FY2020 Project for Ministry of the Environment Japan

FY2020 City-to-City Collaboration Programme for Zero-Carbon society

（City-to-city cooperation project by Toyama City to realize SDGs future city for Bali Province and Semarang, Central Java Province）

Report

March 2021

Japan NUS Co., Ltd

Toyama City

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Glossaries

Abbreviation	Explanation
100RC	100 Resilient Cities
BAPPEDA	Badan Perencanaan Pembangunan Daerah
BAU	Business as usual
BOE	Barrel of Oil Equivalent
BRT	Bus Rapid Transit
CAPEX	Capital Expenditure
CNG	Compressed Natural Gas
DDF	Dual Diesel Fuel
DEPO	Depot
DKP	Dinas Kebersihan dan Pertamanan
ESDM	Ministry of Energy and Mineral Resource
FIT	Feed-in Tariff Program
GNSSA	GERAKAN NASIONAL SEJUTA SURYA ATAP
IPP	Independent Power Producer
IRR	Internal Rate of Return
JCM	Joint Crediting Mechanism
KEN	Kebijakan Energi Nasional
MRU	Mobile Refueling Unit
NDC	Nationally Determined Contribution
PLN	Perusahaan Listrik Negara
PPA	Power Purchase Agreement
RAD-GRK	Rencana Aksi Daerah Penurunan Emisi Gas Rumah Kaca
RAN-GRK	Rencana Aksi Nasional Penurunan Emisi Gas Rumah Kaca
RPJMD	Rencana pembangunan jangka menengah daerah
RPJMN	Rencana pembangunan jangka menengah nasional
RUED	Rencana Umum Energi Daerah
RUEN	Rencana Umum Energi Nasional 2015-2050
RUPTL	Rencana Usaha Penyediaan Tenaga Listrik
SDGs	Sustainable Development Goals
SPBG	Stasiun Pengisian Bahan Bakar Gas
TPA	Tempat Pembuangan Akhir
TPS	Tempat Pengolahan Sampah
JANUS	Japan NUS Co., Ltd.

1. Background, purpose and implementation structure of this work

1.1. Background and objectives

As a national initiative to combat global warming, the Indonesian government formulated the National Greenhouse Gas Emissions Reduction Action Plan (RAN-GRK) in 2013, setting a goal of reducing GHG emissions by 26% compared with BAU by 2020.

In addition, Indonesia has a policy of subsidizing petroleum fuels as a measure to combat poverty, but international fluctuations in the price of crude oil have worsened the nation's finances, and the supply of alternative energy sources to petroleum and the promotion of energy conservation have become issues. In 2014, the Kebijakan Energi Nasional (KEN) national energy policy was enacted with a focus on reducing dependence on fossil fuels, promoting renewable energy and energy conservation as the main framework for the Energy Policy until 2050.

In 2017, the National Energy Plan (Grand National Energy Plan 2015-2050: RUEN) was enacted, which describes specific measures to achieve the goals set in the above energy policy. In order to promote initiatives based on the characteristics and actual conditions of each region, the state governments have been promoting initiatives as local governments by formulating the state-specific greenhouse gas emission reduction action plan (RAD-GRK) in 2013.

Local governments in Indonesia consist of cities and districts under provinces, and low-carbon policies are important at each level.

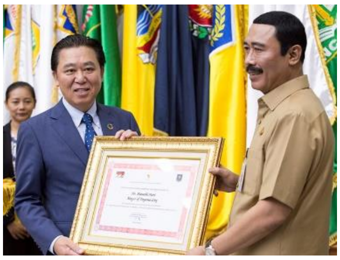

Figure 1-1 Mayor of Toyama City receives a letter of appreciation from the Indonesian Minister of Interior

Against this backdrop, Toyama City, as a futuristic city that would attain SDGs, has been promoting various initiatives with the aim of contributing through collaboration with local governments in Indonesia. Toyama City's ties with Indonesia are deep. In 2014, under a technical cooperation agreement with the province of Tabanan in Bali, Toyama City introduced a small-scale hydroelectric power generation system through a JICA project. Since then, Toyama City has made cooperative agreements with cities such as Semarang, Banda Aceh, Tobintinggi, Tabanan, Klungkung, and Lebong, and has organized projects that contribute to the achievement of the SDGs. In 2018, it became the first Japanese municipality to receive a letter of appreciation from the Indonesian Ministry of Interior for its achievements. Toyama City, as a city of the future for the SDGs, has positioned this initiative as a goal to activate the global partnership for SDG 17, and plans to further promote international collaboration efforts.

The Bali government has implemented the "Project to Support the Future City of Tourism through City-to-city Collaboration under Toyama City and Bali Province" as a JCM city-to-city collaboration project.
The project provided support for reducing the carbon footprint of the tourism sector, mainly in the hotel and transportation sectors. In addition to policy support for fuel shift, the project provided support for JCM applications, business matchmaking, and workshops as part of JCM project formation activities.

As an outcome of this project, a project for the introduction of energy-saving and renewable energy in large-scale hotels has been realized, and preparations are underway to apply for the JCM equipment subsidy program. In this application project, we will continue to study the introduction of energy-saving technologies and renewable energy for large shopping centers, hotels, and government offices.

On the other hand, the biggest environmental challenge facing the province of Bali is the issue of air pollution and CO_2 emissions caused by traffic congestion and the resulting exhaust gases. As one of the world's leading tourist destinations, the province of Bali is fully aware of the need for urgent measures to promote low-carbon and clean energy in the transportation sector, and is expecting support from Toyama City, which has an outstanding track record in transportation policy as a city of the future in terms of the environment.[1]

The world is promoting decarbonization, which aims to move away from fossil fuels, and from this perspective, the spread of electric vehicles and hydrogen vehicles using hydrogen as renewable energy is necessary. However, these decarbonized transportation technologies are still facing challenges in terms of infrastructure, social and economic aspects, and it is thought that it will take a long time before they are widely adopted in Indonesia.

As a measure before the spread of decarbonization technologies, it goes without saying that we should select appropriate technologies, such as switching to fuels with lower CO_2 emissions, and use feasible technologies and means to realize low-carbon systems.

Therefore, DDF (Dual Diesel Fuel, hereinafter referred to as "DDF"), which is a technology of the "Project for Installing CNG and Diesel Co-combustion Equipment in Public Transport Buses in Semarang City," an FY 2018 JCM Model Project implemented by Toyama City in Semarang City, will be utilized as a transit point toward decarbonization. The prospects for decarbonization of the transportation sector are as follows, and this application project aims to make progress toward decarbonization of the transportation sector by promoting technologies that will lead to low-carbonization, one step beyond the current situation.

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[1] Toyama City has received awards including Grand Prize (Minister of Land, Infrastructure, Transport and Tourism Award) in "Compact City Development with Smart Public Transportation" in 2014 in regards to transportation environment awards which promote environmentally sustainable transport (EST)

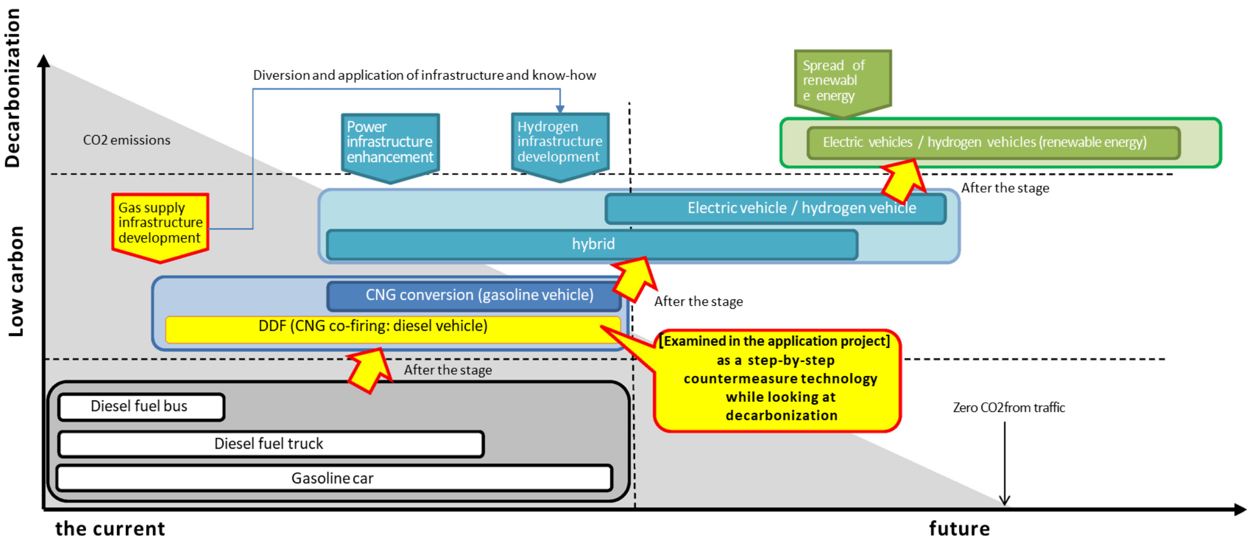

Figure 1-2 Technological steps toward decarbonization of the transportation sector

Source) Made by JANUS

Since DDF can function only with diesel fuel, it can be operated even when there is a gas fuel shortage in areas where gas supply facilities are insufficient, making it highly compatible with local conditions. It is also less expensive than diesel fuel in terms of thermal conversion, so it has significant economic benefits for the adopters. We have also been able to find a local contractor who can implement the system and establish a maintenance system. In addition to vehicles, the system can also be installed in fishing boats with outboard motors and diesel private power generation equipment.

Figure 1-3 DDF system and a case of its installation in public buses in Semarang

Source) Made by JANUS

On the other hand, the gas distribution situation in Indonesia is far from perfect. Although Indonesia is promoting measures to boost the use of its large natural gas reserves in response to the decline in oil production, most of the natural gas produced is either exported or supplied to large-scale users (such as LNG-fired power plants) and there is no system in place to meet latent demand in cities.

In order to ensure a stable supply of gas, it is essential to enlist the cooperation of the Ministry of Energy and Mineral Resources, which is in charge of the energy policies, and Pertamina Gas, which is a gas distributor. As for the gas supply to the transportation sector in Bali, Pertamina Gas, a state-owned gas company, has made a business decision to enter the gas business in Bali under the cooperation agreement between the Governor of Bali and the Minister of Energy and Mineral Resources, and has agreed to proceed with the commercialization of the project in a coordinated manner under the city-to-city collaboration between Bali and Toyama City.

The previous project in Semarang City had problems with gas supply even after the start of monitoring due to the lack of a gas supply system, but as of March 2020, a stable gas supply has been achieved. In this project, we will work together to build a system that can guarantee a stable gas supply by seeking advice from the city of Semarang, which has faced and solved such problems.

In 2017, the City of Semarang started the "Low-Carbon Support Project for Solving Disaster Prevention, Environment, and Energy Issues Towards Creating a Resilient City" and the "Research Project for Developing a Compact City Transportation System" as part of the "City-to-City Collaboration Project for Realizing a Low-Carbon Society in 2017." In the same year, the "Cooperation Agreement between Toyama City and Semarang City on the Establishment of Environment and Public Transport" was signed, and in 2018, the "Project for Low-Carbon Society through the Introduction of Energy-saving Equipment to the Industrial Sector in Semarang City" was implemented as the "City-to-city Collaboration Project for the Realization of a Low-Carbon Society in FY 2018."

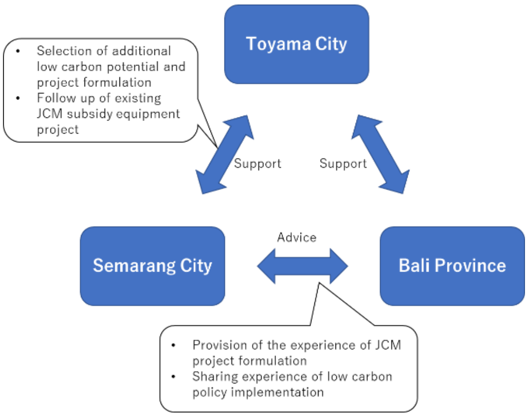

Figure 1-4 Positioning of Semarang City in the application project
Source) Made by JANUS

In 2019, the "Clean Energy Promotion Project Based on the Low-Carbon Society Scenario of Semarang City" was implemented as the "FY2019 JCM City-to-city Collaboration Project," and the formation of equipment assistance projects for the newly built sewing factory and Semarang City Hall building in Semarang City has been discussed. Furthermore, preparations are underway to apply for the JCM Model Project this fiscal year, and support has been provided to carry out the ownership procedures and stabilize the supply of CNG gas for the current JCM Model Project, "CNG and diesel fuel co-combustion equipment installation project for public transportation buses in Semarang City."

In addition, Semarang City shared with the province of Bali its role as a local government and its experience in policymaking and policy implementation during the project in FY2019, and contributed to improving the Bali government's understanding of the effects of the city-to-city partnership project and the JCM project.

When promoting low-carbon policies and JCM projects in city-to-city collaboration projects following the example of Toyama City, it is necessary to consider and implement measures adapted for Indonesia, as laws and regulations, responsibilities and authorities of local governments are different from those in Japan. In such cases, the process of examining the feasibility of the project in light of local laws and regulations is essential and usually takes a long time. Under these circumstances, sharing of the results and experiences of the Indonesian local government can accelerate the implementation of low-carbon policies and the utilization of JCM projects.

Therefore, in this application project, the City of Semarang is positioned as an advisor in the project between Toyama City and Bali province, and the two cities will continue to cooperate and collaborate to promote environmental policies related to low-carbon systems and decarbonization, and to share knowledge on the formation of JCM projects.

On the other hand, we know that there is still abundant low-carbon potential in Semarang City, but there are still unrealized projects concerning the introduction of low-carbon technologies and JCM projects in these potential sites. The details of the project will be described later, but the submitted project aims to strengthen the solidarity of both the Bali province and the city of Semarang in achieving the SDGs by promoting the realization of JCM projects through the introduction of decarbonization and low-carbon technologies to the potential sites that the city of Semarang aims to realize.

1.2. Implementation structure of this work

The implementation structure of this project is shown below.

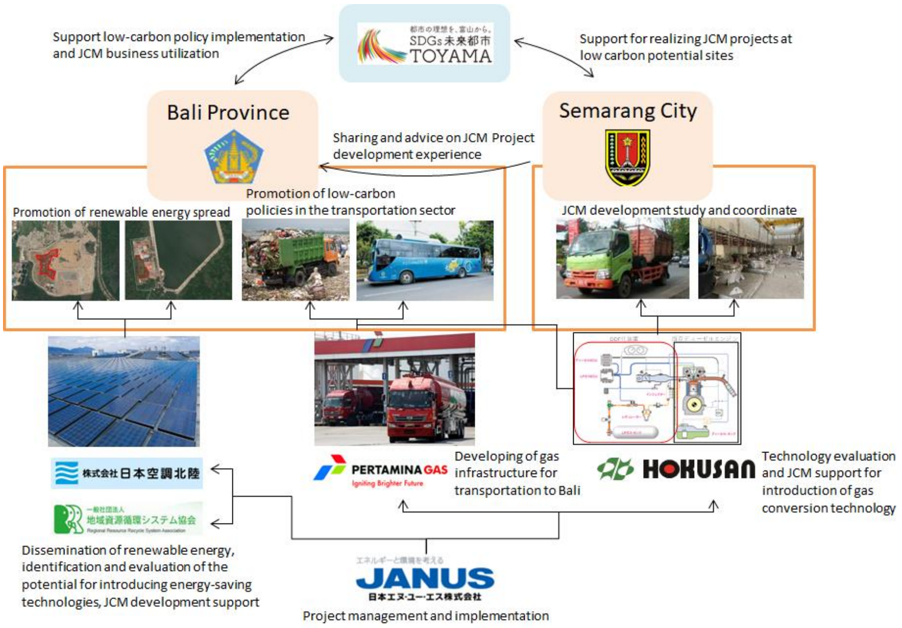

Figure 1-5 Implementation structure of this work (overall)

Source) Made by JANUS

Survey contents are as follows.

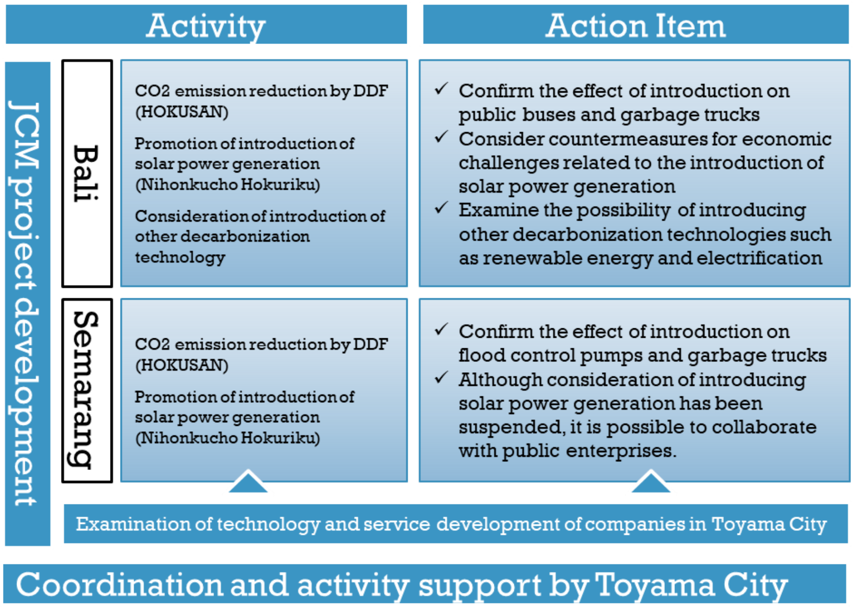

Figure 1-6 Main activities in this project

Source: Made by JANUS

2. Discussion on Commercialization Plan

2.1. Low-carbon initiatives of Indonesia

2.1.1. Low-carbon policy of the central government of Indonesia

As mentioned above, there is a national action plan for reducing greenhouse gas (GHG) emissions (RAN-GRK: Rencana Aksi Nasional Penurunan Emisi Gas Rumah Kaca), which was formulated in the form of a presidential order in 2010, as a pillar of low-carbon initiatives of Indonesia.

It is mentioned, in this plan, that the national commitment is to reduce greenhouse gas emissions by 26% from the scenario (BaU: Business as usual) by 2020 and if international support can be enlisted, the goal is to reduce greenhouse gas emissions by 41%. Accordingly, it is expected that Joint Crediting Mechanism (JCM) will be utilized, and in October 2013, Japan and Indonesia signed an agreement for JCM, and Indonesia became the 8th country subject to JCM for Japan.

The action plan in 2010 was announced during the term of the former president Yudhoyono. At the COP held in Paris on December 21, 2015, the current president Joko Widodo declared that the nationally determined contribution (NDC) is to reduce GHG emissions by 29% compared with BAU by 2030 or by 41% by enlisting international support via JCM, etc. The goal of reducing GHG emissions set in the above-mentioned RAN-GRK was to be attained by 2020, so after NDC was submitted, the RAN-GRK office held a nationwide workshop in 2017, to have discussions with provincial governments and reconsider target values in accordance with NDC[2].

NDC was scheduled to be revised in 2020, but due to the spread of COVID-19, the revision process

[2] https://energypedia.info/wiki/Indonesia:_From_Mitigation_Action_Plans_To_Integrated_Low_Carbon_Development_Planning

has been significantly delayed, and as of February 2021, the latest version is yet to be submitted.[3] Although the latest draft is not available at this time, an updated version of the NDC is expected to be submitted in March 2021.[4] The updated NDC will maintain the goals of the first NDC, but will include more specific and realistic measures to achieve the goals of the first NDC.[5]

In the domestic system of Indonesia, the supply of affordable energy to low-income people is an important element of the support base for the administration, so there are many problems with the rapid shift to renewable energy, but in the new national energy policy (Rencana Umum Energi Nasional 2015-2050: RUEN) enacted in 2015, they aim to decrease the ratio of petroleum to total energy consumption in Indonesia from 49% to 22% or lower by 2025, while increasing the ratio of natural gas from 20% to 22%, the ratio of coal from 24% to 32%, and the ratio of renewable energy from 6% to 23%.

Nuclear power is recognized as the last resort. They plan to promote the shift from the direct use of fossil fuels to electric power, and increase the output of power generation facilities from 44 GW to 115 GW by 2025.

In addition, the following goals of national energy measures have been set.

1) Energy elasticity (Growth of energy consumption/economic growth rate):
   To achieve an energy elasticity of 1 or less by 2025, to attain the goal of economic growth
2) Specific energy consumption (energy consumption per GDP)
   To improve it by 1% per year until 2025
3) Electrification rate:
   To reach 85% by 2015, and get closer to 100% by 2020
4) Penetration rate of household gas
   To reach 85% by 2015
5) Ratio of new renewable energy to primary energy
   To increase it to 23% by 2025 and to 31% by 2050

The national energy policy includes measures for realizing a low-carbon society with natural gas and renewable energy power, and we can understand their low-carbon policy from them.

Table 2-1 summarizes the entire picture of this policy and the measures for realizing a low-carbon society with natural gas and renewable energy power.

Table 2-1 Positioning of natural gas and renewable energy power in the national energy policy

[3] UNFCCC Secretariat "The Latest Submissions" https://www4.unfccc.int/sites/NDCStaging/Pages/LatestSubmissions.aspx
[4] Malaysian English newspaper "The star" https://www.thestar.com.my/aseanplus/aseanplus-news/2021/01/28/jokowis-call-for-global-climate-action-rings-hollow-environmentalists
[5] Indonesian online news ANTARANEWS.com, https://www.antaranews.com/berita/1930776/indonesia-tidak-ubah-target-emisi-dalam-pembaruan-ndc

Item	Description
Goals	■To increase the roles of businesses that lead the transition to a market economy for the efficient operation of the economy ■To develop energy to be exported, and strengthen the base for use of energy for domestic consumers ■To cement strategic partnerships inside and outside Japan ■To become less dependent on foreign countries, and enhance local content
Strategies	■To correct the difference in price between domestic and exported ones ■To help design a master plan for energy ■To introduce the market mechanism involving producers and consumers ■To allocate the roles of the private and public sectors in large-scale development ■To support the private sector in energy development ■To promote the development of technologies and personnel ■To establish a framework for cooperation among energy-related staff ■To brush up the business management skills in energy-related sections
Action plans (gas)	■To improve the access to domestic and overseas gas resources for securing the supply **■To increase the reserve and output of gas by offering incentives** **■To raise gas supply by constructing LNG stations, CNG transportation facilities, and gas distribution networks** ■To research new fields, including small-scale LNG and liquefaction technologies, and develop technologies ■To apply gas prices for realizing economic value that matches the construction of gas supply systems ■To obligate domestic enterprises to supply gas to domestic markets ■To optimize the order of priority for domestic gas supply (for fertilizers, for power generation, for government-run gas companies, and for industrial use) ■To utilize flare gas with small-scale LNG/LPG in an optimal manner
Action plans (gas pipeline)	■To continue the construction of pipelines for establishing domestic gas transportation systems **■To increase gas supply by constructing LNG stations, CNG transportation facilities, and gas distribution networks** ■To use CNG in regions where pipelines cannot be constructed ■To determine the prices for gas transportation and distribution with pipelines in accordance with economic principles ■To construct LNG plants and LNG acceptance stations in regions where demand for gas is high in Java ■To implement ASEAN gas pipeline plans

Item	Description
Action plans (natural gas and LPG)	■ To increase LPG supply in regions where natural gas cannot be supplied ■The government will establish a quality control system for LPG. ■To promote LPG, DME, GTL products, etc. ■To curb petroleum consumption and **promote the use of** LPG and **natural gas** in the transportation section ■To set standards for gas and **intensify competition in the trade of natural gas and LPG**
Action plan (electricity and electrification)	■To upgrade power plants using natural gas and LPG with pipeline networks ■To enhance power generation with renewable energy, diversify fuels for power generation, and reduce petroleum consumption ■To increase power generation using low-grade coal ■To export electric power generated at distant places to neighboring countries ■To develop small-sized gas power generators ■To develop new power generation technologies, such as cogeneration and fuel cells ■To establish power generation operation methods for environmental conservation
Action plans (consumer-use, commercial section)	■To promote the use of natural gas and coal ■To construct roads and storage depots for transporting coal and briquettes ■To recommend energy-saving devices ■To convey information on energy-saving devices to consumers ■To develop transportation technologies, small-scale storage facilities, etc. for facilitating the shift to natural gas consumption
Action plans (industrial section)	■To promote the switch from in-house power generation to the purchase of electricity from electric power suppliers ■To support gas-using factories ■To research, carve out, and promote the use of gas instead of petroleum ■To promote the use of cogeneration-type power generators ■To promote the use of local energy in regions where electrification has not been conducted ■To use briquettes in small factories, including tea plantations, rubber factories, and greenhouse farms
Action plans (transportation section)	■To promote land transportation systems using CNG and LPG ■To promote the use of alternative energy to oil, such as LNG, DME, and gas hydrate ■To develop biodiesel fuel ■To develop electric vehicle systems for public transportation in urban areas ■To set automobile fuel standards

Source: Produced with reference to "PERATURAN PRESIDEN REPUBLIK INDONESIA NOMOR 22 TAHUN 2017 TENTANG RENCANA UMUM ENERGI NASIONAL" in the website of Department of Energy & Mineral Resources; https://www.esdm.go.id/assets/media/content/content-rencana-umum-energi-nasional-ruen.pdf, acquired on Jan. 20, 2020

2.1.2. Mid-term national development plan (RPJMN)

The Indonesian government announced a new mid-term national development plan (RPJMN 2020 to 2024) in January 2020. In this plan, it is assumed that the growth rate of real GDP is 5.7-6.0% per year on average, and it is necessary to invest about 35,000 trillion rupiah, in order to attain the goal. They also set the goal of raising gross national income (GNI) per capita to 5,810-6,000 dollars by 2024[6].

RPJMN includes 9 presidential missions, 5 presidential directives, and 7 development goals, as tabulated below. To attain the development goals, it is necessary to care for the environment, enhance resilience against disaster, and consider measures against climate change.

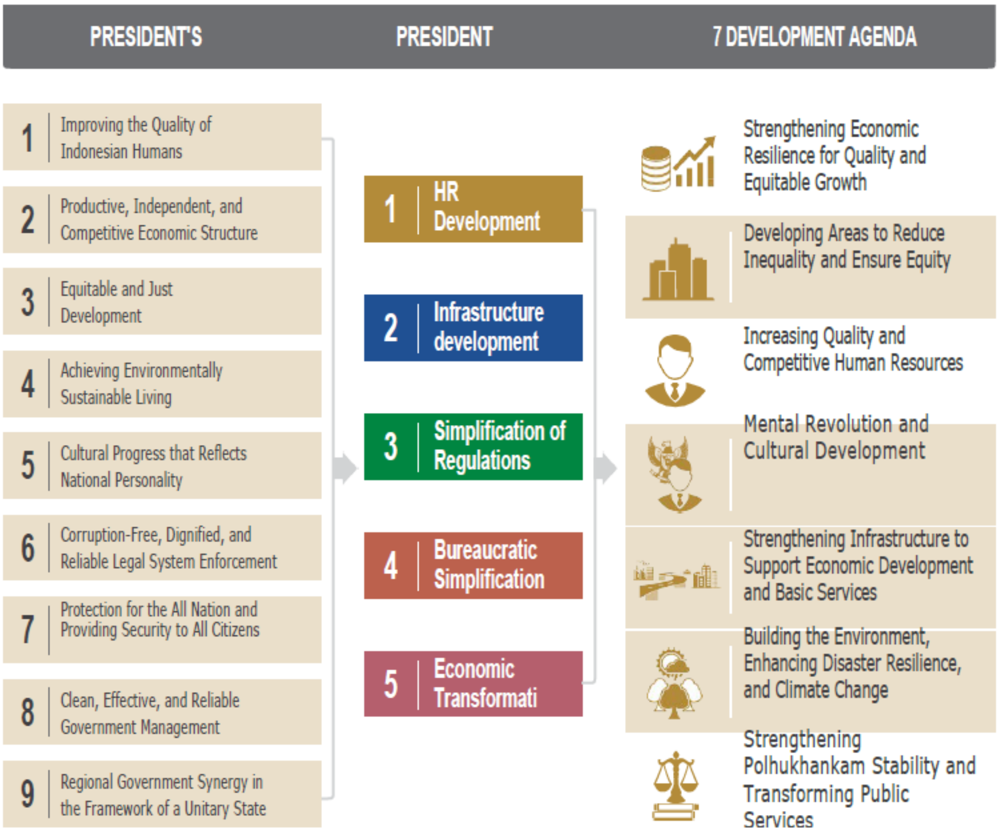

Figure 2-1 Presidential directives and 7 development goals in the mid-term development plan (RPJMN)

Source: Mid-term development plan (RPJMN, 2020-2024)

The macro-development goals in RPJMN include the goal of reducing GHG emissions, and they aim to reduce GHG emissions by 27.3% by 2024, in order to decrease GHG emissions by 29% compared with the scenario (BAU) by 2030, as mentioned in the above-mentioned NDC (Figure 2-2).

[6]The Ministry of National Development Planning/National Development Planning Agency "Rencana Pembangunan Jangka Menengah Nasional 2020-2024, Narasi (mid-term national development plan)"

Figure 2-2 Mid-term development plan (RPJMN); macro-development goals in 2020-2024

Source: Mid-term development plan (RPJMN, 2020-2024)

According to the energy development plan, Indonesia is still dependent on fossil fuels, and it is estimated that energy self-sufficiency rate will decrease from 75% in 2018 to 28% in 2045. To compensate for it, they aim to distribute renewable energy as mentioned in the above-mentioned new national energy policy (RUEN) and increase its ratio to 23% by 2024.

This plan indicates the following policy regarding energy development.

1) To accelerate the development of renewable energy
2) To increase the supply of biofuel
3) To secure energy and develop energy-saving systems
4) To increase the supply of energy to industries
5) To develop new renewable energy (NRE) and support the industrial sector

As for the supply of natural gas, they aim to increase the output from 1.1 million BOE/day in 2018 to 1.2 million BOE/day by 2024.

It is also mentioned that in order to attain the goal of increasing renewable energy, they will concentrate on the development of renewable energy derived from oil palms, and the investment amount until 2024 is estimated to be 32 trillion rupiah.

The diversification of electric power still cannot catch up with the demand for electric power in urban areas, and they still rely on energy derived from fossil fuels. Solar power generation has not been popularized there, because solar panels supplied are limited to expensive, low-quality ones produced in Indonesia, power grids are still to be established, and they have not developed a system for accepting renewable energy.

[Gas supply project]

The mid-term national plan for the period from 2020 to 2024 lists priority national projects to be implemented, and mentions the expansion of gas supply through “Project No. 35: Development of gas infrastructure for supplying gas to 4 million households,” which is described in the gas supply plan[7].

As the backgrounds for the project, their goal is to use domestic gas inside the country as much as possible, and the urban gas supply networks have not been developed sufficiently, as gas is currently supplied to only 0.53 million households. The objective of this project is to expand the gas supply networks between 2020 and 2024 to supply gas to 4 million households by 2024. The equipment investment for it is estimated to amount to 38.4 trillion rupiah. Especially, Semarang is considered as a priority region for connecting the networks. Accordingly, it can be expected that the key infrastructure for gas supply will be established and systems for gas supply for transportation will be developed.

2.1.3. Impact of the novel coronavirus

Indonesia has also been severely affected by the novel coronavirus, and according to the Indonesian Investment Coordinating Agency's announcement as of September 2020, economic growth in the second quarter of 2020 was -5.3% YoY, due in part to the impact of the novel coronavirus.

The importance of promoting more investment in order to recover economic activity has been recognized, especially in Central Java and Semarang, where labor is cheap, productivity is high, and favorable conditions are available, such as the proximity to the capital Jakarta and the presence of an airport in the city. As a result, the local government has announced its intention to promote investment in the region by targeting foreign companies operating there.[8] As a specific tax incentive device, Decree No. 44/PMK.03/2020 by the Minister of Finance came into effect in April 2020.

(1) Impact of the spread of COVID-19 on the energy sector

Indonesia's energy sector has also been greatly affected by the spread of the novel coronavirus. Fuel consumption has fallen steeply, partly due to policies that restrict movement, and likewise, the energy sector has been hit hard by the overall economic slowdown. In terms of fuel sales for the country as a whole, the two-month average for April-May 2020 showed a 35% decrease in sales compared to the previous two-month average, with the impact being more pronounced in large cities such as Jakarta and Bandung.[9]

Pertamina Group has also been severely impacted by the novel coronavirus, with the two-month average of sales for April-May 2020 reported being 38-45% lower than planned. The impact on PLN, the state-owned power company, has also been significant, with its particularly fragile financial position said to be adding to the negative impact.

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[7] The Ministry of National Development Planning/National Development Planning Agency “Rencana Pembangunan Jangka Menengah Nasional 2020-2024, Proyek Prioritas Strategis (priority national project list of mid-term national development plan)”
[8] From the presentation by Indonesian Investment Coordinating Agency at Semarang Business Forum 2020
[9] International Institute for Sustainable Development, July, 2020 “Indonesia’s Energy Policy Briefing”

The Pertamina Group is reducing its refining throughput due to lower demand and is closing its Balikpapan refinery in May 2020. Fuel imports also dropped from 330,000 barrels per day to 100,000-150,000 barrels per day.

Particularly, as for the renewable energy investment sector, new investment has also been depressed due to the impact of the novel coronavirus. The project has not been able to move forward due to the drop in electricity demand, restrictions on logistics and availability of personnel, and difficulties in obtaining funding from financial institutions.

Under these circumstances, as a special measure for projects that were in progress prior to the spread of the novel coronavirus, it has been proposed that the pandemic can be regarded as a "force majeure" clause and that PLN should not be required to pay compensation for damages related to project delays during the pandemic period.[10]

The number of COVID-19 cases in Indonesia has been rising steadily since 2020, and the number of newly infected people was about 2,000 in July 2020, but as of February 2021, more than 10,000 new cases per day have been confirmed.[11]

2.2. Bali

2.2.1. Low-carbon initiatives of Bali

(1) Primary measures and policies

① Mid-term development plan of Bali (RPJMD)

As explained in Section 2.1.2, Indonesia formulated a mid-term national development plan (RPJMN), and provincial governments accordingly produced a mid-term provincial development plan (RPJMD). The latest RPJMD of Bali is for the period from 2018 to 2023[12].

RPJMD is closely related to RPJMN, so the 22 development missions set in the RPJMD of Bali (2018-2023) are consistent with the 7 development missions of RPJMN (2015-2019).

Among the 22 missions set in the RPJMD of Bali, Mission 21 is related to energy development, and it is shown below. Under the mission, there are several goals and target indices.

Table 2-2 Mission 21 in RPJMD of Bali

Mission 21: To actualize a Bali Krama lifestyle by developing a clean, green, beautiful environment							
Goal 2: To realize a clean, green, beautiful living environment							
Index: Environmental index (IKLH)							
Index	Unit	2018 (reference year)	2019	2020	2021	2022	2023
1. Water quality index	Index	63.2	64.7	66.2	67.7	69.2	70.7
2. Air quality index	Index	92.0	92.4	92.9	93.4	93.9	94.4
3. Reduction of GHG emissions	**(%)**	**8.4**	**9.4**	**10.4**	**11.4**	**12.3**	**12.3**

10 The Ministry of Energy and Mineral Resources, "Dampak Covid-19 pada Pengembangan Energi Terbarukan di Indonesia"
11 https://www.worldometers.info/coronavirus/country/indonesia/
12 Mid-term development plan of Bali (RPJMD; 2018 to 2023)

4. Ratio of renewable energy	**(%)**	**0.4**	**0.4**	**1.1**	**7.1**	**13.8**	**20.0**

Source: Mid-term development plan of Bali (RPJMD)

(2) Energy-related measures of Bali

① Energy measures of Bali

The Bali government has designed measures for developing renewable energy. According to the interview with them, there are the following laws and regulations related to it.

- Regulations regarding the comprehensive energy plan of Bali (2020-2050) (RUED) (No. 9/2020)
- Bali governor's regulations on clean energy (No. 45/2019)
- Governor's regulations on battery-type electric transportation aircraft (No. 48/2019)
- Bali governor's ordinance on energy plans 2020-2039 (No. 123/03-M/HK/2020)

② Comprehensive energy plans of Bali (RUED)

In Indonesia, each provincial government formulated a comprehensive energy plan (RUED), based on the national energy policy (Kebijakan Energi Nasional: KEN) and the new national energy policy (RUEN). In September 2020, "the regulations on comprehensive energy plans of Bali (2020-2050)" were enacted, and stipulate the policy for promoting the use of clean energy. Here, clean energy means natural gas and new renewable energy. In the long-term energy plan, the Bali government aims to increase the share of renewable energy in the power sources in Bali from 0.27% in 2015 to 11.5% in 2025 to 20.1% in 2050. According to RUED, plans shall be reviewed every 5 years in principle.

As for the share of fossil fuels in the power sources, they plan to decrease the share of coal-fired thermal power and abolish it by 2050. As for the use of petroleum, they aim to decrease its share from 75.71% in 2015 to 45% by 2050. As for gas, they plan to raise its share from 4.39% in 2015 to 56.2% in 2025, and then it will decline.

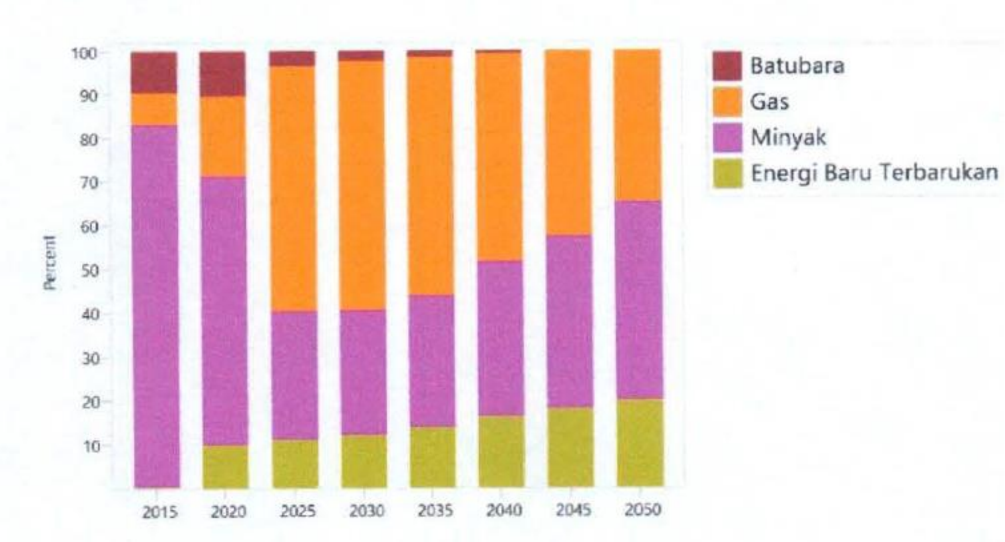

Figure 2-3 Future composition of power sources in Bali

Source: Regulations regarding the comprehensive energy plan of Bali (2020-2050) (RUED) (No. 9/2020)
Legend: (From the top) coal, gas, oil, and renewable energy

Table 2-3 Future composition of power sources in Bali

Energy category	2015	2025	2050
	(%)		
Coal	19.6	3.3	0.0
Gas	4.4	56.2	34.9
Petroleum	75.7	29.3	45.0
New renewable energy	0.3	11.5	20.1

Source: Regulations regarding the comprehensive energy plan of Bali (2020-2050) (RUED) (No. 9/2020)

According to RUED, long-term greenhouse gas emissions are tabulated below (Table 2-4). Considering future economic growth and consumption expansion, it is estimated that GHG emissions will augment from 6,154,000 tons CO_2/year in 2015 to 9,296,000 tons CO_2/year in 2030 to 21,279,000 tons CO_2/year in 2050.

From this table, we can understand that the transportation sector accounts for about 2/3 of emissions. Considering the fact that mainly diesel fuel is used in the transportation sector in Bali, the replacement of fuel for transportation would contribute significantly to the development of a low-carbon society.

Table 2-4 Forecast for GHG emissions in Bali [unit: thousand tons CO_2]

Sector	2015	2020	2025	2030	2035	2040	2045	2050
Industry	167	202	246	317	415	556	742	936
Transport	4,236	4,878	5,524	6,342	7,518	9,115	11,133	13,570
General household	353	434	486	503	517	527	535	542
Commerce	597	707	771	1,096	1,580	2,260	3,125	4,154
Other	801	844	879	1,039	1,238	1,465	1,762	2,076
Total	6,154	7,065	7,906	9,296	11,268	13,923	17,298	21,279

Source: Regulations regarding the comprehensive energy plan of Bali (2020-2050) (RUED) (No. 9/2020)

The RUED of Bali set 3 major policies and 6 supportive measures for them. The following table summarizes the primary policies for gas supply and renewable energy set in the RUED of Bali.

Table 2-5 Major policies regarding gas supply and renewable energy in the comprehensive energy plan of Bali (RUED, 2020-2050)

Strategy	Program	RUED Activities	Related institutions	Period
Policy 1: Access to energy according to local demand for energy				
Improvement in the reliability of production, transportation, and electricity distribution for energy supply	Development of infrastructure for fuel and LPG	● Development of networks for fuel supply, such as gas stations and APMS ● Development of LPG supply networks, such as SPBE (LPG filling stations)	ESDM, Pertamina, and private enterprises	2020-2050
	<u>Development of infrastructure for natural gas supply</u>	**<u>Production of roadmaps for infrastructure and gas supply, and development of LNG infrastructure in northern and southern Bali</u>**		
Policy 2: Priority items for clean energy development				
Promotion of use of natural gas (LPG, LNG, and CNG)	**<u>Development of infrastructure for natural gas supply</u>**	**<u>Development of infrastructure for supply and transportation in northern and southern Bali</u>**	ESDM, Bali Development Planning Bureau, private enterprises	2020-2050
Policy 3: Use of renewable energy in local areas				
Promotion of use of new renewable energy	Improvement in the share of new renewable energy in the composition of power sources	New renewable energy development goal to be attained by 2025: 228 MW **1) <u>Solar power: 213 MW</u>** 2) Micro-hydroelectric: 2.8 MW 3) Rooftop solar panels: 10 MW 4) Biomass: 0.9 MW 5) Wind power: 1.3 MW New renewable energy development goal to be attained by 2050: 537 MW **1) <u>Solar power: 500 MW</u>** 2) Micro-hydroelectric: 6 MW 3) Rooftop solar panels: 20 MW 4) Tidal power: 4 MW 5) Biomass: 3 MW 6) Wind power: 4 MW	Ministry of Labor, Land, and Immigration, Development Bureau, private enterprises, Ministry of Transportation, Ministry of Marine Fisheries, and Ministry of Public Works	2020-2050

The six supportive measures for the primary policies are as follows.

- Supportive measure 1: Conservation and diversification of energy
- Supportive measure 2: Environment and safety
- Supportive measure 3: Energy prices, subsidies, and incentives
- Supportive measure 4: Establishment of infrastructure for citizens and the energy industry, and access to infrastructure
- Supportive measure 5: R&D and application of energy technologies
- Supportive measure 6: Institutions and funding

Among them, the measures for gas supply and renewable energy are tabulated below.

Table 2-6 Major supportive measures for gas supply and renewable energy in the comprehensive energy plan of

Bali (RUED, 2020-2050)

Strategy	Program	RUED Activities	Related institutions	Period
Supportive measure 1: Conservation and diversification of energy				
Diversification of energy	**Replacement of diesel fuel with gas in the residential and transportation fields**	● To revise gas measures in the transportation field ● **To increase vehicles equipped with CNG engines** ● **To allocate the local budget (APBD) for promoting the use of gas fuel** ● To promote the use of gas for housing and develop infrastructure by constructing city gas networks ● To install biogas digesters in 150 houses by 2025 *All of them comply with RPJMD and the strategic plan.	ESDM, Bali Development Planning Bureau, private enterprises, etc.	2020-2050
Use of gas energy in the transportation field	**Optimization of gas use in the industrial, electric power, housing, and transportation fields**	● Natural gas shall be used for governmental vehicles in areas where gas infrastructure and battery-type electric vehicles have been already developed. *Stipulated in the ordinance and the governor's order		
Supportive measure 3: Energy prices, subsidies, and incentives				
Fair energy price	Calculation of appropriate energy prices for supplying renewable energy by utilizing local resources	● **Survey on the feasibility of development of systems for solar power, bio energy, wind power, and tidal power generation** ● **Setting of special/clean electric power prices for producing opportunities to invest in renewable energy, and establishment of regulations for the cooperative scheme**	ESDM, Bali Development Planning Bureau, and private enterprises	2020-2050
Incentives for use of renewable energy	**Provision of energy subsidies and incentives**	**Design of measures regarding the subsidies for electric charges to poor citizens and the development of a new scheme for subsidies for electric charges (funded by local budgets)**		

Bali governor's regulations on clean energy (No. 45/2019) as well as RUED summarize Bali policy for generating clean energy independently. As a measure for distributing renewable energy, they plan to replace diesel fuel and heavy oil with gas, rooftop solar power, biofuel, and other renewable energy.

The following shows a project for installing rooftop solar power panels, which was launched in 2020.

Table 2-7　Rooftop solar power generation project in Bali in 2020

Funding source	Facility capacity [kWp]
Funds from ESDM Renewable Energy/Energy Saving Bureau, Phase I (7 sites)	270
Funds from Korean KEA and BAPPENAS (including recharging equipment installed in solar power systems)	6.6
Funds from ESDM Renewable Energy/Energy Saving Bureau, Phase II (2 sites)	150

Source: Produced with reference to “Proposal Bali Mandiri Energi Dengan Energi Bersih Di Provinsi Bali” in Bali (2020)

(3) Demand for electric power and renewable energy potential in Bali

The power generation in the Bali Island accounts for about 70% of the power supply to Bali, and it mostly relies on thermal power generation. The remaining power supply is from Java via submarine cables. The thermal power generation in Bali is composed of mainly coal-fired one, and natural gas is used for the remaining (there is a diesel power plant, but it is not in operation). The electric power facility capacity in Bali in 2019 was 926 MW, or 1,261 MW when the unused diesel power plant is taken into account. The Bali government aims to increase the facility capacity by 6% every year until 2039, reaching 3,206 MW between 2035 and 2039[13] (Table 2-8).

According to the increasing facility capacity, the Bali government plans to increase the share of gas-fired power generation. Based on the Indonesian plan for electric power supply (RUPTL) of PLN, the government plans to change the fuel for thermal power generation to natural gas. In Bali, they plan to develop a system for gas-fired power generation with a capacity of 350 MW × 2 in Celukan Bawang in the northern Bali island, for realizing power sources for meeting the future demand for electric power.

Table 2-8　Power generation facility capacity and estimated demand in Bali

	2020-2025	2025-2030	2030-2035	2035-2039
Target facility capacity [MW]	1,418	1,897	2,539	3,206
Peak demand [MW]	1,091	1,459	1,953	2,466

Source: Produced with reference to “Proposal Bali Mandiri Energi Dengan Energi Bersih Di Provinsi Bali” in Bali (2020)

The capacity of renewable energy facilities is 1.8 MW for micro-hydroelectric power and about 4 MW for solar power as of 2019. They account for less than 1% of the power sources. On the other hand, the potential of power generation with renewable energy in Bali amounts to 3,686 MW, so

[13] Bali (2020) “Proposal Bali Mandiri Energi Dengan Energi Bersih Di Provinsi Bali” (policy to achieve energy self-sufficiency by introducing clean energy)

future development is expected.

Table 2-9 Potential of power generation with renewable energy in Bali

Category	Tidal	Wind	Biogas	Biomass	Solar	Water	Geo-thermal	Micro-hydroelectric
Facility capacity [MW]	320	1,019	45	147	1,254	624	262	15
Total [MW]	3,686							

Source: Produced with reference to “Proposal Bali Mandiri Energi Dengan Energi Bersih Di Provinsi Bali” in Bali (2020)

2.2.2. Study to develop a commercialization plan to switch to natural gas as fuel

As mentioned in Section 2.2.1(2), Bali Province has been developing policies to promote the development of renewable energy, and based on interviews with Bali Province, four related laws and regulations have been formulated. In particular, based on Indonesia's KEN and RUEN, the RUED formulated in September 2020 has as its main policy to promote the use of natural gas and to promote the development of natural gas supply infrastructure.

On the other hand, as for the current status of natural gas supply infrastructure in Bali, three gas filling stations (SPBG) were developed in 2013 under the initiative of ESDM, but no progress has been made since then. As of 2015, gas consumption in Bali is about 40 liters per day, and the Bali Land Transportation Organization has requested Pertamina Gas, the national gas company, to increase gas demand and improve SPBG.[14] However, the current situation is still far behind compared to other provinces in Java Island.

In the transportation fuel conversion project under consideration in this project, it is assumed that the gas supply system is secured. Therefore, in order to understand the current gas supply system in Bali, the status and plan of SPBG development in the future, and the amount of gas demand (number of fuel units to be converted) necessary to implement the project in the case of receiving cooperation in the fuel conversion project, we exchanged opinions with PT Pertagas Niaga, a gas sales company of Bali Province and PT Pertamina Group, an Indonesian oil and gas corporation.

In the discussion with the Province of Bali, it was agreed that the project, which will lead to the enhancement of gas supply infrastructure in Bali, will rely on the gas supply infrastructure development plan of Pertamina Gas. In addition, in the exchange of opinions with Pertamina Gas, we were able to attract their interest in strengthening the gas supply infrastructure in Bali, and they expressed their willingness to cooperate positively in the study of this project after signing an MoU. In addition, while the development of gas supply infrastructure is essential for the transportation fuel conversion project, it is necessary to consider the project based on the price of gas for transportation in Bali, because the further the distance from the gas supply point, the more the transportation cost and the cost of infrastructure investment required for the development of new SPBG will be added

[14] https://regional.kontan.co.id/news/organda-minta-pertamina-tambah-spbg-di-bali

to the gas price. It was commented that the project should be studied based on the gas price for transportation in Bali, and that if the gas consumption is guaranteed by the government of Bali, investment in the development of gas supply infrastructure can be considered more proactively.

Based on the results of discussions with both parties, it was found that it is important to identify the natural gas supply potential in Bali from the perspective of securing gas consumption by Bali and gas demand by Pertamina Gas. Therefore, in the following, the gas demand associated with the gas conversion is calculated based on the energy demand for diesel vehicles in the entire province of Bali, and the effect of the gas conversion on each sector, such as buses and waste collection vehicles, is analyzed. In addition, based on the MoU with Pertamina Gas, the company plans to proceed with studies that will lead to a decision on commercialization in the next fiscal year or later, while receiving information from Pertamina Gas.

(1) Study on switching to gas for sightseeing buses, etc.

1) Calculation of the potential for CO_2 emission reduction

① Energy Demand and CO_2 Emissions from Diesel Vehicles in Bali Province

According to a 2019 report in the Bali local newspaper Tribun news, daily diesel consumption in Bali is estimated to reach 520 kl.

Figure 2-4 Tribun news article

Source: Tribun Bali (tribunnews.com), "Pertamina Catat Penggunaan Solar di Bali, Konsumsi Capai 520 KL Per Hari", https://bali.tribunnews.com/2019/09/14/pertamina-catat-penggunaan-solar-di-bali-konsumsi-capai-520-kl-per-hari, obtained February 2021.

The main vehicles that use diesel fuel are large vehicles such as buses and trucks. Diesel vehicles are composed of highly durable parts due to the high pressure inside the engine, and the low engine speed means that parts wear less and do not need to be overhauled for a long time. In addition, the exhaust volume can be larger than that of gasoline engines, a feature that makes them suitable for trucks and buses which require more torque.

According to the Bali Statistics Authority, the number of buses and trucks registered in Bali is 163,554 in 2019. The breakdown is 9,142 buses and 154,412 trucks.

Jenis Kendaraan	Banyaknya Kendaraan Menurut Jenisnya dan Kabupaten/Kota di Provinsi Bali (Unit)
	2019
Bus	9 142
Truk	154 412
Sepeda Motor	3 738 803
Mobil Penumpang/Lainnya	450 239
Jumlah	4 352 596

Figure 2-5 Number of vehicles in Bali Province

Source: Badan Pusat Statistik Provinsi Bali, "BADAN PUSAT STATISTIK PROVINSI BALI", https://bali.bps.go.id/, obtained February 2021.

Most of these are assumed to run on diesel fuel, and if we assume that the total amount is 520 kl/day as mentioned above, the annual consumption would be 189,800 kl/year.

Since the CO2 emission factor per liter of diesel is 2.619 kg-CO2, the CO2 associated with the consumption of 189,800 kl amounts to 497,086 t-CO2. As for the conversion of diesel vehicles to gas fuel, the results of the "Project for the Installation of CNG and Diesel Fuel Co-combustion Equipment in Public Transport Buses in Semarang," which was implemented as a JCM Model Project in 2018, show that the CO2 emission reduction effect of 30-40% can be achieved, so the gas conversion of diesel vehicles is one of the effective low-carbon measures in Bali.

On the other hand, the number of tourist buses in operation has decreased significantly in 2020 due to the spread of COVID-19. Looking back at the impact of the pandemic on tourism in Bali, visa-free travel to 160 countries has been restricted since March 2020, and from 2021, measures have been taken to restrict travel even for those with visas due to concerns about the spread of mutated forms of coronavirus.

While the contribution of tourism buses is expected to have decreased significantly due to these circumstances, the same scale of tourism demand is expected to occur again in the post-pandemic period. Therefore, it's safe to say that preparations for emission reduction measures are necessary. In addition, the operation of trucks and other vehicles, including those used for public transportation and waste collection, is essential to society, so it is likely that the same operations are being carried out as before the pandemic.

In this study, we focused our analysis on public buses, which need to be operated continuously and are socially indispensable even amid the active pandemic.

② Public Bus Service in Bali Province

In Bali, public buses (including those used for tourism purposes) are operated in addition to privately operated buses that are owned by tourism companies and operated based on tourism demand.

The public bus service was established in September 2020 under the name of "Trans Metro Dewata" as part of the Bus Rapid Transit (BRT) promotion plan by the Indonesian Ministry of Transportation, and is positioned as the next project after Solo City and Palembang City. Trans Metro Dewata owns 105 buses and operates on four bus routes, and the service will be available free of charge as a trial run until December 2020.

The service will run from 5:00 a.m. to 9:00 p.m., every 10 minutes, and is expected to make 68 trips each way per day.

Figure 2-6 Trans Metro Dewata vehicles

Source: Bali Backpacker's Guidelines "Bali Trans Metro Dewata Bus", https://bali-backpacker.com/trans-metro-dewata-bus-stop-halte-shelter/, obtained February 2021.

Figure 2-7 Trans Metro Dewata information material

Source: Bali Backpacker's Guidelines "Bali Trans Metro Dewata Bus", https://bali-backpacker.com/trans-metro-dewata-bus-stop-halte-shelter/, obtained February 2021.

The following routes have been established for buses to run.

Table 2-10 Trans Metro Dewata Operation Information

Route No.	Route	No. of stops	Vehicles	One-way Distance [km]
Route I (K1B)	Kuta Central Parking Lot - Bus Station	40	31	63.6 km
Route II (K02)	Ngurah Rai Stadium - Airport	24	22	30.2 km
Route III (K3B)	Sanur Beach - Kuta North	24	20	43.0 km
Route IV (K4B)	Bus Station - Ubud	32	32	55.3 km

Source: Made by JANUS from Bali Backpacker's Guidelines "Bali Trans Metro Dewata Bus", https://bali-backpacker.com/trans-metro-dewata-bus-stop-halte-shelter/

The routes for each line are shown below.

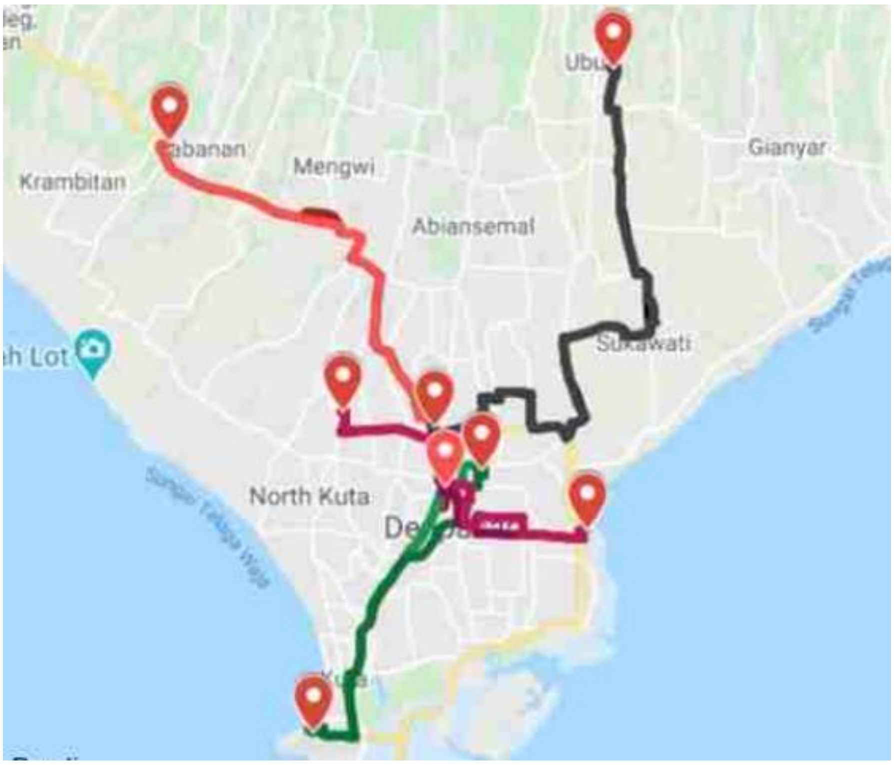

Figure 2-8 Trans Metro Dewata route

Source: Made by JANUS, from Bali Backpacker's Guidelines "Bali Trans Metro Dewata Bus", https://bali-backpacker.com/trans-metro-dewata-bus-stop-halte-shelter/

Based on this information, we estimated the fuel consumption and CO_2 emissions in Trans Metro Dewata.

First, based on the distance traveled and the number of operations on each route, the total daily round trip distance is 36,883.2 km. Assuming 300 days of operation per year, the annual mileage would be 11,064,960 km.

The buses used in Trans Metro Dewat are medium-sized buses manufactured by Mitsubishi, and are the same type of buses operated by Trans Semarang in the "Project for Installation of CNG and Diesel Fuel Co-combustion System in Public Transport Buses in Semarang City," which was implemented as a JCM Model Project in 2018. Therefore, the fuel consumption data can be cited from the project.

Table 2-11 Number of operations, distance, and fuel consumption by route

Route number	Number of	One way	Round-trip	Annual	Estimated	Fuel

	runs [Times/one-way]	distance [km]	distance [km/day]	mileage distance [km/year]	fuel cost*[km/l]	consumption [l/year]
Route I (K1B)	96	63.6	12,211.20	3,663,360	4.7	779,438
Route II (K02)	96	30.2	5,798.40	1,739,520	4.7	370,111
Route III (K3B)	96	43	8,256.00	2,476,800	4.7	526,979
Route IV (K4B)	96	55.3	10,617.60	3,185,280	4.7	677,719
Total	384	192.1	36,883.20	11,064,960	-	2,354,247

*Refer to the figures for the same type of public bus in Semarang City (Trans Semarang).

Based on these values, the net heat generation amount of diesel fuel was calculated, and the CO_2 emissions were calculated as follows.

Table 2-12 Estimated CO_2 emission by routes

Route number	Fuel consumption [l/year]	Net heat generation amount* [GJ/kl]	CO_2 emissions** [t-CO_2/year]
Route I (K1B)	779,438	37,943	2,755
Route II (K02)	370,111	18,017	1,308
Route III (K3B)	526,979	25,653	1,862
Route IV (K4B)	677,719	32,991	2,395
Total	2,354,247	114,605	8,320

*The net heat generation amount is 48.68 GJ/kl, which is the lower IPCC default value shown in Table 1.2 of Chapter 1 of Volume 2 of the 2006 IPCC Guidelines for Greenhouse Gas Inventories.

**Emission factors are IPCC default values given in the 2006 IPCC Guidelines for Greenhouse Gas Inventories, Volume 2, Chapter 1, Table 1.2. A low reading of 0.0726 t-CO_2/GJ was taken.

Trans Metro Dewat is the sole operator that continues to routinely consume fuel of this magnitude for its public transportation service operations.

In considering support for JCM facilities, it is desirable to target a single entity from the perspective of smooth project organization and establishment of a monitoring system, etc., because a form involving many local entities poses many challenges from the coordination perspective. From this standpoint, it can be said that Trans Metro Dewat is a promising operator when it comes to DDF for buses in Bali.

The same type of methodology can be applied to the fuel conversion project using CNG in Trans Metro Dewat as the "Project for Installation of CNG and Diesel Fuel Co-combustion Equipment in Public Transport Buses in Semarang City," which was implemented as a JCM Model Project in 2018.

In this methodology, the reduction amount of emissions is defined as the value obtained by subtracting the project emissions from the reference emissions, and is assumed to be calculated by the following equation.

$$ER_p = RE_p - PE_p$$

ER_p	Reduction amout of emissions in the period p [t-CO_2/p]
RE_p	Reference emissions for the period p [t-CO_2/p]
PE_p	Project emissions in the period p [t-CO_2/p]

The reference emissions are currently used (amount of CO_2 emissions from running on diesel fuel) and are equivalent to 8,320 t-CO_2/year (41,602 t-CO2 for 5 years, as planned project period) as described above. The project emissions are the assumed CO_2 emissions when CNG fuel is partially replaced by CNG tanks and mix-firing equipment. The formula for calculating project emissions is as follows

$$RE_p = \sum_i \left\{ \left[\left(FC_{PJ,CNG,i,p} \times NCV_{CNG} \right) + \left(FC_{PJ,diesel,i,p} \times NCV_{diesel} \right) \right] \times \frac{\eta_{PJ,i,p}}{\eta_{RE,i}} \right\} \times EF_{diesel}$$

RE_p	Reference emissions in the period p [t-CO_2/p]
$FC_{PJ,CNG,i,p}$	CNG consumption of the project bus i in the period p [t/p]
NCV_{CNG}	Net heat generation amount of CNG [GJ/t]
$FC_{PJ,diesel,i,p}$	Diesel fuel consumption of the project bus i in the period p [kl/p]
NCV_{diesel}	Net heat generation amount of diesel fuel [GJ/kl]
$\eta_{PJ,i,p}$	Fuel consumption of the project bus i in the period p [km/l]
$\eta_{RE,i}$	Fuel consumption of the reference bus i [km/l]
EF_{diesel}	CO_2 emission factor for diesel fuel [t-CO_2/GJ]
i	Project bus ID number

Table 2-13 Key default values

Parameter	Data summary and default values	Information source
NCV_{CNG}	Net heat generation amount of CNG [GJ/t]: 46.50	A low IPCC default value as shown in Table 1.2 in Chapter 1 of Volume 2 of the 2006 IPCC Guidelines for Greenhouse Gas Inventories is adopted.
NCV_{diesel}	Net heat generation amount of diesel fuel [GJ/kl]: 48.68	A low IPCC default value as shown in Table 1.2 in Chapter 1 of Volume 2 of the 2006 IPCC Guidelines for Greenhouse Gas Inventories is adopted.
EF_{CNG}	CO_2 emission factor for CNG [t-CO_2/GJ]: 0.0543	A low IPCC default value as shown in Table 1.2 in Chapter 1 of Volume 2 of the 2006 IPCC Guidelines for Greenhouse Gas Inventories is adopted.
EF_{diesel}	CO_2 emission factor for diesel fuel [t-CO_2/GJ]: 0.0726	A low IPCC default value as shown in Table 1.2 in Chapter 1 of Volume 2 of the 2006 IPCC Guidelines for Greenhouse Gas Inventories is adopted.

$\eta_{RE,i}$	Fuel consumption of the reference bus i [km/l]	Calculated from the distance traveled and fuel consumption of each bus.
p	Planned project period [years]: 5	In the Ministerial Ordinance on Useful Lives of Depreciable Assets, large passenger cars (those with a total exhaust volume of 3 liters or more) are applied.
α	Fuel efficiency improvement rate as a result of the project implementation [-]: 4570cc medium-duty bus = 0.870	Established by referring to the results of the "Project for Introducing CNG and Diesel Fuel Co-combustion Equipment to Public Transport Buses in Semarang, Indonesia."
β	Fuel conversion rate as a result of project implementation [-]: Medium-duty bus with exhaust volume of 4570 cc = 0.398	The value is set by referring to the value of medium-duty bus in "Project for introducing CNG and diesel fuel co-combustion equipment to public transportation buses in Semarang, Indonesia."

Based on the above calculations, the project emissions (5 years) are 32,562 t-CO_2/year. The amount of emission reduction is 9,039 t-CO_2/year, which is the value subtracted from the reference emission amount of 41,602 t-CO_2/year.

2) **Economic evaluation**

① **Equipment installation cost**

The equipment required for CNG co-combustion in diesel engine vehicles includes gas fuel injectors for the CNG tank and engine system, a computer that calculates and controls the optimal co-combustion rate, and a user interface that includes a fuel gauge and DDF mode switching.

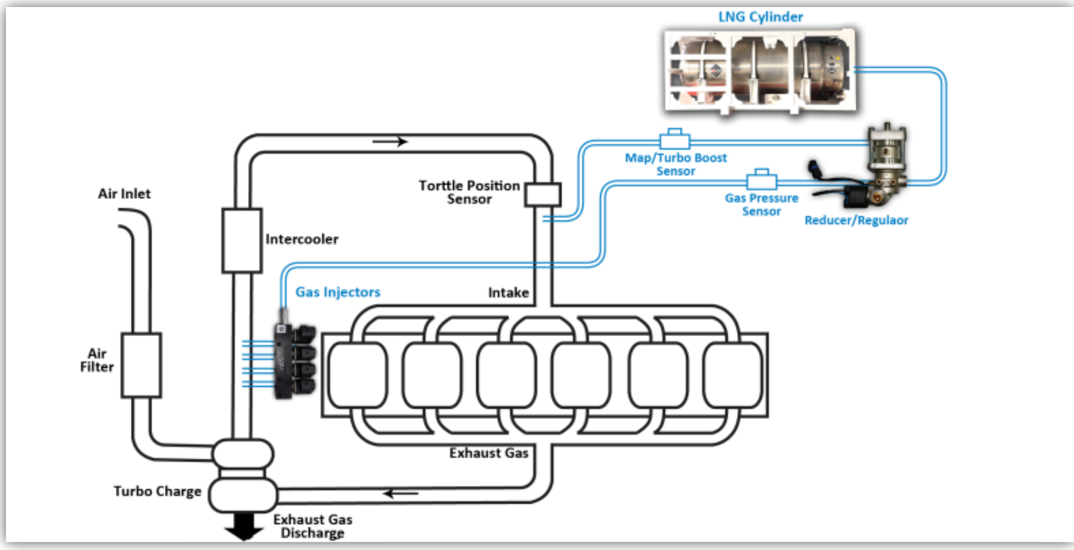

Figure 2-9 Equipment and device layout required for DDF conversion

Source: Made by JANUS from several materials of "JCM Project for installation ofCNG and DDF for public buses in Semarang"

The installation of the equipment will require the cost of these devices, installation work by engineers, the cost of test operation, etc.

In the "Project on Installation of CNG and Diesel Fuel Co-combustion Equipment for Public Transport Buses in Semarang City," which was implemented as a JCM Model Project in 2018, these costs were found to be approximately 1 million yen per medium-sized bus.

Since Trans Metro Dewat owns 105 medium-sized buses, the initial investment required to adopt the system will be around 105 million yen or 14,170,040,486 IDR.

② Operation cost

DDF is a technology that is expected to not only reduce CO2 emissions, but also decrease operating costs thanks to the difference in fuel prices between diesel and CNG as well as the effect of improved fuel efficiency. The current consumption of diesel is 1,667,591 L/year and the price is 7,150 IDR/L. The fuel cost based on this value would be about 16.8 billion IDR (16,832,864,6810 IDR), or about 124.7 million Japanese yen.

③ Economical simulation

For switching to CNG as fuel, it is necessary to adequately assess the price of natural gas supply in Bali. This is because the Indonesian government has set low prices for natural gas supply especially to the transportation sector, in order to make better use of the natural gas produced in the country, but the prices are different in areas where pipeline transportation is available compared to other areas. For example, in Jakarta, the price per unit of CNG is set at 3,100 IDR/LSP, but the price before pipeline development in Semarang is 4,500 IDR/LSP, because the transportation cost of CNG is added to the price.

Since the pipeline is not yet in place in Bali, the calculation here will be based on a provisional value of 4,500 IDR/LSP.

As a result, we found that the fuel cost reduction effect is about 12.4 billion IDR for a five-year projection.

Without JCM Model Project, the investment recoupment period is 6 years, and when assuming that JCM Model Project cover 40% of costs, the recoupment period is 4 years. The results of the economical calculation are shown below.

Table 2-14 Estimation of economic effect for introducing DDF equipment for Trans Metro Dewata by JCM equipment subsidy

Diesel price	7,150	IDR/L
CNG price	4,500	IDR/L
Reference fuel price		
Diesel	16,832,864,681	IDR
Project Fuel price		
Diesel	10,133,384,538	IDR
CNG	4,216,456,034	IDR
Total	14,349,840,572	IDR

Fuel price reduction effect	2,483,024,109	IDR/year
Initial investment	14,170,040,486	IDR
Investment payback year	6	year
Initial investment with JCM subsidy	8,502,024,291	IDR
Investment payback year with JCM subsidy	4	year

	Reference cost			Project cost				Benefit
	CAPEX	Diesel cost	Total	CAPEX	Diesel cost	CNG cost	Total	
0	0			8,502,024,291				-8,502,024,291
1		16,832,864,681	16,832,864,681		10,133,384,538	4,216,456,034	14,349,840,572	2,483,024,109
2		16,832,864,681	16,832,864,681		10,133,384,538	4,216,456,034	14,349,840,572	2,483,024,109
3		16,832,864,681	16,832,864,681		10,133,384,538	4,216,456,034	14,349,840,572	2,483,024,109
4		16,832,864,681	16,832,864,681		10,133,384,538	4,216,456,034	14,349,840,572	2,483,024,109
5		16,832,864,681	16,832,864,681		10,133,384,538	4,216,456,034	14,349,840,572	2,483,024,109
6		16,832,864,681	16,832,864,681		10,133,384,538	4,216,456,034	14,349,840,572	2,483,024,109
7		16,832,864,681	16,832,864,681		10,133,384,538	4,216,456,034	14,349,840,572	2,483,024,109
合計		117,830,052,766	117,830,052,766		70,933,691,765	29,515,192,238	100,448,884,003	17,381,168,763

- Cashflow and IRR

	0	1	2	3	4	5	6
FCF	-8502024291	2,483,024,109	2,483,024,109	2,483,024,109	2,483,024,109	2,483,024,109	2,483,024,109
	-8502024291	-6,019,000,183	-3,535,976,074	-1,052,951,965	1,430,072,144	3,913,096,253	6,396,120,362
IRR（10 year）	26%				Investment payback		

Source: Made by JANUS

(2) **Study on switching to gas for waste collection vehicles**

The province of Bali generates about 4,300 tons of waste per day, of which 60% is organic waste and 20% is plastic waste. Of the total waste, 52% is not disposed of properly due to illegal dumping, open burning, etc. The rest is delivered to final processing sites under the jurisdiction of local governments.[15]

Fiture 2-10 Fire fighting activities at final processing site in TPA Sarbagita (September 27, 2019)
Source: BPBD Bali/Mongabay Indonesia

There are eight final processing sites in Bali, and waste from Denpasar City in southern Bali, Badung, Gianyar, and Tabanan districts is delivered to the TPA Sarbagita final processing site in Suwung, south of Denpasar City. It is said that the waste generated from the above four districts in the southern part of Bali accounts for 80% of the total waste volume in Bali, and is the largest final processing site in Bali. The amount of waste brought in per day, which was around 800 tons in 2014, temporarily dropped to 500-600 tons due to COVID-19, but has now reached 1,150 tons.[16] With a projected daily delivery volume of 2,400 tons, the situation is very tight, as the remaining lifespan of the final processing site is only about 3 to 5 years[17] as of 2016, according to an official of the Denpasar City Cleaning Department, which manages the disposal site. The Bali Provincial Government is planning to build a waste-to-energy plant (PSEL) from 2019 to facilitate waste disposal at the final processing site, but construction has been delayed due to the lack of investors.[18]

In addition, the methane gas generated from the accumulated waste has caused frequent fires, and the fire accidents and the odor from the disposal site have seriously affected the tourism industry and the lives of the surrounding residents in Bali.

Waste collection in the province of Bali is either under the jurisdiction of the Department of Beautification (DKP) of the local government or outsourced to private companies, but the collection is not fully implemented in municipalities that cannot allocate budget for waste collection. In areas where the collection is not carried out, there emerged problems, such as residents illegally dumping garbage into rivers, causing flooding, and the incineration of garbage on roadsides, causing smoke pollution and health concerns for nearby residents.

For Denpasar City, waste is delivered by residents to a temporary collection point (TPS) near their homes between 5 pm and 7 pm daily, and then transported to a final processing site (TPA) via a transfer station (DEPO). The local government is responsible for the transportation from TPS to TPA or DEPO to TPA. In Denpasar City, 127 TPS/DEPOs (transfer stations) have been set up, where

15 https://www.mongabay.co.id/2019/07/02/inilah-data-dan-sumber-sampah-terbaru-di-bali/
16 https://bali.tribunnews.com/2020/11/21/sampah-ke-tpa-sarbagita-suwung-mencapai-1150-ton-per-hari-bali-rencanakan-bangun-psel?page=1
17 https://www.env.go.jp/earth/coop/lowcarbon-asia/project/data/JP_IDN_H28_01.pdf
18 https://www.greeners.co/berita/revitalisasi-tpa-serbagita-suwung-bali-tak-kunjung-selesai/

waste is transshipped to 121 waste collection vehicles owned by the city (as of 2019)[19], and waste is delivered to the TPA, 3 to 4 times a day on average.[20] The following is the process flow of waste collection in Denpasar City.

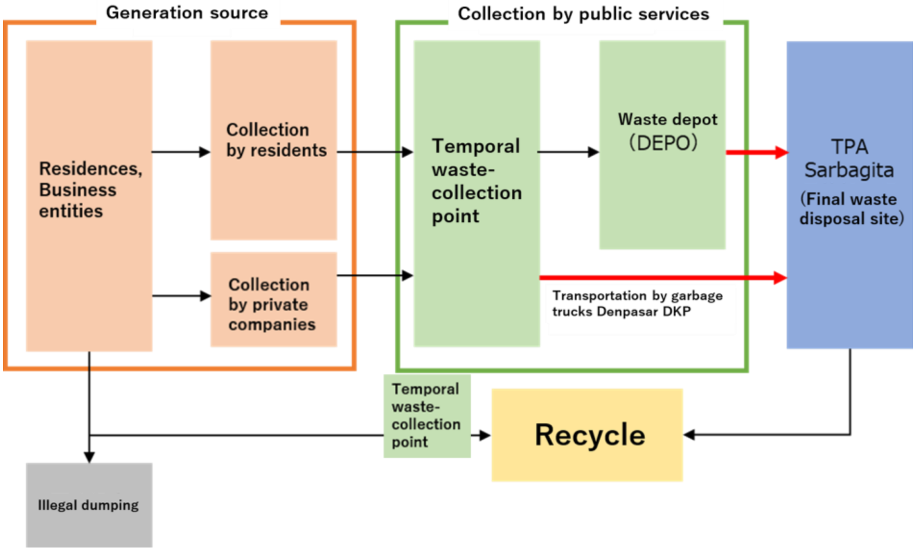

Figure 2-11 The process flow of waste collection in Denpasar City

Source: JFE Engineering Co., Ltd

1） Calculation of the potential for CO2 emission reduction

As mentioned above, in the province of Bali, as in other regions, waste collection and disposal services are offered by the cities and districts. The municipality with the largest amount of waste generation in Bali Province is Denpasar City, and this study uses data on waste collection vehicles in Denpasar City for the calculations. For the results of this study, the Province of Bali and Udayana University lobbied the Cleaning Department of Denpasar City, and they are in the review stage.

Now, we have received the data from Denpasar City on the waste-related vehicles under their jurisdiction, and the breakdown is as follows.

Table 2-15　Waste-related vehicles at the Denpasar City Cleaning Department

Vehicle type	Condition		Total
	Normal	Out of service	
Dump truck	58	10	68
Arm roll truck	20	4	24
Container truck	51	56	107
Compactor truck	12	0	12

[19] https://www.bps.go.id/publication/download.html?nrbvfeve=NWE3OThiNmI4YTg2MDc5Njk2NTQwNDUy&xzmn=aHR0cHM6Ly93d3cuYnBzLmdvLmlkL3B1YmxpY2F0aW9uLzIwMjAvMTEvMjcvNWE3OThiNmI4YTg2MDc5Njk2NTQwNDUyL3N0YXRpc3Rpay1saW5na3VuZ2FuLWhpZHVwLWluZG9uZXNpYS0yMDIwLmh0bWw%3D&twoadfnoarfeauf=MjAyMS0wMi0wNCAxNDo0Njo0Mw%3D%3D

[20] https://www.mofa.go.jp/mofaj/gaiko/oda/seisaku/kanmin/chusho_h25/pdfs/5a11-1.pdf

Truck (normal type)	2	2	4
Sweeper truck	1	0	1
Sweeper mini	1	2	3
Tank car	2	1	3
Medium-sized car	5	2	7
Depot transport vehicle	5	7	12
Bulldozer	2	0	2
Excavator car	1	0	1
Wheel loader	3	0	3
WC truck	1	0	1
Lawn mower	58	7	65
Ground leveling machine	9	0	9
Sensor machine	45	9	54
Three-wheel waste	11	2	13
3-wheel tank car	11	0	11
Container sorting device	10	0	10
Bike	29	2	31
Pick-up truck	22	0	22
Station Wagon	9	1	10

Source: Made by JANUS from reference materials of Denpasar City

Although there are references to vehicles used not only for waste collection but also for land preparation at disposal sites and for road cleaning, here we will focus on "dump trucks," "container trucks," and "compactor trucks," which are in regular operation.

The total number of these vehicles is 121, and they go back and forth between the disposal site and the collection site about four times a day. As there is no clear route for each vehicle, we used 15 km from the center of Denpasar City to the final processing site as the average distance. If four round trips are made per day, the total distance traveled by the 121 vehicles will be 7,260 km, and the total distance traveled in one year will be 2,649,900 km.

Table 2-16 Number of units in operation and travel distance

Number of units in operation	121	car
Number of round trips	4	round trip
Moving distance	15	km
Total daily travel distance	7,260	km/day
Total annual travel distance	2,649,900	km

Made by JANUS from materials of Denpasar City

Assuming that the fuel consumption of waste collection vehicles is comparable to that of a medium-sized bus, and adopting the value of 4.7 km/l from the "Project for the Installation of CNG and Diesel Fuel Co-combustion Equipment in Public Transportation Buses in Semarang," which was implemented as a JCM Model Project in 2018, the fuel consumption required for these trips is 563,809 l/year. CO2 emission is assumed to be 9,963 t-CO2/year for project period, 5 years.

When calculating the CO2 emission reductions based on these values, the results were as follows.

Table 2-17 CO2 emissions calculated from fuel consumption and calorific value

CO2 emission from CNG consumption	1,022	t/5 year
CO2 emission from CNG consumption	2,580	t-CO_2/5 year
Diesel consumption	1,476	kl/5 year
CO2 emission from diesel consumption	5,218	t-CO_2/5 year
CO2 emission from DDF	7,798	t-CO_2/5 year

Source: Made by JANUS

The value obtained by subtracting the project emissions from the reference emission value of 9,963t-CO2 / 5 years is 2,165t-CO2 / year, and this value is the CO2 emission reduction effect in the project.

2） Economical evaluation

① Equipment installation cost

The number of waste collection vehicles to be targeted is assumed to be 121 as described above. Like Trans Metro Dewat, if we assume DDF vehicle modifications at 1 million yen per vehicle, the modification cost for 121 vehicles would be 121 million yen or 16,329,284,750 IDR.

② Operation cost

As in the case of the Trans Metro Dewat study, the shift to DDF is expected to reduce operating costs due to the difference in fuel prices between diesel and CNG as well as improved fuel efficiency. The current diesel consumption is 563,809 L/year based on the above assumptions, and the diesel price is 9,500 IDR/L for industrial use (unsubsidized). The operating cost (fuel cost) based on this value is about 5.3 billion IDR (53,356,180,841 IDR), or about 40 million Japanese yen.

③ Economical simulation

As in the Trans Metro Dewat study, the CNG price is set at 4,500 IDR/LSP as an assumption for the calculation. As a result of the calculation, it was found that the fuel cost reduction effect was approximately 560 million IDRs assuming a five-year period. Without subsidies, the investment recoupment period was 15 years, and with subsidies for JCM equipment, the recoupment period was found to be 9 years at a subsidy rate of 40%.

The calculation results are shown below.

Table 2-18 At the time of introduction of DDF utilizing JCM equipment subsidy for vehicles related to waste collection in Denpasar City economic simulation results

Diesel price	9500	IDR/L
CNG price	4500	IDR/L
Reference fuel price		
Diesel	5,356,180,851	IDR
Project fuel price		
Diesel price	3,224,420,872	IDR
CNG	1,009,781,043	IDR
Total	4,234,201,915	IDR

Economic effect	1,121,978,936	IDR/year
Initial investment	16,329,284,750	IDR
Investment payback year	15	year
Initial investment with JCM subsidy	9,797,570,850	IDR
Investment payback year with JCM	9	Year

year	Reference cost			Project cost				Benefit
	Initial investment	Diesel cost	Total	Initial investment	Diesel cost	CNG cost	Total	
0	0			9,797,570,850				-9,797,570,850
1		5,356,180,851	5,356,180,851		3,224,420,872	1,009,781,043	4,234,201,915	1,121,978,936
2		5,356,180,851	5,356,180,851		3,224,420,872	1,009,781,043	4,234,201,915	1,121,978,936
3		5,356,180,851	5,356,180,851		3,224,420,872	1,009,781,043	4,234,201,915	1,121,978,936
4		5,356,180,851	5,356,180,851		3,224,420,872	1,009,781,043	4,234,201,915	1,121,978,936
5		5,356,180,851	5,356,180,851		3,224,420,872	1,009,781,043	4,234,201,915	1,121,978,936
6		5,356,180,851	5,356,180,851		3,224,420,872	1,009,781,043	4,234,201,915	1,121,978,936
7		5,356,180,851	5,356,180,851		3,224,420,872	1,009,781,043	4,234,201,915	1,121,978,936
8		5,356,180,851	5,356,180,851		3,224,420,872	1,009,781,043	4,234,201,915	1,121,978,936
9		5,356,180,851	5,356,180,851		3,224,420,872	1,009,781,043	4,234,201,915	1,121,978,936
10		5,356,180,851	5,356,180,851		3,224,420,872	1,009,781,043	4,234,201,915	1,121,978,936
11		5,356,180,851	5,356,180,851		3,224,420,872	1,009,781,043	4,234,201,915	1,121,978,936
12		5,356,180,851	5,356,180,851		3,224,420,872	1,009,781,043	4,234,201,915	1,121,978,936
13		5,356,180,851	5,356,180,851		3,224,420,872	1,009,781,043	4,234,201,915	1,121,978,936
14		5,356,180,851	5,356,180,851		3,224,420,872	1,009,781,043	4,234,201,915	1,121,978,936
合計		74,986,531,915	74,986,531,915		45,141,892,213	14,136,934,596	59,278,826,809	15,707,705,106

- Cashflow and IRR

	0	1	2	3	4	5	6
FCF	-9,797,570,850	1,121,978,936	1,121,978,936	1,121,978,936	1,121,978,936	1,121,978,936	1,121,978,936
	-9,797,570,850	-8,675,591,914	-7,553,612,978	-6,431,634,042	-5,309,655,106	-4,187,676,169	-3,065,697,233
IRR（14 years）	7%						

	7	8	9	10
FCF	1,121,978,936	1,121,978,936	1,121,978,936	1,121,978,936
	-1,943,718,297	-821,739,361	300,239,575	1,422,218,511
			Investment payback	

Source: Made by JANUS

2.2.3. Study on formulating a commercialization plan for the adoption of solar power generation

(1) Solar power generation

In the projects in the past years, we discussed the installation of solar power generation systems, mainly in hotels. As a result, it has been confirmed that although Bali has a large number of hotels, there are also many restrictions on the installation of solar power systems due to the traditional tile structure roofs, villa types, etc. Therefore, in the application project, the scope of consideration was expanded to include office-type buildings such as hospitals and government buildings, and potential sites were selected for government facilities with the cooperation of the Province of Bali.

For government facilities, the Ministry of Energy and Mineral Resources has issued a notice "Surat Edaran MESDM No. 363/22/MEM.L/2019" to promote the installation of solar power generation systems, recommending the installation of rooftop solar power systems in government facilities to achieve the goals of reducing the government budget, promoting renewable energy, and reducing greenhouse gas emissions.

The Ministry of Energy and Mineral Resources has been installing solar power generation systems in the Presidential Palace, military headquarters, and central government buildings as a prior initiative. In order to further accelerate the spread of renewable energy, this notice encourages local governments to set specific targets for the introduction of renewable energy and to promote its spread in conjunction with budgetary measures. Facilities under the jurisdiction of local governments include not only government buildings, but also waste disposal plants, water purification plants, drainage plants, dams, testing sites, observation stations, schools, hospitals, and other facilities such as community centers, sports facilities, and religious facilities. It is recommended to estimate and plan the installation of solar panels in these facilities.

This notice was issued in the middle of the last fiscal year, and since then, the installation of solar power generation systems in government facilities has been gaining momentum, and there are high hopes that it will be realized.

Although solar power generation is an already existing and typical project in the JCM Model project, there are still many possibilities for its use as an initiative toward a decarbonized society, and it can be promoted through the framework of city-to-city collaboration projects to government facilities that have not been used in the past.

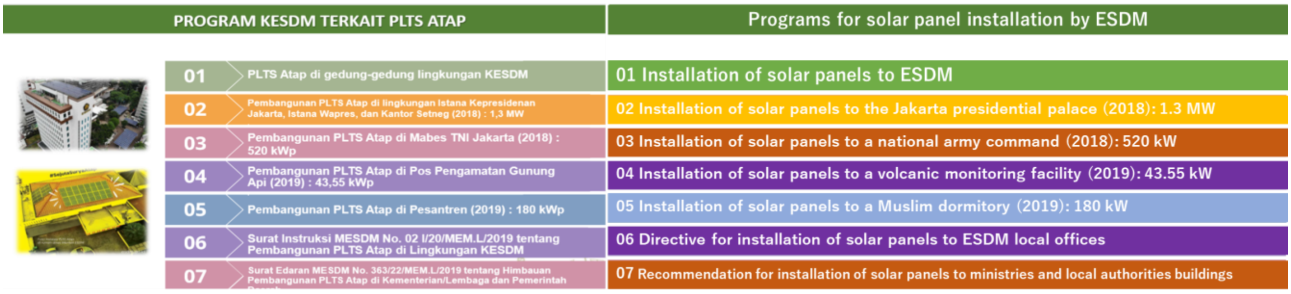

Figure 2-12 Efforts of the Ministry of Energy and Mineral Resources to install solar power systems

Source: Website of the Ministry of Energy and Mineral Resources[21]

In Bali, the Center for Community and Renewable Energy at Udayana University, a national university located in Bali, has proposed a plan for the installation of roof-mounted solar power plants to make Bali self-sufficient in energy.

The draft plan shows the potential of the project, such as the target of building 108 MW of PV power plants in Bali by 2025, and that the installed capacity of PV power plants in Bali as a whole is 1,254 MW, yet only 0.3% has been achieved.

This plan also mentions the possibility of roof-mounted solar power for public facilities, stating that it is a "very promising target for installation."

Figure 2-13 Roof-mounted solar power plant installation plan for Bali's energy self-sufficiency

CORE, “Peta Jalan Pengembangan PLTS Atap Menuju Bali Mandiri Energi”, 2019

In this study, the amount of electricity generated, the amount of CO2 emission reduction, and the cost of installation were calculated for several governmental facilities in Bali, and the feasibility of the installation was examined in cooperation with the State of Bali.

2.3. Semarang City

2.3.1. Semarang City's Initiatives to Become Low Carbon

(1) Major policies and measures

Central Java Province, to which Semarang belongs, has set a target of supplying 21% of its energy

[21] Kementerian Energi dan Sumbur daya Mineral「KEBIJAKAN, REGULASI DAN INISIATIF PENGEMBANGAN ENERGI SURYA DI INDONESIA」,2019. http://iesr.or.id/wp-content/uploads/2019/10/2019-10-10-Bahan-Paparan-Akselerasi-PLTS-Mencapai- 65-GW-pada- 2025-IESR.pdf

needs with renewable energy by 2025, and the Central Java Energy and Mineral Resources Agency has set a target of supplying 17% of its energy needs with solar and geothermal energy by 2025. Currently, 10% of the province's electricity demand is covered by renewable energy sources. In addition, the province has set a goal of reducing its GHG emissions by 46% by 2020.

In 2012, Semarang City also formulated the Semarang City Climate Change Strategy in 2010-2020, which outlines seven strategies[22]: (1) improving energy efficiency; (2) developing an integrated waste management system, (3) managing climate change-induced diseases, (4) improving water supply and distribution services, (5) developing capacity for combating climate change-related disasters, (6) controlling flood and tidal inundation impacts, and (7) managing buildings and using space effectively. In order to achieve its GHG emission reduction target, the city has been actively involved in introducing low-carbon technologies in the past through city-to-city collaboration and the JCM Model Project, and has knowledge of introducing fuel conversion technologies in the transportation sector. In addition, Semarang has been selected as one of the "100 Resilient Cities (100RC)," and as a coastal city, it is expected to make efforts to build a city that is resilient to disasters such as floods and climate change.

In Central Java Province, where Semarang City is the capital, the Regional Action Plan for Reducing Greenhouse Gas Emissions (RAD-GRK) of Central Java Province 2020 was enacted in 2012 and the General Plan of Regional Energy (RUED) was enacted in 2018 as energy-related policies. RAD-GRK and RUED are summarized in the following sections, respectively.

(2) Energy-related Policies in Central Java Province

① Regional Action Plan to Reduce Greenhouse Gas Emissions in Central Java Province 2020 (RAD-GRK)

In Central Java Province, whose capital is Semarang City, the Regional Action Plan for Reducing Greenhouse Gas Emissions (RAD-GRK) of Central Java Province 2020 was enacted in 2012. The greenhouse gas emission reduction targets in RAD-GRK are in line with the National Greenhouse Gas Emission Reduction Action Plan (RAN-GRK: Rencana Aksi Nasional Penurunan Emisi Gas Rumah Kaca) of Indonesia, which was formulated by the presidential decree in 2010. Like the RAN-GRK, the plan calls for a 26% reduction in GHG emissions by 2020. In addition, in the same plan, the total CO2 emissions in Central Java Province were calculated, and it became clear that carbon dioxide emissions have increased rapidly over the years, from a total of 29,418,849 t-CO2 in 2008 to 39,886,167 t-CO2 in 2010. An analysis of the drivers of GHG emissions showed that most of the emissions came from six main sectors: energy, transportation, industry, agriculture, forestry, and waste management. GHG emissions from the energy sector include energy consumption from fuel, coal, and electricity, while the transportation sector accounts for all energy generated from transportation. In the industrial sector, emissions from industrial processes are included, while in the agricultural sector, emissions from the fermentation and management of livestock waste and

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[22] Initiative for urban climate change and environment (IUCCE), “Climate Change Mitigation Action Plan Of Semarang City In 2018-2030”, http://iucce.org/index.php/home/article_pub/105

emissions from the production of methane and N2O from bacterial metabolism in agricultural production are considered to be included. Finally, the forestry sector includes emissions from all vegetation cover from forests, plantations, and other land uses, while the waste management sector includes waste management at TPAs (final processing areas), post offices, incineration, and household and domestic waste management. The six sectors, in order of highest to lowest emissions, are energy, agriculture, waste, industry, and forestry. The following table summarizes the target GHG emission reductions for each sector.

Table 2-19 Greenhouse Gas Reduction Targets by Sector in Central Java Province

label 3.8. GHG Emission Reduction Target

Bidang	Emisi GRK		Drop Target		Aksi Plan	Implemen ting Institution
	2010	2020	Tons of CO2	%		
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Farming	6,395,328	8,964,816	392,200	4.37	Low production of varieties, low emission, irrigation efficiency, use of fertilizers organic, livestock waste treatment, utilization waste agriculture	TPH Agriculture Office, PSDA Office, BLH, Department of Animal Husbandry and Animal Health
Forestry	118,765	730,843	114,000	15.60	Control Fire andan hut land, Rehabili atsi forest andan land, Prevention logging/ logging wild.	Service Forestry, Service Plantation 'Service PSDA, BLH
Energy	16,191,639	29,970,000	3,934,008	13.12	Energy development renewable (biofuel, geothermal, water, solar power), efficiency energy, use of gas fuel (BBG)	ESDM Office, Dinhub, Animal Husbandry Service
Transportation	9,737,000	25,078,000	3,134,784	12.50	Transport management review, improvement I ali bag vehicle feasibility testing	Dishub, Dinas Bina Marga
Indu stri	1,394,548	4,146,926	390,000	9.40	Efficiency of use	Industry and Trade Office,
Waste Management	4,668 .898	6,286 .219	1.40,000	22.27	Development of regional landfills, 3R-based waste management and management domestic and industrial wastewater.	BLH, Department of Human Settlements and Spatial Planning

Source: Regional Action Plan to Reduce Greenhouse Gas Emissions in Central Java Province 2020 (RAD-GRK)

The following is a summary of the reduction targets and strategies in each sector.

Table 2-20 GHG emission reduction targets and strategies by sector in Central Java Province

Department	Goals and Strategies
Agriculture	Reduce GHG emissions from the agricultural sector in a broad sense and minimize the impacts of climate change to achieve agricultural development goals. (1) Improve the understanding of farmers and related parties to predict climate change. (2) Enhance the capacity of the agricultural sector to adapt to climate change, including sustainable agricultural development. Establish a climate change insurance system. (3) Implement efficient technologies to reduce GHG emissions.
Forestry	Achieve sustainable forestry as a life support system for the welfare of the community in the next 20 years. The achievement of the vision will be achieved through balanced forest management along three dimensions of forest function: ecological, economic, and social.
Energy	The reduction of GHG emissions through energy management and conservation of environmental functions will be achieved through the promotion of renewable energy in the region by central and local governments. The goal is to achieve an optimal energy mix by 2025, as follows a. Oil: 20% or less b. Natural gas: 30% or less c. Coal: 33% or less d. Biofuel: At least 5% e. Geothermal energy: At least 5% f. Renewable energy, including biomass, nuclear, hydro, solar, and wind: At least 5% g. Coal liquefaction: At least 2%
Transportation	Develop a comprehensive approach to GHG reduction and identify a set of practical policies. Strategies for reducing GHG emissions in the transportation sector include the following Improving the energy efficiency of transportation, using technologies to reduce GHG emissions from vehicles (greener transportation), and using information technology (the Internet). Reduce the need to travel by car as much as possible by using telecommunications, such as information technology and communication devices, as an alternative to transportation.
Industry	Technological innovations to increase energy efficiency, diversify energy sources, and reduce CO_2 emissions in the cement, textile, and transportation equipment industries.
Waste	In order to reduce greenhouse gas emissions from the waste sector, it is

Management	necessary to collect landfill gas from outdoor dumping sites that have been converted to sanitary landfills and create new sanitary landfills. It is also necessary to close all illegal dumping sites by 2015. Other possible solutions include reducing the amount of waste at the source, such as households, and implementing the 3Rs (Reduce, reuse, recycle) at the source, such as final processing sites. The final processing of waste differs between urban and rural areas in Indonesia, with urban areas focusing on landfill technologies (open dumping, controlled landfill, and sanitary landfill), while rural areas adopt composting technologies. On the other hand, the 3Rs can be applied to both urban and rural areas.

Source: Regional Action Plan to Reduce Greenhouse Gas Emissions in Central Java Province 2020 (RAD-GRK)

② General Plan of Regional Energy (RUED)

Central Java is one of the major oil and gas producing regions in Indonesia, and the energy source in the province is still heavily dependent on fossil fuels, with demand for oil and LPG increasing by 5.5% per year. However, due to the limited amount of fossil-based fuels that can be mined, it is recommended that renewable energy sources be promoted to take advantage of the state's blessed nature. The following figure shows the power supply structure as of 2016 and the target power supply structure for 2025.

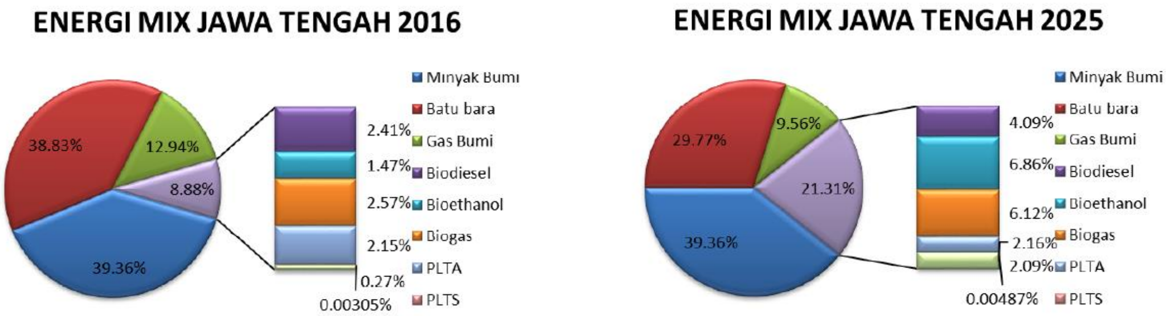


Figure 2-14 Power Supply Composition in Central Java as of 2016 and Target for 2025

(Note) Legend: Red: coal, blue: oil, green: gas, purple: renewable energy (from top: biodiesel, bioethanol, biogas, rooftop PV, other PV)

Source: General Plan of Regional Energy (RUED), Central Java Province (No. 12/2018).

There are three main reasons for the dependence on fossil fuels: first, old equipment is still in use in Central Java, and fossil fuels are used to fuel that equipment. Second, devices that use fossil fuels are more efficient than those that use renewable energy sources and can output larger amounts of energy. Finally, the Indonesian government still provides subsidies for fossil-based fuels, making them affordable for its citizens.

In addition, the goals of RUEN, in line with the goals of RUED, are as follows

i) Reduce dependence on oil and reduce oil in the energy mix to 25% or less by 2025.

ii) Increase renewable energy in the energy mix to more than 23% by 2025 and more than 31% by 2050.

iii) Improve people's access to energy and aim for 100% of electrified households by 2020.

iv) Encourage energy conservation and reduce energy elasticity to less than 1 by 2025.

v) Secure reserves of energy buffers in the region.

2.3.2. Study to develop a commercialization plan to switch to natural gas as fuel

(1) Switching fuel for flood control pumps

The city of Semarang is a lowland area facing the Java Sea, and suffers severe damage from flooding every year. For this reason, the city has facilities to drain swollen river water near the mouth of the river to a regulating reservoir to curb flood damage. In recent years, flood damage has become more serious due to climate change. In this situation, the power for the pumps required for drainage is supplied by diesel power generation equipment, which poses a cost and environmental challenge. Flood control is an adaptation measure to climate change, but it is also considered problematic because the more facilities and operating hours are used, the more CO2 is emitted, which creates a vicious cycle for climate change. The reason for using diesel power generation equipment is that floods occur during severe weather conditions such as heavy rains, which are expected to cause power outages in the transmission system.

Flooding in the city of Semarang	Diesel Generator at Semarang Central Pumping Station	Drainage pump at Semarang Central Pumping Station

Figure 2-15 Flood, drainage pump, and power generation facilities in Semarang City

Source: Courtesy of Department of Public Works, City of Semarang

In the city of Semarang, there are four pump stations in the central, south, east, and west zones, with about 133 pumps, of which 65 pumps depend on diesel generators to power their pumps. Among them, 40 pumps use a lot of fuel and require a lot of improvement, and the fuel consumption of these pumps is 122,072L/year.

In light of this situation, this study examined the possibility of promoting low-carbon power generation through switching to natural gas-based fuel for power generation facilities. The fuel conversion equipment will be a DDF system installed on the existing engine, which is the same equipment that was used to convert the fuel of public buses to natural gas Co-combustion in the FY 2018 JCM Model Project "Introduction of CNG and Diesel Fuel Co-combustion Equipment for Public Transport Buses in Semarang City." The technology can be applied to all types of diesel engines, and has already been used in ships and power generators.

Exchange of opinions with pump station staff, Public Works Department, City of Semarang

Pump station adjustment pond

Figure 2-16 Exchange of opinions and coordination sites with the Public Works Department, City of Semarang

Source: Provided by Hokusan Co., Ltd.

In Semarang City, under the FY 2018 JCM Model Project titled "Project for Installing CNG and Diesel Fuel Co-combustion Equipment in Semarang City Public Transport Buses," the fuel for public buses has been changed to natural gas to achieve a low-carbon effect, but there have been problems with the supply method used by the gas supplier, PT. Pertagas Niaga. The bottleneck was that the MRUs (gas supply vehicles with compressors) that supplied the buses were overloaded by the daily supply and broke down frequently.

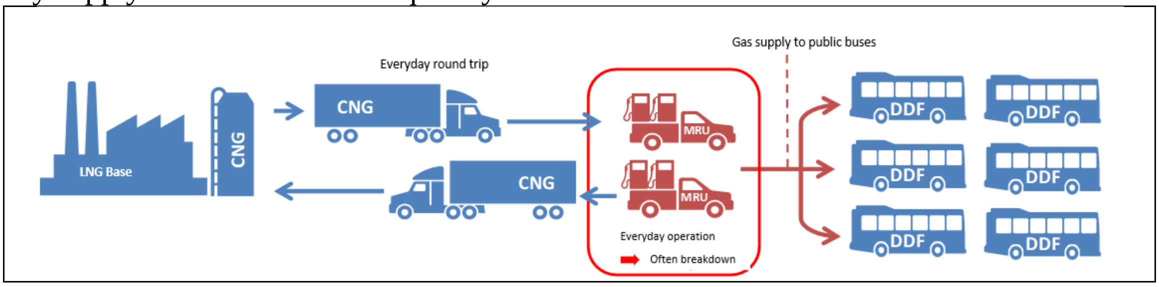


Figure 2-17 Gas supply issues in the project to install CNG and Diesel Fuel Co-combustion equipment in public transport buses in Semarang

Source: Provided by Hokusan Co., Ltd.

On the other hand, for the gas supply to the power generation facilities at the pumping stations, a certain amount of industrial gas will be procured, and tanks filled with the gas will be installed at the pumping stations, and the tanks will be replaced when the remaining gas level drops.

In this method, the bottleneck of gas supply will be eliminated because it is not assumed that the gas will be supplied every day as in the case of the public bus service in Semarang.[23]

Although daily deliveries may be required during periods of frequent flooding, industrial gas can be ordered from a variety of gas suppliers, both state-owned and private, unlike gas for transportation, which is allowed to be sold only to designated companies. In addition to having a large choice of suppliers, it is also possible to order from several companies at once and store the tanks to prepare for increased demand.

By coordinating these technologies, we will establish a system to transport the right amount of gas to the pumping station at the right time, and provide certainty for the realization of the project and the monitoring of the JCM project.

[23] The same means are applied to solve the challenges of public bus operations, but it has not been realized due to problems specific to fuel supply to buses (gas amount, supply pressure, laws and regulations, etc.)

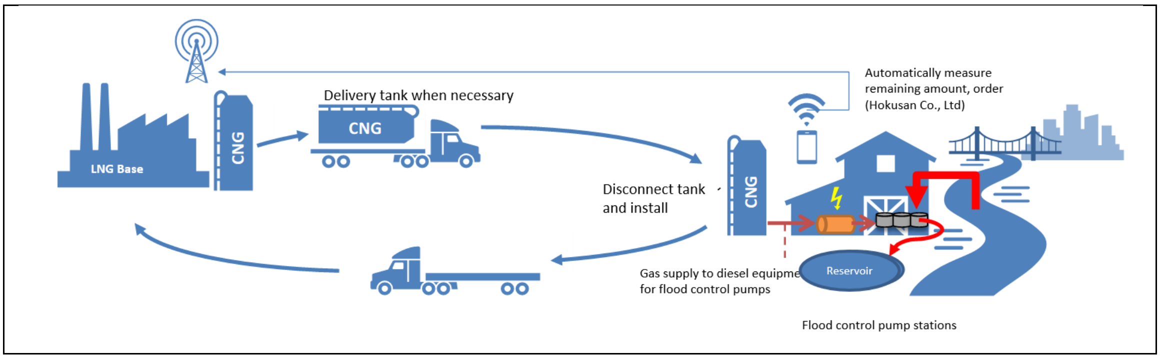


Figure 2-18 Image of the gas supply method to the flood control pumping station in Semarang

Souce: Made by JANUS

1) Calculation of potential reduction amount of CO_2 emissions

① Equipment overview

As mentioned above, a total of 133 flood adjustment pumps are currently in operation in Semarang City. While 65 of them are operated using diesel generators, some only use emergency diesel generators in the event of a power outage, and as state utility PLN is improving the occurrence of power outages each year, some pumps can be operated without relying on diesel generators for the most part. However, 40 pumps, primarily located in Semarang City's central pump station, frequently use diesel generators, making annual fuel cost burdens an issue for the city's public works bureau.

Semarang City's pump stations and pump specifications are outlined below.

Table 2-21 Semarang City pump station and pump specification

	Pump station name	No. of pumps	Power generation capacity (apparent power)	Power rating (power factor = 0.8)	Generator use No. of pumps	Fuel consumption amount*
		[pump(s)]	[kVA]	[kW]	[pump(s)]	[per year]
1	Sedompyong (Banger Selatan)	1	210	168	1	31,777
2	Progo	1				
3	Gudang Senjata	2	125	100	2	
4	Banger	5				
5	Citarum	2				
6	Kartini	7				90,295
7	Buludrain	5				
8	Boom Lama I	4	60	48	4	
9	Boom Lama II	5				
10	Boom Lama III	1	30	24	1	
11	Hasanudin	4	60	48	4	
12	Bandarharjo 1	1	30	24	1	

13	Bandarharjo 2	2	30	24	2	
14	Bandarharjo 3	1				
15	Bandarharjo 4	2				
16	Lanal	2	225	180	2	
17	Kali Baru	8	385	308	8	
18	Polder Tawang	4				
19	Kol. Sugiono	2	275	220	2	
20	Mberok	2	150	120	2	
21	Johar	1	150	120	1	
22	Pompa Agus Salim	1				
23	Kampung Kali	2	400	320	2	
24	Kolam Retensi Kali Smg	8	3800	3040	8	
25	Ujung Seng	1				
26	Water Foundtain	11				
27	Basudewo	1	30	24	1	N.D.
28	Bringin (Mangkang)	2				
29	Madukoro	3	1100	880	3	
30	Semarang Indah	2				
31	Peningkatan sistim polder/Tawang mas madukoro	3				
32	Manggis	3	120	96	3	N.D.
33	Kandang Kebo	6	358	286.4	6	
34	Terboyo	3				
35	Pedurungan Kidul	1	30	24	1	
36	Pasar Waru	4	250	200	4	
37	Majapahit	1	150	120	1	
38	Muktiharjo Kidul	2				
39	Banjardowo	2	250	200	2	
40	Trimulyo	2	150	120	2	
41	Kampung Semarang Utara	1				
42	Kampung Semarang Selatan	1				
43	Argo Kencono Utara	1				
44	Sringin	1				
45	Bawah Tol Kaligawe	3				
46	Tambak Rejo RW 5	1				
47	Tambak Rejo RW 3	1				
48	Rumah Pompa Terboyo 2	1				

49	Rumah Pompa Banjardowo 1	2	250	200	2	
50	Rumah Pompa Kali Pacar	1				
Total		133	8,618	6,894	65	

Source: Provided by Semarang City

In the above pump station data, the power amount is calculated based on the amount of fuel consumed, and CO2 emissions are calculated from the amount of fuel consumed. Assuming that fuel consumption is 0.3L/kWh, the resulting figures are as follows.

Table 2-22 Reference CO2 emission for diesel generator at pump station

Fuel consumption	122,072	L/year
Fuel consumption[kl]	122.072	kl/year
Caloric value per year	5,942	GJ
Reference emission	431	t-CO_2/year
Reference emission per 15 years	6,471	t-CO_2/15 year

Source: Made by JANUS from the data provided by Semarang City

Since diesel generators have the same structure as vehicle engines and the load is constant, it is considered that such generators will see greater effects from the shift to DDF (Diesel Dual Fuel) than vehicles. In this report, we assumed that the same effects as vehicles can be attained, and calculated project emissions as below.

The project period can be considered 15 years, as the equipment that is subject to JCM (Joint Crediting Mechanism) is gas conversion equipment fitted to diesel engines, said equipment falls under the category of “internal combustion power or gas turbine power generation equipment.”

Table 2-23 CO2 emission by DDF introduction for diesel generators at pump stations (project emission)

CNG consumption	644	t/15 year
CO2 emission from CNG consumption	1,676	t-CO_2/5 years
Diesel consumption	959	kl/5 years
CO2 eimission form diesel consumption	3,389	t-CO_2/5 years
CO2 emission from DDF	5,065	t-CO_2/5 years

Source: Made by JANUS from the data provided by Semarang City

Using the above figures, the reduction amount of emissions, obtained by subtracting the project emission amount from the reference emission amount, is about 1,406 tons per 15 years.

2) **Economical evaluation**

① **Equipment installation cost**

After interviewing local remodeling companies, we determined that the cost of remodeling diesel generators used to power pumps will likely be close to that for vehicles. Although the cost depends on the capacity of the gas tank, due to the close proximity of diesel generators it may also be possible to reduce costs, as it is not necessary to prepare a tank for each pump as is the case for vehicles. While it is necessary to examine this point in detail after checking the installation site, in this report our considerations are based on the assumption that DDF installation costs for pumps are on par with those for vehicles.

As such, we set DDF remodeling costs at about 1 million yen per pump, which comes to 121 million yen (5,398,110,661 Indonesian rupiah) for 121 pumps.

② **Operating costs**

The diesel used at pump stations is unsubsidized industrial diesel that costs 11,220 rupiah per liter. Since annual fuel consumption is about 120,000 liters, this comes to a cost of 824,528,000 rupiah, or roughly 6.1 million yen.

As for the price of CNG (compressed natural gas), which is an alternative fuel to diesel, the industrial CNG price is applied as it would not be used for public transportation. Until recently, the industrial CNG price was higher than that for CNG for public transportation, but based on the Ministry of Energy and Mineral Resources' (ESDM) gas utilization promotion policy, from 2020 the price of industrial CNG has been significantly reduced. Targeted sectors are limited and pump stations are not one of them, but based on the assumption for such measure, estimation was conducted by using the price after price down, which is equivalent to 4,000 rupiah per liter.

③ **Economical simulation**

Calculating based on the above initial investment and operating costs, we concluded that it is possible to recoup the initial investment in around 15 years without subsidies, and nine years in the event of a 40% subsidy rate.

Table 2-24 Economic simulation for DDF introduction for diesel generators at pump stations

Diesel price	11,220	IDR/L
CNG price	4,000	IDR/L
Reference fuel cost		
Diesel	1,369,647,840	IDR
Project fuel cost		

Economic effect	350,781,216	IDR
Initial investment	5,398,110,661	IDR
Investment payback year	15	year
Initial investment with JCM	3,238,866,397	IDR
Payback year with JCM	9	year

Diesel	824,528,000	IDR
CNG	194,338,624	IDR
Total	1,018,866,624	IDR

Year	Reference cost			Project cost				Benefit
	Initial investment	Diesel cost	Total	Initial investment	Diesel cost	CNG cost	Total	
0	0			3,238,866,397				-3,238,866,397
1		1,369,647,840	1,369,647,840		824,528,000	194,338,624	1,018,866,624	350,781,216
2		1,369,647,840	1,369,647,840		824,528,000	194,338,624	1,018,866,624	350,781,216
3		1,369,647,840	1,369,647,840		824,528,000	194,338,624	1,018,866,624	350,781,216
4		1,369,647,840	1,369,647,840		824,528,000	194,338,624	1,018,866,624	350,781,216
5		1,369,647,840	1,369,647,840		824,528,000	194,338,624	1,018,866,624	350,781,216
6		1,369,647,840	1,369,647,840		824,528,000	194,338,624	1,018,866,624	350,781,216
7		1,369,647,840	1,369,647,840		824,528,000	194,338,624	1,018,866,624	350,781,216
8		1,369,647,840	1,369,647,840		824,528,000	194,338,624	1,018,866,624	350,781,216
9		1,369,647,840	1,369,647,840		824,528,000	194,338,624	1,018,866,624	350,781,216
10		1,369,647,840	1,369,647,840		824,528,000	194,338,624	1,018,866,624	350,781,216
11		1,369,647,840	1,369,647,840		824,528,000	194,338,624	1,018,866,624	350,781,216
12		1,369,647,840	1,369,647,840		824,528,000	194,338,624	1,018,866,624	350,781,216
13		1,369,647,840	1,369,647,840		824,528,000	194,338,624	1,018,866,624	350,781,216
14		1,369,647,840	1,369,647,840		824,528,000	194,338,624	1,018,866,624	350,781,216
Total		19,175,069,760	19,175,069,760		11,543,391,996	2,720,740,736	14,264,132,732	4,910,937,028

・Cashflow and IRR

	0	1	2	3	4	5	6
FCF	-3,238,866,397	350,781,216	350,781,216	350,781,216	350,781,216	350,781,216	350,781,216
	-3,238,866,397	-2,888,085,180	-2,537,303,964	-2,186,522,748	-1,835,741,531	-1,484,960,315	-1,134,179,099
IRR(14 years)	6%						

	7	8	9	10
FCF	350,781,216	350,781,216	350,781,216	350,781,216
	-783,397,883	-432,616,666	-81,835,450	268,945,766
				Payback

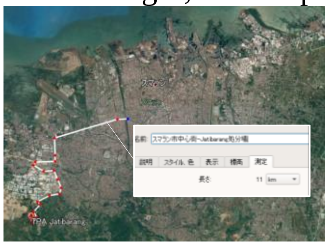
Source: Made by JANUS

(2) **Transportation fuel shift**

In Semarang City, there is a final waste disposal site called Jatibarang Landfill, which is located in the mountains about 10 km from the city center, to which 105 waste collection vehicles[24] collect and transport waste from all over the city. As the vehicles make about five round trips a day, with each vehicle traveling an average distance of 18 km each way, the total mileage for all vehicles is approximately 3.5 million km per year. These waste collection vehicles run on diesel fuel, and are expected to contribute to realizing a low-carbon society through a shift to gas, as with public buses.

Semarang City waste collection vehicles

Jatibarang Landfill



Distance from the city center

Figure 2-19 Waste collection vehicles and landfills in Semarang City

Source: Made by JANUS from cleaning department of Semarang City Web site, Google Map

[24] Article from the Metro Semarang, a local newspaper in Semarang City “DLH Operasikan 88 Kontainer Sampah Baru” in 2018. https://metrosemarang.com/dlh-operasikan-88-kontainer-sampah-baru-54316

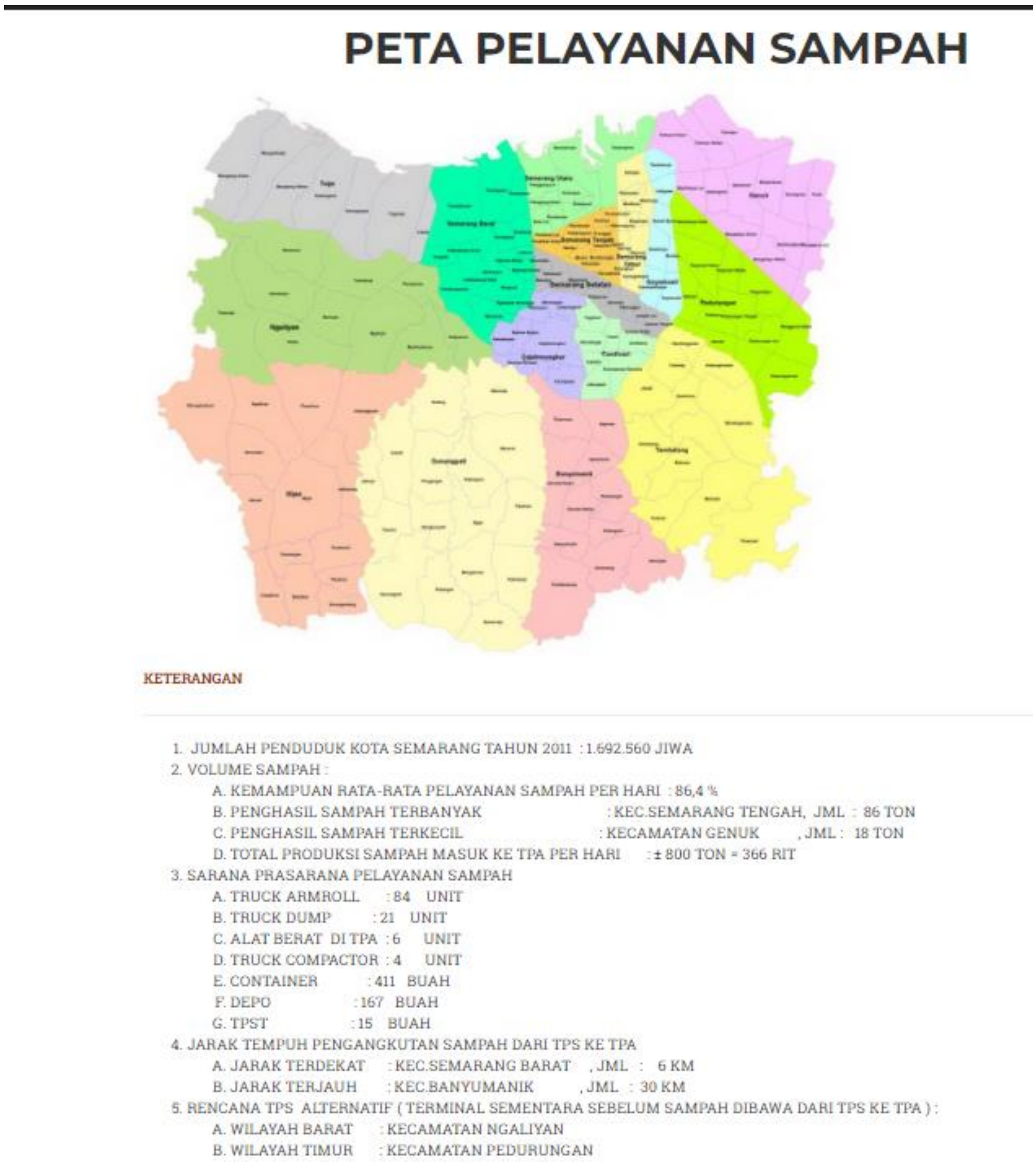


Figure 2-20 Information on waste collection areas on the Semarang City sanitation bureau website

Source: Obtained by cleaning department of Semarang City

All waste collection vehicles are under the jurisdiction of Semarang City, with diesel fuel consumption managed by the city’s finance department, making monitoring easy and thus suitable for JCM commercialization.

An increase in gas demand in Semarang City through the above-mentioned fuel shift project will also contribute to the stabilization of the gas supply to public buses in the “Project for the Introduction of CNG-diesel Hybrid Equipment to Public Buses in Semarang City.” For the supplier PT. Pertagas Niaga, it is efficient in terms of management and contract costs to supply gas to large-scale consumers, so there is a high incentive for supplying it to areas with high demand. It is clear from its share of gas supply in Jakarta that it is selecting large-scale consumers and has little interest in supplying to minor consumers, as there are reports that 98% of gas is supplied to large-scale consumers such as manufacturers, while 2% is supplied to minor consumers such as households and public transportation.[25]

In this way, it seems that supply to small-scale demand areas tends to be neglected, and that this has also prolonged supply issues for public transportation in Semarang City. Recently, the mayor of Semarang City has issued an improvement order to PT. Pertagas Niaga through the Minister of Energy and Mineral Resources in a bid to stabilize supply for public transportation, but further expanding gas demand in Semarang City should contribute to a more stable supply down the road.

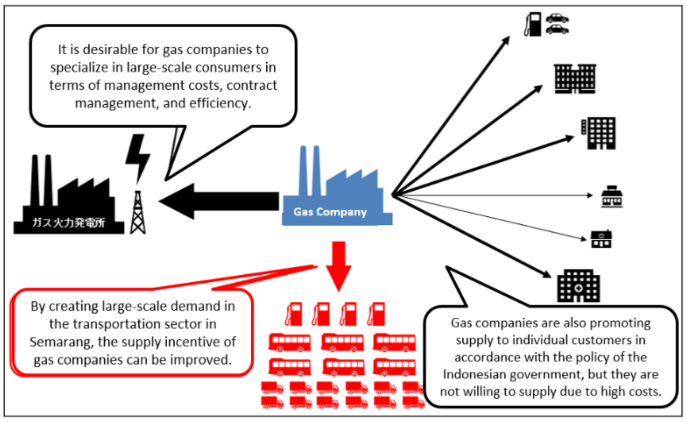


Figure 2-21 Relationship between gas demand and stable gas supply

Source: Made by JANUS

Semarang City also faces gas supply issues in public bus operations, and recognizes that the expansion of demand will help solve this problem. It has high expectations for higher gas use to contribute to a more stable supply. Surveys carried out for project applications will shed light on the effects of a fuel shift, which could lead to Semarang City making decisions on this front. Also, as with the pump station project, for applications to the project for supporting JCM equipment, the plan is to add gas companies to the international consortium and build a framework that guarantees supply, ensuring further certainty of gas supply.

1） Calculation of potential CO2 emission reductions

As mentioned above, there are 105 waste collection vehicles in operation in Semarang City. Each vehicle travels an average distance of 18 km one way, and makes five round trips a day. These vehicles travel a total distance of 9,450 km per day, which comes to 3,499,250 km per year. Since their displacement is similar to that of the midsize buses in the “Project for the Introduction of CNG-diesel Hybrid Equipment to Public Buses in Semarang City,” fuel consumption becomes 4.7 km per liter when taking into account the displacement value of these midsize buses.

Based on this, the current amount of CO2 emissions (reference emissions) is as follows.

Table 2-25 Various data and reference emissions

Operated vechicles	105	Vechicles
Round trip numbers	5	Round trip
Distance	18	km
Total driving distance	9,450	km/day
Total driving distance per year	3,449,250	km/year
Fuel consumption[kl]	734	kl/year
Reference	2,594	t-CO_2/year

[25] Jakarta newspaper (2014), “Oil to natural gas, the government proceed with infrastructure arrange” https://www.jakartashimbun.com/free/detail/20673.html

Reference emission per 5 years	12,968	t-CO_2/5 year

Source: made by JANUS

We calculated the shift to CNG fuel via switching to DDF, referring to the conversion rate and other values in the "Project for the Introduction of CNG-diesel Hybrid Equipment to Public Buses in Semarang City." As a result, project emissions became 2,594 t-CO2 per year, totaling 12,986 t-CO2 for the five-year period of the project.

Table 2-26　CO2 emission after introducing of DDF (project emission)

CNG consumption	1,330	t/5 years
CO2 emission from CNG	3,359	t-CO_2/5 years
Diesel consumption	1,922	kl/5 years
CO2 emission from diesel	6,792	t-CO_2/5 years
Peoject emission	10,151	t-CO_2/5 years

Source: Made by JANUS

The reduction amount of emissions can be obtained by subtracting the amount of project emissions from reference emissions. Based on the above results, the reduction amount came to 2,818 t-CO2 for five years .

2） Economical evaluation

① Equipment installation costs

Referring to the "Project for the Introduction of CNG-diesel Hybrid Equipment to Public Buses in Semarang City," the cost of installing DDF equipment was set at about 1 million yen per vehicle. The total cost of remodeling 105 waste collection vehicles is thus 105 million yen, or 14,170,040,486 rupiah.

The cost effectiveness of reducing CO2 emissions is about 42 million yen when equipment subsidy ratio is 40%, coming to 4,435 yen when divided by the reduction amount of CO2 emissions of 9,470 t-CO2 over the five-year project period. As this figure is close to the standard for JCM Model Project, we will carry out a highly accurate evaluation based on fuel consumption etc. taken from actual operation data.

② Operating costs

We applied diesel fuel costs of 9,500 rupiah/liter, which is the cost for unsubsidized diesel fuel.

As such, with annual consumption currently at about 730,000 liters, fuel costs come to about 51.7 million yen, or 6,971,888,298 rupiah a year.

Assuming that the CNG supply price is 4,500 rupiah/LSP when shifting to DDF, based on a fuel conversion rate of 0.398%, the cost is about 9.73 million yen, or 1,314,384,415 rupiah. As the usage amount for diesel fuel is 0.602%, the cost is about 31.1 million yen.

Given the current situation (reference), the economic effect of carrying out the project is expected to be about 10 million, or 1,460,427,128 rupiah, per year.

③ Economical simulation

Various figures are shown below. For the initial investment of 105 million yen, since the annual cost reduction effect is expected to be about 10 million yen, we anticipate the investment being recovered in ten years. Assuming JCM equipment support in the form of a 40% subsidy rate, the investment would be recovered in six years.

Table 2-27 Economic simulation by DDF installation for waste collection vehicles

Diesel price	9500	IDR/L
CNG price	4500	IDR/L
Reference fuel cost		
Diesel	6,971,888,298	IDR
Project fuel cost		
Diesel	4,197,076,755	IDR
CNG	1,314,384,415	IDR
Total	5,511,461,170	IDR

Economic effect	1,460,427,128	IDR
Initial investment	14,170,040,486	IDR
Payback year	10	Year
Initial investment with JCM subsidy	8,502,024,291	IDR
Payback year with JCM subsidy	6	year

Year	Reference cost			Project cost				Benefit
	Initial investment	Diesel cost	Total	Initial investment	Diesel cost	CNG cost	Total	
0	0			8,502,024,291				-8,502,024,291
1		6,971,888,298	6,971,888,298		4,197,076,755	1,314,384,415	5,511,461,170	1,460,427,128
2		6,971,888,298	6,971,888,298		4,197,076,755	1,314,384,415	5,511,461,170	1,460,427,128
3		6,971,888,298	6,971,888,298		4,197,076,755	1,314,384,415	5,511,461,170	1,460,427,128
4		6,971,888,298	6,971,888,298		4,197,076,755	1,314,384,415	5,511,461,170	1,460,427,128
5		6,971,888,298	6,971,888,298		4,197,076,755	1,314,384,415	5,511,461,170	1,460,427,128
6		6,971,888,298	6,971,888,298		4,197,076,755	1,314,384,415	5,511,461,170	1,460,427,128
7		6,971,888,298	6,971,888,298		4,197,076,755	1,314,384,415	5,511,461,170	1,460,427,128
8		6,971,888,298	6,971,888,298		4,197,076,755	1,314,384,415	5,511,461,170	1,460,427,128
9		6,971,888,298	6,971,888,298		4,197,076,755	1,314,384,415	5,511,461,170	1,460,427,128
10		6,971,888,298	6,971,888,298		4,197,076,755	1,314,384,415	5,511,461,170	1,460,427,128
11		6,971,888,298	6,971,888,298		4,197,076,755	1,314,384,415	5,511,461,170	1,460,427,128
12		6,971,888,298	6,971,888,298		4,197,076,755	1,314,384,415	5,511,461,170	1,460,427,128
13		6,971,888,298	6,971,888,298		4,197,076,755	1,314,384,415	5,511,461,170	1,460,427,128

14		6,971,888,298	6,971,888,298		4,197,076,755	1,314,384,415	5,511,461,170	1,460,427,128
計		97,606,436,170	97,606,436,170		58,759,074,574	18,401,381,809	77,160,456,383	20,445,979,787

- Cashflow and IRR

	0	1	2	3	4	5	6	7
FCF	-8,502,024,291	1,460,427,128	1,460,427,128	1,460,427,128	1,460,427,128	1,460,427,128	1,460,427,128	1,460,427,128
	-8,502,024,291	-7,041,597,164	-5,581,170,036	-4,120,742,909	-2,660,315,781	-1,199,888,653	260,538,474	1,720,965,602
IRR (14year）	15%						Investment payback	

	8	9	10
FCF	1,460,427,128	1,460,427,128	1,460,427,128
	3,181,392,730	4,641,819,857	6,102,246,985

Source: Made by JANUS

3. Development of a framework for project execution

3.1. Bali

3.1.1. Transportation fuel shift

The business execution system will be an international consortium comprised of a gas supply chain as the foundation, Pertamina Gas as the gas supply company, Hokusan as a technology provider, the public bus operator Trans Metro Dewata as the gas consumer and Denpasar City which will be responsible for the operation of waste collection vehicles.

Regarding the gas supply chain, according to Pertamina Gas, the decision regarding the investment on the equipment necessary for supply (CNG stations, vehicles for transportation, LNG satellites, etc.) can be made if the situation allows for the signing of a long-term contract for a fixed amount of gas. In order to work out the details of such a consideration, steps are being taken to sign a study cooperation MoU between Japan NUS Co., Ltd., which organizes this survey, and Pertamina Gas. The following figure shows the schematic diagram of the business execution system.

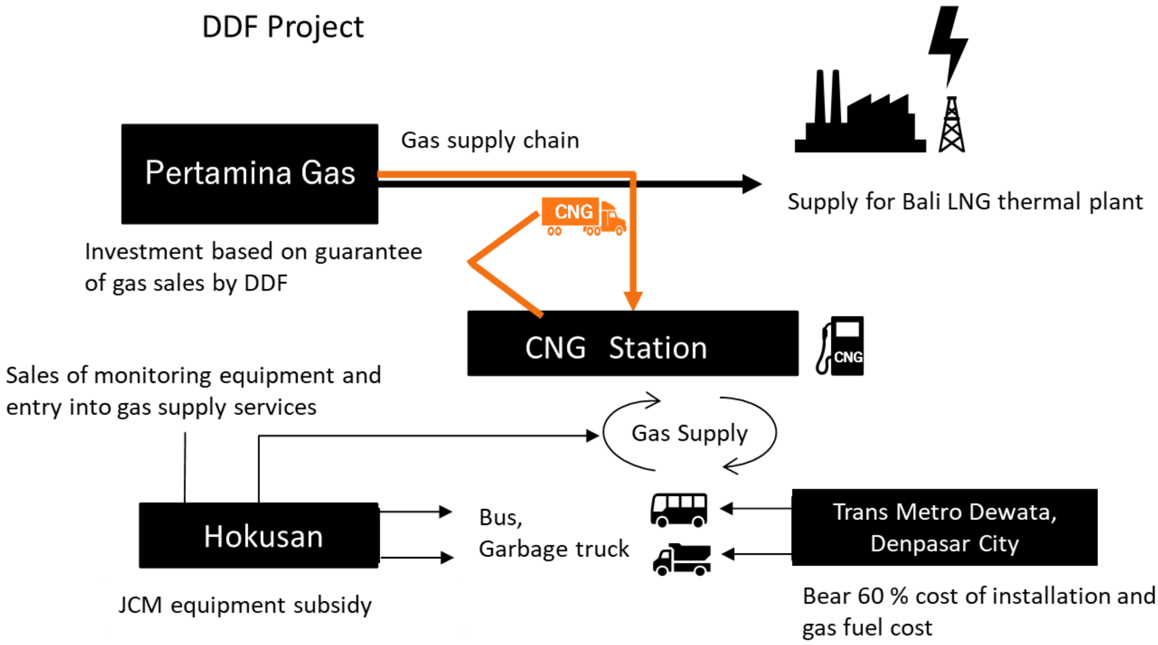


Figure 3-1 Project implementation structure for DDF project in Bali

3.1.2. Introduction and commercialization of solar power generation

There are multiple options for the execution system for the solar power business, depending on the solar power business model. These will be mentioned later, but presently in Indonesia, a model similar to solar power PPA has also become feasible alongside the conventional model of a building owner installing solar panels using personal funds and then recouping the investment by selling electric power. Specifically, it is a system of electric power operators (including the state-owned Electric PLN) covering the initial investment, recouping the equipment cost by charging for electric power and then transferring the equipment to the building owners after completion of the payment (any electric power further generated can be freely used by the building owner for selling purposes or self-consumption).

In case of conventional models, the technology provider Nihonkucho Hokuriku Ltd. would form an international consortium with the owner of the building where the installation is planned, but in case of the model mentioned below, the international consortium formed further includes the electric power operators (PPA operators).

In Indonesia, local companies require a license for the procurement, installation and construction of equipment for solar power generation, along with a certain rate of in-house production for each equipment. Coordination with local construction companies is, therefore, essential for Nihonkucho Hokuriku Ltd. as it does not possess a business license in Indonesia. As such, coordination with JGC Indonesia (JGC Corporation), which is a Japanese company, is being considered. JGC Indonesia possesses the necessary qualifications for all varieties of construction work, bidding participation etc., and it is possible to create a system where Nihonkucho Hokuriku Ltd. can take on a managerial role in design or supervision, with JGC Indonesia being responsible for the construction work.

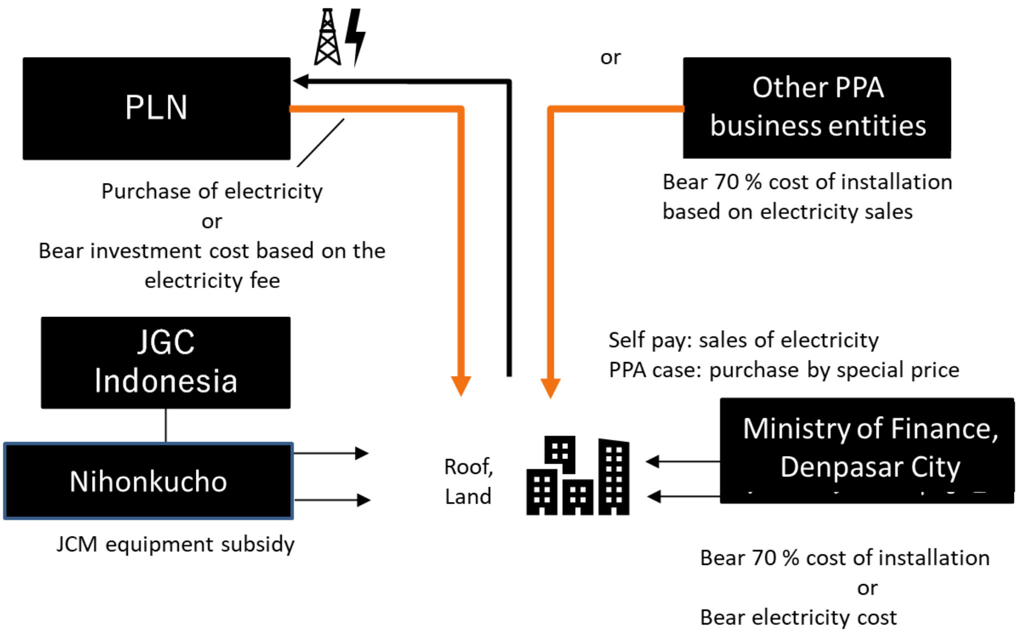


Figure 3-2 Project implementation structure for PV project in Bali

3.2. Semarang City

3.2.1. Fuel Shift

(1) Fuel Shift through Flood Adjustment Pumps

Flood adjustment pumps are managed and operated by the Public Works Department of the City of Semarang, which would imply the formation of an international consortium with the Public Works Department of the City of Semarang, with Hokusan, the technology provider, as the representative operator. On the other hand, from the perspective of stabilizing gas supply, a stronger system formed with the addition of a gas supply company (Pertamina Gas Niaga, in the case of the City of Semarang) to the consortium is preferable.

In case of flood adjustment pumps, they are operated as necessary only during floods instead of regular fuel consumption, so they require a certain amount of fuel to be stored at all times. Because of this, a system of loading a container tank onto a CNG transportation truck, permanently stationing this container and then replacing it after usage, is appropriate. For operations such as the usage of fuel gas and management of the remaining fuel, the expertise of Hokusan Co., Ltd. is indispensable. The following figure shows the schematic diagram of the execution system.

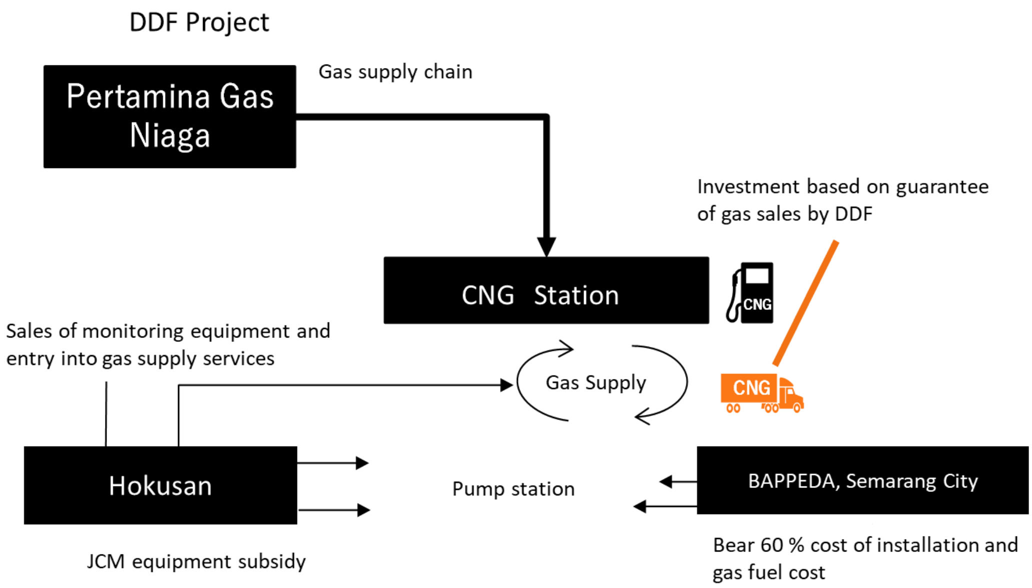


Figure 3-3 Project implementation structure for DDF project at pump stations in Semarang

(2) **Waste Collection Vehicles**

The management and operation of waste collection vehicles are conducted by the Environment Bureau of the City of Semarang. This would imply the formation of an international consortium with the Environment Bureau, with Hokusan, the technology provider, as the representative operator. The following figure shows the schematic diagram of the execution system.

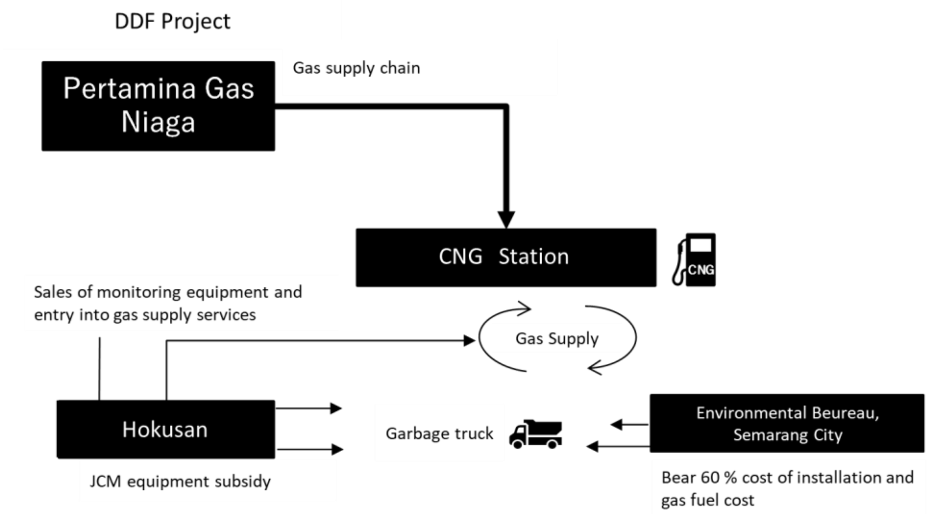


Figure 3-4 Project implementation structure for DDF project for garbage trucks in Semarang

4. Understanding institutional issues and consideration of suggested solutions

4.1. Discussions on issues and countermeasures

4.1.1. Issues associated with shifting fuel to natural gas

The Indonesian government announced a new mid-term national development plan (RPJMN 2020-2024) in January 2020. In this plan, it aims to increase the natural gas supply, and has set the goal of increasing production output from 1.1 million BOE/day in 2018 to 1.2 million BOE/day by 2024. Also, as a priority project to be implemented under this plan, the government stated that it plans to expand the gas supply network from 530,000 households as of January 2020 to 4 million households by 2024 by moving forward with gas infrastructure development.

Other policies have also been formulated to boost gas supply, such as the new national energy policy (RUEN) established in October 2016, under which the government aims to roll out 2 million CNG vehicles and establish 646 CNG filling stations in 2025, as well as the Ministry of Energy and Mineral Resources Regulation No. 25 of 2017 on the acceleration of CNG utilization in the transportation sector, which mentions the responsibility of supplying natural gas to promote utilization of CNG in said sector. If requested by consumers, Pertamina Gas is to be responsible for the supply.

While the government is moving forward with gas supply support measures such as those mentioned above, it also faces issues with the gas supply system. Transjakarta, a Jakarta bus company that was the first to adopt CNG buses, has adopted and operated CNG buses since 2016, but due to the following reasons, this has not become more mainstream.[26]

- There is an insufficient number of SPBG (gas filling stations) with respect to the number of CNG buses and it takes around 30 minutes to fill one up. As such, there is often a long line of buses waiting to be filled.
- Due to the low quality of gas supplied as CNG, a large amount of residue remains in the fuel tank, which is dangerous in terms of operating these vehicles. Some buses have caught fire due to this.
- Looking at vehicle costs, CNG buses are 30% more expensive to run than diesel buses.

Also, as an issue in terms of price, if demand in consumption areas decreases, the supply price is decided through negotiations with Pertamina Gas (including the cost of transportation to the project site, etc.), and if demand is low, the CNG supply price may end up rising above the supply price of diesel. In that case, there would be no incentive for the business operator to carry out the project, and could result in the business itself going bankrupt.

Although policies, such as those above, have been formulated to support the expansion of the use of natural gas, the fact of the matter is that due to various issues, this expansion has not progressed much. As such, in order to proceed with the project to shift fuel to natural gas, increasing the number of natural gas consumers and demand at the project site is extremely important. For example, in addition to shifting gas from Bali's waste collection vehicles and sightseeing buses with JCM Model

[26] Taken from local information gathering by PT JGC INDONESIA in 2021

Project as a foothold, shifting the fuel used in diesel power plants and other facilities in Bali that constantly consume large quantities of diesel to natural gas could also increase demand. According to Bali's energy development plan, the government plans to convert diesel-fired power plants in Bali to gas-fired power plants in the future. This is expected to support the increase in the gas supply.

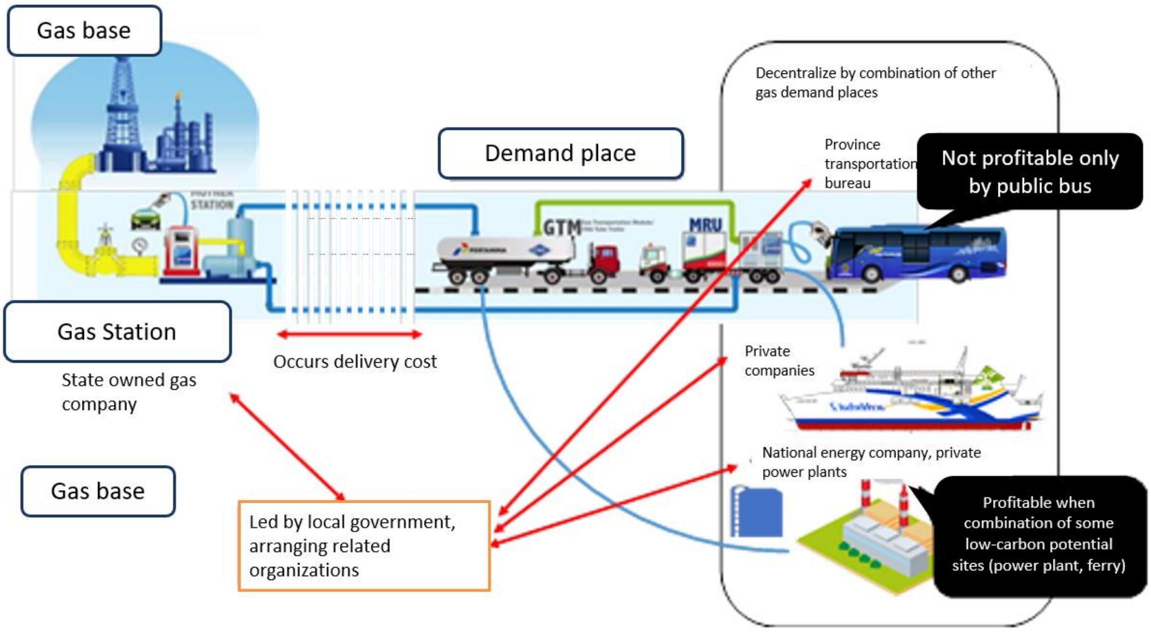


Figure 4-1 Schematic diagram of improvement in feasibility by integrating demand in urban areas

4.1.2. Renewable energy issues

Indonesia's national energy policy envisions increasing IPPs (independent power sources) by using private investors as a means to significantly increase the weighting of renewable energy. In order to do so, the government has moved forward with the development of the feed-in-tariff (FIT) scheme for renewable energy at the same time. However, the purchase price is set based on the power generation cost specified by the government, with renewable energy (solar power, wind power, biomass, biogas, and tidal power) capped at 85% of local production costs. This means that is difficult to attract investment outside of the few prime projects with low power generation costs. Also, for investors there is the possibility of system changes between the planning stage and final stage of such projects, as this policy is revised every few months. Not only that, but as many factors are decided through discussions between relevant parties, this poses a considerable risk for investors.

Such institutional disorder is due to a difference in the views of the central government and state-owned electric power company PLN. PLN is a state-owned enterprise that needs to generate sales, and although the FIT scheme is a national policy, no public funding is provided. As such, PLN has little incentive to purchase electricity at high cost, and has a policy of only purchasing electricity when it can be procured at a lower cost than it would take to newly install such a facility itself. In view of this, the central government has no choice but to set the FIT scheme in a way that makes it easy for PLN to conclude power purchase agreements.

In addition, for solar and wind power, not only is a backup power supply needed in order to respond to load fluctuations, the fragile grid system also needs strengthening, which is apparently making the obtaining of project approval difficult due to the heavy burden placed on PLN.[27] Since the situation is similar in Bali and Semarang City, the target areas of this report, the difficulty in sending power back to the PLN grid is an issue that needs to be overcome.[28]

Meanwhile, ESDM is promoting the use of rooftop solar power generation as the next measure to spread renewable energy. In positioning renewable energy measures, it has designated rooftop solar power as non-commercial power generation, and is moving forward with legislation to promote such power generation.

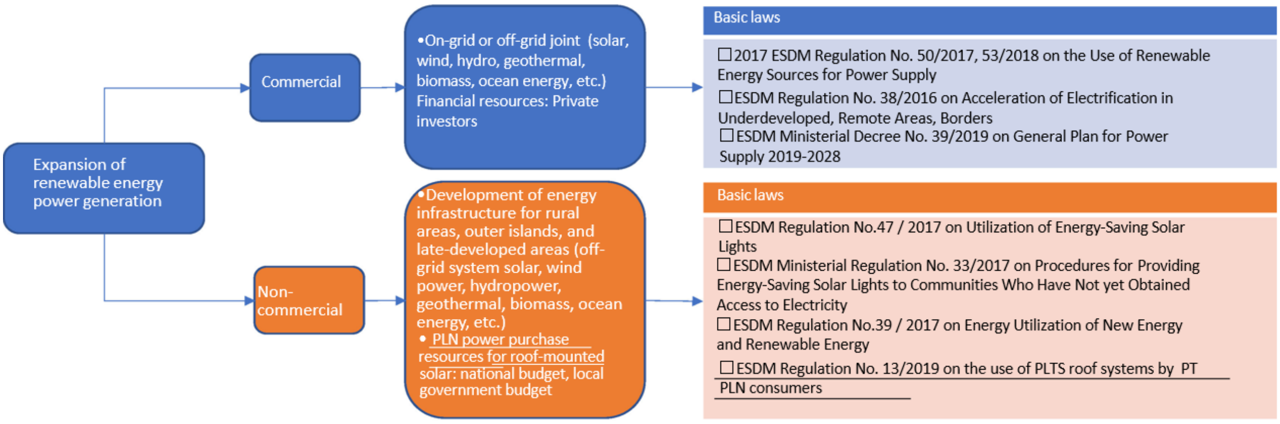


Figure 4-2 ESDM's measures related to the spread of renewable energy

Source: Produced with reference to the ESDM website "KEBIJAKAN, REGULASI DAN INISIATIF PENGEMBANGAN ENERGI SURYA DI INDONESIA"; http://iesr.or.id/wp-content/uploads/2019/10/2019-10-10-Bahan-Paparan-Akselerasi-PLTS-Mencapai-65-GW-pada-2025-IESR.pdf, acquired on 1 February 2021.

Rooftop solar power connection is done through a system in which the amount of power privately generated is deducted from the electricity usage fee based on the power purchase agreement with PLN. 65% of the power transmitted from the installer of the rooftop solar power system (PLTS) to the grid is counted as exported power (Article 6 [1] in ESDM regulation no. 49 of 2018 on the use of PLTS systems by consumers of PLN), and the amount that exceeds the amount of power purchased will be rolled over to the next month (Article 6 [4]) from the same regulation). However, as there is also a provision that invalidates this if the rollover exceeds one year, (Article 6 [5]) of the same regulation), the system is not a typical scheme in which surplus electricity is purchased.

While this regulation came into effect in 2018, it was revised twice in 2019 following criticism that the procedure to obtain permission to construct and install these systems is particularly complicated, making this procedure easier to carry out.

[27] https://money.kompas.com/read/2019/07/01/202201526/ini-upaya-pemerintah-capai-target-ebt-23-persen-di-2025
[28] https://dpd.acehprov.go.id/uploads/RENJA_2019.pdf

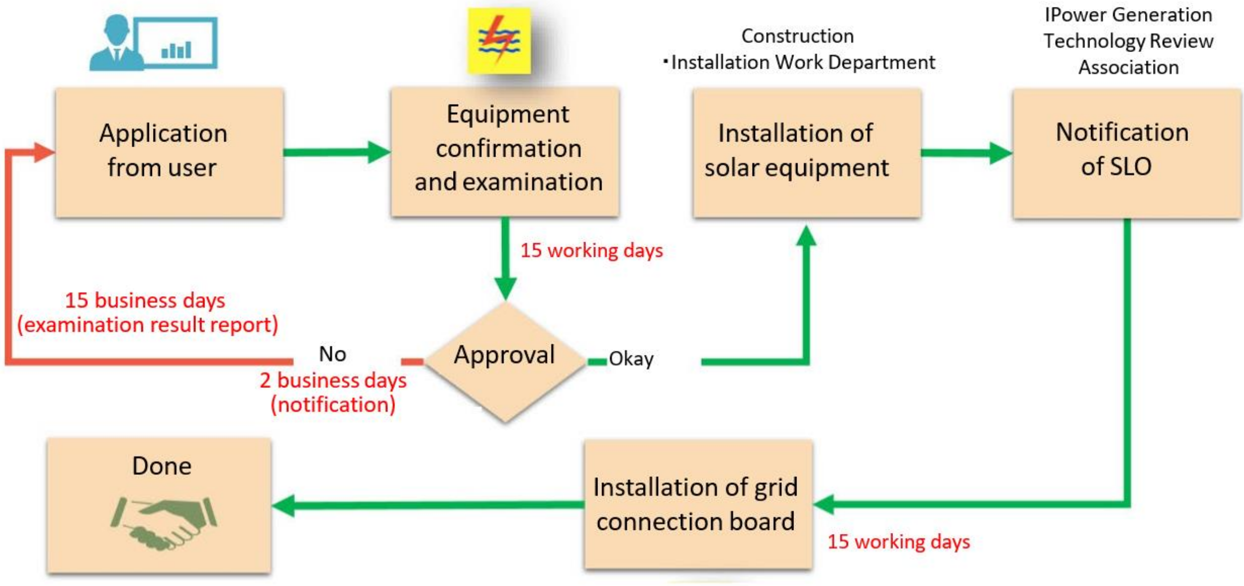


Figure 4-3 Procedures under ESDM regulation related to the use of PLTS systems

Source: Produced with reference to the ESDM website "KEBIJAKAN, REGULASI DAN INISIATIF PENGEMBANGAN ENERGI SURYA DI INDONESIA"; http://iesr.or.id/wp-content/uploads/2019/10/2019-10-10-Bahan-Paparan-Akselerasi-PLTS-Mencapai-65-GW-pada-2025-IESR.pdf, acquired on 1 February 2021.

Table 4-1 Amendments to ESDM regulation related to the use of PLTS systems

License classification	Regulation No. 49/2018	Regulation No. 13/2019	Regulation No. 12/2019
Operating license (IO)	PLTS systems with a capacity that exceeds 200 kVA require an IO.	PT PLN (Persero) consumers that construct and install a PLTS system need to obtain an operating license (IO) in accordance with the laws of the power department.	A. Required for a system with a power generation capacity of over 500 kVA for the purpose of supplying own power. B. Not required for a system with a power generation capacity of less than 500 kVA for the purpose of supplying own power. 2. Application must be submitted beforehand
Qualification authentication (SLO)	Installation of a PLTS system of up to 25 kW requires the acquisition of a Certificate of Worthiness (SLO).	The installation of a PLTS system requires an SLO[29] in accordance with power sector legislation.	A private power generation system of up to 500 kVA in one power facility must fulfill the SLO requirements.

Source: Produced with reference to the ESDM website "KEBIJAKAN, REGULASI DAN INISIATIF PENGEMBANGAN ENERGI SURYA DI INDONESIA"; http://iesr.or.id/wp-content/uploads/2019/10/2019-10-10-Bahan-Paparan-Akselerasi-PLTS-Mencapai-65-GW-pada-2025-IESR.pdf, acquired on 20 January 2021.

This regulation applies to systems that receive power through the connection with the PLN power grid while exporting power generated from solar panels back into the grid or consuming it in-house.

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[29] SLO: Sertifikat Laik Operasi

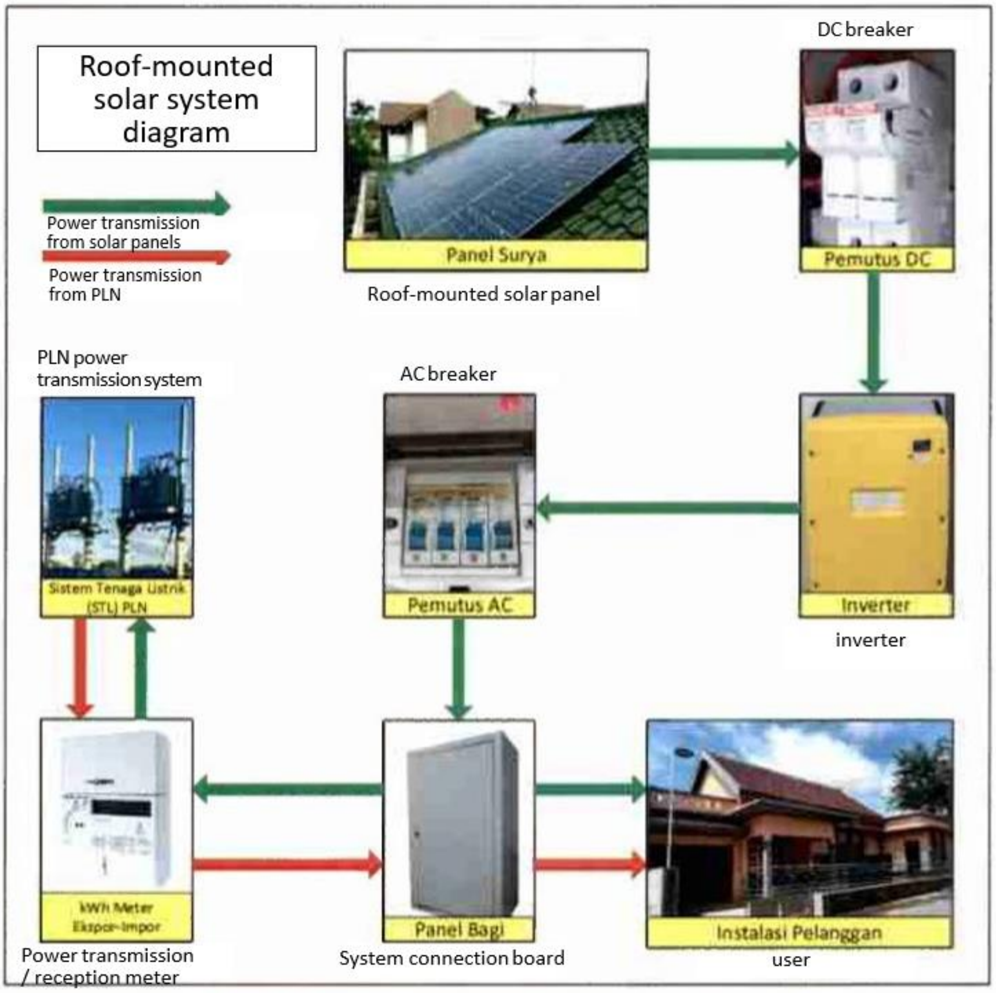


Figure 4-4 System diagram of a rooftop solar power system

Source: Produced with reference to the ESDM website "KEBIJAKAN, REGULASI DAN INISIATIF PENGEMBANGAN ENERGI SURYA DI INDONESIA"; http://iesr.or.id/wp-content/uploads/2019/10/2019-10-10-Bahan-Paparan-Akselerasi-PLTS-Mencapai-65-GW-pada-2025-IESR.pdf, acquired on 1 February 2021.

Prior to the promotion of this regulation, ESDM announced the "National Movement of One Million Rooftop Solar Systems" (GNSSA: GERAKAN NASIONAL SEJUTA SURYA ATAP) together with organizations such as the Ministry of Industry, the Indonesian Renewable Energy Association, and the Photovoltaic Power Generation Association, declaring that it will carry out the following measures.

(i) Encourage and accelerate the construction of rooftop solar power systems in residential housing, public facilities, government offices, commercial buildings, and industrial parks until orders in the gigawatt (GW) range are reached by 2020.

(ii) Promote the growth of competitive domestic industrial solar power generation systems and create employment opportunities (green jobs).

(iii) Promote a reliable, sustainable, and competitive power supply to support Indonesia's commitment to the Paris Agreement on Climate Change and support efforts to achieve the UN's Sustainable Development Goals (SDGs).

In connection with the above declaration, the Minister of Energy and Mineral Resources submitted the “Surat Edaran MESDM No. 363/22/MEM.L/2019” request form to the Presidential Palace, the Vice Presidential Palace, the state, and local government offices.

Under these circumstances, in order to further accelerate initiatives on this front, it is necessary to set specific targets for the introduction of renewable energy by the central and local governments and, together with budgetary measures, push forward with moves to plan, manage targets, and make improvements for introducing renewable energy. Facilities owned by the government include not only offices, but also waste disposal sites, water purification plants, drainage plants, dams, various test sites, observatories, schools, hospitals, other public halls, and sports facilities. As making it mandatory to make estimates and formulate plans for the installation of solar panels on such facilities will help shine light on which have installation potential and which installation locations should be prioritized, we expect this to contribute to the consideration of planned initiatives.

4.2. Concrete measures for system improvement and consideration of suggested solutions

4.2.1. Improving systems for the use of natural gas and consideration of suggested solutions

In Indonesia, the use of natural gas that can be produced within the country is being expanded in the industrial and transportation fields for the purpose of curbing the import and consumption of petroleum products and reducing carbon emissions. In the midst of this, in regards to CNG (compressed natural gas), the national energy policy (RUEN), enacted in October 2016, is targeting the introduction of 2 million CNG vehicles and the installation of 646 CNG filling stations by 2025. ESDM’s Ministerial Regulation No. 25, 2017 outlines specific guidelines for the spread of CNG, and mentions utilizing the national budget, local financing, etc., to expand pipelines, establish CNG stations, as well as the distribution of CNG bi-fuel conversion kits for diesel engines. The mid-term national development plan (RPJMN 2020-2024) outlines the Indonesian government’s plans to expand the supply of natural gas, aiming to increase production volume from 1.1 million BOE/day in 2018 to 1.2 million BOE/day by 2024, and also expand the gas supply networks from 530,000 households as of January 2020 to 4 million households by 2024.

Meanwhile, ESDM has designated the target areas in which it aims to spread the use of natural gas as “strategic areas,” and plans to move forward with this plan in stages. In rural areas in particular, it needs to pay attention to supply issues caused by inadequate pipeline infrastructure. While gas supply stations can be easily installed in areas with well-developed pipeline infrastructure, this can only be achieved in some metropolitan areas such as the capital city Jakarta. In other areas, gas supply companies take requests (orders) from users and enter into contracts with them to carry out the land transportation and supply of gas. In the case of land transportation, sometimes gas is supplied to offline gas stations, and when there are no gas stations available, gas is supplied via mobile refilling units (MRUs).

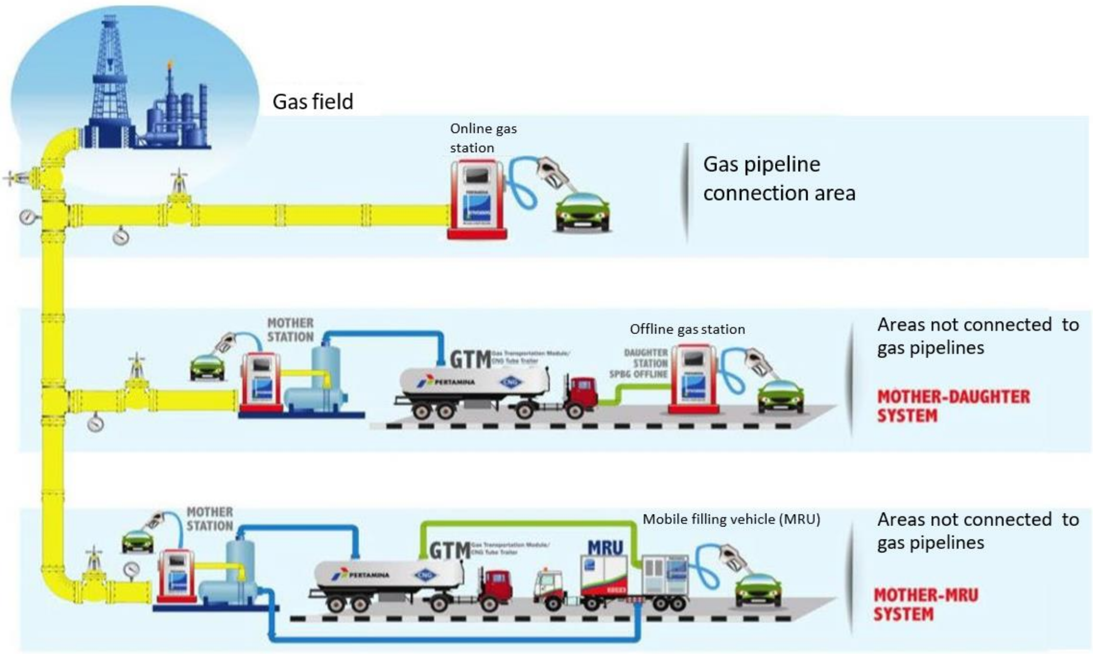
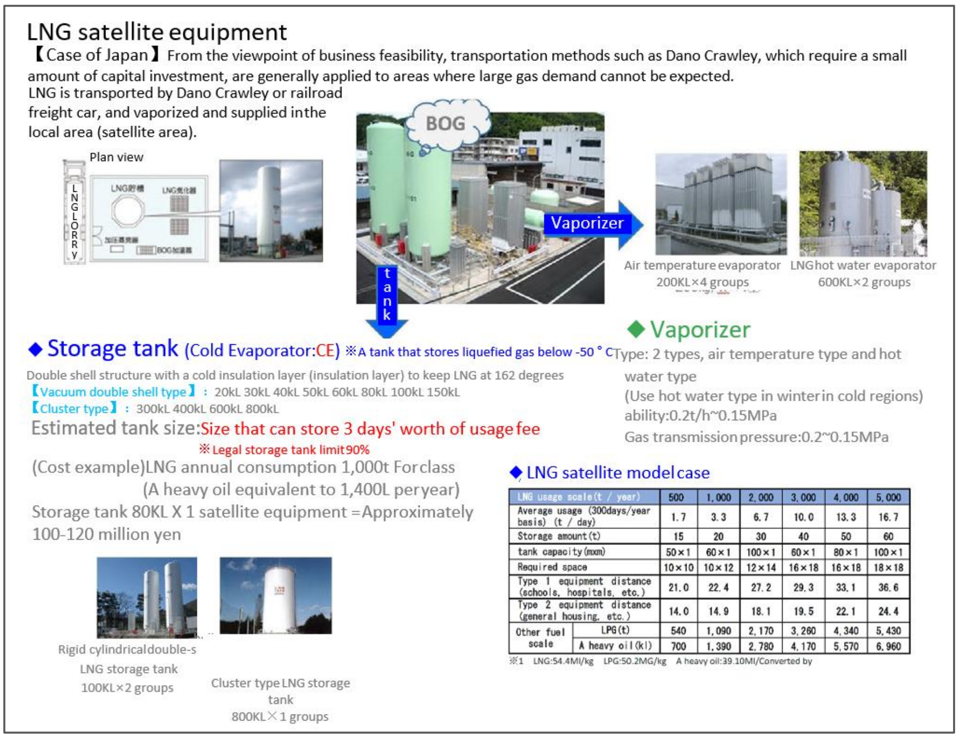


Figure 4-5 Method to supply gas to areas with/without a gas pipeline connection

Source: Produced with reference to materials (PENGGUNAAN BBG CNG UNTUK SEKTOR TRANSPORTASI) received from Pertamina Gas.

In Japan as well, there are cases where transportation methods such as tank trucks, which generally require less capital investment than pipelines, are applied in areas where large gas demand is unlikely to be expected. An example of equipment required at that time is shown below.



LNG usage scale(t / year)		500	1,000	2,000	3,000	4,000	5,000
Average usage (300days/year basis) (t / day)		1.7	3.3	6.7	10.0	13.3	16.7
Storage amount(t)		15	20	30	40	50	60
tank capacity(mxm)		50×1	60×1	100×1	60×1	80×1	100×1
Required space		10×10	10×12	12×14	16×18	16×18	18×18
Type 1 equipment distance (schools, hospitals, etc.)		21.0	22.4	27.2	29.3	33.1	36.6
Type 2 equipment distance (general housing, etc.)		14.0	14.9	18.1	19.5	22.1	24.4
Other fuel scale	LPG(t)	540	1,090	2,170	3,260	4,340	5,430
	A heavy oil(kl)	700	1,390	2,780	4,170	5,570	6,960

※1 LNG:54.4MI/kg LPG:50.2MG/kg A heavy oil:39.10MI/Converted by

Figure 4-6 Gas pipeline connection / non-connection areas in Japan Gas supply methods and equipment

Source: Provided by Hokusan Co., Ltd.

If gas pipeline infrastructure is underdeveloped, there are risks of additional transportation costs due to the added step of land transportation, and no guarantee of supply, and on the other hand, the user needs to guarantee the supplier with a minimum usage amount.

As individual delivery for each customer cannot be carried out efficiently, the transportation cost per unit is high. Due to this, distribution costs cannot be absorbed when supplying to small-lot customers, meaning that even if there is demand, it is sometimes difficult to meet it.

Therefore, as a plan to improve the system, not only from the viewpoint of reducing burdens related to oil imports, but also in terms of reducing carbon emissions, gas conversion (use of CNG) for generators and other diesel-powered equipment related to infrastructure, as well as public transportation, we expect the government to promote the spread and expansion of natural gas and absorb the cost of bulk transportation by tapping into demand in urban and other areas.

Since the construction and expansion of pipelines are expected to take time due to land acquisition issues and the size of the initial investment, gas supply companies will have to rely on land transportation by tanker truck or sea transportation by ship for a certain period of time. Even if pipeline infrastructure is underdeveloped, a stable gas supply will contribute to improving the reliability of the gas infrastructure and lead to the expansion of gas use.

In Bali, LNG is already being supplied, and it is expected that CNG can be supplied by a small satellite that integrates an LNG tank and a vaporizer. As mentioned above, gas company Pertamina Gas is ready to make capital investment to build a supply chain by operating these facilities and making a calculation that can expect a return on investment from gas sales. An example of LNG satellite equipment is shown in the figure below, and equipment that can meet various demands is already widespread.

Figure 4-7 LNG satellite equipment lineup and CNG supply

Source: Provided by Hokusan Co., Ltd.

4.2.2. Improving systems associated with the spread of solar power generation and consideration of suggested solutions

As stated in section4.1.2, for solar power generation, with the FIT scheme in place and measures to promote the installation of rooftop solar panels under way, there are expectations for them to work as an incentive to make use more widespread by reducing electricity costs. On the other hand, as PLN has no choice but to secure a backup adjustment power source for electricity flowing back into the grid via solar power systems, which incurs additional costs, there are issues such as difficulty in receiving electricity in grid areas where adjustment power is weak.

In particular, Bali, which is the target of this report, only has a small transmission capacity. It thus faces the risk of being unable to fully cope with load fluctuations due to solar panel facilities becoming more widespread. As such, when taking into account forms of solar power generation in addition to rooftop solar power systems for the purpose of in-house consumption, such as land-based mega solar plants, grid connection will likely prove difficult. In order to make solar power generation more mainstream going forward, it is also important to pursue the improvement of infrastructure development, such as strengthening the power grid, while holding discourse with PLN.

In addition, the adoption of this system faces restrictions such as obligations to use Indonesian products. While the price of solar panels made in Indonesia is high, the quality is considered inferior, and there are reports of situations where such investments did not provide sufficient returns.

Therefore, as a plan to improve the system, we look for the implementation of measures for infrastructure development, a prerequisite for the spread of solar power, by strengthening the power grid and preparing adjustment power, as well as the easing of restrictions, such as the in-house production rate, with an eye to improving investment returns while also keeping the protection of local industry to an appropriate level.

For Japanese firms, Indonesia’s rooftop solar power systems have the potential to become a large market in the future. It is thus necessary to find room for such companies to enter the market through deregulation.

4.3. Suggested solutions for system improvement

4.3.1. Regional government-led potential site integration

In Bali and Semarang City, there are currently only a handful of facilities owned by public institutions with the potential for carbon emission reduction.

While the greenhouse gas (GHG) emissions for each of these potential carbon reduction sites is not particularly large, by taking action as a whole they could contribute to the reduction of GHG emissions in urban areas.

Coordination across multiple facilities and stakeholders is key to achieving decarbonization at these potential sites. Local governments that supervise such efforts must take on the role of a coordinator, formulating policies and making adjustments. Therefore, as system development necessary for execution, it is vital for local governments to take the initiative to clarify and implement concrete policies.

As mentioned in Chapter 2, in Indonesia, in addition to the national development plan, local governments have also formulated long-term development plans, medium-term development plans, and action plans. In Bali and Semarang City, there are policies for promoting the reduction of carbon emissions. While targets have been set, many specific projects are still in the conceptual stage. We think that these plans will start to take shape going forward.

Given that Indonesia's development plan is tied to its budget, it needs to select a more specific development plan and move forward with making policy decisions, including the formulation of a budget.

Neither city has made GHG emission estimates for the city as a whole, nor formulated priority action plans based on such data. The accumulation of objective data, including numerical proof, is vital when it comes to policy making. As such, local governments should first cooperate with universities and research institutions to gain a better understanding of GHG emissions in urban areas and analyze future emission trends. Based on this, they then need to formulate and execute a priority action plan.

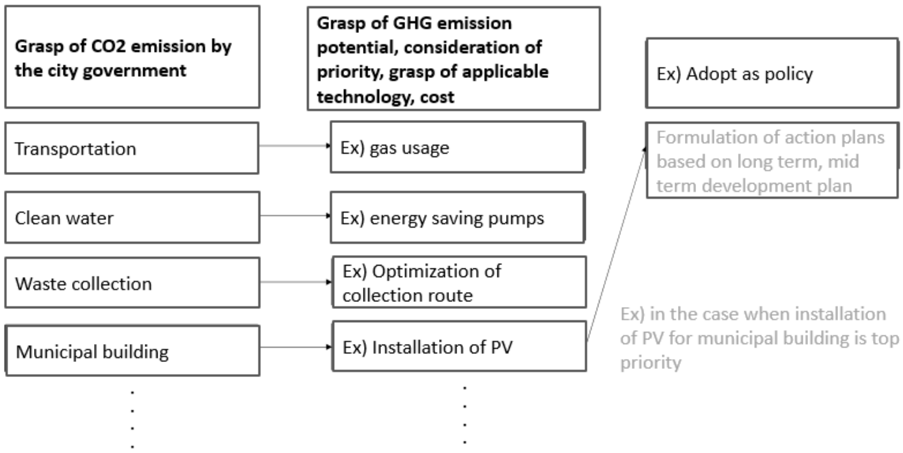


Figure 4-8 Steps to grasp GHG emissions and set priorities

4.3.2. Spreading awareness of initiatives through monitoring and public announcements

When carrying out a program to reduce carbon emissions, it is necessary to properly monitor the effects of doing so regardless of whether support for JCM equipment is being utilized. In particular, in projects for converting fuel to natural gas, establishing a monitoring system for fuel consumption is vital to accurately grasp the effects of GHG reductions and economic improvement. As such, when aiming to switch the fuel used in waste collection vehicles in Denpasar City and waste collection vehicles and flood pumps in Semarang City, it is necessary to install monitoring equipment and establish a new data management department in order to strengthen the management system for fuel consumption and other data.

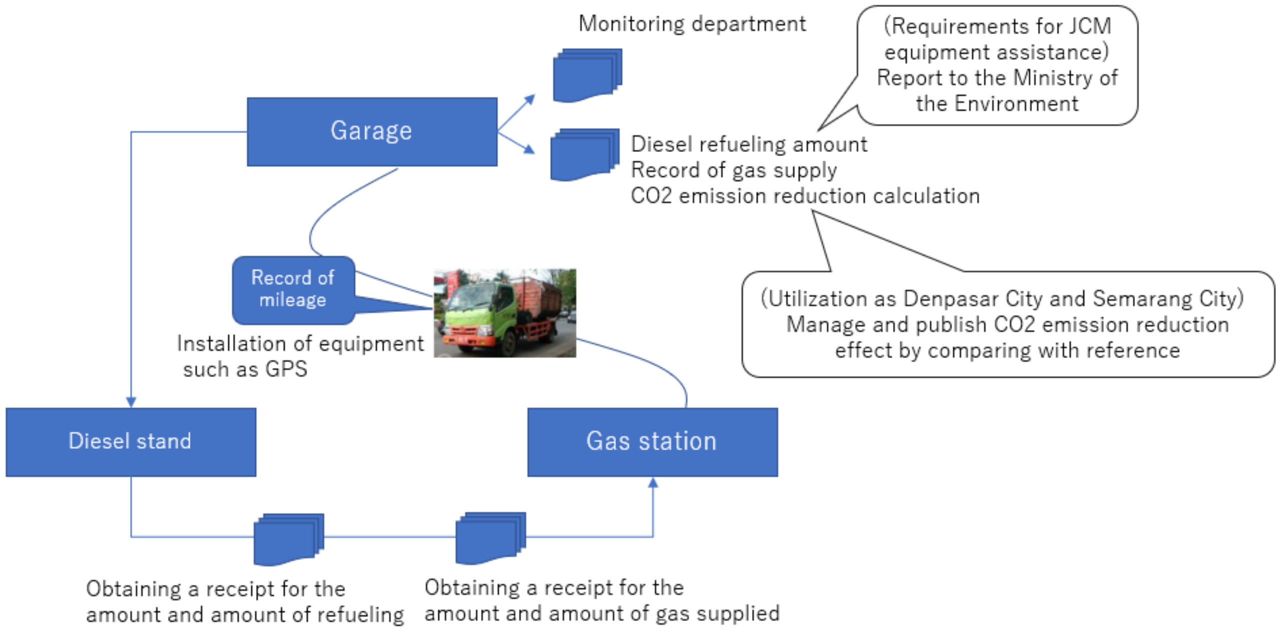


Figure 4-9 Image of the operation and monitoring of waste collection vehicles

Souce: Made by JANUS

5. Estimation of the reduction amount of greenhouse gas emissions

5.1. Discussion on the methodology for reducing greenhouse gas emissions

5.1.1. Outline

There are two projects to be implemented on a full-scale basis. One of them is a project of installing a device for using two kinds of fuels (diesel and CNG) in public buses, waste collection vehicles, and diesel generators for flood adjustment pumps, to improve fuel combustion efficiency through the shift to natural gas and the installation of the device and then reduce GHG emissions.

The other is a project of installing solar power generation equipment to curtail GHG emissions.

Indonesia implemented similar projects in the past, so MRV methodologies for respective projects have been already formulated. As for the fuel shift project, it is possible to estimate the reduction amount of GHG emissions, by utilizing the MRV methodology ID-AM026 (Introduction of CNG-Diesel Hybrid Equipment to Public Buses), which was approved the other day.

The following section describes the methodology for fuel conversion and PV project.

5.1.2. Consideration on the methodologies related to the target project

(1) **Fuel conversion**

Among fuel conversion projects, of those related to vehicles, "Joint Crediting Mechanism Approved Methodology ID_AM026 ‘Introduction of CNG-Diesel Hybrid Equipment to Public Buses,’" approved in the 2018 JCM Model Project, “Project for introducing CNG and diesel hybrid equipment to public buses in Semarang City, Indonesia” can be applied. While this project is an example of duel gas fuel being used in public buses with diesel engines, the same concept can be used as a reference for waste collection vehicles. Also, while it is necessary to take into account the characteristics of diesel generators when looking at fuel conversion for diesel generators that provide power to flood adjustment pumps, theoretically, we consider it acceptable to develop them based on the same methodology.

The details of this methodology are outlined below.

① Target project

This methodology targets projects that install equipment that enables the combined use of two fuels, namely diesel and CNG, in diesel-powered power generation equipment.

② Eligibility requirements

The eligibility requirement for Methodology AM026 is a device that can use both CNG and diesel that will be installed in public buses that area already in operation, or will be newly rolled out going forward. Based on the same idea, the requirement for this project is defined as “the introduction of equipment that can use both CNG and diesel for diesel-powered vehicles/power generation equipment that is already in operation, or will be newly rolled out going forward.”

③ Emission sources and target gases

The GHG calculated in Methodology AM026 is carbon dioxide emitted from diesel fuel and CNG used for public transportation. We note that while CNG is expected to be transported from the procurement site to the usage site via tanker truck, GHG emitted when doing so are small enough versus the project emissions that it has been excluded from emission sources. Based on the same idea, this project sets the target gas as carbon monoxide produced from CNG and diesel fuel used for diesel-powered vehicles and power generation equipment.

Table 5-1 Emission sources and target gases

Category	Emission source	Target GHG
Reference emissions	Diesel fuel combustion	CO2
Project emissions	Diesel fuel combustion	CO2
	Fuel for CNG fuel	CO2

4) Calculation method for reference emissions

a. Calculation basis and assumptions

Methodology AM026 calculates CO2 emissions produced from diesel fuel combustion that has been reduced by replacing diesel fuel, which has a high CO2 emission factor, with CNG, which has a low CO2 emission factor, after equipment has been installed. In addition, similar cases in the past have shown that the introduction of such equipment can increase fuel combustion efficiency, improve vehicle fuel efficiency, and reduce CO2 emissions more than the difference in CO2 emission factors. We thus intend to evaluate these effects.

Reference emissions are defined in this methodology as the amount of GHG expected to be emitted during the project period if the project was not implemented, or in other words, if no equipment has been installed. Also, project emissions are classed as the CNG consumption and diesel consumption of project equipment, and are calculated from the net calorific value of CNG and diesel, the CO2 emission factor of diesel, and the fuel consumption of project equipment and reference equipment.

b. Equations, etc.

The equation used in Methodology AM026 is as follows.

$$RE_p = \sum_i \left\{ \left[\left(FC_{PJ,CNG,i,p} \times NCV_{CNG} \right) + \left(FC_{PJ,diesel,i,p} \times NCV_{diesel} \right) \right] \times \frac{\eta_{PJ,i,p}}{\eta_{RE,i}} \right\} \times EF_{diesel}$$

RE_p	Reference emissions in the period p [t-CO2/p]
$FC_{PJ,CNG,i,p}$	CNG consumption from project equipment i in the period p [t/p]
NCV_{CNG}	Net calorific value of CNG [GJ/t]
$FC_{PJ,diesel,i,p}$	Diesel fuel consumption of project equipment i in the period p [kl/p]
NCV_{diesel}	Net calorific value of diesel fuel [GJ/kl]
$\eta_{PJ,i,p}$	Fuel economy of project equipment i in the period p [km/l]
$\eta_{RE,i}$	Fuel economy of reference equipment i [km/l]
EF_{diesel}	CO2 emission factor of diesel fuel [t-CO2/GJ]
i	Project equipment ID number

While in Methodology AM026, project equipment refers to public buses, when applying it to this project, project equipment will be replaced with diesel generators for waste collection vehicles and flood adjustment pumps. For diesel generators for flood adjustment pumps, the point to keep in mind when referring to this project is fuel efficiency (energy efficiency). In regards to fuel efficiency, the unit of measurement for "fuel efficiency of project equipment i in the period p" and "fuel efficiency of reference equipment i" needs to be set as kW/l.

In Methodology AM026, the fuel consumption of project equipment i in the period p ($\eta_{PJ,i,p}$) is determined based on monitoring data after the project has been implemented. The following equation will thus be used in order to reflect actual fuel consumption.

$$\eta_{PJ,i,p} = \frac{TD_{PJ,i,p}}{HFC_{PJ,diesel,i,p} \times 10^3}$$

$$HFC_{PJ,diesel,i,p} = \sum_i FC_{PJ,CNG,i,p} \times \frac{NCV_{CNG}}{NCV_{diesel}} + \sum_i FC_{PJ,diesel,i,p}$$

$\eta_{PJ,i,p}$	Fuel economy of project equipment i in the period p [km/l]
$TD_{PJ,i,p}$	Total mileage of project equipment i in the period p [km/p]
$HFC_{PJ,diesel,i,p}$	Estimated total consumption of diesel fuel for project equipment i in the period p [kl/p]
$FC_{PJ,CNG,i,p}$	CNG consumption of project equipment i in the period p [t/p]
NCV_{CNG}	Net calorific value of CNG [GJ/t]
NCV_{diesel}	Net calorific value of diesel fuel [GJ/kl]
$FC_{PJ,diesel,i,p}$	Diesel fuel consumption of project equipment i in the period p [kl/p]
i	Project equipment ID number

Also in regards to this calculation, in the case of diesel generators for flood adjustment pumps, we will apply it by replacing fuel assumption as kW/l and mileage as kWh.

In Methodology AM026, fuel costs in the reference scenario are conservatively determined in advance through one of the following three options, in order to guarantee substantial emission reductions.

(Option 1)

Collect data on daily mileage and diesel fuel consumption for Bus i prior to installing a device that enables the use of both CNG and diesel fuel. Select the highest value (most efficient value) from this measurement data collected over a period of at least 60 days, and set this as the fuel consumption for Reference Bus i.

(Option 2)

The catalog value of Bus i's fuel consumption converted from diesel fuel combustion to CNG/diesel hybrid combustion in the project is determined as fuel consumption of Reference Bus i. Catalog values typically display better fuel economy than calculated values for buses in operation. As such, basing reference bus default fuel economy values on catalog values results in conservative figures.

(Option 3)

The default value set by this method is applied as the fuel consumption for reference bus i. The default value is determined from the latest catalog value for public buses produced by Japanese manufacturers. This typically results in conservative figures, as the default value is more fuel efficient than the calculated value for buses in operation.

Similarly, for diesel generators for floor adjustment pumps, collecting data on the fuel consumption (kW/l) value of existing power plants, or quoting manufacturers' catalog values or values for the latest diesel generators of the same size (such as those of Japanese manufacturers), is a conceivable method.

5) Method for calculating project emissions

In Methodology AM026, GHG generated by the combustion of diesel and CNG consumed during the project period is calculated using the following equation.

$$PE_p = PE_{CNG,p} + PE_{diesel,p}$$

$$PE_{CNG,p} = \sum_i \left(FC_{PJ,CNG,i,p} \times NCV_{CNG} \times EF_{CNG} \right)$$

$$PE_{disel,p} = \sum_i \left(FC_{PJ,diesel,i,p} \times NCV_{diesel} \times EF_{diesel} \right)$$

PE_p	Project emissions for the period p [t-CO_2/p]
$PE_{CNG,p}$	Project emissions from CNG consumption of project equipment during the period p [t-CO_2/p]
$PE_{diesel,p}$	Project emissions from diesel fuel consumption of project equipment during the period p [t-CO_2/p]
$FC_{PJ,CNG,i,p}$	CNG consumption of project equipment i in the period p [t/p]
NCV_{CNG}	Net calorific value of CNG [GJ/t]

EF_{CNG}	CO_2 emission factor of CNG [t-CO_2/GJ]
$FC_{PJ,diesel,i,p}$	Diesel fuel consumption of project equipment i in the period p [kl/p]
NCV_{diesel}	Net calorific value of diesel fuel [GJ/kl]
EF_{diesel}	CO_2 emission factor of diesel fuel [t-CO_2/GJ]
i	Project equipment ID number

The amount of emission reductions is calculated by subtracting the projection emission amount from the reference emission amount and using the following equation.

$$ER_p = RE_p - PE_p$$

ER_p	Emission reduction amount for the period p [t-CO_2/p]
RE_p	Reference emissions for the period p [t-CO_2/p]
PE_p	Project emissions for the period p [t-CO_2/p]

7) Major default values

Based on the values set in Methodology AM026, the main default values can be set as follows.

Table 5-2　Major default values (referencing to Methodology AM026)

Parameter	Data overview	Source
NCV_{CNG}	CNG net calorific value [GJ/t]	Order of priority: a) Values provided by fuel suppliers b) Values measured by project participants c) Regional or country default values Or d) The IPCC default values shown in Table 1.2 of Volume 2, Chapter 1 of the 2006 PCC Guidelines for Greenhouse Gas Inventory. Low values will be adopted.
NCV_{diesel}	Diesel net calorific value [GJ/kl]	Order of priority: a) Values provided by fuel suppliers b) Values measured by project participants c) Regional or country default values Or d) The IPCC default values shown in Table 1.2 of Volume 2, Chapter 1 of the 2006 PCC Guidelines for Greenhouse Gas Inventory. Low values will be adopted.
EF_{CNG}	CO2 emission factor for CNG [t-CO2/GJ]	Order of priority: a) Values provided by fuel suppliers b) Values measured by project participants c) Regional or country default values Or d) The IPCC default values shown in Table 1.2 of Volume 2, Chapter 1 of the 2006 PCC Guidelines for Greenhouse Gas Inventory. Low values will be adopted.
EF_{diesel}	CO2 emission factor for diesel fuel [t-CO2/GJ]	Order of priority: a) Values provided by fuel suppliers b) Values measured by project participants

		c) Regional or country default values Or d) The IPCC default values shown in Table 1.2 of Volume 2, Chapter 1 of the 2006 PCC Guidelines for Greenhouse Gas Inventory. Low values will be adopted.
$\eta_{RE,i}$	Fuel economy for reference equipment i [km/l] The fuel consumption of reference equipment is determined in advance using the following method. [Option 1] The fuel consumption of reference equipment is determined based on the measurement data of equipment i prior to the installation of equipment that enables the use of both CNG and diesel. Data sets for the daily mileage and diesel fuel consumption of equipment i will be collected for at least 60 days prior to the installation of equipment that enables the use of both CNG and diesel. The highest (most efficient) value will be selected from the measurement data set and designated as fuel consumption for reference equipment i. [Option 2] The catalog value for the fuel consumption of equipment i, which converts combustion from diesel fuel to CNG/diesel hybrid combustion, will be designated as fuel consumption for reference equipment i. [Option 3] Reference will be made to the catalog values of the latest Japanese equipment of the same scale as the equipment target for this project.	[Option 1] Measurement data. [Option 2] Catalog values for fuel economy provided by equipment manufacturers. [Option 3] Catalog values of equipment manufactured in Japan of the same scale.

8) Major monitoring items

The value of total mileage needed to calculate fuel consumption, etc. is used as a major monitoring item in Methodology AM026, with an odometer or GPS used to carry out these measurements. Meanwhile, in the project targeting diesel generators for flood adjustment pumps, fuel consumption is calculated based on the amount of power generated and the amount of fuel used. As such, the amount of power generated is the target major monitoring item. As the measurement of the amount of power generated is constantly monitored and recorded at the pump station, data can be obtained without any issues. In regards to fuel consumption, it is necessary to install instruments that can measure fuel consumption for both diesel refueling equipment and newly installed CNG refueling equipment.

Table 5-3 Major monitoring items

Parameter	Measuring equipment
$TD_{PJ,i,p}$	System connection board installed in project equipment i, etc.
$FC_{PJ,diesel,i,p}$	Diesel refueling equipment
$FC_{PJ,CNG,i,p}$	CNG refueling equipment

(2) **PV**

As for the solar power generation project, we can refer to ID_AM013 (Installation of Solar PV System), which has been already approved. In addition, as mentioned in Section 4.1.2, the transmission capacity of the tested site is low, so there is a possibility that they will fail to cope with the load fluctuation due to the distribution of solar power generation, and it is necessary to discuss the case where the connection to grids is not conducted and so on. The above-mentioned ID_AM013 (Installation of Solar PV System) can be applied to private power generation. As for ID_AM014 (Installation of Tribrid Systems to mobile communication's Base Transceiver Stations), they have established a methodology for reducing energy consumption by replacing grid power with the tribrid system, which is developed by combining solar PV, electricity storage, and power control or boosting the efficiency of diesel generators. Either of the above methodologies is considered applicable to this project.

We will explalin ID_AM013 (Installation of Solar PV System) as follows.

1） **Case of grid connection**

The objective of the solar power generation project is to reduce CO_2 emissions by replacing the electric power generated by using fossil fuels with the one generated by using sunlight, which is renewable energy. The already-approved ID-AM013 (Installation of Solar PV System) is to be used, and the reduction amount of GHG emissions has been estimated by multiplying the output after equipment installation by the grid CO_2 emission coefficient in the region concerned.

① **Target project**

This methodology is used for the project of reducing GHG emissions by establishing solar power generation systems in Indonesia.

② **Eligibility requirements**

The eligibility requirement for ID_AM013 (Installation of Solar PV System) is that it is applied to a project that satisfies all of the criteria shown in Table 5-4. This requirement was used in this survey, too.

Table 5-4 Eligibility requirements for the methodology (solar power generation project)

Number	Eligibility requirements
Requirement 1	A new solar power generation system is established in a project.
Requirement	The design of solar power generation modules is certified by IEC 61215, IEC 61646, or IEC 62108,

2	and their safety is certified by IEC 61730-1 and IEC 61730-2.
Requirement 3	Equipment for monitoring the output of solar power generation systems and solar radiation intensity is set at a project site.

③ Emission sources and target gases

Table 5-5 shows the emission sources and target gases for this methodology.

Table 5-5 Emission sources and target gases (solar power generation project)

Category	Emission sources	Target GHG
Reference emissions	Combustion of fossil fuels at power plants	CO_2
Project emissions	Since power is generated by solar power generation systems, greenhouse gases are not emitted in this project.	-

④ Method for calculating reference emissions

(a) Grounds and preconditions for calculation

In ID_AM013 (Installation of Solar PV System), default emission coefficient was conservatively set for the local grid of Indonesia. The emission coefficient of each power plant was calculated from the highest thermal efficiency among power plants in operation in Indonesia to secure maintenance performance, and it is 0.795 t-CO_2/MWh for coal-fired power plants, 0.320 t-CO_2/MWh for gas-fired power plants, and 0.533 t-CO_2/MWh for diesel power plants.

In ID_AM013 (Installation of Solar PV System), different emission coefficients are used according to whether the system is directly connected to domestic or local grids and whether it is connected to independent grids or generators for self-consumption. In this project, it is assumed that the electric power procured from the government-run electric power company PLN is replaced or sold, so we will use the emission coefficient of PV Case 1 of ID_AM013 (Installation of Solar PV System), and for local grids, we will use 0.616 t-CO_2/MWh of Jamali grid, to which Bali belongs.

(b) Equation, etc.

The equation used in this methodology is as follows.

$$RE_p = \sum_i \left(EG_{i,p} \times EF_{RE,i}\right)$$

RE_p	Reference emissions in the period p [t-CO_2/p]
$EG_{i,p}$	Output of the solar power generation system i of the project in the period p [MWh/p]
$EF_{RE,i}$	Reference CO_2 emission coefficient of the solar power generation system i of the project [t-CO_2/MWh]

⑤ Method for calculating project emissions

As mentioned above, the project discussed in this survey generates power with a solar power generation system, so the project will not generate GHG gases. Accordingly, project emissions can be calculated as follows.

$PE_p = 0$

PE_p : Project emissions in the period p [t-CO_2/p]

⑥ Method for calculating the reduction amount of emissions

The reduction amount of emissions in this methodology can be calculated by the following equation.

$$ER_p = RE_p - PE_p$$

ER_p	Reduction amount of emissions in the period p [t-CO_2/p]
RE_p	Reference emissions in the period p [t-CO_2/p]
PE_p	Project emissions in the period p [t-CO_2/p]

⑦ Major default values

For major default values in this methodology, ID_AM013 (Installation of Solar PV System) is used. As mentioned above, Jamali grid will be adopted for local grids.

Table 5-6 Major default values (solar power generation project)

<table>
<tr><th>Parameter</th><th>Outline of data</th><th>Information source</th></tr>
<tr><td>$EF_{RE, i}$</td><td>The value of the reference CO_2 emission coefficient EFRE,i of the solar power generation system i of the project is chosen from the emission coefficients based on the national/local grids (EFRE,grid) or independent grid and/or captive diesel power generator (EFRE,cap), with the following method.
If the proposed solar power generation system in the project is directly connected to domestic/local grids or connected to them via independent grids or domestic grids not connected to generators for self-consumption, EFRE,grid is set as follows.
<table>
<tr><td>Jamali grid</td><td>0.616 t-CO_2/MWh</td></tr>
<tr><td>Sumatra grid</td><td>0.477 t-CO_2/MWh</td></tr>
<tr><td>Batam grid</td><td>0.664 t-CO_2/MWh</td></tr>
<tr><td>Tanjung Pinang, Tanjung Balai Karimun, Tanjung Batu, Kelong, Ladan, Letung, Midai, P Buru, Ranai, Sedanau, Serasan, and Tarempa grids</td><td>0.555 t-CO_2/MWh</td></tr>
<tr><td>Bangka, Belitung, S Nasik, and Seliu grids</td><td>0.553 t-CO_2/MWh</td></tr>
<tr><td>Khatulistiwa grid</td><td>0.532 t-CO_2/MWh</td></tr>
<tr><td>Barito grid</td><td>0.666 t-CO_2/MWh</td></tr>
<tr><td>Mahakam grid</td><td>0.527 t-CO_2/MWh</td></tr>
<tr><td>Tarakan grid</td><td>0.493 t-CO_2/MWh</td></tr>
<tr><td>Sulutgo grid</td><td>0.325 t-CO_2/MWh</td></tr>
<tr><td>Sulselbar grid</td><td>0.320 t-CO_2/MWh</td></tr>
</table></td><td>Default emission coefficients were calculated from the research into electric power systems in Indonesia and the most efficient diesel power generation (the default thermal efficiency: 49% exceeds the value of diesel power generators that lead the world). The default value is revised when necessary.</td></tr>
</table>

	Kendari, Bau Bau, Kolaka, Lambuya, Wangi Wangi, and Raha grids	0.593 t-CO_2/MWh		
	Palu Parigi grid	0.517 t-CO_2/MWh		
	Lombok, Bima, and Sumbawa grids	0.561 t-CO_2/MWh		
	Kupang, Ende, Maumere, and Waingapu grids	0.507 t-CO_2/MWh		
	Ambon, Tual, and Namlea grids	0.533 t-CO_2/MWh		
	Tobelo and Ternate Tidore grids	0.532 t-CO_2/MWh		
	Jayapura, Timika, and Genyem grids	0.523 t-CO_2/MWh		
	Sorong grid	0.525 t-CO_2/MWh		

⑧ **Major monitoring items**

Major monitoring items in this methodology are as follows.

Table 5-7 Major monitoring items (fuel shift project)

Parameter	Measurement device
$EG_{i,p}$	Power generation amount is measured with monitoring devices, etc. set in the project site.

2） **Case where grid connection is not conducted**

As mentioned above, the transmission capacity of the tested site is low, so there is a possibility that they will fail to cope with the load fluctuation due to the distribution of solar power generation, and it is necessary to discuss the case where the connection to grids is not conducted and so on. In the above-mentioned ID_AM013 (Installation of Solar PV System), the net reduction amount of emissions for private power generation is evaluated, while adopting the power generation efficiency 49%, which has not been achieved even by globally leading diesel generators.

① **Target project**

This methodology is used for the project of reducing GHG emissions by establishing solar power generation systems in Indonesia.

② **Eligibility requirements**

The eligibility requirement for ID_AM013 (Installation of Solar PV System) is that it is applied to a project that satisfies all of the criteria shown in Table 5-8. This requirement was used in this survey, too.

Table 5-8 Eligibility requirements for the methodology (solar power generation project)

Number	Eligibility requirements
Requirement 1	A new solar power generation system is established in a project.
Requirement 2	The design of solar power generation modules is certified by IEC 61215, IEC 61646, or IEC 62108, and their safety is certified by IEC 61730-1 and IEC 61730-2.
Requirement 3	Equipment for monitoring the output of solar power generation systems and solar radiation intensity is set at a project site.

③ Emission sources and target gases

Table 5-9 shows the emission sources and target gases for this methodology.

Table 5-9 Emission sources and target gases (solar power generation project)

Category	Emission sources	Target GHG
Reference emissions	Consumption by grid power and privately generated power	CO_2
Project emissions	Since power is generated by solar power generation systems, greenhouse gases are not emitted in this project.	-

④ Method for calculating reference emissions

(a) Grounds and preconditions for calculation

In ID_AM013 (Installation of Solar PV System), default emission coefficient was conservatively set for the local grid of Indonesia. The emission coefficient of each power plant was calculated from the highest thermal efficiency among power plants in operation in Indonesia to secure maintenance performance, and it is 0.795 t-CO_2/MWh for coal-fired power plants, 0.320 t-CO_2/MWh for gas-fired power plants, and 0.533 t-CO_2/MWh for diesel power plants.

On the other hand, Indonesia is an insular country, including many regions where electric power grids are isolated or in-house power generation is conducted. In this project, we will use the emission coefficient of PV Case 3 of ID_AM013 (Installation of Solar PV System), in order to discuss the case where the system is not connected to national/local grids, and use the emission coefficient 0.533 tCO_2/MWh, considering the power generation efficiency 49%, which has not been achieved by globally leading diesel power generators.

(b) Equation, etc.

The following equation is used for this methodology.

$$RE_p = \sum_i \left(EG_{i,p} \times EF_{RE,i}\right)$$

RE_p	Reference emissions in the period p [t-CO_2/p]
$EG_{i,p}$	Output of the solar power generation system i of the project in the period p [MWh/p]
$EF_{RE,i}$	Reference CO_2 emission coefficient of the solar power generation system i of the project [t-CO_2/MWh]

⑤ Method for calculating project emissions

As mentioned above, the project discussed in this survey generates power with a solar power generation system, so the project will not generate GHG gases. Accordingly, project emissions can be calculated as follows.

$PE_p = 0$

PE_p : Project emissions in the period p [t-CO_2/p]

⑥ **Method for calculating the reduction amount of emissions**

The reduction amount of emissions in this methodology can be calculated by the following equation.

$$ER_p = RE_p - PE_p$$

ER_p	Reduction amount of emissions in the period p [t-CO_2/p]
RE_p	Reference emissions in the period p [t-CO_2/p]
PE_p	Project emissions in the period p [t-CO_2/p]

⑦ **Major default values**

For major default values in this methodology, ID_AM013 (Installation of Solar PV System) is used.

Table 5-10 Major default values (solar power generation project)

Parameter	Outline of data	Information source
$EF_{RE,i}$	For the value of the reference CO_2 emission coefficient $EF_{RE,i}$ of the solar power generation system i of the project, $EF_{RE,cap}$: 0.533 tCO_2/MWh is adopted if the proposed solar power generation system of the project is connected to the internal system that is not connected to domestic/local grids, but connected to only independent grids and/or power generators for self-consumption.	The default emission coefficient is based on the results of a survey on new highly efficient engines powered by diesel fuel. The default value is revised when necessary, according to the results of a survey conducted by JC or project participants every three years.

⑧ **Major monitoring item**

The major monitoring item in this methodology is as follows.

Table 5-11 Major monitoring item (fuel shift project)

Parameter	Measurement device
$EG_{i,p}$	Power generation amount is measured with monitoring devices, etc. set in the project site.

6. Cooperation among cities for actualizing a low-carbon society (discussions with local staff)

This fiscal year, the cooperative project among cities was conducted while it was impossible to carry out an on-site survey or invite personnel due to the spread of COVID-19. By holding remote meetings, exchanging emails, and so on, we explained the details of our survey and the situation of our activities, to win the understanding of local staff, and gathered information by enlisting cooperation from the Bali government, officials of City of Semarang, and Pertamina, and had discussions.

7. Activities of project formulation for JCM Model Project in fiscal year 2019

As for the results of the Inter-City Collaborative Project in fiscal 2019, in addition to the planned construction of a sewing factory (PT.Star Alliance Co., Ltd.) in the City of Semarang, the specific project of installation of solar panels on the rooftop of the city hall of Semarang was proposed. We had discussions with the aim of making these projects subject to the equipment subsidy program, but the construction of the housing for machinery for the sewing factory had to be delayed along with the company's operations, and plans for solar power installations had to be put on hold due to the effects of the spread of the novel coronavirus.

Regarding the city hall of Semarang, funds had been budgeted for the execution of the project this year, but due to the reallocation and reduction of the budget as part of counter-measures to control the spread of the novel coronavirus, the project has also been put on hold.

In the future, the company plans to work on budgetary provisions necessary for these projects together with the new projects considered in this survey, while keeping an eye on the pandemic and when it will subside.

8. Summary of the project and outlook for the future project

This survey examined JCM projects taking into consideration the low-carbon policies of the municipalities of Bali and the City of Semarang on the national, state and municipal levels, and confirmed the effectiveness of business projects that could become subject to the JCM equipment subsidy program.

In the future, the company plans to estimate the cost and effectiveness in greater detail and facilitate better decision-making so as to compensate for the lack of information. However, as vital steps, such as system development, site inspection, and contract negotiations, could not be taken in a sufficient manner due to the effects of the spread of the novel coronavirus, discussions under the framework of the Inter-City Collaboration Project need to be continued from the next fiscal year onward in order to finalize decision-making and project plans, as is being requested from the on-site teams as well.

Further, as Toyama City pursues initiatives as the future city for SDGs, it will not only adopt policies for climate change mitigation, but also plans to continue the cooperation exhibited during the inter-city collaboration through the sharing of initiatives related to the activities required for the achievement of SDGs, expand into local areas and explore the possibilities for contributions.

Regarding policies to tackle climate change, the path from low-carbon to non-carbon is becoming clearer and local needs are also changing rapidly. For example, in the field of transportation, technologies related to electrification and hydrogen are gaining more and more attention. The company has received appeals for non-carbon technology from Bali aside from the proposed businesses, and the utilization of micro-hydroelectric power and methane gas from waste materials is also attracting a lot of interest from the City of Semarang. For the development of JCM businesses capable of meeting such demand, it is desirable to understand needs, study the feasibility of installation and formulate plans through the Inter-City Collaboration Project.

The summary of the results of this survey and future business plans assuming the continuation of the Inter-City Collaboration Project are shown in the figure below.

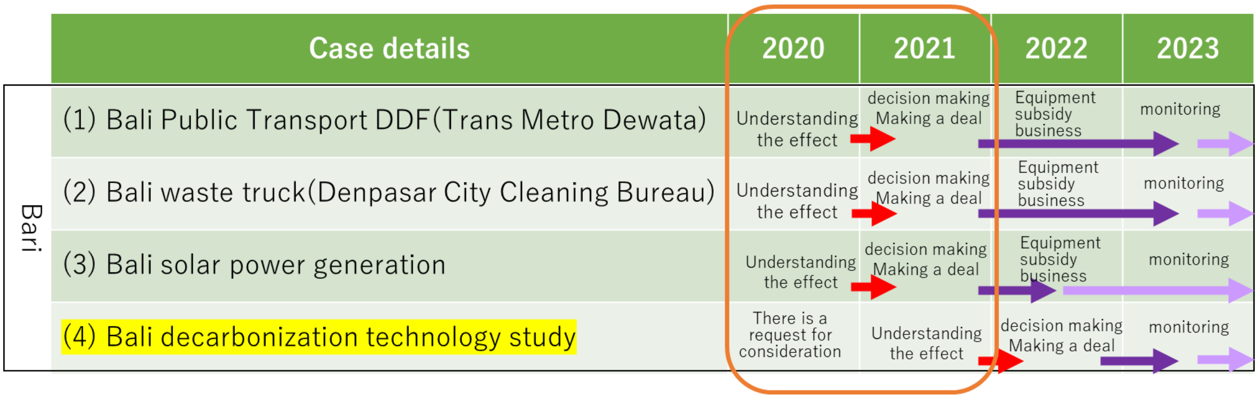
（1）Bali

・Summary of the Results

Project Candidate	**Economical performance [Years for Investment Recoupment]**	**CO_2 Emission Curtailment Amount [t-CO_2/PJ Period]**	**JCM Equipment Subsidy [Yen、USD]**	**Cost-Effectiveness [Yen/t-CO2]**	**Challenges and Future Policies**
Shift to DDF for Public Transportation (Trans Metro Dewata)	5	9,039	42,000,000 Yen	4,646	Future Policies: Consultation with Bali Transportation Agency and Trans Metro Dewata. Discussion on the execution system, budgets, and expenditure. Regarding gas supply, sharing the results of this survey with Pertamina Gas and asking for a decision on investment.
Waste Collection Vehicles (Denpasar Cleaning Agency)	5	2,165	48,400,000 Yen	22,358	Challenge: Low cost-effectiveness considering travelling distance. Future Policies: Consultation with Denpasar Cleaning Agency based on information on actual travel data, fuel consumption, garbage collection area, etc. Discussion on the execution system, budgets, and expenditure. Regarding gas supply, sharing the results with Pertamina Gas along with the study results of Trans Metro Dewata and asking for a decision on investment.
Bali Solar Power (1) Ministry of Finance Building	-	1,637	37,994 US dollars	2,437	Challenge ①: Problems with Initial Investment Future Policies: Proposal in tandem with initial investment cost curtailment measures such as Solar Power PPA
Bali Solar Power (2)	-	2,292	52,501 US dollars	2,405	

Denpasar Water Purification Plant Building					System. Consultation with PLN. Challenge ②: The scale at each site is too small. Future Policies: Creating proposals with multiple sites under the same owner (a national institution or municipality) will be considered. E.g., Integrating Denpasar City into a single project.
Bali Solar Power (3) Denpasar Reservoir Site	-	9,822	269,483 US dollars	2,881	
Bali Solar Power (4) Denpasar Disposal Site	-	4,518	124,555 US dollars	2,894	
Solar Power Total Amount	-	18,268	484,536 US dollars	2,785	

・Future Business Plans



(2) City of Semarang

・Summary of the Results

Project Candidate	**Economical performance [Years for Investment Recoupment]**	**CO_2 Emission Curtailment Amount [t-CO_2/PJ Period]**	**JCM Equipment Subsidy [Ten thousand Yen,]**	**Cost-Effectiveness [Yen/t-CO_2]**	**Challenges and Future Policies**
Shift to DDF for Flood Adjustment Pumps	9	1,406	1,600	11,379	Challenge: Lack of detailed data Future Policies: Continuation of data collection. In an effort to work toward decarbonization, installation of low-carbon technology other than DDF will also be considered.

Shift to DDF for Waste Collection Vehicles	7	2,818	4,200	14,905	Challenge: JCM System and the manufacturer selection due to public bidding. Future Proposal: To consider an appropriate system for JCM in cooperation with Infrastructure Companies like BPS in the City of Semarang.

・Future Business Plans

	Case details	2020	2021	2022	2023
Semarang	(1) Semarang City Flood Control Pump DDF (Public Works Bureau)	Understanding the effect	decision making Making a deal	Equipment subsidy business	monitoring
	(2) Semarang City Waste Collection Vehicle (Environment and Forestry Bureau)	Understanding the effect	decision making Making a deal	Equipment subsidy business	monitoring
	(3) Semarang City Solar power generation ・ renewable energy	On hold	decision making Making a deal	Equipment subsidy business	monitoring