various challenges and obstacles

However, an ambitious endeavor such as this is not without its challenges. Even though the 100% Renewables Roadmap for West Nusa Tenggara may lay out the path forward, there are a number of challenges that must be overcome for its implementation to be successful. As the roadmap is a not legally binding document, it will be up to the government to implement its recommendations. On the ground, there will be a number of competing interests and priorities for the regional and national governments, which must be managed to achieve the best outcomes. The challenges cut across political, financial, technical, and social aspects and must be addressed in a sustainable way. It will take concerted and continuous effort and political will to enable this transition, but at the end the benefits will be significant.

5.1.1 Political, legal and institutional aspects

5.1.1.1 Political and legal support for roadmap implementation

To achieve the long- and short-term goals and targets defined in the document, the buy-in and support of the government and other concerned stakeholders should be solicited. The roadmap, and more particularly the targets and strategies contained therein, need to be integrated into regional development documents in order for them to become official development goals and pathways of the province in the midst of political changes in the future.

5.1.1.2 Limited local government involvement in energy sector planning and management

The energy sector in Indonesia is quite centralized, with a limited role and authority for regional governments. The WNT Government is limited in the powers it has at its disposal to implement the roadmap. For example, in the electricity sector, all plans for the construction and procurement of power plants, transmission, distribution, and buying and selling electricity are carried out by PLN. The whole regulation of the sale and purchase of electricity is also regulated through relevant ministerial and presidential Regulations. However, the roadmap document could be used as a tool to communicate and advocate the potential of 100% RE in WNT and to support the achievement of Indonesia's RE target.

To implement the roadmap, the WNT government needs to define the role and scope of its authority in the energy sector, which in turn also determines the incorporation of this roadmap in the province's development agenda. As for the *working level,* coordination between government agencies (SKPDs) is crucial. All elements in the WNT Provincial Government need to understand that the energy sector is not the *domain of the MEMR Agency alone*, and that SKPDs need to work together in each of their work programs to realize this roadmap.

5.1.1.3 Inconsistency and uncertainty in regulations supporting renewable energy

Legal and regulatory certainty and ease of investment are key in accelerating the energy transition in Indonesia. The implementation of this roadmap will also intersect strongly with supporting regulations for renewable energy set nationally. However, the inconsistency of such regulations can be a hindrance. One major uncertainty is related to RE electricity prices and private participation in RE development connected to the PT PLN network, as well as the rules for the Domestic Component Level (TKDN). The WNT government, through its authority, needs to advocate to stakeholders regarding the urgency of RE development in WNT and make policy efforts that can contribute to reducing the risk of RE investment (de-risking), such as

providing easy licensing and initiating the implementation of public-private partnerships for RE projects.

5.1.2 Economic and financial aspects

5.1.2.1 Fossil fuel subsidies make it difficult for RE to compete

Subsidies to fossil fuels are a fundamental challenge for RE deployment in Indonesia. It cannot be denied that these subsidies are needed to maintain energy security and provide access to affordable energy, given that Indonesians are still very dependent on fossil fuels. However, these subsidies are a paradox when it comes to encouraging the energy transition. For example, the Domestic Market Obligation (DMO) means that the price of electricity from PLTU does not reflect the actual cost, and for electricity interests (PT PLN) is pegged at USD 70 per ton.[46] This policy also makes PLN prioritize the use of PLTU over renewable energy, which in several cases is actually more competitively priced.

Energy subsidies are the purview of the government at the national level. Reforming and redirecting the allocation of such subsidies directly to the economically vulnerable rather than giving them to energy products in general has been voiced by various parties. However, such reforms should not be haphazard but should be followed by the collection and utilization of a database of poor families and a well-targeted subsidy distribution scheme. Thus, coordination between local and national governments from various ministries and agencies is necessary to provide targeted energy subsidies.

5.1.2.2 Limited government fiscal capacity and the need for alternative financing for the roadmap

The fiscal capacity of the government, both at the national level and provincial level, is a challenge in the context of implementing the roadmap. In general, the regional budget (APBD) tends to be devoted to personnel expenditure and only leaves a small portion for capital expenditure, including infrastructure. As such, the WNT government should explore alternative financing options such as:

- Local government loan facilities for infrastructure development
- Issuance of municipal bonds
- Public-private partnerships (PPP)
- Private and enterprise investment in a business-to-business context

[46] https://iesr.or.id/subsidi-energi-fosil-menghambat-transisi-energi

Note that not all of these alternative funding options will be appropriate with each renewable energy technology—the business model and project structure would determine the right modality. As for the private sector and business entities, it needs to be emphasized that both are important actors in RE development because the large capital costs required cannot be borne entirely by public funds. The energy transition agenda must be adopted into national development efforts, with the creation of an attractive market for investors and financing institutions to enter the RE sector.

5.1.2.3 Unpromising economics and high risk of RE investment

The RE sector is classified as a high-cost investment and is associated with medium to high risks during planning, construction and long-term operations. Like any investment, renewable energy development is certainly expected to provide sufficient returns in accordance with the level of risk. For example, the return on investment of a utility-scale solar project is highly dependent on capital expenditure (including land and transmission costs), debt portion and interest rates, and most importantly, solar radiation. In the case of Indonesia, despite being in the tropical zone, there are high levels of evaporation, humidity and cloud cover. Therefore, although irradiation is evenly distributed throughout the year, the duration of sunlight is short, resulting in a lower solar module capacity factor when compared to other regions such as South America and Southern Europe (see Solar Atlas, 2020). These resource-related restrictions will further affect investment feasibility. In addition, the high *soft cost* components (e.g. licensing, customs, project development costs, and uncertainty) and land acquisition costs are also a challenge. In addition to solar modules, other technologies such as biomass also face specific risks related to the long-term vulnerability of raw material supply during the operational period, in terms of both availability and price.

5.1.3 Technical aspects

5.1.3.1 Inadequate inventory of RE potential in WNT

While the modelling results show that 100% renewable energy based on local resources is generally possible, implementation will require more granular data for determining business cases and technology options. A critical aspect in the development of RE revolves around the assessment and data related to RE potential, which currently presents significant challenges. For example, when estimating the feasibility of developing mini-hydro power plants (MHPs), there are limitations in data related to factors like rainfall patterns and river discharge. This insufficiency hinders the creation of accurate databases essential for the development of sustainable MHPs. Another issue is the unreliability and limited availability of historical data.

Similarly, in the wind sector, prospective investors often find themselves needing to independently conduct wind measurements using meteorological masts due to the scarcity of available data. This lack of comprehensive data impedes the progress and decision-making in wind energy projects.

In the biomass sector, understanding feedstock potential is essential for project feasibility and the development of effective business models. Assessing the readiness of the feedstock supply chain for biomass-based plants is crucial for ensuring the viability and success of such ventures.

Moreover, the availability and accuracy of data for solar sources such as solar irradiance, shading analysis, and local weather conditions plays a pivotal role in providing precise information about solar potential. The unavailability of this data will be a significant challenge in the planning and implementation of solar energy projects and also can affect long-term performance and economic viability.

Addressing these data deficiencies is imperative for fostering a more conducive environment for sustainable RE development.

5.1.3.2 Readiness of the electricity infrastructure and network for the integration of variable RE

The next challenge for RE development in Indonesia, as well as efforts to achieve the roadmap, is the readiness of the electricity infrastructure, especially in the face of variable and intermittent RE penetration such as large amounts of solar power and wind power. Network stability could be impacted with high shares of variable RE. To mitigate this, a more detailed study of network impacts and RE integration is needed. Upgrades to network infrastructure, such as battery integration both as *balancing* and *storage*, control automation, and other such measures should be investigated.

5.1.3.3 Capacity building and development of research and human resources

The roadmap is an ambitious plan for the WNT Provincial Government, therefore the people of WNT need to be actors and subjects of its implementation. The development of physical RE infrastructure as planned in the roadmap will not be optimal without adequate readiness and support for research, capacity building, and human resource development. In addition, capacity building and dissemination of research and knowledge related to RE play an important role in the adoption of sustainable technologies. Cooperation with international organizations, academic institutions, research bodies, and business entities to form a

vocational education, technical certification, and RE learning and development center is an important agenda in realizing the roadmap.

5.1.4 Social, educational, and cultural aspects

5.1.4.1 Limited understanding of new RE technologies

Renewable energy technologies continues to develop rapidly, supported by research and business development globally. This leads to new technologies such as hydrogen-based energy, fuel-cells, electric vehicles, batteries and charging systems, etc. The limited understanding of the uses and constraints of these technologies can hamper their uptake. Therefore, the long-term sustainability of the roadmap depends on being able to quickly develop and adopt knowledge related to these new technologies. The involvement of academic institutions such as Mataram University and Sumbawa University of Technology, in collaboration with foreign and national research institutions, is important in this regard. The roadmap can be a means and enabler for the growth of research development, research, and knowledge of RE technology in local academic institutions.

5.1.4.2 Lukewarm acceptance of RE technologies by communities

Community acceptance of the use of RE technologies, such as electric or induction stoves to replace LPG stoves, can be a challenge. Certain technologies might need communities to adapt their behavior, creating some hesitation. Cooking especially is sensitive to such impacts, but other measures such as energy efficiency measures, electric vehicles, etc. may also face some resistance. The use of electric stoves will potentially not be in accordance with the cooking patterns or culture of the community. In addition, the use of electric stoves will potentially increase the electricity bill. Biomethane derived from livestock manure could also intersect with the community's perspective on unclean livestock manure. Research on community behavior *is* needed before policies related to RE technologies are implemented.

5.1.4.3 Lack of capacity, skilled labor and green jobs to sustain the local economy

A crucial obstacle lies in the need to address the growing demand for labor in the renewable energy sector in WNT. This necessitates a concerted effort to overcome the reliance on external labor and foster a skilled workforce locally. A significant challenge is the

establishment and enhancement of skills programs, which is emerging as a pressing regional priority.

To address this challenge, a proactive approach involves expanding expertise in renewable energy. One such initiative is the adoption of the TESHA (Solar Hydro Wind Energy) study program for vocational schools, currently exemplified at SMKN 1 Lingsar and potentially extendable to other vocational institutions. Moreover, collaboration with the Work Training Center (Balai Latihan Kerja or BLK) becomes imperative. This collaboration aims to provide essential basic and intermediate training tailored to the renewable energy sector, contributing to the development of a skilled workforce.

In addition to acknowledging this barrier, policymakers from multiple levels of governments must consider strategic policy interventions to facilitate progress by including the establishment of a certification institution accessible throughout WNT, thereby formalizing and standardizing the skill sets acquired through training programs. By transforming these challenges into opportunities, the region can create green jobs, improve well-being, and stimulate the local economy, fostering a sustainable and resilient energy future.

5.1.4.4 Insufficient integration and inclusion of gender-balanced perspectives and the limited engagement of women and youth

The current scenario reveals glimpses of progress, with women's groups showcasing initiatives such as converting waste from tofu production and animal manure into cooking fuel. Likewise, vocational schools in WNT are actively involved in training programs related to appropriate technology and renewable energy maintenance. However, these efforts, though commendable, underscore the prevailing barriers that impede the full realization of a sustainable and inclusive renewable energy sector.

To overcome these obstacles, targeted initiatives must be instituted to actively encourage the participation of women and youth across the entire renewable energy supply chain. Establishing mentoring programs, fostering educational collaborations, and initiating skill development programs are crucial steps toward unlocking the untapped potential within these demographics. This not only empowers them to contribute meaningfully but also positions them to engage in decision-making processes within the renewable energy domain. To this end, multiple levels of governments, in support of and for creating an enabling environment for such initiatives, must focus and get involved in the formulation of policies that actively promote gender balance, incentivize youth participation, and facilitate educational programs geared towards renewable energy.

5.2 Monitoring and evaluation

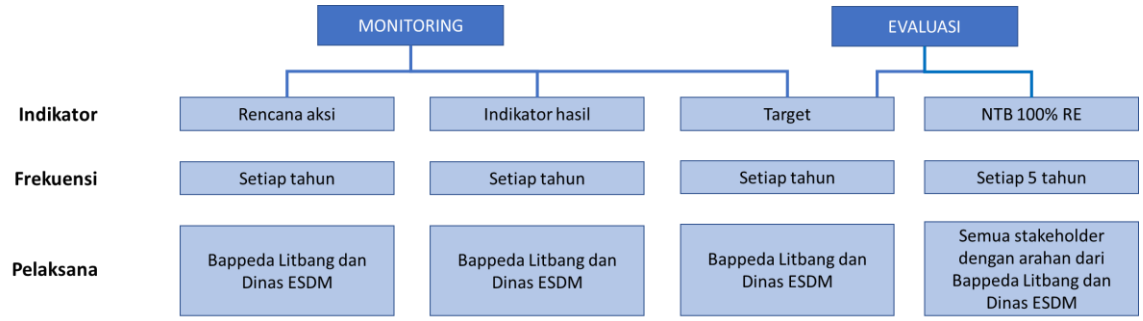
Regular monitoring and evaluation is important in ensuring efforts to achieve 100% RE in WNT by 2050. Therefore, a series of management cycles are needed which consist of several aspects, namely planning, budgeting, implementation, and monitoring and evaluation. All of these cycles must be interrelated, sustainable and carried out efficiently and effectively.

Monitoring and evaluation aims are as follows:

- Produce information on the progress and quality of the implementation of actions and strategies to achieve 100% RE that have been outlined in this roadmap.
- Identify problems and potential problems in implementing actions and strategies.
- Provide an assessment of the successful implementation of actions and strategies in terms of outputs, benefits and impacts.
- Describe successes, shortcomings or failures in the implementation of actions and strategies.

Another benefit of monitoring and evaluation is to increase transparency and apply the principle of public accountability for the achievement of WNT's vision of 100% RE by 2050. Information from monitoring and evaluation results provides baseline evidence of how the WNT government manages public resources as accountability to the community.

The focus of monitoring is on the process, by comparing implementation with the action plan specified in the roadmap in Chapter 3. The focus of evaluation is on outputs, outcomes and impacts related to the objectives of WNT's 100% RE vision 2050. Monitoring and evaluation activities for the implementation of the roadmap can be carried out by the Regional Development Planning, Research and Development Agency (Bappeda Litbang) together with the ESDM Office. The implementation of monitoring activities needs to be carried out every year, while evaluation activities can be carried out every five years according to the period of regional government.



The method for calculating each indicator and target has been described in the detailed action plan in Chapter 3.

Meanwhile, the method of collecting data or information for monitoring and evaluation activities can be done in two ways:

1. Completion of survey questionnaires to stakeholders in households, industries, commercial buildings, including government or public buildings, malls or shopping centers, hotels and offices, transportation and electricity.
2. Review of documents obtained or issued by relevant agencies, PLN, BPS, and Pertamina.

The results of monitoring and evaluation need to be conveyed to the public both through the publication of data online via a website and through the publication of reports that are printed and distributed to the public. Thus, the implementation of the roadmap can be monitored by various stakeholders.

5.3 Summary of policy recommendations

A number of recommendations are set out to address the challenges mentioned above. The following is a summary of these recommendations, but the full analysis can be found in the **Local Policy Recommendations** document.

- For supply security, there should be multiple sources of energy deployed. Although solar PV presents itself as the most scalable and cost-effective technology option, it will need other sources or storage systems to integrate it into the electricity system.
- While the roadmap lays out potential actions for individual sites and technologies, detailed studies will be needed to determine suitability. This applies to the choice of location for a wind farm, or the choice of renewable fuel for a specific industrial process.
- Stakeholder engagement from the beginning is key to allow for sustainable deployment of renewable technologies. Combined with transparent policies and information, these processes can help overcome initial resistance from communities or other stakeholders.
- Energy efficiency and conservation is crucial to keep down overall system costs, as well as reduce the overall use of resources, which has positive environmental impacts.
- For transportation, collective i.e. public transport with ride-sharing options can reduce individual car ownership and improve overall system efficiency, congestion, etc.
- Siting is important. For example, when using excess heat from CHP or electrolyzers, the demand center must be in close proximity.
- The costs of the transition are too much for one actor to bear alone. Therefore, partnerships and the strategic utilization of resources are key to successfully achieving energy and climate goals.

100% RENEWABLES CITIES & REGIONS ROADMAP

The 100% Renewables Cities and Regions Roadmap project is implemented by ICLEI – Local Governments for Sustainability and funded by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) through the International Climate Initiative (IKI).

https://renewablesroadmap.iclei.org/

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