Project commissioned by the Ministry of the Environment in FY2021

FY2021 City-to-City Collaboration Programme for Zero-Carbon society （Support Project for Developing a Sustainable Eco-friendly Smart City: An Intercity Collaboration between Toyama City and Male’ City）

Report

March 2022

Japan NUS Co., Ltd.

Toyama City

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Table of Abbreviations

Abbreviation	English
ADB	Asian Development Bank
Avgas	Aviation Gasoline
BOG	Boil off gas
BRT	Bus Rapid Transit
CDM	Clean Development Mechanism
CHEC	China Harbour Engineering Company Ltd
CNG	Compressed natural gas
EPC	Engineering, Procurement and Construction
EV	Electric Vehicle
FCF	Free cash flow
FIT	Feed in Tariff
FSRU	Floating Storage and Regasification Unit
GEF	Global Environment Facility
GHG	Green house gas
IRR	Internal Rate of Return
JCM	Joint Crediting Mechanism
JFJCM	The Japan Fund for the Joint Crediting Mechanism
LNG	Liquefied Natural Gas
LPG	Liquefied petroleum gas
LRT	Light Rail Transit
MATI	Maldives Association of Tourism Industry
MMA	Maldives Monetary Authority
MMBtu	Million British thermal unit
MoED	Ministry of Economic Development
MoEn	Ministry of Environment of the Maldives
MoF	Ministry of Finance
MRT	Mass Rapid Transit
MRV	Measurement, Reporting and Verification
NDC	Nationally Determined Contributions
ODA	Official development assistance
PMS	People mover system
PPA	Power Purchase Agreement
PV	Photovoltaics
SAP	Strategic Action Plan
STELCO	State Electric Company Limited
TA	Technical Assistance
UNFCCC	United Nations Framework Convention on Climate Change

1. Purpose and background of the task

1.1. Purpose

The Paris Agreement, which entered into effect in November 2016 and entered the implementation phase in 2020, calls for the acceleration of climate change measures by non-governmental entities, including municipalities and cities, in addition to the central government. In addition, the "Online Platform Ministerial Meeting on Recovery from the COVID-19 and Climate Change/Environmental Preparedness" held in September 2020 also confirmed the need for decarbonization policies for local governments with activities directly related to communities and the importance of local community-led development approaches. In Japan, too, the government has declared its goal of reducing greenhouse gas emissions to zero by 2050, aiming for a decarbonized society, and the number of municipalities declaring virtually zero CO_2 emissions has skyrocketed to over 300.

Thus, the role of cities and local governments in considering and implementing specific local climate change measures and projects is becoming increasingly important. To realize a decarbonized society all over the world, it is necessary to accelerate the movement toward building a sustainable decarbonized society, especially in Asia where economic growth is remarkable. There is a growing international movement to support the efforts of cities to decarbonize and lower the carbon footprint of their activities, as these cities are the places that support social and economic development.

In addition, under the current situation of the spread of the novel coronavirus, cities have to deal with the challenges related to the spread of the infection and at the same time readjust and consider new measures to achieve sustainable development, and thus collaboration among cities to build new methods and new cities is extremely important.

In this project, Japanese research institutes, private companies, and universities, together with Japanese cities that have experience and know-how in building a carbon-free and low-carbon society, will conduct a research project to support overseas local governments in their efforts to build a carbon-free and low-carbon society, to realize a carbon-free domino, and to introduce equipment that will contribute to shaping a carbon-free and low-carbon society.

Based on the above, this research work for the Maldives was conducted in Malé, the capital city of the Maldives, which is significantly affected by climate change. The purpose of this research work is to discuss the establishment of a sustainable environment-friendly city based on the excellent environmental technologies and knowledge possessed by companies in Toyama City in cooperation with Toyama City.

1.2. Background

The Maldives is a small island nation consisting of about 1,200 atoll islands of various sizes, and is vulnerable to sea-level rise and natural disasters due to climate change. Therefore, the direct impact of global warming on the living environment and the impact on tourism and fishery, which are the main industries, will be enormous. Therefore, as a mitigation measure, the Maldivian government has made a "Carbon Neutral Country" declaration to achieve zero net emissions by reducing the use of fossil fuels and curbing greenhouse gas emissions. The government has set an ambitious goal of making 60% of the electricity on all Maldivian islands come from renewable energy sources, but this

goal is still far from being achieve [1].

In the Maldives, one-third of the population, or 145,000 people, reside in the Greater Malé Metropolitan Area, among which Malé Island, which houses government offices, diplomatic missions, and other capital functions, is known as one of the most densely populated areas in the world. To disperse this overcrowding and to accommodate the expected refugees from the islands that will be submerged in the future due to rising sea levels, the construction of a 4 km^2 artificial island, Hulhumalé, began in 1997. So far, 4.28 km^2 of area has been developed, and it is expected that 240,000 people will move to the area in the future. The area is divided into Phases I and II according to the stage of development, with 60,000 to 65,000 people currently living in Phase I, where reclamation and development are largely complete. Phase II, which is under development, has completed high-rise housing and will soon have 30,000 people moving in [2].

The city government of Malé is planning to develop the Hulhumalé area as a smart, compact, and environment-friendly city, and has requested the support of Toyama City, which is a city of the future, in terms of renewable energy, waste disposal, transportation infrastructure, energy conservation, and institution building, all of which are essential for environment-friendliness.

The connection with Toyama City came about through a training course on inter-city collaborative projects for the realization of a low-carbon society organized by the Ministry of the Environment, which was held in Toyama City in November 2019. The Hulhumalé Housing Development Cooperation (HDC) of Malé City, which participated in the training, has shown great interest in Toyama City's policies regarding compact cities, mainly the LRT (Light Rail Transit: a next-generation tram system, hereinafter "Light Rail"), and the environmental technology possessed by companies in Toyama City, and requested the Embassy of Japan in the Maldives to provide support. In response, in January 2020, the Ambassadors of the Embassy of Japan in the Maldives and the Embassy of the Maldives in Tokyo paid a courtesy call on the Mayor of Toyama City and confirmed their intention to work together.

In FY2020, as the first year of the inter-city collaboration project, the traffic situation, energy consumption situation, waste generation situation, and related policies in Malé were collected for planning and study, and a system of collaboration was established with the HDC and related ministries.

2. Overview of the Maldives and Malé City

2.1. Basic information [3]

The Maldives is an island nation in the Indian Ocean, located southwest of India. It has an area of 298 km^2, which is about half the size of Tokyo's 23 wards, and is an island nation consisting of 1,192

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[1] Ministry of Housing & Environment Male', Republic of Maldives TOWARDS CARBON NEUTRALITY URL:https://www.climateinvestmentfunds.org/sites/cif_enc/files/meeting-documents/3._maldives_salle_south_africa_-_srep_meeting_final_2_0.pdf

[2] Mainichi Asia Business Research Institute, "Feature: Maldives, Pearl of the Indian Ocean on the Move" （https://mainichi.asia/2108maldives_hdc/）

[3] Website of the Ministry of Foreign Affairs of Japan: Basic Data of the Republic of Maldives （https://www.mofa.go.jp/mofaj/area/maldives/data.html）

islands.

The population is 534,000, of which 373,000 are Maldivians and 161,000 are foreigners. The main industries are fisheries and tourism, with a GDP of US$5.7605 billion and a GDP growth rate of 5.9%.

The fisheries sector accounts for 5.1% of GDP, but accounts for 6.9% of employment and 96% of export products (2018). The main species of fish are bonito (53% of the total landings) and tuna (38% of the total landings), and bonito flakes are also produced as a specialty product.

Tourism is the main source of foreign currency earnings, accounting for about 20% of the GDP. 145 out of 1192 islands in the country are resort islands based on the "One Island, One Resort Plan." The country received 1.48 million tourists in 2018, with China (283,000 tourists), Germany (117,000 tourists), and the UK (114,000 tourists) being the top visiting nationalities. Japan ranked ninth with 42,000 visitors.

As for the relationship with Japan, it is a traditionally pro-Japanese country and maintains friendly and cooperative relations through cooperation in the international arena. The Maldives is located at a strategic point on Japan's sea lanes and has geopolitical importance. Therefore, it is our policy to support the Maldives in overcoming its development challenges as a small island nation, and to achieve sustainable economic development and further socio-economic development through effective and efficient use of ODA. In the country assistance policy for the Maldives, the basic policy of assistance is to "address vulnerabilities and support sustainable economic growth," and the priority areas are "development of local industries" and "environment, climate change countermeasures, and disaster prevention.

2.2. Government of the Maldives

The political system of the Maldives is republican and the head of state is President H.E. Mr. Ibrahim Mohamed Solih as of 2022. Under the president, the vice president and the attorney general are appointed, and there are 19 ministries in charge of administration.

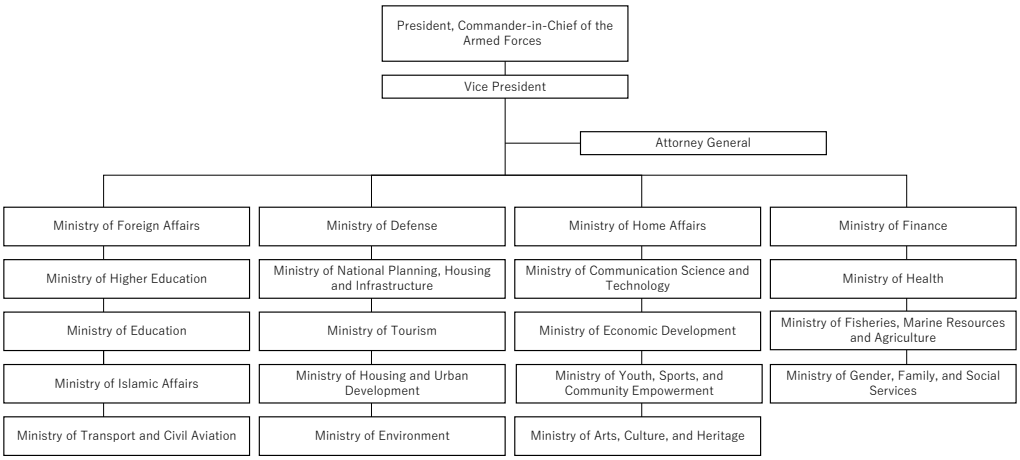

Figure 2-1 National governance structure of the Maldives[4]

[4] Prepared by JAPAN NUS CO., LTD from "The cabinet," the website of Maldives Presidential

Local governments have long been governed under a centralized system. Specifically, during the Maumoon Abdul Gayoom administration (1978-2008), the administrative sector consisted of 20 administrative atolls, with the central government in Male assuming administrative authority.

The government of Mohamed Nasheed, which came to power in 2008, attempted to decentralize the government and established 189 electoral districts in 7 provinces, 17 atolls, 4 cities and 189 islands.

A city is considered to be an area with a population of 10,000 or more, and is responsible for forming a city council, exercising local administrative authority, communicating with the central government, and managing uninhabited islands and resorts within the designated area. The currently enacted cities are Malé, Addu, Hvamla, and Kulhudusi.

As an administrative division, "atolls" are islands within the geographical division of atolls, each of which has its own administrative island council that gathers to form the Atoll Council, which manages the uninhabited islands and resort islands within the district, and also plays the role of communicating with the central government. Island councils have been established on each of the 189 inhabited islands, and are responsible for the island's administration.

2.2.1. Major policies and measures

The mainstay of policies and measures in the Maldives is the Strategic Action Plan (SAP), which is a five-year plan. The plan is currently in its implementation period from 2019 to 2023 and is positioned as the central policy framework and written plan that will guide the direction of development in the Maldives over the next five years.

SAP also integrates the government manifesto with existing sector priorities and has a monitoring function to track the progress of government policies and development priorities. It has just been formally rolled out to the operations of relevant ministries and agencies on October 1, 2019.

SAP is composed of five main sectors: Policy, Target, Strategy, and Action, with 33 sub-sectors.

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https://web.archive.org/web/20150920062619/http://www.presidencymaldives.gov.mv/Index.aspx?lid=16

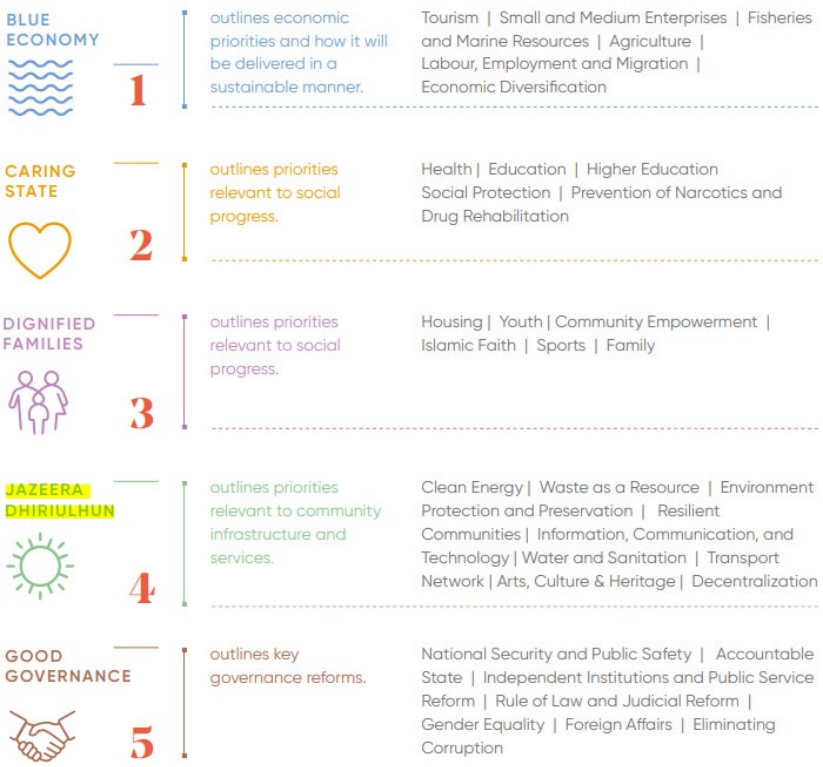


Figure 2-2 Five major policy sectors and subsectors in SAP

Source: Prepared by NUS Corporation based on the Strategic Action Plan [5]

2.2.2. Environmental problems and countermeasures in the Maldives and Malé City

In 1987, an "unusually high tidal wave" in the Indian Ocean flooded a quarter of the urban area of Malé, the capital of the Maldives, flooded farms, and swept away landfills with water. At the UN General Assembly that year, Maldivian President Maumoon Abdul Gayoom made the first proposal to the international community on the need to tackle climate change [6]. In his argument, President Gayoom cited scientific evidence that "human activity releases greenhouse gases that cause global warming, which in turn causes glaciers to melt and seawater to expand, ultimately raising the world's sea level. Subsequent surveys and studies have revealed that the Maldives, where 80% of the land area is less than one meter above sea level, is at risk of being submerged if global warming is at its most severe. Since then, the Maldives has positioned global warming as an issue that leads to national security and has embarked on countermeasures.

First of all, the construction of the artificial island of Hulhumalé began in 1997 as a countermeasure against rising sea levels that could lead to the nation's destruction. Originally, the main purpose of the project was to create a migration site from the overcrowded Malé, but it was also intended as a relocation site in the event that future sea-level rise forces people to move [7]. In addition, as mentioned

[5] Government of Maldives, "Strategic Action Plan 2019-2023" (https://presidency.gov.mv/SAP/)

[6] Janet Larsen, Earth Policy Institute, Plan B Updates,「Rising Seas and Powerful Storms Threaten Global Security」, OCTOBER 09. 2008. (https://www.earthpolicy.org/plan_b_updates/2008/update76.html)

[7] Asahi Shimbun, "Maldives moves ahead with expansion to double artificial island area to accommodate

above, the government has set a policy to become carbon neutral by 2020, and has been promoting renewable energy expansion programs and other initiatives to support this goal [8] The history of the creation of Hulhumalé Island is shown below.

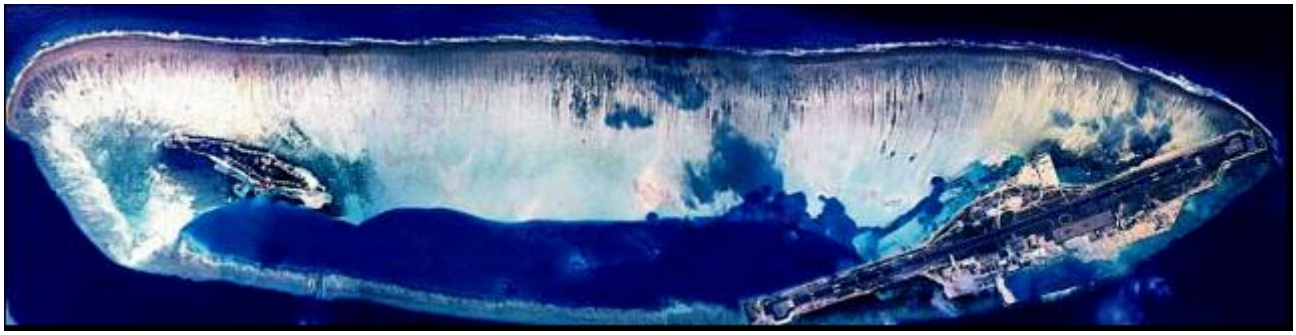


Figure 2-3 Hulhumalé Island before reclamation in 1997

Figure 2-4 Hulhumalé Island in 2015 (the reclaimed area in the center is Hulhumalé Phase I)

Figure 2-5 Hulhumalé Island in 2018 (The reclaimed area on the left is Hulhumalé Phase II)

Source: Materials provided by HDC

In addition to measures against global warming, environmental measures such as coral reef conservation and measures against marine plastic waste are also being implemented from the perspective of preserving the marine ecosystem, which is a resource for the tourism and fishing

migration," March 21, 2018
(https://www.asahi.com/articles/ASL3P41DTL3PULBJ002.html)

[8] Dr. Maryam Shakira, Minister of Environment and Energy, Republic of Maldives, "Climate Change and Coral Reef Conservation," Panel Discussion at the International Conference on Global Warming Prevention and Coral Reef Conservation - Islands and Island Nations in Coexistence with Nature: From the Perspective of Global Warming Countermeasures and Coral Reef Conservation - Presentation Material, 2013
(https://www.env.go.jp/nature/biodic/coralreefs/iccccrc2013/pdf/year2013629/panel/mariyam.pdf)

industries that account for 90% of the Maldives' GDP[8].

The city of Male, which is the subject of this study, has a population of about 145,000, which not only has about 1/4 to 1/3 of the total population of the Maldives, but also accommodates a large number of foreign workers. In addition to being the political and economic center of the Maldives, it is also a trading port that receives imports to the islands. From the perspective of energy consumption and waste issues, it can be said that Malé has a large contribution to the entire country of Maldives, and therefore the urgency of the measures is high.

A kickoff meeting was held between Toyama City, the Ministry of Environment of the Maldives, Male' City and HDC to discuss the environmental issues in the Maldives and Male' City[9], and the following major issues were identified.

1. **Climate change mitigation**: Climate change mitigation policies are needed in the Maldives. Although CO_2 emissions are not high on a global scale, diesel fuel accounts for 99% of the energy used, and it is necessary to replace it with energy with lower CO_2 emissions. The project is also considering plans to use LNG in the future, and has already introduced and promoted the use of solar power generation. In addition, an energy plan (roadmap) is scheduled to be completed soon, and the plan is to promote decarbonization with an eye to utilizing waste power generation and ocean energy.
2. **Coping with climate change**: vulnerability to the impact of climate change, such as coastal erosion and tsunamis.
3. **Public transportation problems**: Public transportation infrastructure is inadequate. In particular, the city of Malé has a heavy traffic volume, and the lack of parking space and air pollution caused by exhaust gas is a problem.
4. **Waste problem**: In the Maldives, waste is currently collected in each of the five districts, but there are problems with collection and disposal. The waste will be incinerated at a waste power plant to be built on the Tirafushi Island.

The Maldives has been actively accepting support from international organizations and foreign countries for implementing measures to address these major environmental issues. In Japan, the Asian Development Bank (hereinafter referred to as "ADB") is planning to contribute funds to a waste power generation project on the Tirafushi Island in the capital region of Malé through the JFJCM (Japan Fund for JCM), which applies the JCM system to loans from ADB. In addition, Japan and the Maldives concluded the Low Carbon Growth Partnership in 2013 as an eligible country for the JCM equipment subsidy project, and have been promoting the spread of excellent low-carbon technologies by establishing the JCM Joint Committee. In July 2019, they decided to issue the first JCM credit in the Maldives for a 15-month monitoring period from 2017 to 2018 for the "Project for Installation of Photovoltaic System on School Building Roofs".

In this project, Toyama City is expected to cooperate in the efforts to achieve further low-carbon

[9] Implemented by Microsoft Teams on October 8, 2020.

and decarbonization, and we will work together to promote the project mainly through the JCM equipment support program.

2.3. Background of cooperation with Toyama City

The background to the implementation of the research project in the Maldives under this inter-city collaboration is as follows.

In November 2019, the HDC of the City of Malé participated in a training course on inter-city collaborative projects held in Toyama City (training course sponsored by the Ministry of the Environment and IGES, "Training on Inter-city Collaborative Projects for the Realization of a Low-Carbon Society"), and showed great interest in learning about Toyama City's efforts to achieve a decarbonized society and its renewable energy and energy-saving technologies, in addition to its excellent transportation systems such as Light Rail. Subsequently, expectations for the inter-city collaboration project were raised by Malé City, and in January 2020, the Japanese Ambassador to the Maldives and the Maldivian Ambassador to Tokyo paid a courtesy visit to Toyama City and exchanged opinions with Mayor Mori. During the discussion, the following needs were identified, especially for the development of the Hulhumalé area: improvement of public transportation, low carbon emission through the use of gas, optimization of energy consumption through the dissemination of energy-saving technologies, and introduction of technologies such as energy utilization for waste disposal. In response to this, information was disseminated to the companies involved in the design and construction of the light rail in Toyama City, as well as other companies in the city that have low-carbon technologies, to gain expressions of interest and build a system of support by Toyama City and the companies in the city.

In March 2020, discussions with Malé City were scheduled to conclude a cooperation agreement and further specify each project, but this could not be realized due to the spread of the novel coronavirus. However, with the cooperation of the Embassy of Japan in the Maldives, discussions were held remotely on getting expressions of interest and the specifics of each project, which led to the proposal and adoption of the project, and this year is the second year of the three-year project.

Training on the City-to-City Collaboration for Creating Low-carbon Society held in Toyama city in 2019 [10]

Ambassadors pay a courtesy call to the Mayor of Toyama City (January 2020)

Figure 2-6 Activities leading up to inter-city collaboration in Toyama City and Malé City

When considering decarbonization measures for local governments, it is essential to collaborate with agencies that have regulatory and management authority over urban planning and development. Usually, these authorities and roles are given to municipalities, but in the Malé metropolitan area, the agency responsible for development planning and regulation is the HDC, a state-owned company with 100% state capital. The HDC was also merged with the Malé Metropolitan Industrial Corporation in 2020, and was given the authority to develop and manage the islands of Grifal and Tirafushi, which will be developed as industrial sites. In this way, it plays a role in planning and formulating a vision for the development of the Malé metropolitan area, as well as providing some of the infrastructure investment, as well as regulatory and administrative services.

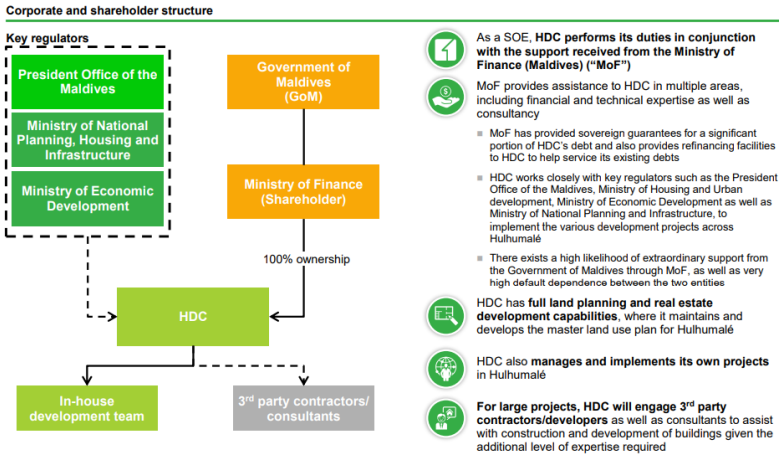
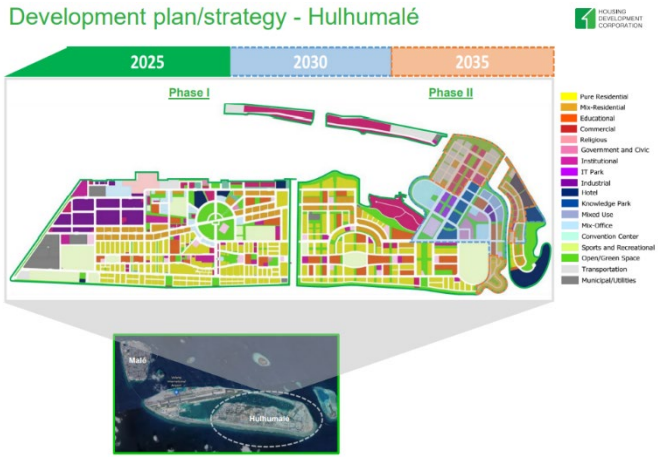
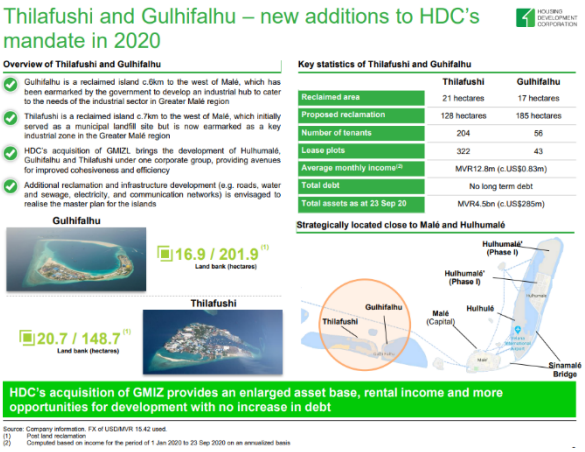


Figure 2-7 Structure, roles and powers of the HDC

Source: Material provided by HDC

[10] Website of IGES (https://www.iges.or.jp/jp/events/20191127)





Development plan of Hulhumale　　Development plan of Thilafushi

Figure 2-8　Formulating a master plan for HDC development

Source: Material provided by HDC

In the Toyama City Inter-city Cooperation Project, the city has decided to promote support for decarbonization by sharing policy recommendations, achievements, and experiences, and introducing owners of decarbonization technologies, etc., in cooperation with the HDC, which has such a role and authority in the Malé metropolitan area, as well as with related ministries and agencies and Malé City. In addition, the HDC has formulated a policy to deal with environmental issues including decarbonization, and through this inter-city cooperation, we plan to discuss the formulation of a more committed policy equivalent to Toyama City's decarbonization declaration.

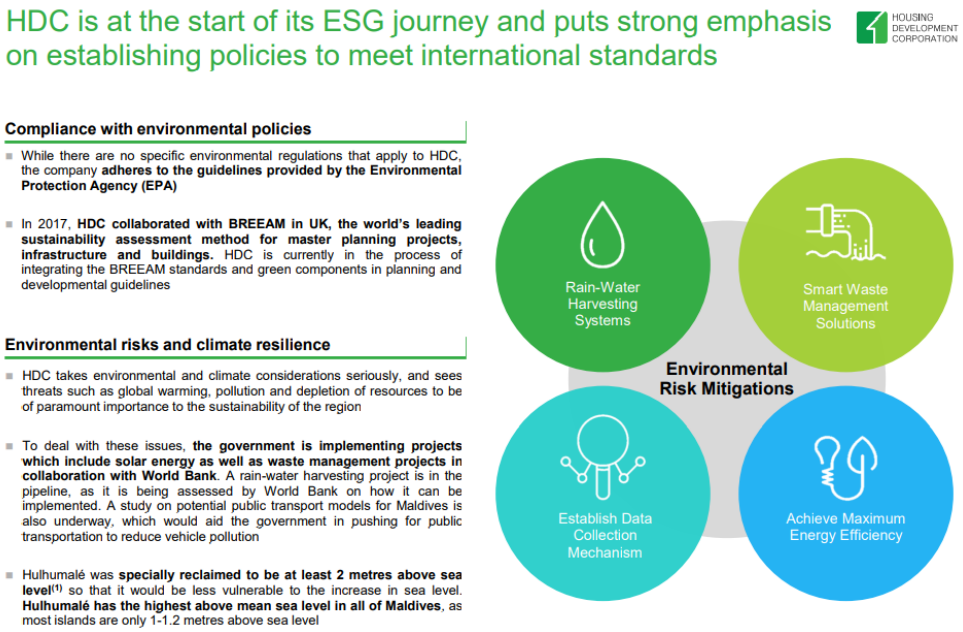


Figure 2-9　HDC's policy for addressing environmental issues

Source: Material provided by HDC

3. Discussion on JCM project formation

In this study, the following activities were carried out to reduce greenhouse gas emissions and form JCM projects that contribute to the reduction of greenhouse gas emissions in the areas of transportation-derived CO_2 emissions reduction by improving public transportation, low-carbon power generation by changing the fuel used for diesel power generation facilities to natural gas, renewable energy promotion, and low-carbonization through the recycling of organic waste, as measures against climate change in Malé City, mainly in the Hulhumalé area.

(1) Mitigation of CO_2 emissions from transportation by improving public transportation
(2) Low-carbon power generation through change of fuel for diesel power generation facilities
(3) Low-carbonization through the promotion of renewable energy
(4) Low-carbonization through the recycling of organic waste

In FY2020, the first year of the project, we collected information that will serve as the basis for these studies and examined the feasibility of the project in consultation with related organizations. This year, based on the results of the survey, we have organized the results in more detail.

Chapters 3.1 to 3.4 below show the contents and results of each study.

3.1. Mitigation of CO_2 emissions from transportation by improving public transportation

In the Maldives, including the Malé metropolitan area, public transportation is inadequate, and many residents own motorcycles and cars. As a result, the roads are becoming increasingly congested and narrow due to the parking of cars. In addition, as the number of cars increases, the rate of CO_2 emissions is also on the rise, and there is a need to develop more efficient and low-carbon means for public transportation.

Against this backdrop, the HDC, which is responsible for the development policy of the Hulhumalé Island, showed great interest in the adoption of the light rail system, which is a pillar of Toyama City's compact city policy.

The reason for this, according to the HDC, is that "although the population of the Hulhumalé Island is currently 45,000, 160,000 people are expected to migrate from the Male Island, and most of them are expected to commute to the Male Island and other places, which may worsen traffic congestion and increase CO_2 emissions in the transportation sector, thus making urgent low-carbon public development necessary."

Also, there is a strategy to meet tourism demand mainly in the Hulhumalé area by developing new tourist spots on the Hulhumalé Island, as the flow of tourists has been from the airport directly to the resort. There are also plans for business centers, research centers, and other facilities to meet business demand. Therefore, it will be essential to improve the public transportation system to improve access to travel and accommodation for tourists and business travelers.

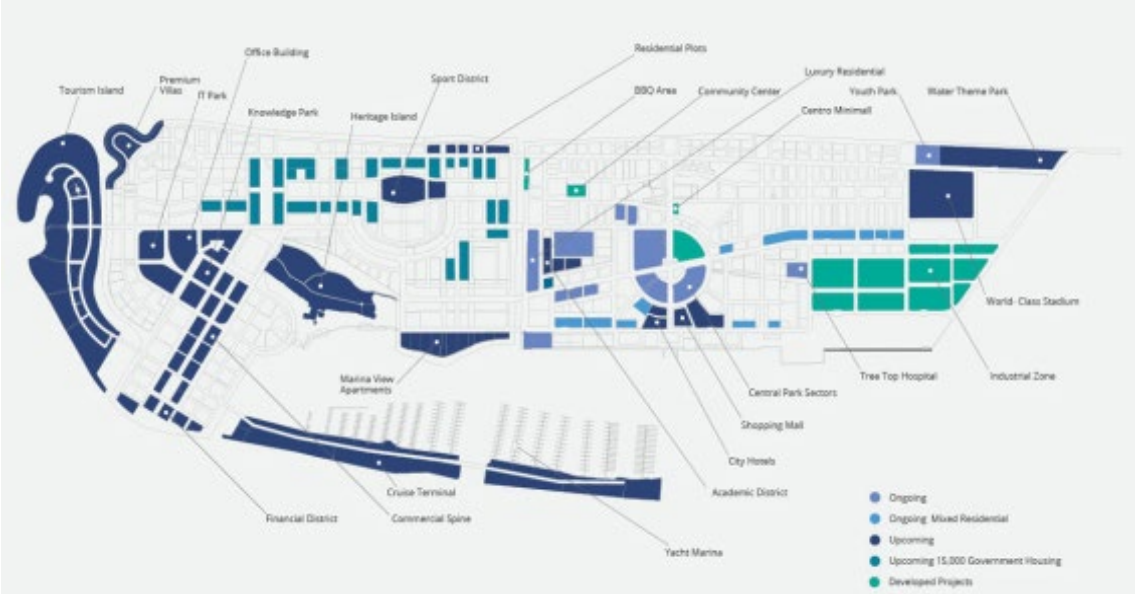


Figure 3-1 Plan for developing tourism and business facilities in the Hulhumalé Island

Source: Material provided by HDC

In the survey in 2020, the possibility of adopting the light rail was examined, but as detailed in the next chapter, it was found that it may not necessarily be an appropriate option given the size of the Hulhumalé Island, the number of people to be transported, and the construction period.

Therefore, in this fiscal year's work, the following items were investigated, and the possibility of

introducing the most appropriate means of transportation was sorted out and examined using both long-term and short-term approaches.

(1) Optimal public transportation study and policy for developing a transportation master plan as a long-term measure (3.1.1)

-Regarding the current public transportation situation found from last year's work (3.1.1 (1))

-Transportation master plan development policy review (3.1.1(2))

(2) Decarbonization of public transportation as a short-term measure (3.1.2)

-Coordination with new public transportation sector decarbonization projects (3.1.2 (1))

-The existing public transportation decarbonization projects (3.1.2 (2))

3.1.1. Optimal public transportation study and policy for developing a transportation master plan as a long-term measure

(1) Regarding the current public transportation situation found from last year's work

In the survey conducted in FY2020, policy documents such as development plans for transportation in the Maldives were collected from websites, Malé City, local cooperating organizations, etc. and organized. After understanding transportation systems and policies as well as public transportation plans and policy goals, we examined policies and institutional promotion measures for the adoption of the light rail.

In the Maldives, the SAP, which presents the government's development goals and priorities, includes the following points on transportation as a policy (Policy 3) and targets (Target 3.1 and 3.2).

・To reduce vehicle congestion by 30% in the capital city of Malé from 2018.

・In the capital city of Malé, at least 60% of the population use public transportation on a daily basis.

To achieve these goals, the strategy (Strategy 3.2) is to promote efficient public transportation systems in Malé Metropolitan District.

The report that served as the basis for the discussion of the policy first mentions the growth rate of cars and motorcycles. The growth rate since 2000 is estimated to be 10% per year, and the total number of internal combustion engine vehicles as of 2012 is reported to be 556,497.

Since the completion of the bridge connecting the Malé Island to the Airport Island and the Hulhumalé Island, which was built after the publication of this report, the number of privately owned cars as a means of land transportation is expected to increase further.

This increase in the number of cars and motorcycles easily causes traffic congestion in the Malé metropolitan area, where land is small, and is considered a major urban challenge for the Malé metropolitan area.

In response to this situation, the Maldivian government and Malé City have been studying the solution of transportation issues through the adoption of public transportation as the People Mover

System (hereinafter referred to as "PMS"). This is related not only to the worsening traffic situation caused by the increasing number of motorcycles and cars, but also to the goals for low-carbon and decarbonization in the transportation sector. As for specific public transportation systems, a monorail and a light rail are being considered. Related plans include the "Hulhumalé Phase 1 and Phase 2 Master Plan & Urban Design Review 2015," which proposes to operate the PMS on a one-way "circulation" route. However, the rationale behind the proposed route or why it was chosen as a "circular" route is not stated, and whether the route plan is in line with people's demand is open to examination. In addition, the economic or financial evaluation has not been completed.

Figure 3-2 Route map proposed in the "Maldivian Transport Master Plan Study"

Source: Material provided by HDC

In addition, there is the "9+6" Greater Malé program, which is a comprehensive development plan for the Greater Malé region, centered on the Malé Island, that runs until 2050. This plan calls for the construction of a bridge connecting the four islands (west: Villingilli and Gulhifalhu, east: Hulhulé, Hulhumalé) with the capital city of Malé at the center, as well as a bridge between Thilafushi and Gulhifalhu in the west. Each island is characterized by its clearly defined role, as the Gulhifalhu Island will serve as a hub for cargo transportation to other islands and Hulhumalé is positioned as a residential island.

Figure 3-3 Plan for bridge connections in the Greater Malé region

Source: Material provided by HDC

This positioning is called the "7+1" island center program, and the following land-use policies are outlined for each island as a development plan until 2050.

Malé

- Keep the population within 120,000.
- Relocate the cargo port to the west and move some of the residents to the east.

Villingilli

- Planned to be a cargo warehouse area
- Population expected to be 15,000.

Hulhulé

- Planned to be a business and airport area (transportation hub)
- Expectations for job creation

Hulhumalé Ⅰ

- Planned to be a residential area
- The population is expected to be 60,000.

Hulhumalé Ⅱ

- Construction began in 2014. Planned to be a residential area
- Population expected to be 100,000.

Gulhifalhu

- It will be a port, warehouse, and mini-industrial area.

Funadhoo

- It will be a tourist industry and entertainment facilities area.

The new bridge is to be built by India's ODA and is expected to be completed in 2023 [11]. As mentioned above, since residential, industrial, business, and other centers are connected, it is effective to predict and cover travel to each island rather than just to the Hulhumalé Island in the assumption of public transportation. With these predictions in mind, this study examined the possibility of decarbonizing buses, which have already been introduced and are functioning as public transportation.

(2) Review of the results of last fiscal year's survey and the outline of the Transportation Master Plan

As mentioned above, the HDC, which is the company in charge of the Hulhumalé development, visited Toyama City during the 2019 JCM Intercity Cooperation Seminar and was interested in the city's convenient public transportation based on the light rail system, which led to the request for

[11] NEXT IAS," Greater Malé Connectivity Project (GMCP)."
https://www.nextias.com/current-affairs/27-08-2021/greater-mal-connectivity-project-gmcp

cooperation in the Hulhumalé development.

On the other hand, the development of public transportation needs to be linked to local development plans and policies and introduced in a purposeful manner, for which careful forecasting and planning are essential.

Let's take a look back at the history of light rail development in Toyama City. Toyama City has positioned the development of the light rail system as a solution to the problems of the declining birthrate and aging population, dependence on automobiles, and depopulation of the city center. The city has made efforts to improve the convenience of public transportation in the city by using the light rail system as a core project to realize "compact city development," which has resolved traffic congestion, improved the value of the city center, and raised land prices. Mayor Masashi Mori, who has served as mayor of Toyama since 2002, has personally led these projects, establishing the publicly- and privately-owned Toyama Light Rail Co. and promoting about 30 related revitalization projects, including the "Grand Plaza Development Project," the "City Train Loop Project (Centrum)," and the "Machinaka Residence Promotion Project."

The decision was made to convert the Toyama Port Line to a light rail system as a step toward shifting from automobile-dependent urban development to "compact urban development based on public transportation." This is because the use of public transportation, such as streetcars, is essential to Toyama City's urban development plan, which aims to connect urban areas scattered throughout the region by public transportation, and to create a clustered urban structure "dango-to-kushi" (dumplings and skewers) rather than a concentrated urban structure. In addition to reusing abandoned railway lines, the city of Toyama has taken on the responsibility of supporting the project by purchasing the railcars and leasing them to the operating company, thereby avoiding the cost burden.

Thus, in addition to a strong policy backing for public transportation, it is important to choose the most appropriate model of transportation based on local issues and future visions.

For the introduction of a light rail to be effective in the Hulhumale area, it is important to further clarify the current master plan and examine the most appropriate way to implement it in light of the policy goals. Based on this understanding, the following steps were proposed to the HDC as a review procedure in the study.

1. Select the best means of transportation for Hulhumalé
2. Survey the current situation and analyze the effects of the introduction of the system
3. Develop a master plan for implementation
4. Detailed survey and design
5. Equipment procurement (use of the JCM system)

The process for producing a general public transportation master plan is as follows.

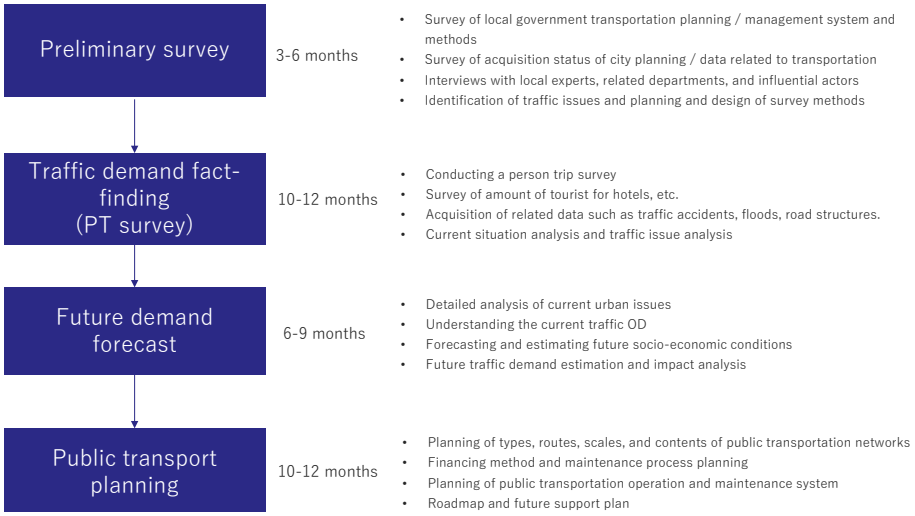


Figure 3-4 Process for Producing a Public Transport Master Plan

Source: Compiled by Dainippon Consultants Co.

Table 3-1 below shows some of the common public transportation options.

Table 3-1 Public transportation options

format	subway	monorail	LRT (elevated)	LRT (ground)	Bus (guideway)
Feature	Dedicated track by tunnel or viaduct Massive high-speed railway that runs	Orbital transportation that guided by a single rail	Light rail transit which runs on a dedicated track on the viaduct	Light rail transit which runs in orbit on the ground (road or open space)	A new transportation system that realizes semi-automatic driving that does not require steering operation by tracing this on a dedicated track equipped with a guide rail with a guide wheel. It can also be used as an ordinary bus on general roads
Example		Haneda	Yurikamome	Toyama	Nagoya
					
Advantages	Mass and high-speed transportation is possible	It is easy to elevate and only little space required. Little noise and vibration, and no gas emission.	Because it runs on a dedicated elevated track, there is no traffic congestion and accidents. The construction cost of the track structure can be saved by reducing the size and weight of the vehicle,	The ratio of dedicated tracks is high, and the operation is not easily affected by traffic. Larger transportation capacity than trams by forming several cargos	It will not be caught in traffic by separating it from other road. Barrier-free can be achieved by eliminating steps.
Disadvantages	High construction cost and long time required for construction work	Vehicles are more expensive and have less capacity compare with ordinary railways	Transportation volume is small and speed is slow for the construction cost	More expensive than trams	If will not reduce carbon emission unless switch it to electric or hydrogen buses.
Maximum transport capacity (person / hour / one way)	64,000	21,000	16,000	11,000	4,000
Profitability					
Construction cost	25-30 billion yen / km	8.5-14.5 billion yen / km	8.5 to 16.5 billion yen / km	Approximately 3.5 billion yen / km	Approximately 5 billion yen / km
Vehicle cost	Included	Included	Included	Approximately 300 million yen / both	Approximately 80 million yen / both
Operation cost				Approximately 610-840 million yen / 10km	Approximately 300-530 million yen / 10km

format	Bus (ground-only lane)	Bus Rapid Transit(BRT)	Share bike	SKYWAY
Feature	A transportation system that secures a dedicated driving lane and performs high-speed transportation	A system that can flexibly respond to road conditions by combining improvements such as driving routes, vehicles, stops, and fare collection based on fixed-route buses and driving in general lanes.	Environmentally friendly, safe, active and efficient sustainable transportation. Actively used overseas as a complement to public transportation	The system of SkyWay, a Belarusian start-up company. High-speed driving (150km / h) is possible with a mechanism similar to a cable car.
Example	Jakarta	Tokyo BRT		Dubai
				
Advantages	It does not get caught in traffic by separating it from other road. Barrier-free can be achieved by eliminating steps.	By introducing IC card systems and road improvements, it achieves transportation capacity, functions and flexibility, same as trams.	It is environmentally friendly and the introduction cost is low.	Construction cost is low. about 1/10 of monorail
Disadvantages	Wide road space is required because it requires a dedicated lane on the general road.	Since it runs on general roads, it may cause traffic congestion.	It is just a complement. The maintenance of bicycle parking lots and the separation from pedestrians can be an issue.	Transportation capacity is small. The capacity is 7 to 168 people (when connected).
Maximum transport capacity (person / hour / one way)		3,120		
Profitability				
Construction cost		50-700 million yen / km		
Vehicle cost				
Operation cost				

Source: Prepared by Sato Kogyo Corporation from a variety of material

Here is a summary of the Malé City plan. After discussing and exchanging views with the HDC on the above-mentioned study policies, it was found that the City of Malé has the following policy plans.

First of all, since the priority for public transportation should be the implementation of alternative means of transportation to bikes and cars, the policy was to give top priority to convenience for residents. While the cost of construction and operation will be taken into consideration, the top priority is convenience, and they wanted to design a route that would allow people to walk to the bus stop in four minutes, no matter where they live on the Hulhumalé Island. The standard of four minutes was based on the fact that the distance between stops in the transportation system is 200-300 meters (about five minutes walking distance), but given this distance between stops, it may be difficult to operate a light rail or tram because it is less than the acceleration/deceleration interval required for their operation. Therefore, given the distance of the stops, operation by bus becomes a more suitable means.

The advantage of bus operation is that it can also be used for inter-island travel. The city of Malé has a plan to connect all the islands in the Greater Malé region with bridges, as described above in the "9+6" Greater Malé program," and is considering a transportation network across these islands. With the construction of the bridges, they intend to make vehicles the main means of inter-island travel, and they also plan to reduce the amount of travel by boats.

The current bridge connecting Hulhumalé and Malé, and the planned bridge connecting Malé to other islands, are not expected to be equipped with steel tracks in terms of strength and road width, making it difficult to use light rail.

Even in the case of light rail installation only within the Hulhumalé Island, securing a temporary site for construction, in addition to the road width, will be an issue. For the Hulhumalé Island, while the Phase II site on the east side is available, the Phase I area on the west side has been already developed and inhabited by residents, making it difficult to secure a temporary site. In addition, a certain number of lanes must be maintained during the construction period to minimize disruption to existing traffic. Also, during operation, it is necessary to secure a yard (garage). Although land for the terminal has been secured for the current public bus service, it is necessary to secure land when considering a new means of transportation.

These studies are summarized as preliminary findings in the "TRANSPORT MASTERPLAN REPORT 2019. The report includes preliminary engineering studies on long-term planning, long-term road network development planning, bus and other transit networks, performance assessment of existing networks, economic and financial evaluation, staging decisions and their implementation, and transit system security. Four types of PMSs, BRT, MRT, LRT, and AGT, are discussed, and each is considered as an option.

The transportation characteristics needed for Hulhumalé include not being a mass transit system as seen in large cities in other countries, short distances between stations, and high frequency of use.

While this demand is currently being met by cars and motorcycles, the development of bus routes is highly suitable as a low-carbon alternative to these modes of transportation. In addition, while Hulhumalé is still in the process of development, residents are moving to the area and stores are

opening in parallel, and the area is already functioning as a city, so there are restrictions on the development of transportation infrastructure involving large-scale construction.

In addition, it is necessary to consider the movement characteristics of all the islands that can be accessed by land transportation, not only within Hulhumalé, but also on the islands of Male and Hulhulé, which are connected by bridges, and on the island of Tirafushi, which is scheduled to be connected by a bridge in the future.

Given this situation, it is assumed that decarbonization of bus routes already in operation and enhancement of convenience will be most effective.

On the other hand, in order to guide people to decarbonized public transportation, it was mentioned earlier that it is necessary to establish a policy as a master plan that takes into account urban development, land planning, and decarbonization policies, based on mobility characteristics based on in-depth surveys as mentioned above, and to promote various measures based on this policy.

Naturally, the challenge with such an approach is that it requires many steps, including research and policy decision-making, before results can be achieved.

For the smooth implementation of these studies, there is room to consider the use of the ADB's Technical Assistance (TA) program and other programs, including the financing required for the infrastructure development phase. However, to ensure sufficient connections with this inter-city collaborative project and room for the participation of the companies involved, it is desirable to use the Japanese technical cooperation program.

One possible Japanese technical cooperation program is the use of the JICA SATREPS program [12]. This is because the SATREPS program includes the "Smart Transportation Strategy for Realizing THAILAND 4.0" project as an example of a project that considers the formulation of a transportation master plan as an exit strategy. In order to curb the rapidly increasing CO_2 emissions from automobiles in Bangkok, the capital of Thailand, this project aims to contribute to the realization of policy planning that balances the elimination of traffic problems, the realization of a low-carbon society, and the improvement of the total happiness of citizens by utilizing ICT technology to integrate and visualize big data and 3D data on the digital earth and constructing a policy evaluation system based on the quality of life of citizens.

[12] International Science and Technology Cooperation Program to Address Global Issues. This is a 3-to-5-year research program conducted jointly by the Japan Science and Technology Agency (JST) and the Japan International Cooperation Agency (JICA) to conduct joint research with researchers in developing countries

Figure 3-5　Outline of the project "Smart Transportation Strategy to Realize Thailand 4.0"

Source: Material provided by Dainippon Consultants Co.

In addition to Dainippon Consultants Co., Ltd. which is participating in this inter-city collaboration project, the University of Toyama is also a member of the SATREPS program as a proposing corporation.

Therefore, it was decided to consider collaboration in conducting a similar research and development project based on the situation in the Maldives and promoting the formulation of a public transportation master plan, in parallel and in coordination with this inter-city collaboration project.

(2) Review of the policy for designing a transportation master plan

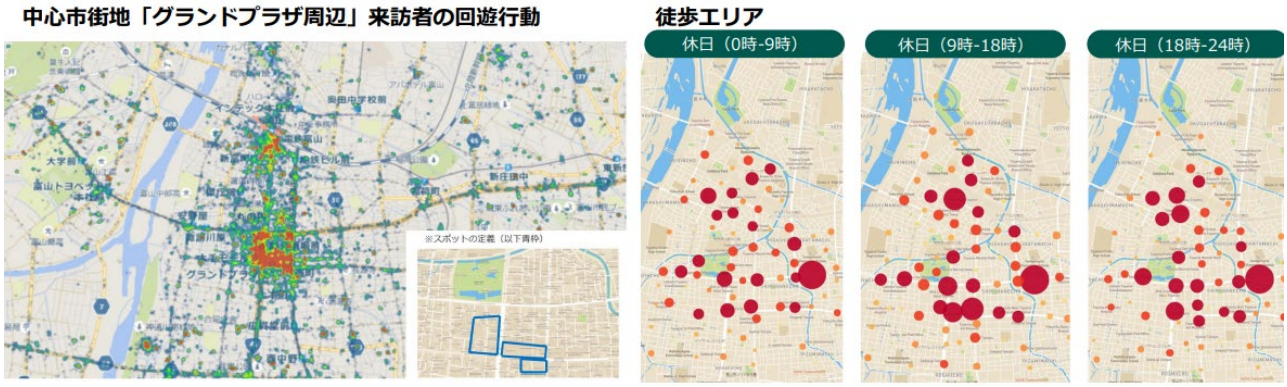
a) Understanding traffic dynamics and urban design

In formulating a master plan, it is essential to first collect data to serve as the basis for the plan to ensure the effectiveness of the plan in improving the convenience of public transportation and decarbonization, which are its main objectives.

However, in the Maldives, there is a lack of statistical information and insufficient data on transportation. In addition, the dynamics of the Malé Metropolitan Area are changing on a daily basis due to the start of resettlement associated with the Hulhumalé development, so caution should be exercised in referring only to fragments of data for a single point in time.

Considering this situation in the Maldives, the use of IoT-based traffic monitoring systems will be effective in understanding the traffic dynamics. In recent years, with the spread of smartphones, technology has been developed to safely acquire and use location data, etc., separate them from personal information, and there are examples of its use in traffic dynamics.

For example, in Toyama City, the Ministry of the Environment's Minister's Secretariat, Environmental Planning Division has commissioned a study on regional decarbonization measures using mobility data in FY2020: “Data-driven decarbonization city planning —Under the urban development strategy of Toyama City—”, the study was conducted to visualize the means of transportation to the area around Toyama Station, the living conditions of commuters and users of the Takayamamoto Line, and walking behavior in the area around Toyama Station using data on transportation, and to examine how the data can contribute to the various measures currently being taken.



(Left: visualization of migration behavior, Right: Walking area)

Figure 3-6　Example of a dynamic survey using IoT in Toyama City

Source: Ministry of Environment [13]

By collecting this kind of data in the Malé metropolitan area, it will be possible to understand the dynamics of people in real-time and on a continuous basis, in a way that is closer to the actual situation.

In the above-mentioned "Commissioned work for the study of regional decarbonization measures using mobile data: Data-driven decarbonized city planning," Beacon, a technology for locating smartphone devices using Bluetooth Low Energy, is used to collect location information. In Japan, unerry Inc. has developed an open platform in collaboration with several major apps, and is offering the service under the name "Beacon Bank."

Although no similar platform has been confirmed in the Maldives, Beacon technology essentially involves the detection and data accumulation of Bluetooth radio waves emitted from smartphone devices by Beacon devices (about several thousand yen/unit). Thus, it is first necessary to build a system to install devices at key locations and monitor the movement of devices.

Therefore, we examined the policy of using the SATREPS program to propose an urban design study that includes appropriate mobility selection, starting with the construction of a transportation database.

b)　Outline of the SATREPS program

In the international science and technology cooperation program, SATREPS, a proposal to derive an ideal urban design for the Maldives, which is facing not only transportation issues, but also climate change issues, may be in line with the purpose of the program.

Therefore, the SATREPS program is positioned as an urban design study that includes social experiments that contribute to the identification of issues and solutions, mainly in the area of transportation, from the perspective of climate change mitigation and adaptation. Based on the results of this study, the program aims to connect to technical cooperation and infrastructure exchange.

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[13] Digital Garage, Inc., "Commissioned work to study decarbonization measures for the region using mobile data－Data-driven decarbonization town planning," Business Report, 2021

Figure 3-7 SATREPS program framework and proposed exit strategy

Source: Material provided by Dainippon Consultants Co.

In addition to Dainippon Consultants, which is the co-proposer of this project, we interviewed Mr. Dai Nakagawa, Vice President of the University of Toyama, Department of Urban and Transportation Design, Faculty of Urban Design, who is also the supervisor of Toyama City's transportation policy.

Mr. Nakagawa, Supervisor of Transportation Policy, has a research field of urban policy and transportation policy, and has a track record of research on advanced urban transportation systems that generate urban vitality and the policies necessary to realize their implementation. He is also well versed in public transportation policies such as the introduction of light rail in the compact city policy as Toyama City Transportation Policy Supervisor.

In addition, we have conducted research on the relationship between the timing of railroad development in Asia and CO_2 emissions from motorization [14]. The study compares and evaluates the share of automobiles in new railroad stations and surrounding urban areas in Japan, Malaysia, and Indonesia, and shows that public transportation in the early stages of urban development is an important factor in achieving a low-carbon urban structure.

These previous studies suggest that, given the situation in the Maldives, it is necessary to promote the development of public transportation quickly before the spread of automobiles.

For example, in the case of the island of Malé, it is possible to promote a semi-forced shift to public transportation by restricting the use of automobiles, for example, by allowing automobiles only on the main roads that run around the circular roads and in the center of the island and allowing only bicycles or electric motorcycles on the other narrow roads. In this way, congestion mitigation and relative improvement in convenience and accessibility of public transportation can be expected, in addition to low-carbon benefits.

[14] Yuma Tsumura, Dai Nakagawa, Ryoji Matsunaka, Tetsuharu Oba, "A study on the timing of Asian metropolitan railway development with motorization and its effect on CO2 emissions from transportation," IATSS Research 43 (2019) 161–175.

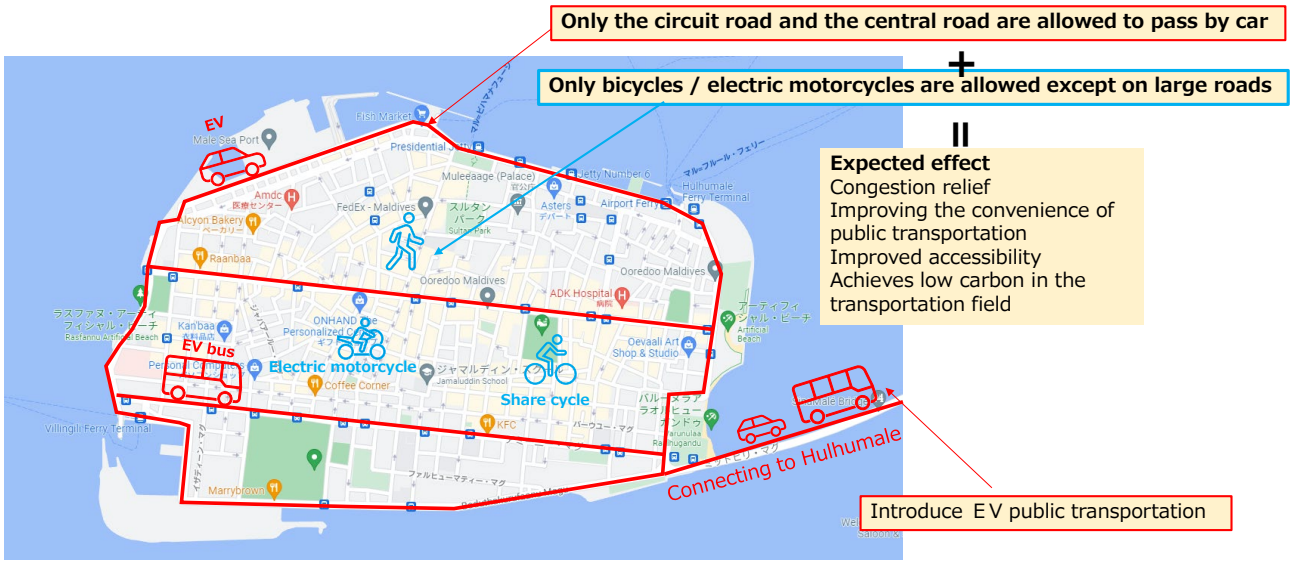

Figure 3-8 Schematic diagram of the transportation policy (example)

A similar example is Copenhagen, Denmark, which has been focusing on bicycle-oriented transportation policies.

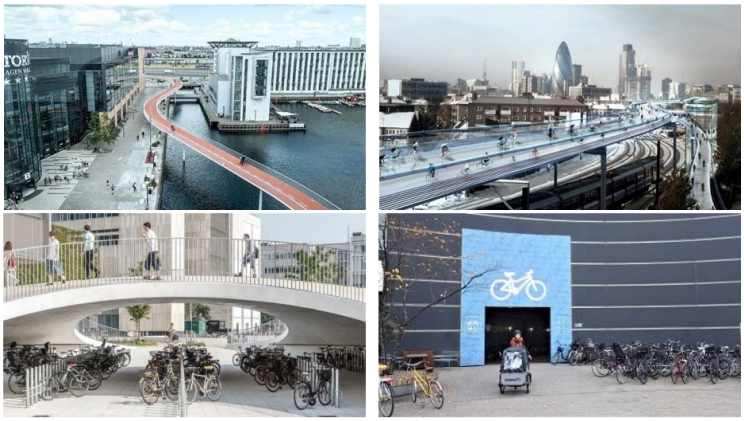

Figure 3-9 Previous cases of bicycle-centered urban design

Source: Material provided by Dainippon Consultants Co.

Thus, it was decided that the SATREPS program would be used to collect data and conduct studies to develop an urban design that includes not only core public transportation, but also coordination with other transportation modes.

On the other hand, from the perspective that the development of core public transportation prior to the spread of cars and motorcycles affects the low-carbon nature of a city, it was thought that decarbonizing and improving the convenience of buses, which currently exist as public transportation, would be effective in this regard as well. In terms of decarbonization, the current bus network will be studied as a JCM project, while improvements of convenience and more effective routes and frequencies will be made in accordance with the SATREPS program and the resulting transportation master plan.

c) Local structure for public transport master plan development and SATREPS program

As a result of the discussion with HDC regarding the above-mentioned public transport development study procedure, master plan formulation and utilization of the SATREPS program, a proposal was obtained to exchange opinions with the National University of Maldives regarding the collaboration with local research institutions required for the SATREPS program. We were also approached about the need to exchange views with the relevant ministries: The Ministry of Environment, the Ministry of Transport and Civil Aviation, and the state-owned MTCC as the operator of public transport.

Therefore, we set up an opportunity to discuss with each organization and obtained their opinions on this policy as follows.

・Maldives National University (MNU)

In an online meeting including the Vice-Chancellor of the National University of the Maldives (held on September 21, 2021), the Vice-Chancellor commented that it is very promising to collaborate with Japan in the area of transportation. An agreement was reached on the selection of appropriate researchers for research collaboration in the SATREPS program, as well as an understanding of the roles and responsibilities of local research institutions required in the SATREPS program.

Subsequently, we had the opportunity to have a local meeting (held on October 31, 2021) with six experts from the National University of Maldives, who mainly specialize in climate change, environmental sociology, and environmental science.

In the same discussion, it was commented that the automobile capacity of roads in Hulhumalé is expected to be saturated by 2030, and that solving traffic issues is an urgent issue. Also, due to the lack of baseline information on current traffic, it was suggested that a pilot study should be conducted while gathering information from a wide range of stakeholders, including the police and traffic agencies. We also obtained information on related business plans such as the shared cycle project by the Bank of Maldives. In applying for the SATREPS program, we confirmed that we would discuss the distribution of responsibilities and detailed research plans based on the proposed policy draft prepared by the Japanese side.

Figure 3-10　Exchange of opinions with the National University of Maldives

・Related ministries and agencies

In the on-site meeting with the Ministry of Transport and Civil Aviation and MTCC (held on

November 4, 2021), it was commented that although there is a plan to develop a transport master plan with the support of the GEF, there is a lack of technical know-how and coordination among the ministries. They welcomed Japan's cooperation, such as the SATREPS program, to complement their efforts in addressing these issues. In the implementation of the SATREPS program, we were also able to gain an understanding of how to work with local researchers to push for its implementation.

Figure 3-11 Exchange of opinions with the Ministry of Transport and Civil Aviation and MTCC

Regarding the Ministry of Environment of the Maldives, opinions were exchanged on the formulation of the Transport Master Plan through SATREPS program at the on-site meeting (held on November 4, 2021) including the Vice Minister. The Ministry of Environment also shared that they are planning to announce the Master Plan for decarbonization of the transportation sector for the Malé metropolitan area, and that they are planning to conduct an inception workshop. They agreed to share information on the content of the workshop, and also agreed to continue to exchange views on the proposal of the SATREPS program, along with the progress report.

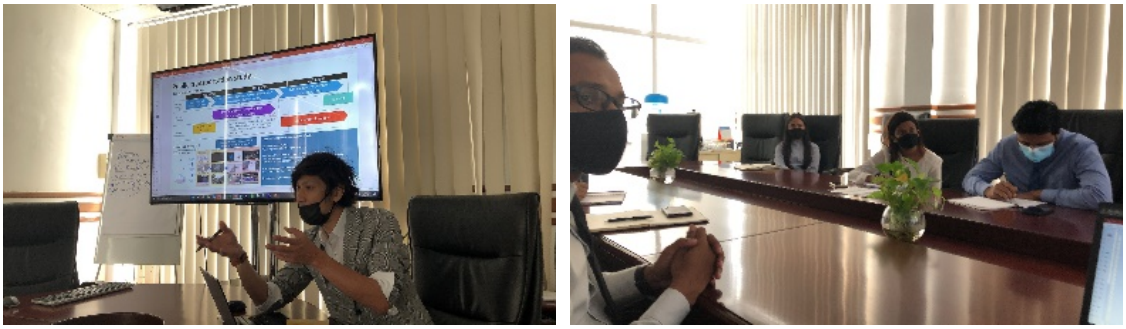

Figure 3-12 Exchange of opinions with the Ministry of Environment of Maldives

As mentioned above, for the study of long-term decarbonization through the improvement of public transport in the Malé metropolitan area, it was decided to proceed with the formulation of a master plan for transportation as a systematic plan of action, including institutional and policy measures, starting with the collection of transportation data and including measures to promote means of transportation other than public transportation, and it was agreed that the SATREPS program would be used for this activity. In the future, we will seek advice from Dainippon Consultants, the co-proposer of this proposal, and the Toyama City Transportation Policy Supervisor, which will lead to a more concrete proposal in the next fiscal year.

3.1.2. Discussion on decarbonization of public transportation as a short-term measure

(3) Cooperation with decarbonization projects in the transportation sector

a) Project to establish new EV bus routes by GEF and the government of the Maldives

The Ministry of Transport and Civil Aviation of the Maldives (hereinafter referred to as the "Ministry of Transport") and the Ministry of Environment, Climate Change and Technology of the Maldives (hereinafter referred to as the "Ministry of Environment of the Maldives") have been considering the introduction of decarbonized public transportation not only in the Hulhumalé Island, but also in other islands of the Male' Metropolitan Area in order to reduce traffic congestion and CO_2 emissions from traffic. A study was conducted with the support of the Global Environment Facility (GEF, hereinafter referred to as "GEF") and they decided to launch "Integrated Sustainable Low Carbon Transport Project in the Maldives" by 2023.

The project aims to develop an integrated transportation plan for the Malé metropolitan area, and to strengthen cooperation among government agencies to ensure energy security and reduce air pollution through low-carbon transport and fossil fuel reduction. The project is made up of the following three elements.

Element 1: Systematizing integrated, sustainable, low-carbon transportation

Element 2: Short-term solution through demonstration of low-carbon electric transportation

Element 3: Scaling up and preparing for widespread adoption of integrated, sustainable, low-carbon transportation

Project Element 1 will develop and coordinate the government capacity to develop the necessary policy and institutional framework for a transportation system focused on sustainable low-carbon options, and to address policy gaps. It will also assist the government in developing a low-carbon transportation and electrification plan for the Malé region to develop a transportation sector that will improve the mobility of commuters.

Element 2 complements Element 1 through a feasibility study on the introduction of renewable-based electric boats, a demonstration of a public transportation system based on electric buses, and a sharing scheme for electric bikes. In addition, it will develop an electric mobility strategy that includes the financing mechanism.

Element 3 focuses on addressing information and awareness issues and increasing understanding of how sustainable low emission transportation among large stakeholders can influence behavior.

b) Collaboration with existing businesses

As mentioned above, the existing project is a GEF-funded program. The GEF is a trust fund established at the World Bank as a financial mechanism for five environment-related conventions: the United Nations Framework Convention on Climate Change, the Convention on Biological Diversity, the Convention to Combat Desertification, the Stockholm Convention on Persistent Organic Pollutants (POPs Convention), and the Minamata Convention on Mercury.

Usually, international organizations such as the World Bank, UNDP, and UNEP implement projects using GEF funds. This project is being led by UNEP.

In principle, the GEF provides grants for incremental costs incurred in implementing projects in response to global environmental issues, but does not provide full funding for individual projects (co-financing). This is said to be significant [15] as a lever to ensure that development projects are formulated in an environmentally friendly manner, but in the case of this project in the Maldives, funding for dissemination is an issue.

Against this background, when the activities related to the inter-city collaboration project were presented to the Ministry of Environment of the Maldives and the Ministry of Transport of the Maldives during the field survey conducted in November 2021, they asked us to consider collaboration with this project.

Specifically, with respect to the above-mentioned demonstration project for Element 2, the GEF project is supposed to support electric buses and infrastructure (including recharging facilities and solar power generation) as public transportation at the demonstration level, and we were asked to consider the possibility of leveraging the Intercity Collaboration Project and the JCM Equipment Subsidy Project for dissemination outside the scope of such support. The details of the target bus and infrastructure specifications, route plans, etc. are shown below.

Table 3-2 Equipment to be installed through the GEF EV Introduction Project

e-Bus	• *Total 15 e-Buses (12 in daily route operations, while 3 in reserve fleet)* • *Bus Size: 6.53 × 2.23 × 2.8 m* • *16+1 seat capacity* • *Low floor and AC*
Battery	• *68 kWh, Lithium-ion (LFP)*
Charging Infra	• *Total 4 chargers* • *150 kW DC Fast charger* • *Location: Main Depot* • *<1.5 hours charging time for full charge* • *Type of charging: Night charging at Depot*
Depot, Bus stops	• *15,000 sq. ft. Depot at Hulhumale (as no space in Male city)* • *23 Bus stops on 2 Routes*
Route details	• *2 routes (R1 and R2) identified (as shown in diagram below)* • *Route length: R1 - 4.78 kms; R2 - 3.34 kms* • *No. of trips per day: R1 – 80 trips with 6 buses; same for R2* ** Trip length, battery size, charger location will require more than one time charging for Route R1 e-Buses. This aspect to be further detailed later before procurement.*
Bus Service Hours	• *5:30am to Midnight 0:00*

Source: Project Brief: Integrated, Sustainable and Low Emissions Transport in the Maldives

[15]Ministry of Foreign Affairs of Japan Website Foreign Policy > ODA and Global Issues > Global Environment > Global Environment Facility (GEF)
https://www.mofa.go.jp/mofaj/gaiko/kankyo/kikan/gbl_env.html

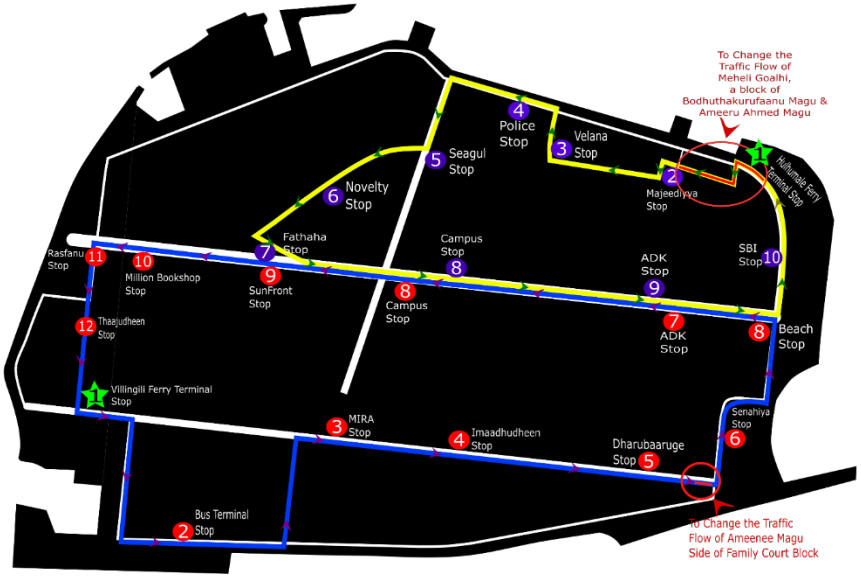

Figure 3-13 Bus routes planned for the GEF EV introduction project

Source: Material provided by the Ministry of Environment, Maldives

In this study, the Maldives Public Transport Corporation (MTCC), a state-owned company, is responsible for conducting the feasibility study. MTCC has estimated the total capital investment to be US$26,36,384 and the monthly operating cost to be US$1,05,069.

Table 3-3 Cost estimates for EV Introduction Projects by GEF

	Qty	Rate USD	Total USD	
e-Bus - C6 Bj6650 Foton	15	1,06,800	16,02,000	61%
Chargers - 150kW	4	72,500	2,90,000	11%
Paving and Steel Canopy	1	2,20,000	2,20,000	8%
Bus Depot	1500	58	87,549	3%
Grid Installaton	1	3,89,105	3,89,105	15%
Bus Stand	23	2,075	47,730	2%
Total Project Capex			**26,36,384**	**100%**
GEF Contribution (INV)			**2,86,100**	**11%**
Remaining for co-Financing			**23,50,284**	**89%**

Source: Material provided by the Ministry of Environment, Maldives

As shown in the table above, the budget from the GEF will be used to procure two of the total 15 electric buses and one of the four charging stations, amounting to 11% of the project capital investment. For the remaining budget, the Government of Maldives is expected to utilize appropriate financing mechanisms, and in relation to the said financing, the JCM Equipment Subsidy Project attracted interest.

c) Possibility of utilizing the JCM Equipment Subsidy Project

Among the projects planned in the GEF project, the introduction of electric buses in Element 2, which has been strongly requested by the Ministry of Transport and Civil Aviation of the Maldives and the Ministry of Environment of the Maldives due to its particularly high CO_2 emission reduction effect, will be considered as a potential project for the JCM Equipment Subsidy Project.

As mentioned above, the support for the GEF project is limited, covering the purchase of two of the 15 buses and four charging stations, amounting to 11% of the total installation cost. Regarding power sources, renewable energy power is expected, but support for solar power generation systems is not covered by the GEF project.

Other facilities such as pavements and buildings for depots are also supported in the GEF project, but from the perspective of the JCM Equipment Subsidy Project, they are not eligible for support because they do not directly contribute to carbon dioxide emission reduction. The following figure illustrates the overall budget for the system.

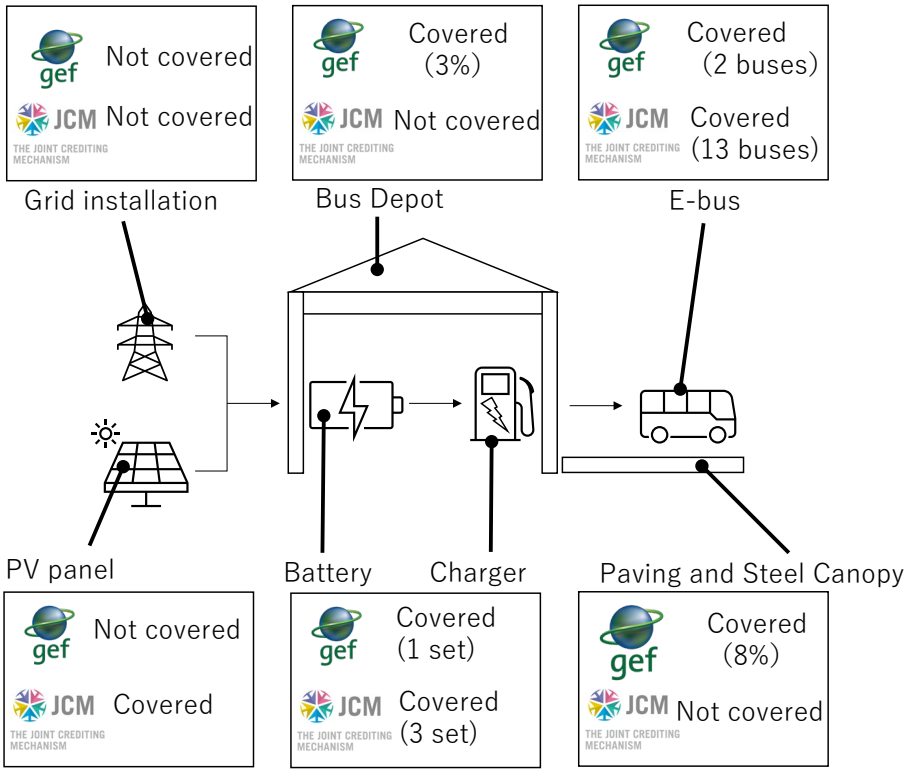

Figure 3-14 System overview and scope of JCM equipment assistance

The CO_2 emission reduction, costs and feasibility of this assumption are described in detail in Chapter 3.1.3.

(4) Discussion on decarbonization projects for existing bus lines

The GEF project is a project where the introduction of EV buses on newly built bus routes is being considered, while in the Malé Metropolitan Area, six routes connecting the islands of Malé, Hulhulé and Hulhumalé are being operated by 32 buses. The organization that manages this is MTCC, the

state-owned transport corporation.

MTCC has developed a plan to introduce EV buses when renewing its bus fleet in 2019, from the perspective of decarbonization, and the study has been ongoing for three years.

However, due to the lack of funds, operational management, and technical knowledge of charge stations, it was decided not to introduce the system. However, we have plans to gradually upgrade them to EV buses in conjunction with the GEF project, etc., and aim to achieve EV conversion within five years. In discussions with MTCC in the field, we have received a request for cooperation in this project.

Figure 3-15 MTCC's announced plans to introduce electric buses in 2019 [16] [17]

Figure 3-16 Discussion with MTCC (HDC's Facebook post on the right)

Regarding this request, we requested the provision of necessary data, including the detailed specs

[16] https://oneonline.mv/en/12553

[17] https://psmnews.mv/en/47500#:~:text=Maldives%20Transport%20and%20Contracting%20Company,in%20Male'%20City%20to%20MTCC.

and fuel consumption of buses, the distance of each bus route, and the number of runs, in order to discuss the utilization of the JCM equipment subsidy project as a solution to problems with funds and technologies. The obtained data are shown below.

Table 3-4 Public bus information provided by MTCC

Bus / Van	Brand	Fuel Type	Bus Type	Bus Length (M)	Engine Model	Average Fuel Consumption (based on last 3 months data)	Current Fuel Rate (MVR)	Status (as at 22/11/2021)
B0A T1107	Volvo	Diesel	City Bus	12	84004X2B7RLE EURO IV	-	11.63	Grounded
B0A T1108	Volvo	Diesel	City Bus	12	84004X2B7RLE EURO IV	-	11.63	Grounded
B0A T1109	Volvo	Diesel	City Bus	12	84004X2B7RLE EURO IV	1,957.33	11.63	Grounded
B0A T1110	Volvo	Diesel	City Bus	12	84004X2B7RLE EURO IV	421.67	11.63	Grounded
B0A C1128	Volvo	Diesel	Shuttle Bus	12	VOLVO 9100	1,637.00	11.63	Grounded
B0A C1129	Volvo	Diesel	Shuttle Bus	12	VOLVO 9100	-	11.63	Grounded
B0A C1135	Man	Diesel	Shuttle Bus	12	CLA16.220	236.67	11.63	Grounded
B0A C1174	Yutong	Diesel	Shuttle Bus	12	LZYTATE63J1020526	366.33	11.63	In Operation
B0A C1183	Yutong	Diesel	Shuttle Bus	12	LZYTATE61J1020525	986.00	11.63	In Operation
B0A C1136	Man	Diesel	Shuttle Bus	12	CLA16.220	-	11.63	Grounded
B0A C1154	Man	Diesel	Shuttle Bus	12	CLA16.220	526.67	11.63	Grounded
B0A C1156	Man	Diesel	Shuttle Bus	12	CLA16.220	-	11.63	Grounded
B0A C1175	Yutong	Diesel	City Bus	12	LZYTAGD67J1022868	2,984.33	11.63	In Operation
B0A C1176	Yutong	Diesel	City Bus	12	LZYTAGD60J022873	2,877.00	11.63	In Operation
B0A C1178	Yutong	Diesel	City Bus	12	LZYTAGD69J1022872	2,986.67	11.63	In Operation
B0A C1179	Yutong	Diesel	City Bus	12	LZYTAGD69J1022869	2,921.00	11.63	Grounded
B0A C1180	Yutong	Diesel	City Bus	12	LZYTAGD67J1022871	2,732.33	11.63	In Operation
B0A C1181	Yutong	Diesel	City Bus	12	LZYTAGD65J1022867	544.67	11.63	In Operation
B0A C1182	Yutong	Diesel	City Bus	12	LZYTAGD65J1022870	1,141.33	11.63	Grounded
B0A C1184	Yutong	Diesel	Shuttle Bus	12	LZYTAGD60J1024380	3,187.33	11.63	Grounded
B0A C1185	Yutong	Diesel	Shuttle Bus	12	LZYTATE67J1037054	2,682.67	11.63	In Operation
B0A C1186	Yutong	Diesel	Shuttle Bus	12	LZYTATE69J1037055	2,453.33	11.63	In Operation
B0A C1187	Yutong	Diesel	Shuttle Bus	12	LZYTATE60J1037056	2,263.67	11.63	In Operation
B0A C1189	Yutong	Diesel	Shuttle Bus	12	LZYTATE69J1037053	3,572.33	11.63	In Operation
B0A C1190	Yutong	Diesel	Shuttle Bus	12	LZYTATE63J1034790	3,000.00	11.63	In Operation
B0A C1191	Yutong	Diesel	Double Decker Bus	12	LZYTAGE61J1034786	3,961.67	11.63	In Operation
B0A C1192	Yutong	Diesel	Double Decker Bus	12	LZYTAGE67J1034797	-	11.63	In Operation
B0A C1193	Yutong	Diesel	Double Decker Bus	12	LZYTAGE63J1034787	3,205.00	11.63	In Operation
B0A C1194	Yutong	Diesel	Double Decker Bus	12	LZYTAGTAGE67J1034732	3,102.00	11.63	In Operation
B0A C1195	Yutong	Diesel	Double Decker Bus	12	LZYTAGTAGE65J1034788	2,981.33	11.63	Grounded
B0A C1196	Yutong	Diesel	Double Decker Bus	12	LZYTAGTAGE63J1034790	729.33	11.63	In Operation
B0A C1197	Yutong	Diesel	Double Decker Bus	12	LZYTAGTAGE65J1034791	1,791.33	11.63	Grounded

Source: Information provided by MTCC

Table 3-5 Public bus mileage information provided by MTCC

#	Route	Length (KM)	Scheduled Trips per day	Oneway	Round trip	Frequency (mins)	Service Time	Number of Stops	Commute Details (August)	Commute Details (September)	Commute Details (October)
Route 1	West Park Bus Stop – Hulhumale'	20.61	61	1257.21	2514.42	15 – Sunday to Thursday 20 – Fri/Sat/Holidays	05:30 – 23:30	21	94,027	102,036	105,224
Route 2	Carnival – Hulhumale'	15.63	56	875.28	1750.56	15 - Sunday to Thursday 30 - Friday excluding Friday prayer break time 20 - Saturday / Holidays	05:40 – 23:00	9	36,036	44,888	45,555
Route 3	West Park Bus Stop - VIA	13.45	19	255.55	511.1	60.00	06:00 – 00:40	7	3,069	3,427	4,144
Route 4	Hulhumale'- Velana International Airport	14.8	76	1124.8	2249.6	30.00	05:35 – 00:35	11	30,980	34,149	33,604
Route 6	Hulhumale Phase 1 – Phase 2 Connection Route	4.06	37	150.22	300.44	30.00	0545 – 2345	12	-	112	42,252
Total		68.55	249	3663.06	7326.12	-	-	-	-	-	-

Source: Information provided by MTCC

From the above table, the fuel consumption is 55,249 L per three months, or an average of 614 L per day as a 90-day conversion. The operating distance per route is between 4 km and 20 km, the number of round trips is between 19 and 61, and the total operating distance is 3,663 km/day. The fuel consumption value obtained by dividing the total operating distance and total fuel consumption is 5.96 km/L.

It is assumed that the electrification of buses will be phased in within five years. We decided to calculate the possibility of making use of the JCM Equipment Subsidy Project and the effect of CO_2 emission reduction if the above 32 buses for six routes are replaced with electric buses, and discuss the use of the JCM Equipment Subsidy Project with MTCC. The results of the reduction effect are shown in the next chapter.

3.1.3. Estimation of current traffic-derived CO_2 emissions and lower carbon effects

As mentioned above, as a result of this fiscal year's project, we have received a request from the local community for cooperation in two projects regarding the introduction of EV buses: a new route business plan by the GEF and an existing route bus project by MTCC.

In the following, we calculate the CO_2 emission reduction effect for each project and discuss the possibility of utilizing the JCM Equipment Subsidy Project.

(1) Calculation of the CO_2 emission reduction effect by the GEF project and the possibility of utilizing the JCM Equipment Subsidy Project

As shown in Chapter 3.1.2, the GEF project plans to operate two new bus routes with the introduction of EV buses. Route 1 is 4.78 km and 80 round trips, and Route 2 is 3.34 km and 80 round trips, for a total of 649.6 km/day or 237,104 km/year.

As a reference case, assuming that a diesel bus is used to travel the relevant operating distance. When assuming fuel consumption based on travel distance, fuel consumption values (km/L) must be

set. In the JCM Equipment Subsidy Project, when local data is not available, the value of the latest equipment with high efficiency is used for the sake of conservative review. As values for the latest equipment with high efficiency in diesel buses, we referred to "Route bus and general bus fuel efficiency" in the fuel efficiency performance values for automobiles (March 2020), which are evaluated annually by the Ministry of Land, Infrastructure, Transport and Tourism based on the "Implementation Guidelines for Evaluation and Publication of Automobile Fuel Efficiency Performance (Notification No. 61 of the Ministry of Land, Infrastructure, Transport and Tourism, 2004).

In the relevant performance values, fuel consumption data for vehicles of Isuzu, Toyota, Hino, and Mitsubishi Fuso Truck and Bus were organized, and fuel consumption values ranging from 3.95 km/L to 10 km/L were indicated. Therefore, the value of 10 km/L was referred to as the value of the latest equipment with the highest efficiency. Fuel consumption is obtained by dividing the driving distance by the fuel consumption value shown on the left, and can be estimated as 23,710 L based on the formula below.

237,104 km/year ÷ 10 km/L = 23,710 L/year (fuel consumption)

Since the CO_2 emission factor for diesel fuel is 2.619 kg-CO_2/L, the CO_2 emissions associated with the use of the above-mentioned fuel would be about 62 t-CO_2/year.

The useful life applied to the JCM Equipment Subsidy Project is five years, as the project falls under the category of "passenger vehicles" in the "vehicles and transportation equipment" section of the Ministerial Ordinance on the Useful Life of Depreciable Assets (Appended Tables 1 and 2).

Therefore, the total emission reduction of this project is about 310 t-CO_2/year.

In the case of JCM Equipment Subsidy Projects, for the first project in the relevant country, either 50% of the equipment that contributes to CO_2 emission reduction or the emission reduction cost guideline of 4,000 yen/t-CO_2, whichever is lower, will be applied.

In the case of the GEF project, 15 buses and charging stations are applicable as facilities that directly contribute to CO_2 emission reduction. The 15 buses are estimated to cost a total of 1,602,000 US dollars (about 180 million yen), and the charging stations (stands) are estimated to cost 290,000 US dollars (about 33 million yen). The total project cost is about 213 million yen, of which about 11% will be funded by the GEF, so about 190 million yen will be covered by JCM.

Since this is the first JCM Equipment Subsidy Project for EV buses in the Maldives, assuming a 50% equipment subsidy, approximately 95 million yen can be expected to be subsidized. However, based on the 4,000 yen cost-effectiveness standard for CO_2 emission reduction, the maximum subsidy amount is 1.24 million yen, which is 310 t-CO_2 multiplied by 4,000 yen/t-CO_2. The subsidy rate as a percentage of the project cost is less than 1%, which means that the subsidy effect is very small.

In addition to the significantly low financial merit of the equipment assistance project, the suitability of the JCM Equipment Subsidy Project from the perspective of credits is also low.

There are few examples of JCM/CDM application in the transportation sector, and while the CO_2 emitted by the transportation sector is said to be one-fourth of the total emissions, the reduction ratio

of the transportation sector among the CDM projects registered with the UNFCCC (United Nations Framework Convention on Climate Change Secretariat) is said to be 1/1119% [18], suggesting the difficulty of applying the market mechanism to the transportation sector. In this project, too, the low-carbon effect on the equipment price is small, making it difficult to apply the JCM Equipment Subsidy Project.

(2) Calculation of the CO_2 emission reduction effect by the MTCC project and the possibility of utilizing the JCM Equipment Subsidy Project

On the other hand, in the MTCC project, six routes are operated by 32 buses, which is a more promising target for reduction due to the high fuel consumption.

As mentioned above, the fuel consumption is 55,249 L/90 days, or 614 L/day. Multiplying the CO_2 emission factor of 2.619 kg-CO_2/L, the CO_2 emission is about 1.6 t-CO_2/day, or about 587 t-CO_2/year assuming 365 days of operation per year.

Since it is expected that renewable energy will be used to the maximum extent as a power source for EV buses in the MTCC project, the installation of solar panels on the roofs of MTCC-managed facilities (bus terminals, etc.) is also considered here to supply electricity to the charging stations. The shortfall is to be compensated by grid electricity, and the project emissions are calculated using the electricity emission factor for grid electricity.

Regarding the amount of electricity required by the 32 EV buses, the total distance traveled by all the buses in a day is 7,326 km, and the electricity cost (electricity consumption per distance) of the EV buses is tentatively set at 1.2 kWh/km, adopting the value stated in the Guidelines [19] for the Introduction of Electric Buses by the Ministry of Land, Infrastructure, Transport and Tourism. 3,663 km multiplied by the amount of electricity needed to drive 1 km (1.2 kWh), or about 4,400 kWh, is the amount of electricity needed per day. Assuming 365 days of operation per year, the annual energy requirement is approximately 1,606,000 kWh. The charging stations will be located in three locations: two bus terminals and a maintenance area managed by MTCC. The following figure shows the location of the sites and what each site looks like.

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[18] Mitsubishi UFJ Morgan Stanley Securities, "Contribution: Toward solving transportation CDM issues," Monthly Energy Forum, December 2009
https://www.sc.mufg.jp/company/sustainability/cef/article-04.html

[19] Ministry of Land, Infrastructure, Transport and Tourism, Bureau of Motor Vehicles, "Guidelines for Introducing Electric Buses," December 2018
https://www.mlit.go.jp/common/001265916.pdf

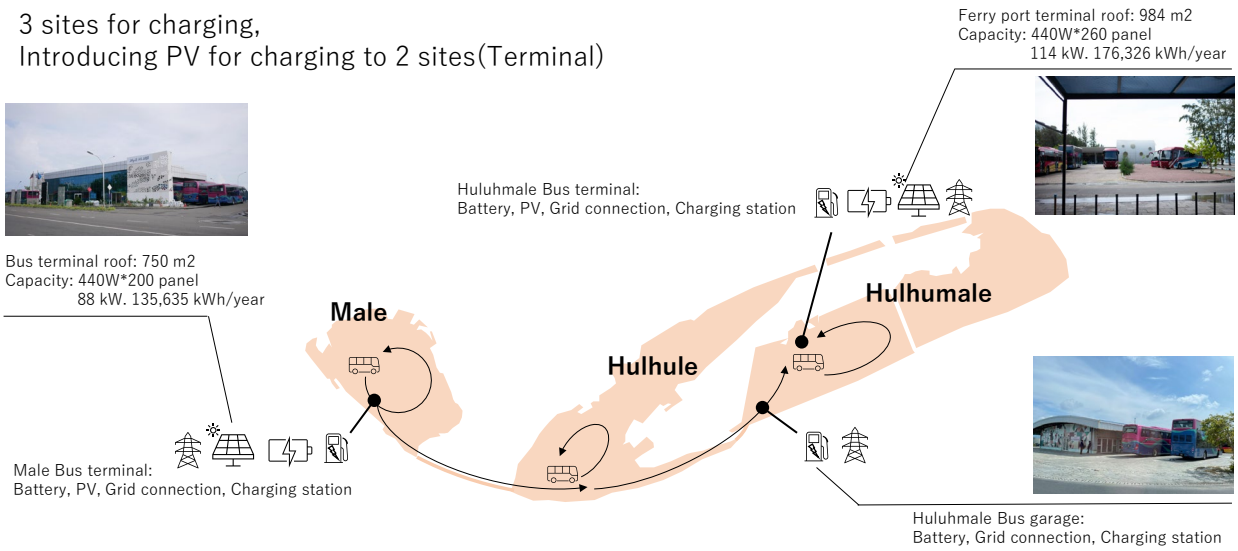

Figure 3-17　Proposal for solar power and charging station layout

Now, let's consider the contributions of renewable energy sources.

Facilities that are under MTCC management and are expected to be used for roofing are the Male Bus Terminal (750 m^2) and the Hulhumalé Ferry Port (984 m^2). The number of panels installed, annual power generation, and installation costs for both facilities are as follows.

Table 3-6　Rooftop area and estimated solar power generation for MTCC-managed facilities

Site	Area [m2]	Site image	Capacity [kW]	Power generation [kWh]	Initial cost [USD]
Greater Male Bus Terminal	750		88.0kw 440W*200panel	135,635	102,908
Huluhmale Ferry port terminal	984		114.4kw 440W＊260panel	176,326	130,871
				Total 311,961 kWh	

Source: Japan Air-conditioning Hokuriku Production Data

The estimated amount of solar power generation at both locations is about 312,000 kWh, and the bus operation corresponding to this amount of electricity can be considered zero-emission.

1,294,000 kWh (312,000 kWh subtracted from 1,606,000 kWh required for EV bus operation) will be supplied from grid power.

The fuel consumption, i.e., the distance that can be traveled with 1 L of diesel, is 5.97 km as mentioned above, but if the same distance is to be traveled by electricity, 7.16 kWh of electricity is

required according to the following formula.

Distance traveled per liter of diesel (km) × Electricity per unit (kWh/km)

5.97 km × 1.2 kWh/km

= Electricity requirement equivalent to 1 liter of diesel

= 7.16 kWh

Since the grid emission factor in the Maldives is 0.533 t-CO_2/MWh, the CO_2 emission from running 1 km with 7.16 kWh generated from grid electricity is 0.0038 t-CO_2 according to the following equation.

Electricity requirement equivalent to 1 L of diesel × Emission factor of Maldives Electricity Grid = Emission amount

7.16 kWh × 0.533 t-CO_2/MWh / 1000 (unit adjustment) = 0.0038 t-CO_2

The CO_2 emission factor per 1 L of diesel is 0.0026 t-CO_2/km, which means that in cases where grid-derived electricity is used as the power source, CO_2 emissions are estimated to be higher than that for diesel. In other words, the project emissions exceed the reference emissions, and the JCM Equipment Subsidy Project is not viable.

Therefore, instead of targeting 32 units, the study will be based on the amount of renewable energy.

The amount of electricity that can be generated by solar power is about 312,000 kWh/year, and the distance that can be traveled with this electricity is about 260,000 km/year according to the following equation.

Annual solar power generation ÷ electricity consumption per distance = solar power-derived electricity mileage (years)

(312,000 kWh/year) ÷ (1.2 kwh/km) = (260,000 km/year)

Since the project emissions for the above distance will be zero, the CO_2 emissions generated by driving the same distance with diesel fuel as a reference case will be equivalent to the reduction.

The diesel fuel required for a 260,000 km trip is about 43,000 L, according to the following equation.

Solar power mileage (year) ÷ Diesel bus fuel consumption (km/L) = Diesel consumption (year)

(260,000 km) ÷ 6 km/L = 43,000 L/year

Based on the CO_2 emission factor for diesel fuel, the CO_2 emissions associated with the above usage are as follows.

Diesel consumption (year) x Diesel fuel emission factor = CO_2 emissions

43,000 L/year × 2.619 kg-CO_2/L ÷ 1,000 (unit adjustment) = 112 t-CO_2/year

Assuming that the legal useful life applicable to the EV buses and equipment is five years, the total emission reduction over the entire project period is 560 t-CO_2.

In light of the CO_2 emission reduction cost-effectiveness guideline of 4,000 yen/t-CO_2, approximately 2.24 million yen can be considered as the upper limit of subsidy (if the project cost is 50% or less) based on the total emission reduction in question.

In the above study, the target facilities are solar power and recharging stations and 32 EV buses, and the following costs are estimated based on a simple preliminary calculation.

Table 3-7 Project cost projection

	Qty	Total (USD)	Total (JPY)	Reference
PV panel	1 set	233,779	27,000,000	Caliculated by NIKKU *Cost of PV panels only, not including construction and transportation costs.
Charger	3 set	870,000	99,000,000	Rate in GEF project (290,000USD)
e-bus	32	3,417,600	392,000,000	Rate in GEF project (106,800USD)

The total value is about 518 million yen, but the contribution of the subsidy is negligible based on the criteria of the JCM Equipment Subsidy Project described above, and the subsidy effect is only marginal. Even if only solar panels, which directly contribute to CO_2 emission reduction, are included in the equipment, the subsidy effect is less than 10%, which is a level that makes it unlikely to make the JCM Equipment Subsidy Project viable.

Here, we assume a purely solar power generation project. In the case of solar power, 17 years is applied as the useful life, and more emission reductions can be expected as the project life increases. The reduction effect when using solar power generation is 1,904 t-CO_2 according to the following equation.

Annual emission reductions × lifetime of equipment = emission reductions over the project period

112 t-CO_2/year × 17 years = 1,904 t-CO_2

In light of the CO_2 emission reduction cost-effectiveness guideline of 4,000 yen/t-CO_2, the upper limit of the subsidy would be approximately 7.6 million yen based on the total emission reduction, which is equivalent to approximately 30% of the 27 million yen cost of the solar power generation

equipment mentioned above.

However, in this case, a comparison should be made with the case where PV power generation facilities are evaluated as an alternative to the electricity grid, and a methodology that can evaluate higher reduction effects should be considered.

The above estimates suggest the difficulty of applying the JCM Equipment Subsidy Project in the transportation sector, both in terms of the subsidy effect and CO_2 emission reductions through the JCM equipment assistance. On the other hand, the local government is also highly interested in reducing CO_2 emissions from public transportation, and there are high expectations that the JCM Equipment Subsidy Project will provide a good example of CO_2 emission reduction in the transportation sector. Therefore, we intend to conduct a comparative evaluation of the potential for decarbonized transportation, not only for EVs, but also for hydrogen use.

3.1.4. Implementation structure and schedule

(1) Discussion on the master plan for public transportation

As mentioned in Chapter 3.1.1, the Public Transport Master Plan will assume the use of the SATREPS program, an international science and technology cooperation program, and will promote proposals mainly from research institutions as required by the program.

The National University of the Maldives, the largest university in the Maldives, will be a research institution on the Maldivian side, and the University of Toyama is expected to be the representative research institution on the Japanese side.

Researchers from the two universities have agreed on the general policy of the proposal, and they plan to further refine the proposal through further exchanges of opinions between the two universities, aiming to submit the proposal in FY2022.

Since the project is based on inter-city collaboration, Japan NUS Co., Ltd., the proposing corporation, and Dainippon Consultants, the co-proposer, will support the proposal-making and various adjustments, while Toyama City, HDC, the Ministry of Environment of Maldives, the Ministry of Transport of Maldives, and MTCC will cooperate. In addition, from the perspective of examining public transportation methods and optimal transportation infrastructure based on traffic dynamics, we will seek cooperation from Sato Kogyo Corporation and Kawada Kogyo Corporation, which are joint proposers and have experience in the construction of Toyama Light Rail. With this structure, we plan to proceed with activities starting with the conclusion of the MoU on research proposals.

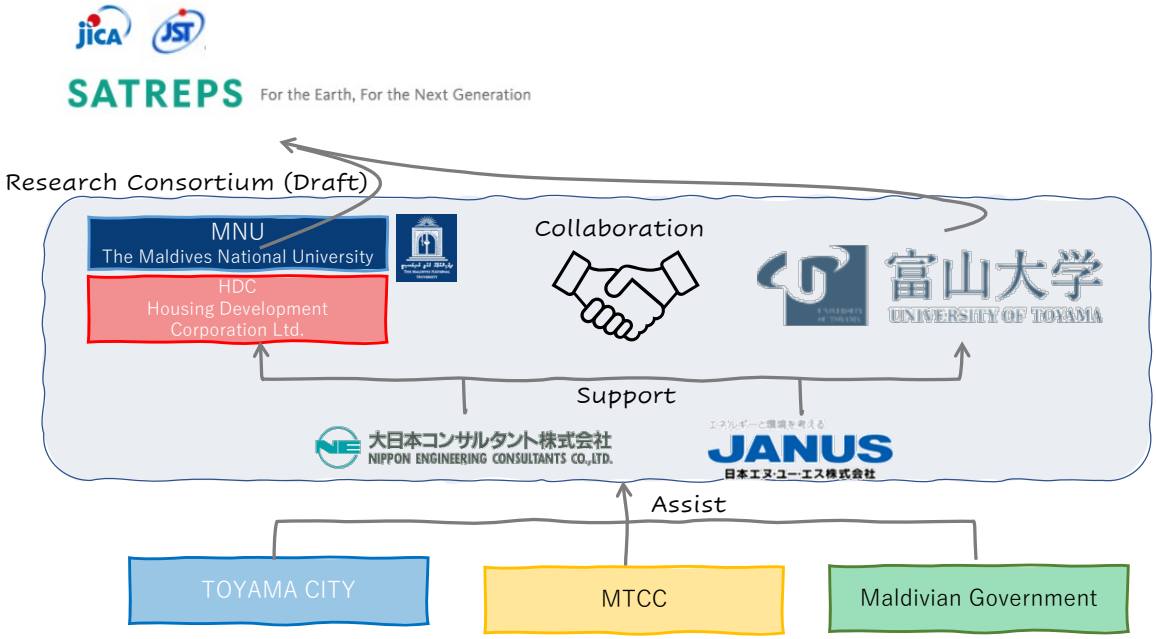

Figure 3-18 Proposed Implementation Structure for the Public Transport Master Plan Development Project

(2) EV bus JCM equipment subsidy project

As summarized in Chapters 3.1.2 and 3.1.3, we discussed the JCM equipment subsidy project, which includes EV buses and infrastructure such as solar panels to power them, as a short-term measure to reduce CO_2 emissions from transportation. In the JCM equipment subsidy project, Japanese companies are required to participate as representative companies, and we considered a system in collaboration with Hokusan Co., Ltd. and Japan Air Conditioning Hokuriku Co.

Hokusan Co., Ltd. and the proposer, Japan NUS Co., Ltd., have received a subsidy from the Ministry of the Environment for the "FY2021 Subsidy for Projects to Curb Carbon Dioxide Emissions (Project to Construct a Community-Based Decarbonized Logistics System Using Battery Exchangeable EVs and Battery Stations). We are currently working on a master plan and economic evaluation of the project in Toyama City, which will use replaceable-battery EV systems in logistics trucks, powered by solar power on the roofs of logistics companies, and use them as emergency power sources in times of disaster.

Based on this experience, Hokusan Co., Ltd. has the knowledge of utilizing solar power-derived electricity for transportation, and can provide technical support for system design and construction. We are also very interested in getting involved in the JCM equipment subsidy for the EV bus project being considered in the Maldives. The company also has experience as a representative operator of a JCM equipment subsidy project in Semarang, Indonesia, where it was selected as a subsidy provider for gas changeover JCM equipment for public buses and has been conducting monitoring.

Regarding solar panels, Japan Air-Conditioning and Refrigeration Hokuriku Co., Ltd. has an extensive track record in the construction of solar panels in Toyama City and the Hokuriku region, and is interested in supplying panels to the Maldives in line with the company's policy of overseas expansion. The company has a wealth of experience in building systems that combine solar power

and storage batteries, and is capable of handling the design and technical studies required for EV bus charging stations.

Although both companies are currently interested in the project, it is essential to collaborate with local companies regarding local construction management and imports. As described in Section 3.1.3, the current costs are rough estimates, and it is necessary to proceed with detailed cost estimation and calculation of construction costs for each facility, as well as to work out a detailed plan with MTCC, which will be the owner of the EV bus project.

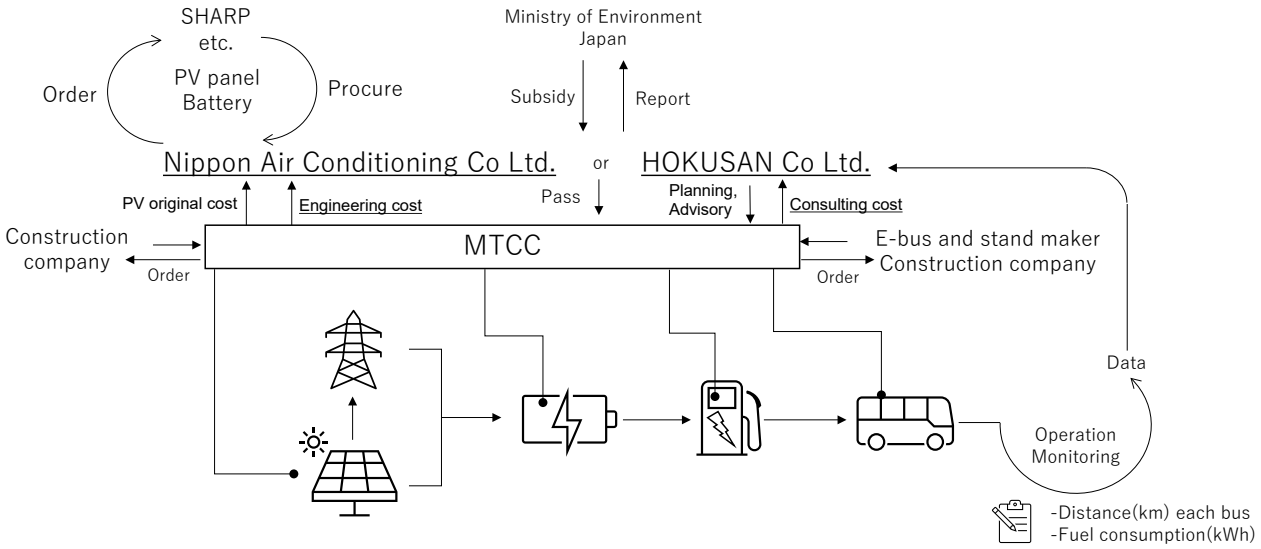

Figure 3-19 Proposed Implementation Structure for the EV Bus JCM Equipment Subsidy Project

3.2. Field of low-carbon power generation through gas changeover of diesel power generation facilities

In the Maldives, power generation is mainly based on diesel fuel due to the inherent land and resource constraints of the island nation. Diesel power generation is still the main power source in remote island regions around the world, including Japan, because of its advantages of being small and light in comparison to its power output, being suitable for any location, and having high start-up and thermal efficiency. While promoting the spread and expansion of renewable energies such as solar power, the country has no choice but to rely on diesel power generation as a baseload power source to cope with load fluctuations.

The amount of electricity generated by diesel power in Hulhumalé and Malé is about 400 million kWh/year, diesel fuel consumption is about 100 million liters/year, and CO_2 emissions are 265,000 t-CO_2/year, accounting for about 20% of the total GHG emissions of the Maldives.

Population	15769
Area of Island (km²)	2.000
Distance from Male' (km)	4.1
Nearest Airport	Velana International Airport
Electricity Provider	STELCO
Peak Load Time	21:00
Total daily peak load (kw)	-
Total Installed Capacity (kW)	17400
Installed Gen sets	800, 1000x7, 1600x6
Monthly Average Usage (kWh)	4,272,559.50
Yearly electricity production (kWh/yr)	51,270,714.00
Yearly Billed Amount (kW)	46,034,939.00
Oil Consumption Yearly	13,536,795.00
Total Lube oil consumption (liter/yr)	68,916.00
Solar PV Installed (kw)/Year	-
Yearly Production from Solar PV (kwh)	-
Synchronizing Panel	Yes
Type of Synchronizing Panel	Auto
Electricity cable Installed Year	2003
Distribution Cable size/mm²	70185
CO2 emission (tCO_2)	36,040.36

Power generation capacity in Hulhumale

Population	127079
Area of Island (km²)	1.900
Distance from Male' (km)	0
Nearest Airport	Velana International Airport
Electricity Provider	STELCO
Peak Load Time	15:00
Maximum Peak Load (kW)	56048
Total Installed Capacity (kW)	80320
Total Generator Sets (kW)	1000x6, 1600x9, 2000x2, 2160x3, 4320, 5760, 6500x2, 8730x2, 8900
Monthly Average Usage (kWh)	28,080,134.33
Yearly electricity production (kWh/yr)	336,961,612.00
Yearly Billed Amount (kW)	27,772,229.00
Yearly Oil Consumption (Liters)	86,055,128.00
Total Lube oil consumption (liter/yr)	273,114.00
Solar PV Installed (kw)/Year	675kw / 2013
Yearly Production from Solar PV (kWh)	911325
Synchronizing Panel	Yes
Type of Synchronizing Panel	Auto
Electricity cable Installed Year	1949
Distribution Cable size/mm²	70180
CO2 emission (tCO_2)	229,113.17

Power generation capacity in Male

Figure 3-20 Power generation capacity, output and diesel fuel consumption in Malé and Hulhumalé Island

Source: ISLAND ELECTRICITY DATA BOOK 2018 [20]

[20] MINISTRY OF ENVIRONMENT AND ENERGY REPUBLIC OF MALDIVES," ISLAND ELECTRICITY DATA BOOK," 2018 (http://www.environment.gov.mv/v2/wp-content/files/publications/20181105-pub-island-electricity-data-book-2018.pdf)

As an alternative to diesel power generation, natural gas co-combustion in existing diesel power plants is being considered as a lower carbon technology option.

Natural gas is considered to be a relatively clean energy source, with lower CO_2 emissions per unit of heat compared to diesel.

The results of last year's study on the use of liquefied natural gas (LNG) to reduce carbon emissions suggested the possibility of significantly reducing CO_2 emissions from diesel power generation.

The use of natural gas is being considered not only by this project, but also by the Maldivian Ministry of Environment and STELCO, the state-owned electricity corporation, and Indian companies are planning to invest in the project. On the other hand, even in the Maldives, there are reports that question the use of natural gas being a fossil fuel as the country strives to decarbonize.

It has been pointed out that the development of natural gas (LNG) supply and utilization facilities require a large initial investment and a construction period, which may delay the achievement of carbon neutrality in the Maldives, and it has been argued that if initial investment and a long construction period are required, priority should be given to initiatives that aim for decarbonization.

However, there is no stable renewable energy option to meet the current electricity demand, and the CO_2 emissions from diesel power generation should not be left untouched while waiting for technological breakthroughs. Therefore, there are some who argue that the promotion of natural gas use should not be dismissed as the best option available, and it is a bit of a standoff.

In light of these developments, this year we examined the use of compressed natural gas (CNG), which requires less initial investment and a shorter construction period, as well as the use of hydrogen as a renewable energy carrier, and tried to make comparisons.

3.2.1. Discussion on the possibility of adopting hydrogen derived from renewable energy

(1) Production and availability of hydrogen derived from renewable energy produced in the Maldives

a) Necessity of technologies using hydrogen

The most feasible power source in the Maldives among renewable energy is sunlight.

The output from solar power generation varies with the amount of sunlight, so it cannot become a base-load power source for realizing stable power supply.

In addition, the supply of electric power must be always equal to the demand for electric power, and the imbalance between supply and demand would disturbe power frequency, leading to troubles, such as a power outage. Accordingly, it is necessary to keep a stable power source idling to cover the fluctuation in solar power output as a backup for balancing supply and demand.

Namely, diesel power generation must be maintained to some degree in the Maldives, so there are problems with the costs and operation management for electric power and system management. In detail, advanced operation would be required for controlling the operation of diesel power generators while taking into account not only the fluctuation in load (demand), but also the fluctuation in solar power output due to the weather. Therefore, suppliers would have the burden of operation management, and it would augment the costs for power generation and risks. These are bottlenecks to the popularization of solar power generation.

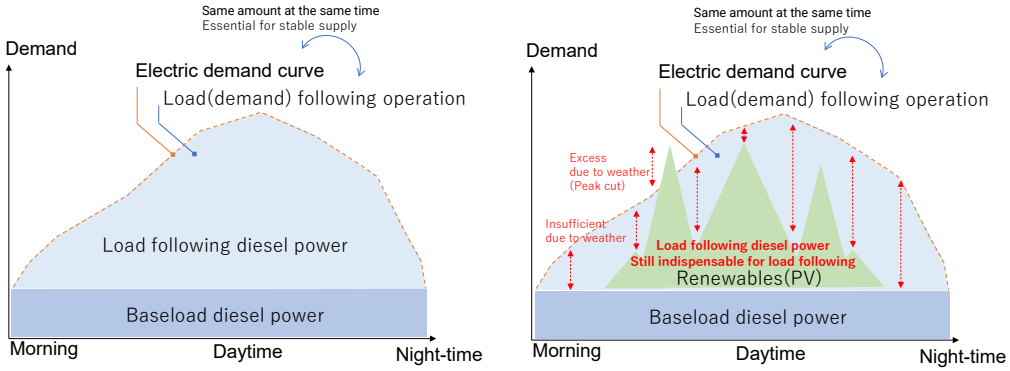

Figure 3-21 Estimated fluctuation in renewable energy

One solution for stably generating electric power is the use of storage batteries. The charge/discharge efficiency of lithium-ion batteries is said to be 90-95%. It they are connected to renewable energy power plants and core grids, surplus power will be stored and discharged when supply is sufficient, to stabilize grid power. In the case of storage batteries where power conversion and storage devices are integrated, a large number of batteries need to be installed for covering the load, so there are problems with costs and installation area, and when spontaneous discharge is taken into account, it is difficult to store power for several seasons or years.

In light of such constraints of storage batteries, Power to Gas (P2G) systems are attracting attention, because they can produce hydrogen via water electrolysis with unstable solar power, store it, and supply power with fuel cells. The efficiency of hydrogen power is considered to be around 44% (electrolysis efficiency: 80% × power generation efficiency of fuel cells: 55%) or 70% when a cogeneration system is assumed. Just by installing more hydrogen storage tanks, it is possible to boost capacity easily at low cost, and there is no spontaneous discharge from the storage tanks, so it is possible to store a lot of energy for several seasons or years [21].

This can be utilized not only for supplying electric power, but also as fuel for vehicles and vessels, so it is expected to remove the bottlenecks to the distribution of renewable energy. In particular, Toshiba Corporation has engaged in the development of systems for supplying electricity stably by taking advantage of storage batteries and hydrogen and making the best of unstable renewable energy.

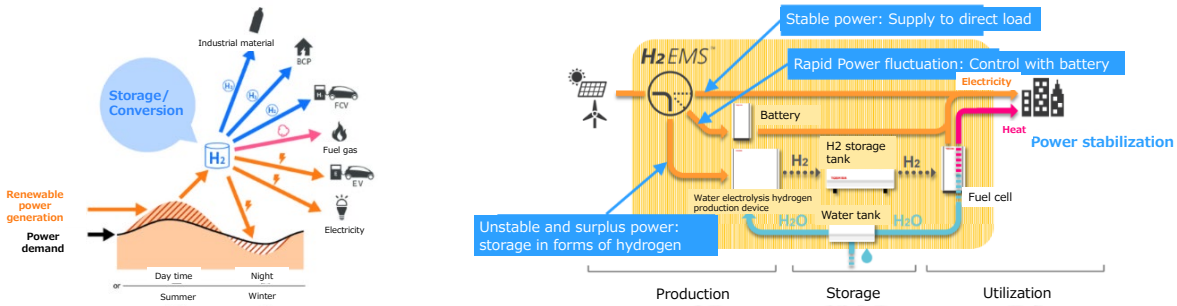

Figure 3-22 Hydrogen-based technology of Toshiba Corporation

[21] Fumio Nishiwaki, "Instability of renewable energy power generation should be covered by hydrogen," Toyo Keizai Online, 2018. (https://toyokeizai.net/articles/-/231887?page=3)

Source: Toshiba Energy Systems & Solutions Corporation [22]

As an outcome of development, they commercialized a self-standing hydrogen energy supply system named H2One™, assuming that hydrogen would be produced and consumed in each region, and it was installed in Toyama City. As a model for producing and consuming hydrogen in each region, Toshiba Corporation is discussing methods for utilizing the system according to the following locational characteristics.

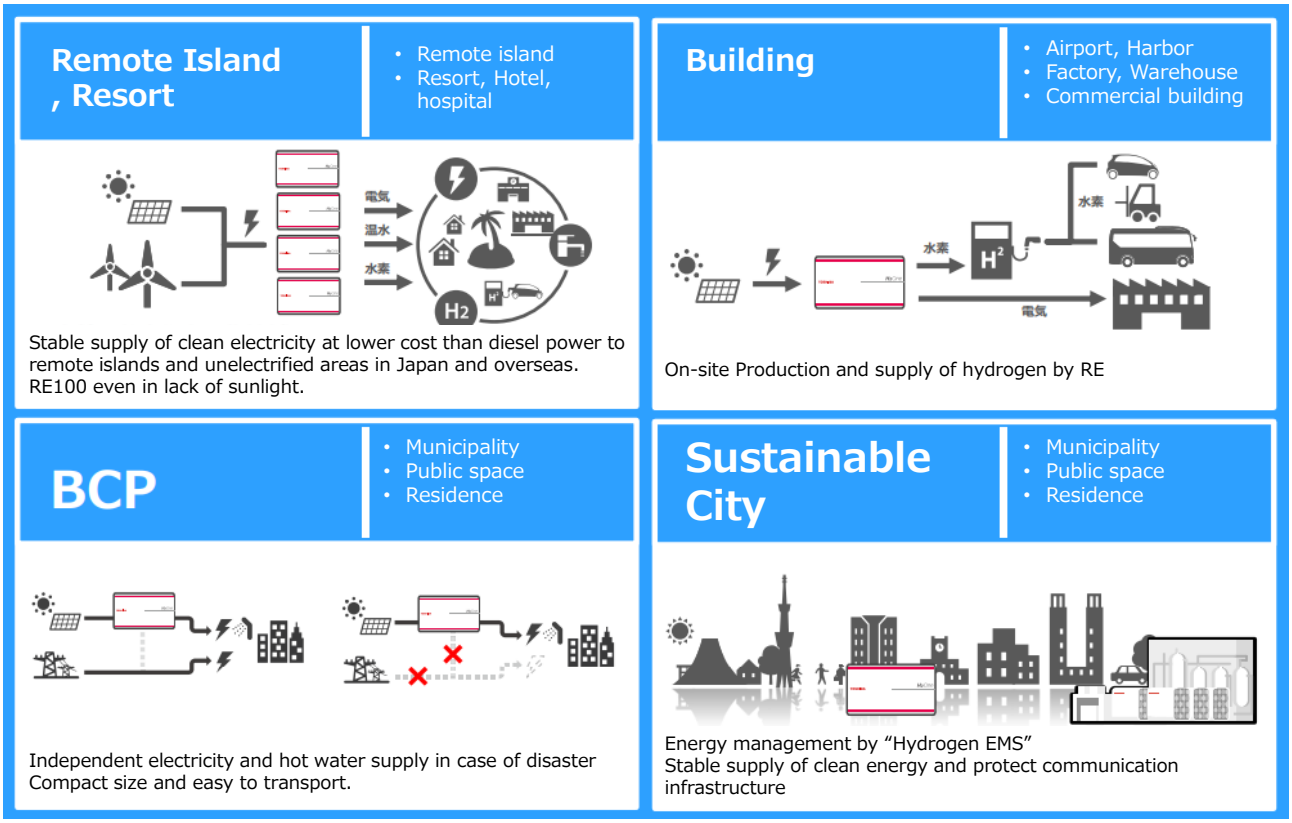

Figure 3-23 Strategies for distributing H2One™, a self-standing hydrogen energy supply system of Toshiba Corporation

Source: Toshiba Corporation [23]

Toyama City was planning to adopt renewable energy-derived hydrogen stations and industrial fuel-cell vehicles, to develop hydrogen infrastructure, as Toyama Council for Hydrogen Energy Promotion aimed to actualize a low-carbon society. By expanding H2One™, it is possible to utilize renewable energy-derived hydrogen for supplying electric power and hot water to buildings, etc., recharging EVs, and so on. Accordingly, it has been adopted as H2One Multi-station™, and is now

[22] Website of Toshiba Energy Systems & Solutions Corporation (https://www.toshiba-energy.com/hydrogen/product/)

[23] 1st Tokyo Promotion Conference for Actualizing a Hydrogen Society in FY2016: Toshiba's initiatives for realizing a hydrogen society "utilization of the self-standing hydrogen energy supply system H2One and renewable energy-derived hydrogen," Jun. 27, 2016 (https://www.kankyo.metro.tokyo.lg.jp/climate/hydrogen/suishin27.files/28-1_presen1_toshiba.pdf)

in operation.

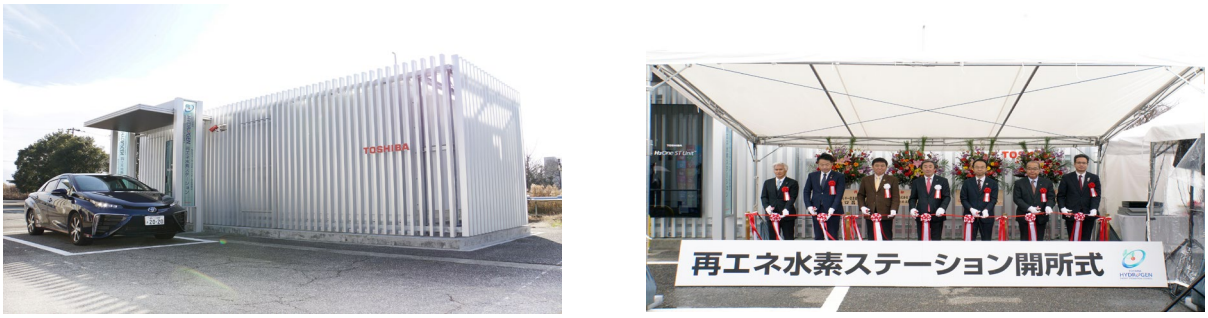

Figure 3-24　Hydrogen station in Toyama City

Source: Toshiba Energy Systems & Solutions Corporation [24]

b)　Needs for use of hydrogen in the Maldives

As mentioned above, hydrogen can be utilized for technically solving the problem with stable supply, which is a bottleneck to the distribution of renewable energy. However, their system needs to be recognized and understood by local officials, so we introduced the technology in this survey, and studied the needs from local officials.

① Ministry of the Environment of the Maldives

On Thursday, November 4, 2021 during the on-site survey, we had an opportunity to meet the officials of the Ministry of the Environment of the Maldives, and interviewed them about the outline of the intercity collaboration project and the policies for using hydrogen derived from renewable energy, etc. From the Ministry of the Environment, the vice minister and the officials in charge of climate change, waste, and energy divisions participated. Our side included Japan NUS Co., Ltd. and HDC.

They commented that they are interested in especially the utilization of hydrogen. They had discussed it, because it could be used as a technology for distributing renewable energy, but they considered that it is not feasible from the cost aspect.

Accordingly, they are planning to shift from the current diesel power generation to green hydrogen via LNG as a transitional technology. They also commented that the attractive characteristic of hydrogen is the possibility of using it as fuel for automobiles and for power generation.

Regarding renewable energy, they understood the above-mentioned problem with the coordination capacity and mentioned that it is necessary to deal with load fluctuations. Regarding solar power generation on land, the national power company STELCO, the World Bank, ADB, etc. are planning to install solar panels, while available rooftop area is limited. Accordingly, they advised that it is necessary to coordinate with their existing plans.

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[24] Press release of Toshiba Energy Systems & Solutions Corporation: Start of operation of H2One ST Unit™, a renewable energy-derived hydrogen station for local production and local consumption, for Toyama Council for Promoting Hydrogen Energy, Jan. 2020 (https://www.toshiba-energy.com/info/info2020_0123.htm)

Regarding LNG for the transitional technology, they recognize it as key fuel for achieving net zero emissions in 2030, and informed us that the utilization of LNG is recommended in the net zero plan for 2030, which was produced with support from the World Bank, and the roadmap for net zero, which was produced with support from ADB. There is a plan to construct an LNG-fired power plant with an output of 200 MW in the Thilafushi Island, but discussions on decarbonization and costs are continued, and they have not reached a conclusion. Regarding green hydrogen, they commented that they would welcome a proposal for a solution to cost-related problems.

Figure 3-25　Scene of exchange of opinions with the Ministry of the Environment of the Maldives

② National power company STELCO

On Sunday, October 31, 2021 during the on-site survey, we met the staff of the national power company STELCO, which manages power generation and power systems in the capital area of Malé, and interviewed them about the outline of the intercity collaboration project, their power supply plan, and the possibility of discussing renewable energy-derived hydrogen.

Firstly, they mentioned that STELCO recognizes that the renewable energy that can be adopted in the Maldives is limited to solar power. Then, they informed us that there is a plan to install a solar power generation system with an output of 15 MW and storage batteries to cover load fluctuations. However, the capital area of Malé has land constraints for installing solar panels and storage batteries, so they recognize that LNG-based power generation is currently the best means for realizing a low-carbon society, because floating solar power generation systems and other technologies for renewable energy are still under development. Regarding hydrogen, they mentioned that they would like to shift gradually, but it is necessary to set systems far from residential areas for safety.

Figure 3-26 Outer appearance of STELCO

From the interviews with the Ministry of the Environment of the Maldives and STELCO, it was found that they consider solar power generation as the primary means for distributing renewable energy, recognize the problems of land constraints and fluctuations in power grids, and are keenly interested in hydrogen for realizing decarbonization, while thinking that LNG is a near-term solution for a low-carbon society.

The Ministry of the Environment found cost issues through discussions so far, while STELCO recognizes that it is necessary to discuss details from the aspect of safety, etc.

Considering these recognitions of local parties, we decided to discuss proposals for solutions to the above issues, to promote the installation of systems.

c) Feasibility of use of hydrogen

Considering the fact that it is challenging to adopt renewable energy (solar power) as an energy source for hydrogen use, it is appropriate to install autonomous decentralized equipment in each facility or district rather than large-sized centralized equipment for solar power generation and hydrogen production through water electrolysis.

Enlargement would provide economics of scale, but it is necessary to create demand while solving the issues related to development, such as the securing of land and costs, so it takes time to secure land and a budget, and make political decisions. Accordingly, an approach for distribution based on small-scale demonstration in a model spot suited for hydrogen use is considered effective.

For electric power, ENE-FARM (household fuel cells), which has been already distributed in Japan, could be utilized. ENE-FARM induces a chemical reaction between hydrogen extracted from city gas and LP gas and oxygen in the atmosphere to generate power, and provides hot water by using the generated heat. Since it contributes greatly to energy saving, it has been distributed.

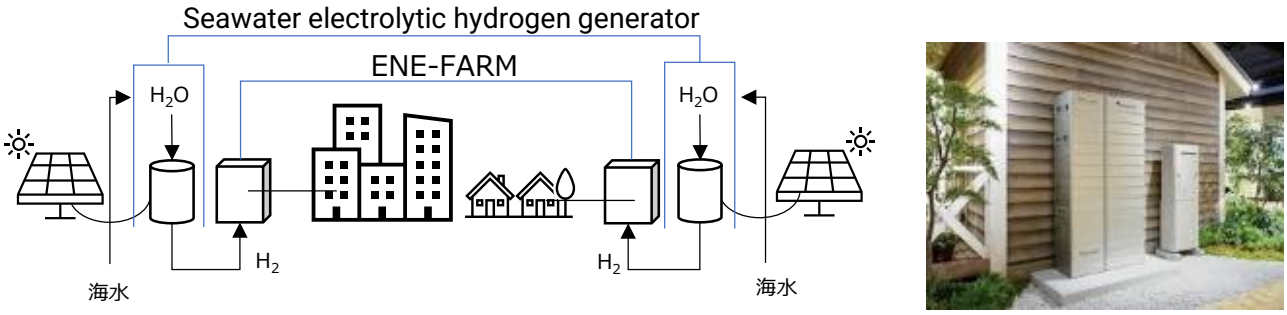


Figure 3-27 Schematic diagram of use of ENE-FARM

When renewable energy-derived hydrogen is used, it is unnecessary to install a reformer for extracting hydrogen from city gas or LP gas, so a simpler structure can be achieved. With the aim of distributing hydrogen infrastructure, they have developed ENE-FARM for directly using hydrogen by removing a reformer from the conventional model.

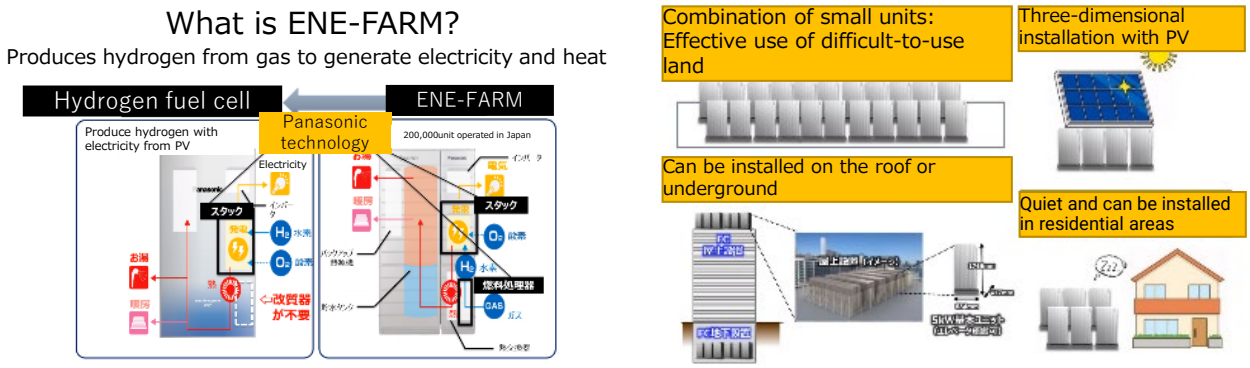


Figure 3-28 Mechanism and distribution of ENE-FARM

Source: produced by Hokusan Co., Ltd. based on reference material

ENE-FARM is designed for households, so it is quiet and can be installed underground or with solar panels, overcoming land constraints. In this survey, we seeked model spots, and received an inquiry about the “Green Building” Scheme, which utilizes renewable energy 100%, from HDC. The Green Building Scheme was designed based on the BREEAM (Building Research Establishment Environmental Assessment Method) of the U.K., which is an international index for gauging the sustainability of a building or region. In the Hulhumalé Development area, a model of the next-generation building is planned, and we reached an agreement that we will exchange opinions about the feasibility of installation of ENE-FARM.

The distribution of ENE-FARM may contribute to the stabilization of the power system in the capital area of Malé. For example, ENE-FARM is utilized in the Japanese electric power market, and about 1,500 units of ENE-FARM are used in the VPP aggregator demonstration project, to contribute to the stabilization of power grids, etc. by adjusting the output of fuel cells according to the power generation cycle with renewable energy, etc.

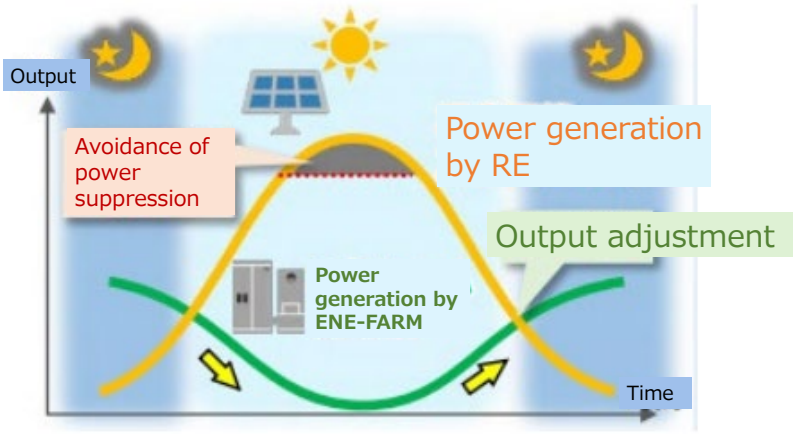


Figure 3-29　Schematic diagram of the output adjustment of ENE-FARM

Source: Material of Agency for Natural Resources and Energy of METI [25]

Technologies for applying hydrogen to transportation are under development around the world, but it has been pointed out that there are problems with costs for hydrogen stations, including hydrogen gas compression equipment for supplying fuel. In this situation, it may be possible to use "SimpleFuel™," which was jointly developed by IVYS Energy Solutions and PDC Machines in the U.S.

SimpleFuel™ was installed in the factories of Toyota Motor Corporation. It is a hydrogen station that produces hydrogen through the electrolysis of water by using the power generated by solar panels inside the premises of factories, compresses it, and refuels fuel cell (FC) forklifts.

The production volume of hydrogen is up to 99 Nm^3/day (about 8.8 kg/day). It can refuel seven or eight FC forklifts, and it can be set in a small space because of its compact size, so it is considered to be suited for refueling FC forklifts in factories.

Figure 3-30　Envisioned supply of hydrogen to transportation means with SimpleFuel™

Source: Produced by Hokusan Co., Ltd. based on reference material

It could be used for airport vehicles, public buses, boats, etc. whose operation ranges and energy

[25] Agency for Natural Resources and Energy, METI: "Interim Summary of Challenges in Future Hydrogen Policies and Countermeasures (Provisional)," March 2021 (https://www.meti.go.jp/shingikai/energy_environment/suiso_nenryo/pdf/025_01_00.pdf)

consumption can be estimated easily. The adoption of EVs is being discussed for public buses operated by MTCC. Keeping in mind that fuel-cell vehicles are more economical when travel distance is longer, we will have discussions, including the comparison with hydrogen use.

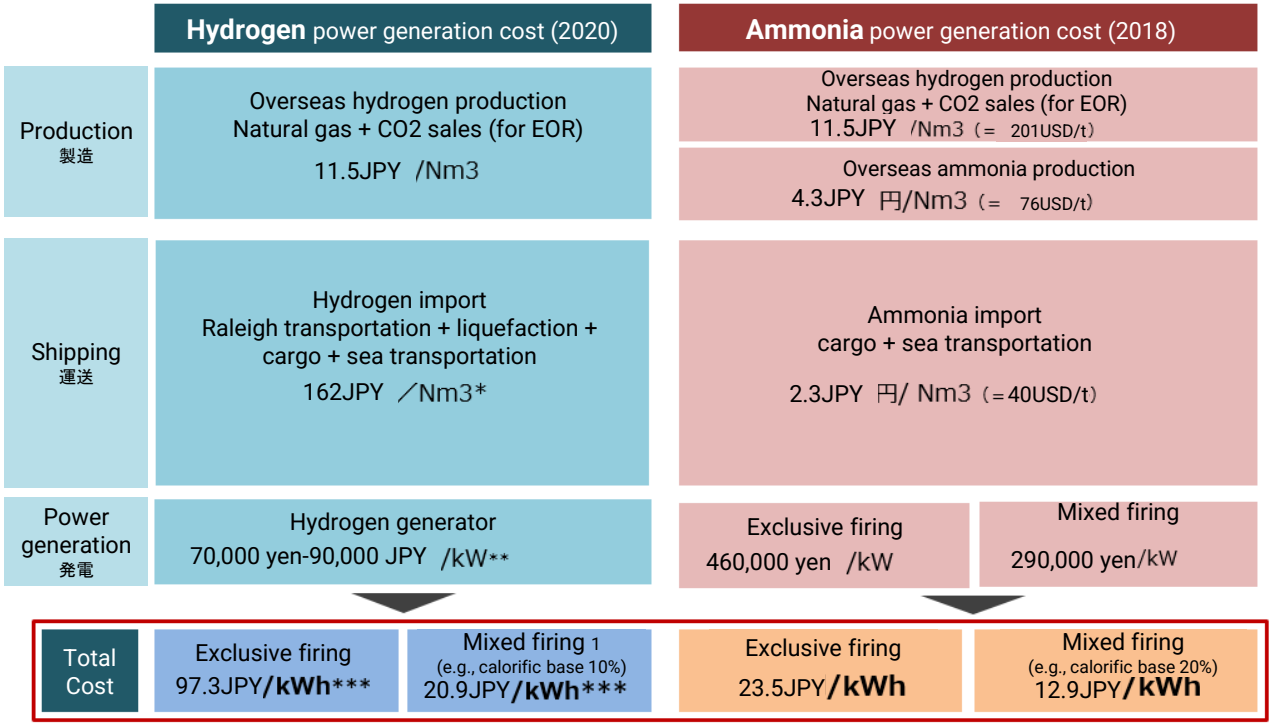
d) Feasibility of using ammonia

As mentioned earlier, renewable energy sources are limited to solar power in the Maldives, and it has location-related constraints. Thus, to achieve carbon neutrality, it is highly likely that procuring hydrogen derived from renewable energy from overseas is an option to be considered.

Regarding the transportation and storage of hydrogen, they are interested in using ammonia (NH_3) along with liquefied hydrogen that is liquefied and compressed by cooling. Liquefied ammonia has a hydrogen density of about 1.5 times that of liquefied hydrogen and liquefies at 25°C and 10 MPa. Moreover, compared to liquefied hydrogen, energy loss occurs in the conversion process to ammonia. However, the energy required for its transportation is smaller. Thus, ammonia becomes a more beneficial option the longer the distance traveled [26].

Energy importing countries prefer selecting fuels with high transportation efficiency because it directly affects the costs. Therefore, as a decarbonized fuel, ammonia is an option to be considered. As shown in the figure below, when comparing the power generation costs, including the costs for the supply chain of hydrogen and ammonia, based on the case of Japan, which is an energy importing country, the power generation cost of ammonia is lower.

Table 3-8 Cost comparison of hydrogen and ammonia



Source: Produced by Hokusan Co., Ltd. based on reference material

[26] Kojima, Ichikawa, Hydrogen Energy Systems Society in Japan, Vol. 36, No. 4, 34-41, 2011

In terms of utilization, Mitsubishi Power Co., Ltd. is developing an ammonia gas combustion turbine, and in 2021 it started to remodel a 40,000 kW class turbine. Also, IHI succeeded in realizing a natural gas and ammonia co-fired gas engine and aims to reach a 100% liquid ammonia-fueled firing in 2025. Regarding co-combustion with diesel, although it is used mainly in ships, JFE Engineering has succeeded in an ammonia and diesel co-combustion and plans to proceed with development to increase the ammonia ratio to 80% in the future [27].

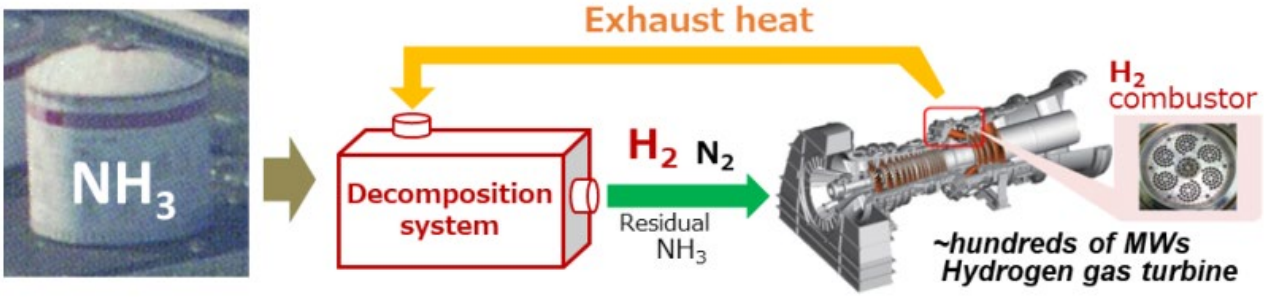
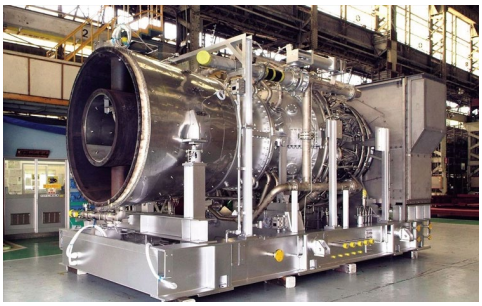
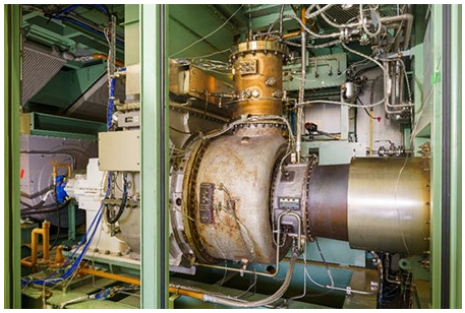


Figure 3-31 Example of the hydrogen technology



Ammonia gas turbine(Dedicated burning)
Mitsubishi
In 2021, we started to remodel the existing 40,000 kW class gas turbine.



Ammonia gas turbine
IHI
Succeeded in co-firing natural gas and ammonia (70%). Aim for exclusive burning in 2025.

Figure 3-32 Case of ammonia gas turbine technology development

Source: Produced by Hokusan Co., Ltd. based on reference material

(2) Technical examination of natural gas supply feasibility

a) Overview of natural gas supply and power generation technology

Natural gas is a flammable gas used as the so-called city gas in Japan and refers to a naturally stored gas containing carbon compounds such as methane and ethane.

In island countries such as Japan, which import natural gas, liquefied natural gas is mainly imported by tankers. Natural gas is liquefied by cooling it to -162°C at atmospheric pressure. By doing so, its volume is compressed to about 1/600, allowing more gas to be transported with a small volume. Thus, the transportation cost and portability are improved.

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[27] Nippon Keidanren(Japan Business Federation) “Challenge Zero” Website Innovation Example “Ammonia Direct Combustion Technology ‘Application to Marine Diesel Engines’” (https://www.challenge-zero.jp/jp/casestudy/74)

LNG needs to be regasified to be used as gas. Regasification is the process of raising the temperature of LNG and evaporating it to return natural gas to gas. Therefore, regasification equipment, LNG storage equipment, and land are required when using natural gas.

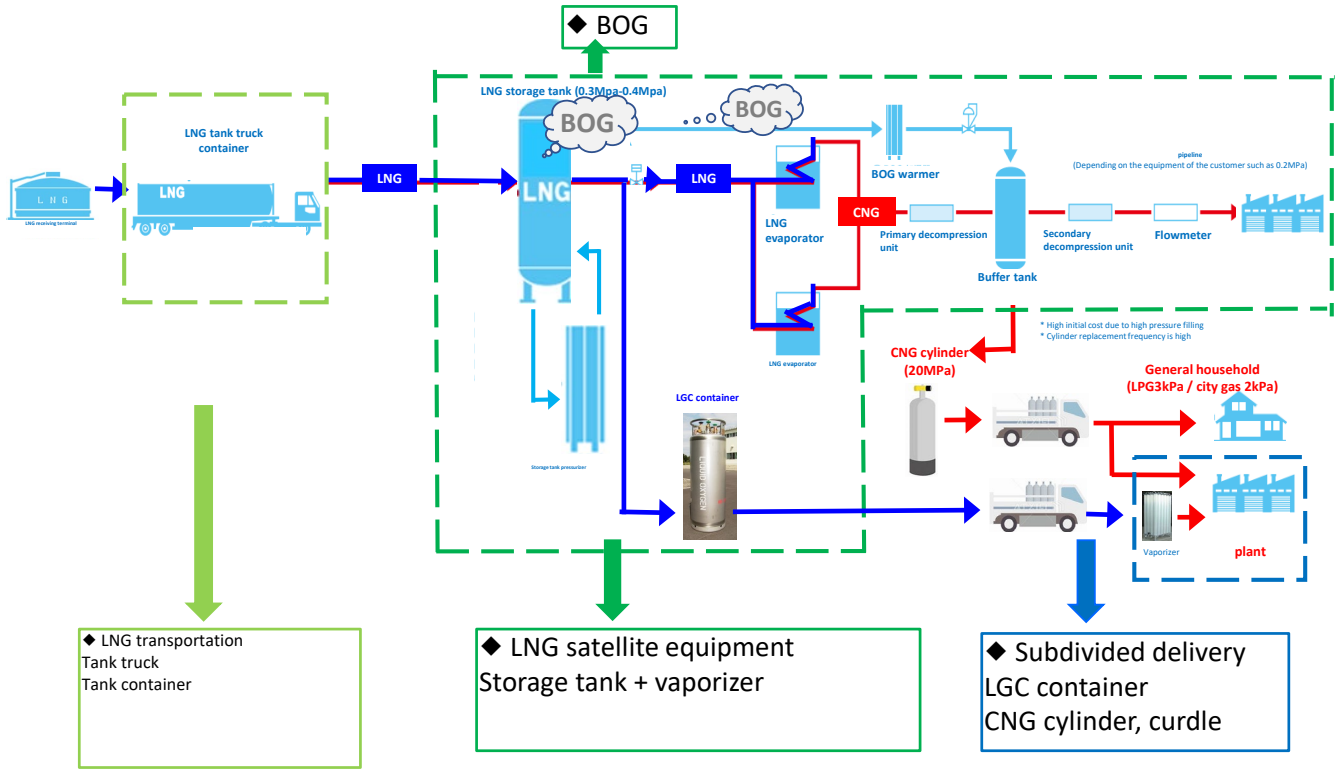

Figure 3-33 Process flow of delivery, storage, and vaporization of LNG

Source: Produced by Hokusan Co., Ltd. based on reference material

Compressed natural gas (CNG) has the same composition as liquefied natural gas (LNG). However, unlike the liquefied one, it does not require cooling, so transportation and storage facilities are much simpler. On the other hand, while LNG takes up 1/600 of the natural gas volume at atmospheric pressure, CNG is compressed to about 1/200 of the natural gas volume. Hence, the volume is large, so transportation costs are an issue.

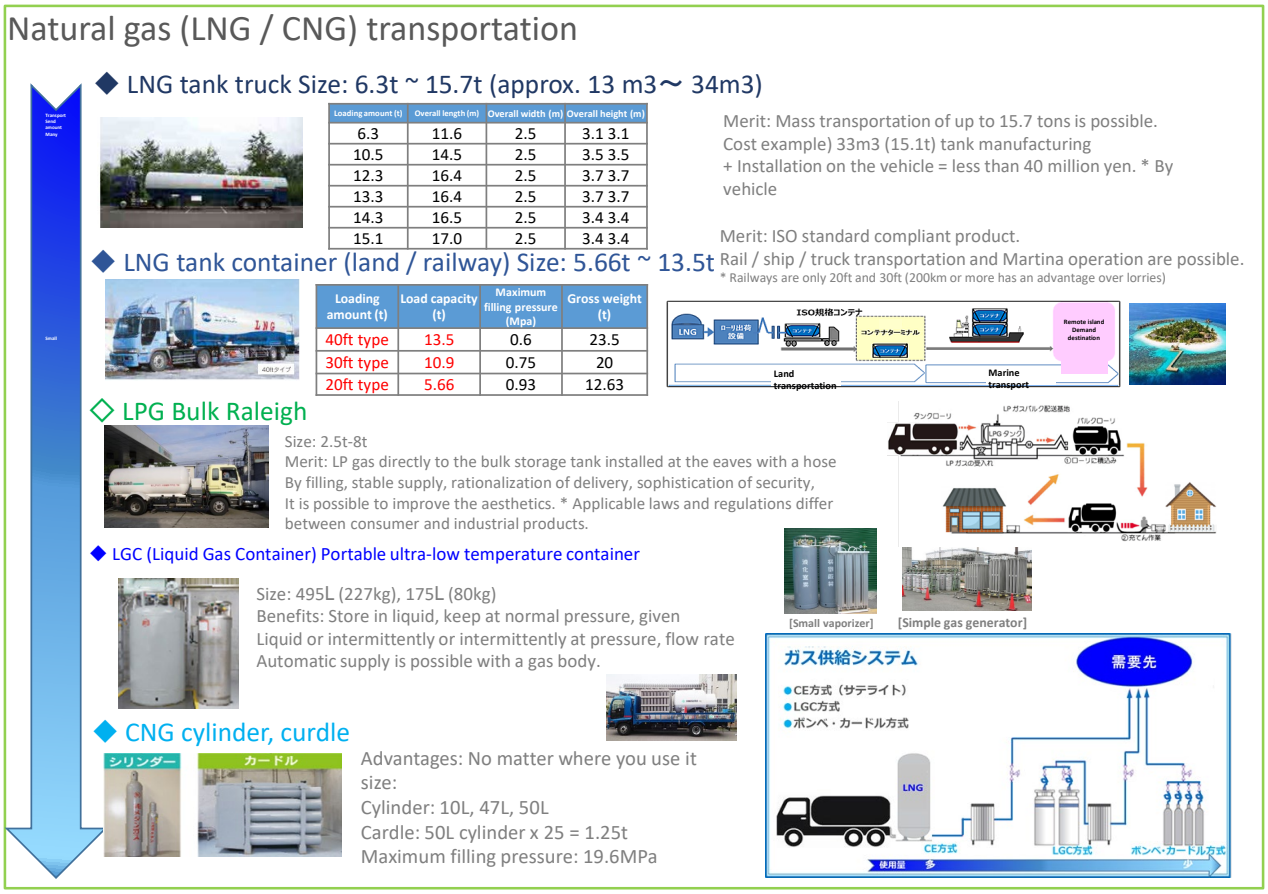

Figure 3-34　Comparison of LNG and CNG transport volumes

Source: Produced by Hokusan Co., Ltd. based on reference material

b)　LNG introduction plan in the Maldives and Male region

In its 2019 annual report, STELCO, a state-owned electric power company responsible for providing electricity in the Male metropolitan area, has announced investment plans for future power generation configurations, including LNG, solar power, battery technology, and hybrid systems [28].

The capacity of the LNG power generation facility is estimated to be 200 MW and would be constructed on the Thilafushi Island. Since the electricity demand in the Greater Male region is estimated to exceed 260 MW, and the amount of electricity generated in the region is one-fourth of the Maldives as a whole, clean and low-priced LNG is preferable to diesel. Moreover, the existing diesel power plant would continue to be used for load adjustment.

[28] STATE ELECTRIC COMPANY LIMITED(STELCO)ANNUAL REPORT, 2017. (https://www.stelco.com.mv/download/stelco-annual-report-2017?wpdmdl=5602&refresh=600bb5ef7547f1611380207)

Figure 3-35 Power grid development plan for the Greater Male area

This plan is also reflected in the biennial report (BUR: BIENNIAL UPDATE REPORT TO THE UNFCCC) submitted to UNFCCC by the Maldivian government. In it, you can find the plan to promote the use of LNG as one of the mitigation measures [29].

Che energie, an Indian gas-related company, is studying the fuel transportation issue. In its plan, the company is considering installing a hub in the Gulhifalhu Island consisting of floating gas storage and regasification units (FSRU) with a capacity of about 130,000-140,000 m^3 to send small LNG carriers to outer islands. This capacity would cover the energy consumption of the entire Maldives for about 40 days.

Thus, the supply chain for LNG utilization in the Maldives is being established. On the other hand, there is a problem with transmission lines in the plan to build an LNG thermal power plant on the Thilafushi Island. Regarding this point, a plan to construct a bridge connecting the Thilafushi Island and the Male Island is currently underway, and India is moving to provide funding through ODA [30]. Specifically, in August 2020, India's Foreign Minister Subramaniyam Jaishankar has promised a 100 million dollar subsidy for the construction of the bridge and a new 400 million dollar loan.

However, considering the bridge's design, financial planning, and construction, it is expected to take about five to ten years to complete it.

However, as it is necessary to reduce emissions promptly, it is essential to take some mitigation measures against the dependence on the existing diesel power generation plants without waiting for

[29] MINISTRY OF ENVIRONMENT "MALDIVES FIRST BIENNIAL UPDATE REPORT TO THE UNFCCC," 2019. (https://unfccc.int/sites/default/files/resource/First%20BUR%20of%20Maldives.pdf)
[30]DW.com" India seeks to counter China influence in Maldives with bridge project," 13 Aug 2020. URL:https://www.dw.com/en/india-seeks-to-counter-china-influence-in-maldives-with-bridge-project/a-54555981

the completion of power plants and transmission lines.

The City-to-City Collaboration Program prioritizes using renewable energy. However, as the baseload diesel power facility must operate for load adjustment, using natural gas to minimize CO_2 emissions is reviewed as an option. Specifically, the method of converting existing diesel equipment into diesel and natural gas co-firing power generation can be used.

c) Natural gas technology

As mentioned above, in this proposal, we do not consider the permanent usage of LNG in power generation, but as a milestone toward low carbonization. Thus, we suggest the adoption of co-firing technology in existing diesel power generation facilities.

This is called dual-fuel (referred to as DF below) technology. It has been used in ships and large vehicles with diesel engines as well as power generation facilities. DF technology was also used in the 2018 JCM equipment subsidy project, "The introduction of CNG and diesel co-firing equipment to public transportation buses in Semarang City, Indonesia." Hokusan Co., Ltd., the co-operator of this project, is the representative company in the JCM project.

DF technology can be applied to all diesel engines, including those of vehicles, ships, or generators. By mixing the diesel fuel spray in the engine with natural gas, the amount of diesel used is reduced, which leads to less CO_2 emissions. Moreover, it can be cost-effective due to the difference in the number of thermal units. Furthermore, since it is only necessary to add devices such as a gas tank, piping, a supercharger, and a control system to the existing diesel generator, there are merits in terms of construction cost and construction period.

Natural gas conversion technology for diesel power generation equipment is found in Europe, China, India, and Japanese heavy electric manufacturers, and engineering companies also have the technology. For example, the dual-fuel engine gasification conversion technology developed by JFE Engineering Corporation has a track record of operating for 20,000 hours and a gas fuel ratio of 95%, making it a highly efficient facility globally. In developing countries, there is a tendency to prioritize lower prices over performance. However, it is highly possible that it will be used in the case of the JCM equipment subsidy project financing the project and ensuring price competitiveness.

JFE Engineering Corporation has already delivered nine facilities in Japan and overseas and has installed some in India, Indonesia, and other countries. Thus, it has a high market advantage in developing countries.

Introduction record in India (NEDO demonstration)

Introduction record in Indonesia

Figure 3-36 Example of JFE Engineering Corporation's DF technology

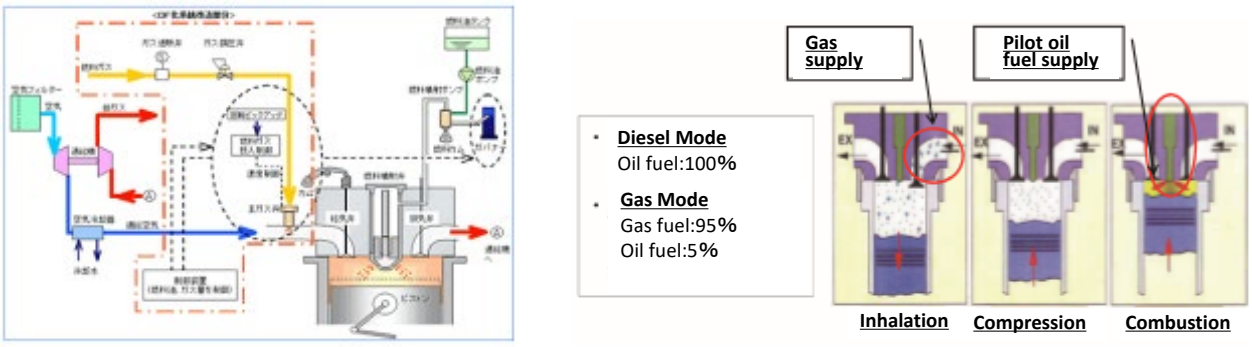

Figure 3-37 Combustion in a natural gas co-fired engine

Source: JFE Engineering Corporation 21 [31]

Hitachi Zosen Corporation, which aims to install waste power generation and seawater desalination equipment in the Maldives, also has similar dual-fuel technology and has the advantage of partnering with the engine manufacturers used by many of Maldives' diesel power plants.

3.2.2. Fuel comparison

It is currently challenging to meet the energy demand in the Male metropolitan area by relying only on renewable energy. Thus, hydrogen, ammonia, and LNG/CNG are expected to replace diesel fuel, which is currently the primary fuel, as much as possible. In this case, it is necessary to consider importing them.

Hydrogen and ammonia, which are considered zero-emission fuels, would lead to zero emissions in the Maldives, but would cause greenhouse gas emissions in the production areas. Therefore, it is essential to pay attention to greenhouse gas emissions throughout the entire supply chain when selecting fuels, for example, by choosing options that use CCS and CCUS technologies and renewable energy in the hydrogen production process at production sites.

Fuel would be shipped by sea for import. Due to factors such as the close distance and routes, the Maldives would most likely import it from India or Sri Lanka.

The figure below shows the natural gas (LNG and CNG), hydrogen (natural gas-derived, brown coal-derived, by-product hydrogen, and renewable energy-derived) and ammonia supply chains and carriers (liquefied hydrogen, MCH, and ammonia) and possible supply flows.

[31] JFE Engineering Corporation: "Technology for using gas fuel in a dual fuel engine," Jan. 2013, JFE Technological Journal No. 31, p.p. 89-90 (https://www.jfe-steel.co.jp/research/giho/031/pdf/031-22.pdf)

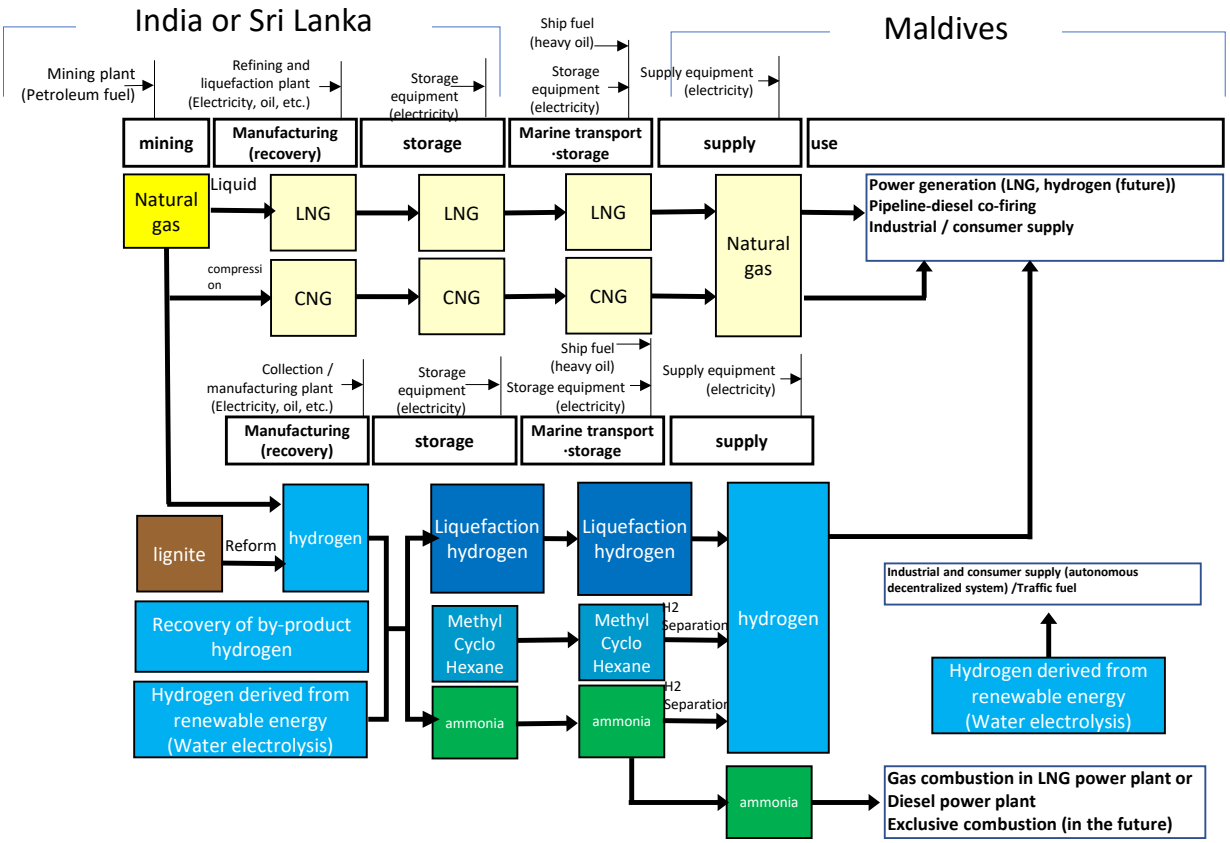

Figure 3-38 Suggested LNG, hydrogen, and ammonia supply chains

In the case of supply chains with the lowest greenhouse gas emissions, it is expected to compare them by creating a life cycle inventory for each fuel type and carrier combination. However, since these supply chains are mere suggestions, it is challenging to estimate accurate values.

We will show the estimated results obtained in a comparative evaluation [32] based on various documents while assuming that Japan imports zero-emission fuel from Australia.

[32] JAPAN NUS CO., LTD. was commissioned by a private organization to conduct a survey in FY2020.

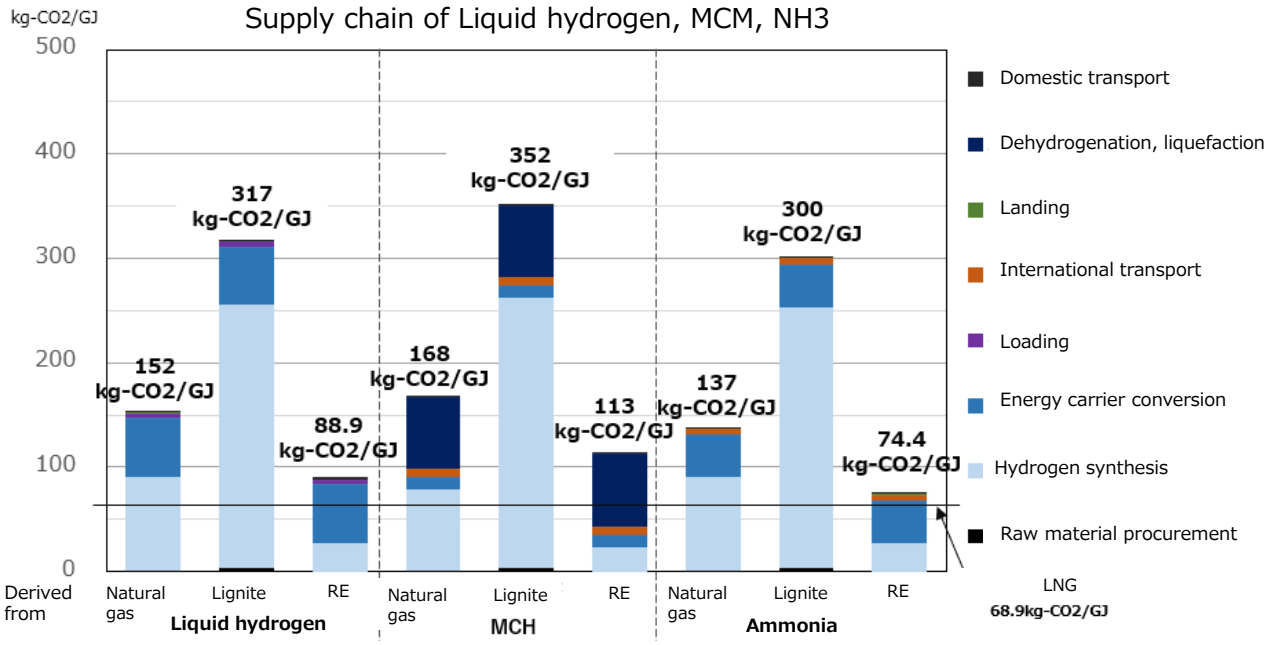

Figure 3-39 Lifecycle inventory for each carrier (example)

As shown in the figure, even with hydrogen derived from renewable energy, if the electrical grid is used for carrier conversion (liquefaction and reforming), CO_2 emissions may be higher than that from LNG in the entire supply chain. However, it should be noted that these estimates are based on data from the demonstration plant and that future technology that is expected to be more efficient and larger in scale may have lower emissions than LNG.

In any case, a certain volume of CO_2 would be emitted during transportation of fuel and at its country of origin. Thus, when considering achieving zero-emission power in the Male metropolitan area, firstly, it is recommended to focus on using hydrogen derived from renewable energy and promoting converting renewable energy into hydrogen as much as possible in the Maldives. Secondly, the Maldives should select the fuels to import while taking into consideration the state of technological development and the decarbonization movement in the exporting country.

Accordingly, we will focus on renewable power to hydrogen production via electrolysis and using ENE-FARM (residential fuel cells) in the Male metropolitan area and study their potential and the feasibility as a demonstration project.

3.2.3. Implementation plan and system

a) Hydrogen

As mentioned above, hydrogen-fueled technology can provide self-sustaining power. Thus, we will consider installing solar power generation panels and water electrolysis systems for hydrogen production in each district and facility. Additionally, we will study the idea of installing electricity and hot water or hydrogen supply equipment for vehicles. Possible components of these systems include solar panels, seawater desalination equipment, water electrolysis systems for hydrogen production, ENE-FARM (residential fuel cells), and water electrolysis systems for hydrogen

production and compression and dispensing equipment (for vehicles). We will conduct a study regarding sites and facilities with high potential to use these systems in the future. We assume owners of green buildings, including HDC, which has multiple buildings in Hulhumalé, would become users of such systems. As for hydrogen supply to vehicles, MTCC Plc. is likely to use them as well.

Hokushi Co., Ltd. would represent the JCM equipment subsidy program as a system design, security, and monitoring equipment provider. Nihonkucho Hokuriku Co., Ltd. is expected to be responsible for the design of the renewable energy system needed for hydrogen production.

All technologies in these systems will be installed in collaboration with Japanese manufacturers. Regarding the use of hydrogen derived from renewable energy, although the technology is in the dissemination stage, it has been pointed out that the high installation cost is a constraint on the dissemination even in Japan. Thus, it is hard to install it at present from a financial point of view in a country like the Maldives, where the electricity price is relatively high. Under such circumstances, even with the JCM equipment subsidy, it is expected that there will remain problems in terms of economic efficiency. However, this depends on the amount of demand and EPC costs. For this reason, we will try to understand the installation issues through a demonstration project by relying on the JICA's SDGs business support project survey. Along with these efforts, we will investigate using this model facility as a promotion base in the Maldives.

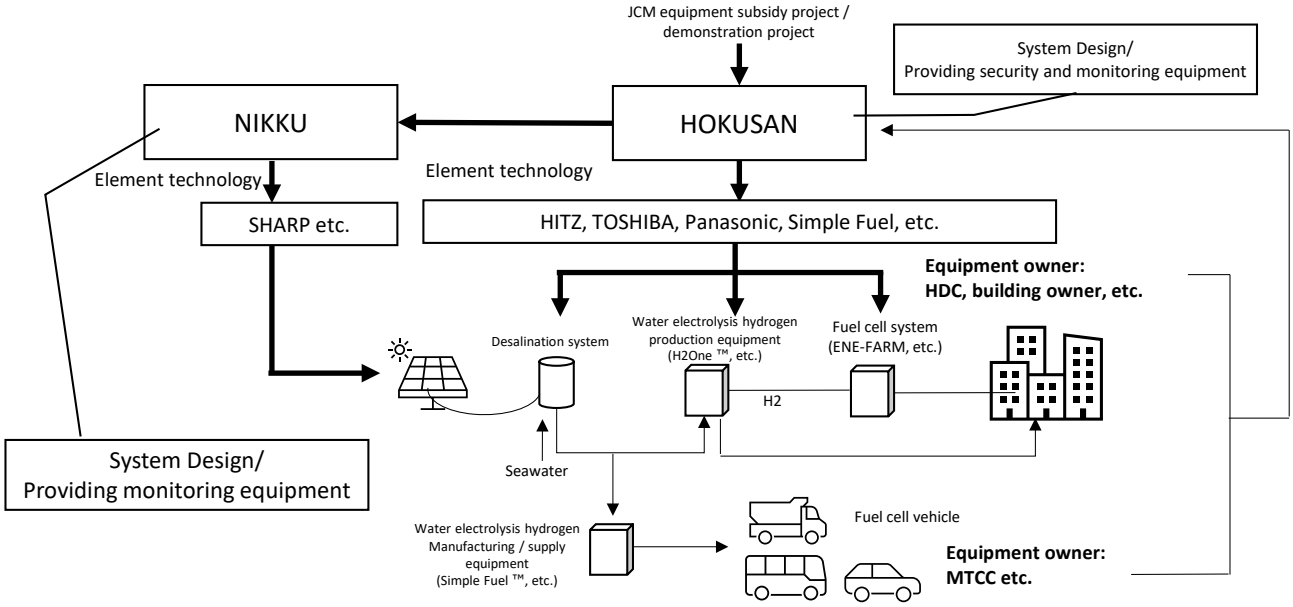

Figure 3-40 Suggested implementation system for the hydrogen dissemination project

b) Natural gas

As mentioned above, we will consider a collaboration to introduce natural gas technology when the Maldivian government constructs the supply infrastructure. When establishing the LNG infrastructure, the government plans to build a new LNG thermal power plant. However, we were informed that the existing diesel power plant would continue to be used due to the power load fluctuations. Therefore, we will consider adopting co-combustion technology through supplying natural gas to the existing diesel power plant from the storage facility via a pipeline and in the form

of CNG and using DF and gas operation technologies.

This project will be implemented through an international consortium between Hokushi Co., Ltd., an energy company in Toyama City, as the representative company, and STELCO, a national electric power company that owns and operates a diesel power plant in the Male metropolitan area, as the local company.

It is expected that Indian companies would invest in the gas supply infrastructure. Since the key to establishing this project is the stable gas supply, we will also consider strengthening the project's foundation by inviting companies responsible for the gas supply chain to the international consortium as needed.

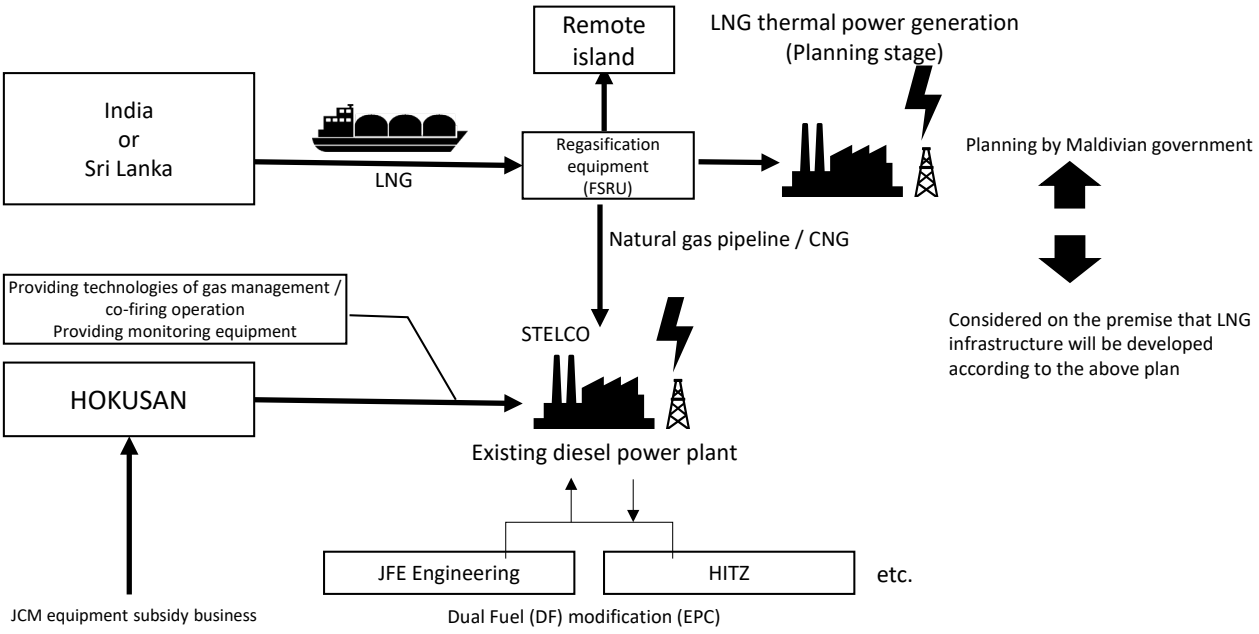

Figure 3-41 Suggested implementation system of the natural gas project

Regarding the schedule of this project, it is necessary to wait for the establishment of the gas supply chain. According to ADB's "A Brighter Future for Maldives Powered by Renewables (Road Map for the Energy Sector 2020–2030),"[33] there is a possibility that investments will be made in the development of LNG receiving terminals between 2020 and 2023.

Despite the spread of the novel coronavirus, 2023 is also the target year for SAP. Therefore, decisions regarding adopting LNG will most likely be made by 2023, and procurement will be realized after a negotiation phase for contracts to develop LNG introduction bases and procurement. Thus, for the time being, we plan to continue to pay close attention to these trends, identify local needs and investigate the feasibility of the project.

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[33] ADB "A Brighter Future for Maldives Powered by Renewables (Road Map for the Energy Sector 2020–2030)", November 2020.
https://www.adb.org/sites/default/files/publication/654021/renewables-roadmap-energy-sector-maldives.pdf

3.3. Renewable energy popularization field

Maldives has great potential for solar power generation due to its abundant amount of solar radiation. Thus, the utilization and popularization of solar power generation are already in progress. In particular, island resorts proactively use renewable energy. Since they target environmentally conscious Western customers, they are not only focusing on conserving marine life, which is a tourism resource, but also increasing their consideration of other environmental aspects such as waste and energy. In this survey, we aimed to use multiple resort islands in the Male metropolitan area as concrete examples for adopting solar power generation, and based on interviews with the resort owners, we attempted to create a project.

3.3.1. BISON's Male Atoll resort development

As renewable energy generation is already widespread in Maldives, we inferred that a certain number of businesses in Maldives are in charge of such industry. Thus, we assumed it would be easier to develop the project by cooperating with these businesses. Hence, we searched for renewable energy companies. We were able to get in touch with Renewable Energy Maldives, a company that has experience executing international support projects. As a renewable energy developer, the company has established solar power generation projects throughout Maldives.

After several online meetings, we reached an understanding and a cooperation agreement with the City-to-city Collaboration Program and were introduced to potential projects. One of them is a resort development project by BISON, a Maldivian construction company.

BISON plans to create a resort in the northwestern part of the Male metropolitan area and manage it as part of its business. The company's vision is to supply most of the electric power with renewable energy, centering on the seawater desalination plants, which are facilities with a particularly high power load.

Hitachi Zosen Corporation, which takes on orders for waste power generation businesses, was considering spreading its seawater desalination facilities, one of its technologies, in Maldives. Based on this, BISON considered using an integrated system, a facility that supplies water using renewable energy, in cooperation with Hitachi Zosen Corporation.

Based on information such as the number of rooms and the resort area in BISON's resort development plan, a system with a seawater desalination volume of 1,000 m^3/day and required electric energy of 1,209 kWp was designed.

The RO system, which is part of the water production facilities, is distorted when the power is lost and the pressure is reduced, which adversely affects the system. Thus, it is necessary to install a diesel power generator as a backup power source or a battery that meets the power demand so that pressure is always applied.

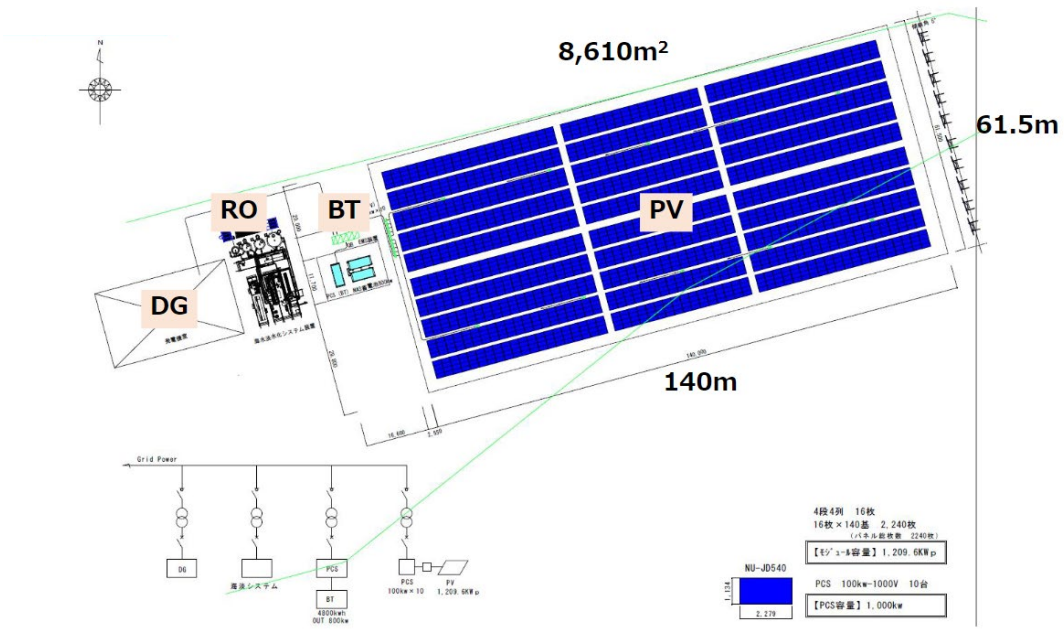


Figure 3-42　Layout of solar power generation equipment for resorts for BISON

Source) Nihon Kucho Hokuriku

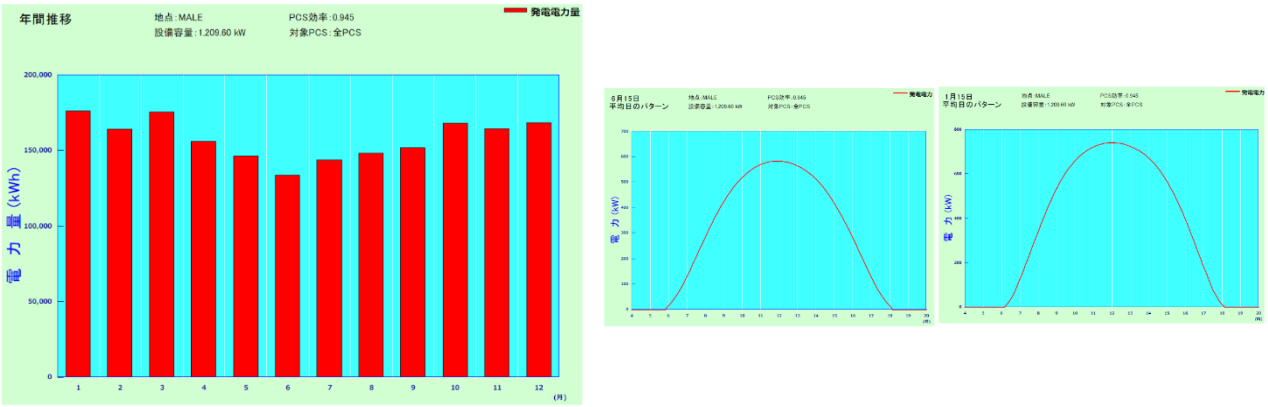


Figure 3-43　Estimated variation in power output in the resort

Source) Nihon Kucho Hokuriku

Based on the results of these basic investigations, on Tuesday, November 2, 2021, during the field survey period, we visited BISON with Hitachi Zosen Corporation, which was visiting Maldives at the time, to discuss the details of the business policy. We contacted Nihon Kucho Hokuriku Co., Ltd. online and exchanged opinions during this visit.

Through our visit, we found out that BISON had difficulty raising funds due to the deterioration of loan conditions at the Central Bank of Sri Lanka, which was their financer, due to the spread of the novel coronavirus. BISON reported that they were in the process of considering other financers, such as the Bank of Singapore, and that they would reconsider the matter as soon as they establish some prospects regarding the financing issue.

As for the resort development, BISON introduced cases where the company supplying the equipment provided a financer with their proposal. In this scenario, BISON would undertake the

strategy of using the currency, products, and labor of the country of said company. From this point of view, they asked us about the availability of Japanese funding. The Central Bank of Sri Lanka, which BISON and others are considering as their financer, has a very high-interest rate of 12 to 14%. However, in the case of a Japanese company investing using a corporate loan, the interest rate is a small percent. Thus, there is no doubt that cooperation with Japanese investors would be advantageous, as it would be settled in yen. Therefore, we decided to consider it in the future.

Moreover, when developing a resort, it is common for the company providing the equipment to propose a design, including management equipment, based on the location of the resort rather than the owner.

Therefore, we confirmed that we, the Japanese side, would create a demo proposal for the solar desalination facility and propose it to the resort owner.

As of February 2022, BISON has informed us that they are expecting to receive funding and plan to reconsider the matter.

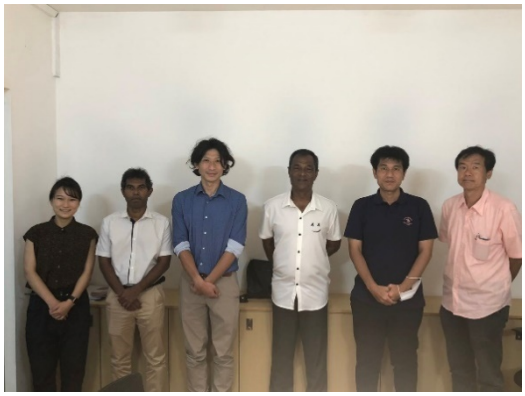


Figure 3-44 Scene of exchange of opinions with BISON

3.3.2. Crossroads Island Resort

The Crossroads Island is a resort located 8 km south of the Male Island and is developed and managed by Thailand's Singha Group. The resort has a Hard Rock hotel (198 rooms) and a Hilton hotel (174 rooms) and plans to expand to the surrounding three islands.

The resort uses diesel power generation equipment to generate electric power. However, considering the market needs, the group is considering transforming the resort into an eco-resort in the future. The resort also plans to use renewable energy, and they were attracted to the idea of using it combined with the seawater desalination facilities to supply water.

Currently, the resort's demand for water supply is 500 m^3/day. Although there are some issues regarding the location of the solar power and storage batteries, we agreed to pursue further discussions and exchange information on the matter.

Desalination system（RO）

Intake

Figure 3-45　Equipment in the Crossroads Island

3.3.3.　Cases of solar power generation utilization at existing resorts

As we consider using solar power generation at resorts, we thought it would be helpful to have examples of existing resorts using solar power generation systems as a reference. After the Embassy of Japan in Maldives introduced us to such resorts, we had the opportunity to visit an advanced resort, which is considered a "bio-luxury resort" and operates using renewable energy and waste recycling.

The resort is located on the island of Raa Atoll in northern Maldives. The resort investor is an Indian businessperson, the general manager is German, and the service manager is Italian. The customers are mainly from Europe, Russia, and the Middle East. The resort accommodates 300 guests (150 rooms) in peak periods, and 360 staff members reside at the resort.

Approximately 4,000 solar modules with a capacity of 900 kWp were installed on the island. The panel manufacturer is DEHI SOLAR, and the maximum output per panel is 325 W (1658 x 992 x 6 mm). However, it is impossible to rely 100% on renewable energy due to cost and stability issues. Thus, the resort uses a combination of solar modules and diesel power generation facilities.

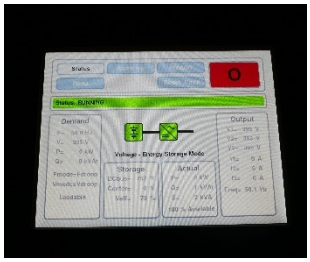
The resort's power demand is 400-1300 kW. The DG output relies on a 1000 kW2 system or a 500 kW2 system. The 1000 kW units are always operating. The 500 kW units operate according to demand, but the output cannot be controlled. Hence, solar power is used when the solar power output exceeds 500 kW, and when the output is less than 500 kW, the resort switches to the diesel system. The system switching is automatic, but as a measure against momentary power failure, a storage battery is used as a buffer. The battery has a storage of 20 kWh x 10 sets (power for 24 minutes).

PCS adopts ABB's power storage type ESS converter to stabilize and control the grid power supply.

Since the utilization of solar power generation is one of the initiatives that show guests the resort's efforts to be eco-friendly, the reception always displays the monitoring data of the amount of power generation and CO_2 emission reduction.

PV panels on rooftop

Spare PV panels



PCS

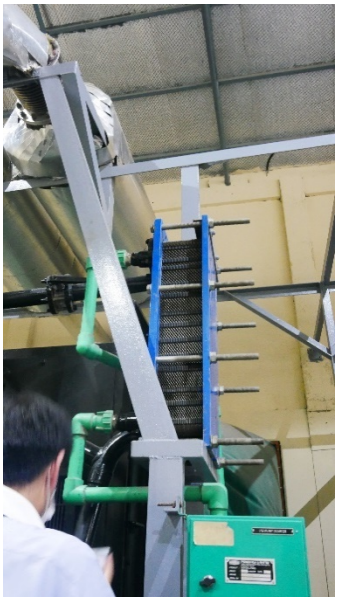
Power generation

Figure 3-46 Solar power generation system and equipment in the Reethi Faru Island

As for diesel power generation facilities, the resort uses a generator made by Powerlica, Cummins' OEM, with a configuration of 1000 kW2 systems and 500 kW2 systems, and a capacity of 1500 kW that can back up the peak demand.

As an energy-saving initiative, hot water is generated from the exhaust heat of diesel generators and used as hot water for showers. To enable using the exhaust heat, heat exchangers are attached to each of the four units. A heat exchanger with a design pressure of 6 BAR, 100℃, and 21 L/h manufactured by UK EXCHANGERS (UK) is installed in the 1000 kW units. The heated water is distributed through pipes with a heat-insulating cover to guest houses, restaurants, etc., and it has a separate system from the cold water distribution system.

Disel generator



Heat exchanger

Hot water piping

Figure 3-47 Diesel power generation equipment in the Reethi Faru Island

Regarding solar power equipment, the resort has adopted the Power Purchase Agreement (PPA) method. This means that the equipment is not owned or managed by the resort. The Maldivian renewable energy developer Swimsol provides power supplying services under a power retail agreement. In other words, it is a business model that recovers equipment costs in the form of electric power instead of selling equipment to resorts, which is similar to the Japanese roof rental solar business. Since payment is set according to the generated power, there is an advantage that initial investment is not required, and the developer is expected to continue to repair equipment failures.

Resorts prefer the PPA method because they are less likely to bear the technical and cost burdens related to the initial investment, management and operation, and maintenance of solar power generation equipment.

Therefore, we estimate it would be a better business opportunity to enter the industry as a PPA operator rather than selling equipment when introducing solar power equipment to resorts.

3.3.4. Possibility of introducing solar energy generation to the local islands in the Male metropolitan area

The seawater desalination plants at resort islands have a significant power load. Thus, as mentioned above, we have been considering the adoption of solar power generation at resorts in collaboration with Hitachi Zosen Corporation, which has RO water production equipment and technology. On the other hand, there are cases where local islands primarily use seawater desalination equipment as their water source. Hence, we assumed that these islands would have similar needs.

In addition, as the Maldives has a one-island-one-resort policy, tourists could not visit or stay in the local islands in principle. However, easing regulations has made it possible to accept tourists in the local islands in recent years, and the development of guest houses is in progress.

The Thulusdhoo Island, which is located in the suburbs of the Male metropolitan area, is

aggressively constructing guest houses and developing resorts. The island is also famous as a surfing spot, and the factory of Coca-Cola Company is located there. It is a 30-minute speedboat ride from Male and is home to 250 households, and has a population of 1,750. The guesthouses have 200 rooms and can accommodate up to 400 tourists, and they are expected to expand further in the future.

Figure 3-48　Location of the Thulusdhoo Island

In addition to the severe coastal erosion and the progress of land reclamation, the island council (the island's government) is considering a land-use plan that includes the use of the reclaimed land.

The water demand from the guest houses in the Thulusdhoo Island is estimated to be up to 100 m^3/day based on the information of the island council that the guest houses have 200 rooms (two beds per room) and that the water consumption per tourist is 250 L/day. In addition, there are 250 households and about seven people per household, and the water consumption per person is 150 L/day. Therefore, their demand is about 260 m^3/day, which makes the adequate amount of water to be produced about 500 m^3/day.

Currently, the island does not have a water production facility, and the only way to acquire water is to purchase bottled water from Male or Coca-Cola, but the cost is high. The island council owns the facilities and considers supplying water to the residents and guest houses. Since we had the opportunity to propose using solar power generation along with these facilities, we decided to investigate the matter while taking into account the local situation and the land use plan.

On the other hand, the island was damaged by the tsunami caused by the 2004 Sumatra earthquake, and ADB and others provided reconstruction assistance, and seawater desalination facilities and sewage treatment facilities were constructed.

However, these are not currently in operation because maintenance and parts replacement were not performed properly. Thus, we believe it is necessary to consider operation and management systems for solar power generation or operate them by the PPA method.

Sewage treatment plant

Desalination system

Figure 3-49 Equipment in the Thulusdhoo Island

3.3.5. Project implementation system and estimation of CO_2 emissions reduction

As a result of examining the implementation system for each candidate project based on the project inquired about by BISON, we estimate that Nihonkucho Hokuriku would procure the panels and collaborate with Renewable Energy Maldives, a local solar system construction company we are cooperating with, to introduce a solar power generation system. In addition, Hitachi Zosen Corporation would be responsible for installing the seawater desalination equipment that would use the power generated by the solar power generation system, and BISON, the resort owner, would be the off-taker.

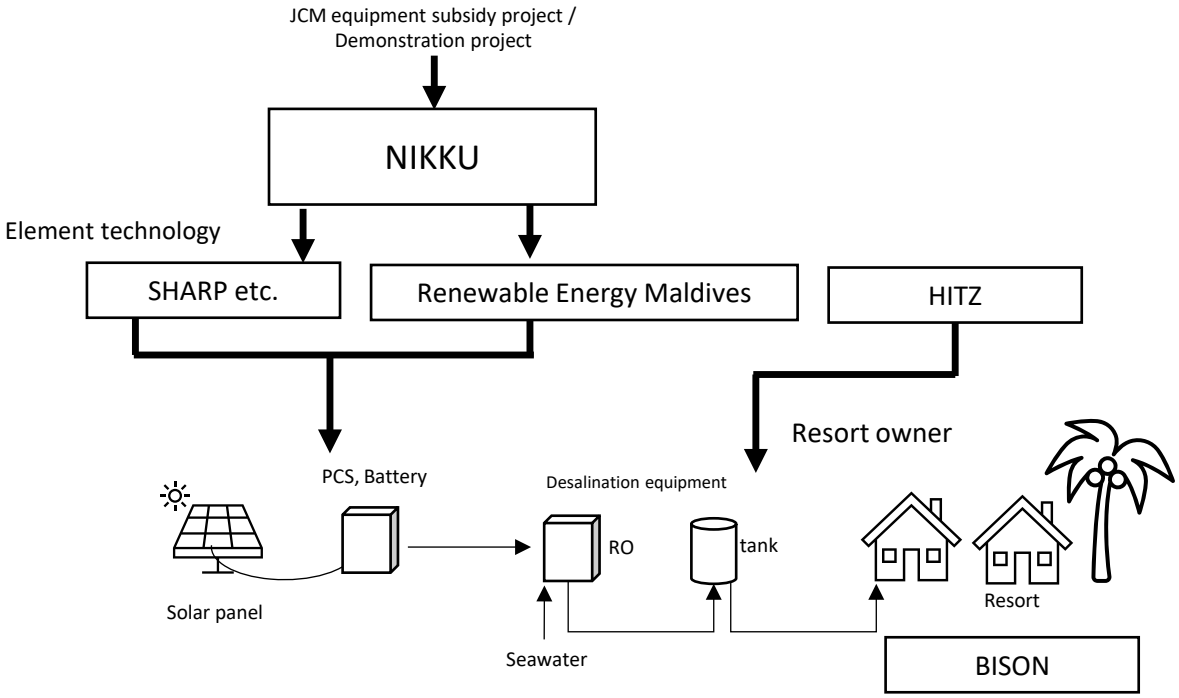


Figure 3-50 Envisioned project for installing a solar power generation system for resorts

Currently, after obtaining information on the details of BISON resuming their plan, we will start investigating the matter closely and draw a cost estimate. As we mentioned above, it may be necessary to consider relying on a PPA. From the viewpoint of monitoring, which is required when

considering applying for the JCM (Joint Crediting Mechanism) equipment subsidy project, a business that includes equipment operation and management is suitable. Thus, we will consider establishing the operation and management system while comprehensively examining and evaluating the risks of this being an overseas business.

Based on the BISON case, you can calculate the simple CO_2 emission reduction amount and cost-effectiveness as below.

The amount of solar power generation with an installed capacity of 1,209 kWp is estimated to be about 1,695,000 kWh based on the fact that the power generation efficiency was about 16% according to the power generation estimate calculated last year in Male.

Assuming that diesel power generation is used, and taking into reference Male's grid factor, which is 0.533 t-CO_2/MWh, the following formula would result in about 900 t-CO_2/year.

Power generated (year) x Grid emission factor = CO_2 emissions
1,695,000 kWh/year x 0.533 t-CO_2/MWh/1000 (unit adjustment) = 900 t-CO_2/year

The CO_2 emission reduction means that the solar power generation would make up for 900 t-CO_2/year of the diesel power generation equipment's emissions. Regarding the useful life of the equipment, based on the Ministerial Ordinance concerning the Useful Life, etc. of Depreciable Assets (Finance Ministry Ordinance No.15 in 1965), as the solar power generation facility would solely be used to produce energy for the seawater desalination plant, it falls under the category of water supply and drainage, sanitary equipment and gas equipment that is considered affiliated buildings. Thus, the useful life of the solar power generation facility is estimated to be 15 years.

Therefore, the amount of CO_2 emission reduction during the project period will be 13,500 t-CO_2.

Since this is the second solar power generation facility in the Maldives, a subsidy of 40% of the total project cost or cost-effectiveness at 4,000 yen/ t-CO_2, whichever is lower, will be applied.

Since the project cost is an issue that needs to be examined in the future, we will examine here the subsidy impact based on cost-effectiveness. Multiplying the previously mentioned reduction effect of 13,500 t-CO_2 by 4,000 yen will result in 54 million yen. If this amount is 40% or less of the project cost, it will be the subsidy's upper limit.

Regarding the cost of solar panels alone, the installation cost of the 1,145 kW solar system, which was investigated for the roof-mounted solar power system in Male in last year's survey, is of a similar scale and can be used as a reference. The installation cost was about 1.3 million US dollars (about 150 million yen) in that survey. Thus, it is expected that the BISON business will have a sufficient subsidy if the equipment cost is similar.

3.4. Utilization of organic waste

Waste is a major environmental issue in the Maldives and the Male metropolitan area. Since it is an island country, the dumpsites are limited, and waste is not disposed of properly. Therefore, there are concerns regarding the capacity of the dumpsites as well as the impact of the pollution resulting from harmful substances and plastics on the ocean.

Organic waste in the Male metropolitan area is finally disposed of unsorted with other waste on the nearby waste dumpsite in the Thilafushi Island. Although there is a plan to install a waste-to-energy plant at the dumpsite, organic waste has high water content and may adversely affect the efficiency of power generation from waste. Thus, it is excluded, and its disposal method is undecided.

These organic wastes are resources that can be used for energy and composting using the methane fermentation process. Hence, recycling can contribute to solving the waste problems and achieving a low-carbon society. In last year's project, we examined the feasibility of the methane fermentation process and considered the current compost import value. Our survey has shown that the methane fermentation process would be cost-effective even with the cost of the installation of the fermentation equipment. On the other hand, since methane fermentation equipment requires specialized knowledge to guarantee its stable operation, the Maldives faces some issues regarding operating as it has few engineers. In addition, we received some information that when the former Ambassador of Japan to the Maldives, Mr. Yanai, exchanged opinions with the Maldivian Minister of the Environment, Mr. Aminath Shauna, he expressed high interest in composting organic waste and that he wants to "adopt automatic composting machines that are not labor-intensive." Therefore, this year, we focused on the composting of organic waste and examined the possibility of adopting it.

3.4.1. Information on waste management in Male City

(1) Waste management conditions

The Master Plan for Handling Waste in the Male Metropolitan Area divided the Maldives into waste management zones, and the Male Metropolitan Area is classified as Zone 3. Zone 3 consists of 32 inhabited islands and 86 tourist resort islands (population 295,000: 53% of the Maldives' total population). Zone 3 covers Kaafu Atoll, including the Greater Male region, Vaavu Atoll to its south, and Alif Alif Atoll and Alif Dhaal Atoll in the west. Generally, each island stores unsorted waste at the waste collection point on the island and then ships to the Thilafushi Island. However, since there are no established shipping and storage systems or rules, it has become the norm in many local islands to dump the waste into the ocean and on the island or burn it in open fields to reduce its volume. Resorts are primarily obliged to dispose of waste properly on the islands. Nonetheless, there are cases where they are dependent on shipping them to the Thilafushi Island due to problems with disposal equipment and processing costs.

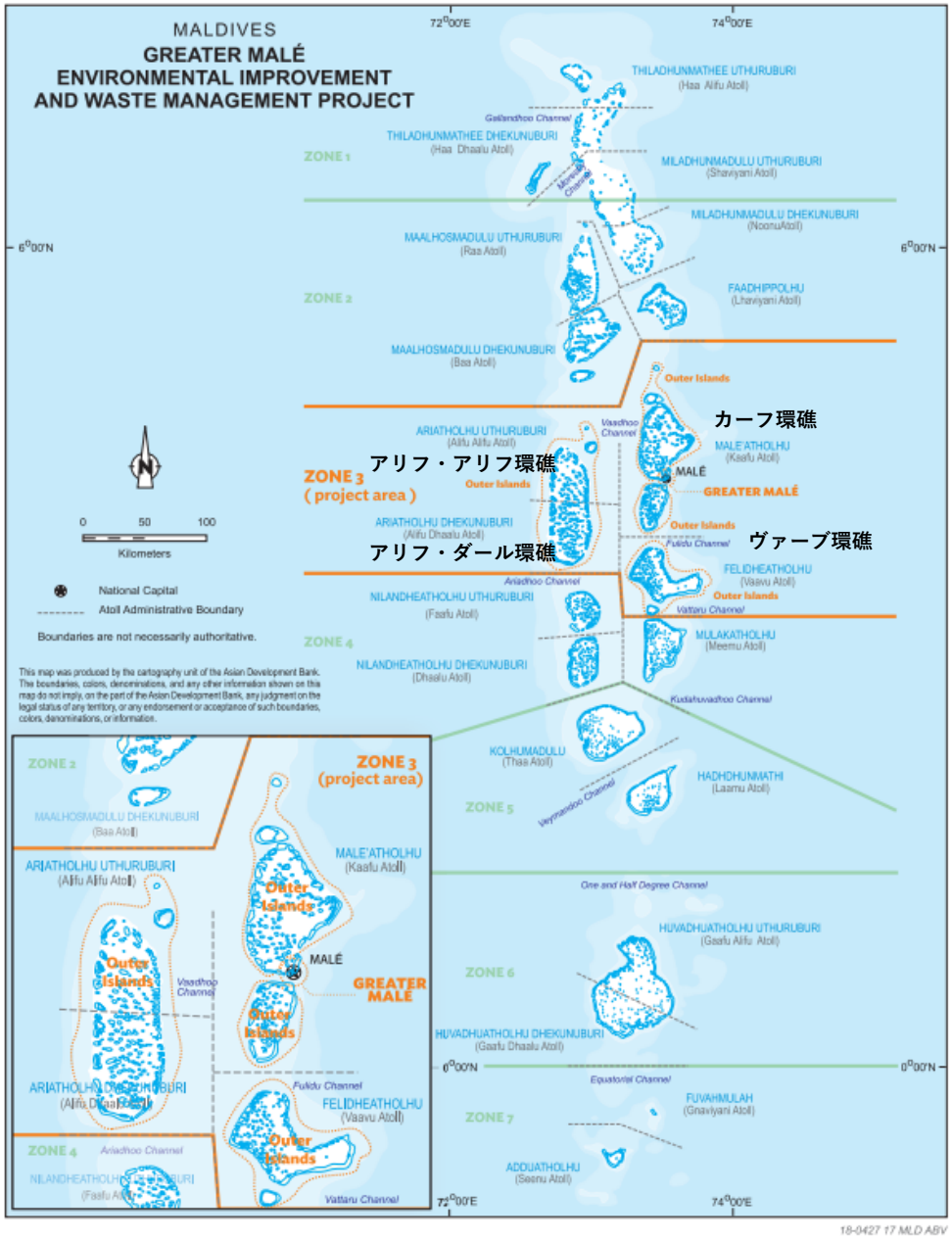


Figure 3-51　The Maldives and Waste Management Zone 3 [34]

(2) Examples of waste management

When we conducted the field study from October 26th to November 9th, 2021, we investigated the waste management conditions of each island. The study results are as follows.

a) Male Island (urban area)

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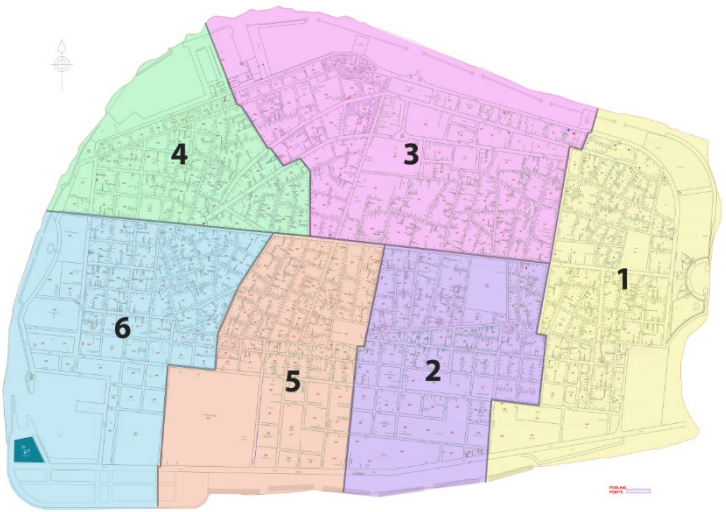
[34] Asian development Bank“Proposed Grant and Technical Assistance Grant and Administration of Grant Republic of Maldives: Greater Malé Environmental Improvement and Waste Management Project”, Project Number: 51077-002 June 2018.
https://www.adb.org/sites/default/files/project-documents/51077/51077-002-rrp-en.pdf

The Male Island is the most populous and has the largest amount of household waste in the entire Maldives. Furthermore, as the population grows, there is an increase in buildings and renovations, leading to construction waste being left scattered. Thus, this island is one of the Maldives islands that should urgently undertake waste management measures.

Based on the World Bank's estimate (amount of waste generated: 1.8 kg/person/day in the urban area) and the Male population estimate (as of 2014), it is estimated that approximately 229 t/day of waste is generated. This figure accounts for nearly 40% of the total amount of waste generated in the Maldives.

The Waste Management Corporation (WAMCO) was established in the Maldives in 2009 to handle waste management properly. Since 2016, WAMCO has been in charge of collecting waste from households on the Male Island, the Hulhumalé Island, and the Villingili Island. Initially, the company collected garbage from each household. However, due to the spread of the novel coronavirus, they switched to collecting garbage from collection points outside as an infection control measure. It is planned to set up a garbage station in each district in the future, and from June 2022, it is being considered to sort garbage into Dry and Wet.



Collection point in Male

Figure 3-52 Conditions in the Male Island

b) Hulhumalé Island (urban area)

As mentioned above, the Hulhumalé Island was artificially created to meet the housing needs that arose due to the population growth and the overcrowding of the Male Island and prepare for the land's disappearance due to coastal erosion as a result of climate change. Currently, it has the second-largest population after the Male Island, and it is expected that 240,000 people will migrate to there in the future due to the promotion of further migration from Male.

The development of the Hulhumalé Island consists of Phase 1 and Phase 2. As of 2021, Phase 1 has been completed and it is now home to approximately 60,000 to 65,000 people. Condominiums have been completed in Phase 2 as well, and migration is in progress.

Based on the World Bank's estimate (amount of waste generated: 1.8 kg/person/day in the urban area) and the population estimate as of 2014, it is estimated that 28 t/day of waste is generated. However, in the case that 240,000 people migrate to the island as planned, the amount of waste generated would be 432 t/day. Hence, it is expected that the amount of waste will increase in direct proportion to the population. Therefore, it is necessary to put in mind the future population when considering waste collection, transportation, and storage systems and infrastructure.

Figure 3-53 Conditions of the Hulhumalé Island

c) Thulusdhoo Island (local island)

As described in Chapter 3.3.4, the Thulusdhoo Island, located about 30 minutes by speedboat from

the Male Island, is a local island with a population of 1,750 people and 250 households. It has guesthouses on the island and is also a tourist island. The 200-room guesthouses can accommodate up to 400 tourists and have problems with securing water for daily use and disposing of waste.

Based on the World Bank's estimates (amount of waste generated: 0.8 kg/person/day in local islands), it is estimated that the residents generate 1.4 t/day of waste. Furthermore, assuming that the amount of waste generated from the guesthouses is equivalent to the amount of waste generated on the resort island estimated by the World Bank (3.5 kg/person/day), 1.4 t/day of waste will be generated if the guesthouses accommodate 400 tourists.

According to an interview with the island councilors, waste is sorted into wet and dry waste. Previously, a composting facility was installed to treat organic waste, but the project was canceled, and now the waste is dumped into the ocean after collection. The composting equipment will be installed again in the near future to improve the situation. Regarding the dry waste, there is no waste collection system, and the island residents themselves collect and dump it at the collection point which results in the waste piling up there. After being brought in, it is burned in an open field when it reaches a certain height to reduce its bulk.

(Reference: Google Map)

Land use plan

Dumping site

Figure 3-54 Conditions of the Thulusdhoo Island

d) Resort Islands (Crossroads Island and Reethi Faru Island)

The Maldives succeeded with its one-island-one-resort concept, and tourism has become a major industry along with fishing. Tourism accounts for 26% of GDP directly and 70% indirectly [35].

Currently, there are 145 tourist resorts in the Maldives, and their waste management is under the

[35] Government of Maldives and UNDP Sign 'Re-imagining Tourism' Project | UNDP in Maldives

jurisdiction of the Ministry of Tourism. "Regulations on Environmental Protection and Conservation in the Tourism Industry" require all resort islands to dispose of waste in a way that has the least impact on the environment. However, in reality, due to the inadequate infrastructure and the lack of monitoring, waste is not properly managed in many cases.

To understand the actual situation, we investigated the conditions of waste treatment in the Crossroads Island, which was mentioned as one of the potential sites for solar power generation in Chapter 3.3.2. According to the interview with the resort owner, the resort has introduced a small incinerator and composting equipment to achieve zero waste. However, it broke down and had not been operating properly as of October 2021. As shown in the lower-left figure, most of the garbage piled up unsorted due to the countermeasures against the novel coronavirus and the malfunction of the small incinerator. The waste is not treated on the island and is transported to Thilafushi Island.

Waste management　　View of the resort

Figure 3-55　Conditions of the Crossroads Island

In addition, we investigated the actual conditions of waste treatment at Reethi Faru Resort, located in the northern Raa Atoll, which was introduced as an environmentally friendly resort in Chapter 3.3.3. As described in Chapter 3.3.3., this resort is an eco-friendly resort with the theme of bio-luxury. We were able to conduct our study through the introduction of former Ambassador Yanai of the Japanese Embassy in the Maldives.

During our visit to the resort, we have noticed some eco-friendly measures such as providing drinking water in glass bottles and eliminating disposable plastics as much as possible at guest rooms. Regarding organic waste, it is treated in a methane fermentation facility, and the generated methane gas is used directly for cooking. Regarding the fermentation residue, it is used as liquid fertilizer. On the other hand, waste (plastic, etc.) that cannot be treated on the island is transported to Thilafushi Island, which is about 155 km away. Therefore, the resort faces a problem with disposing of packaging materials such as styrofoam, which is indispensable for transporting food.

Segregation in kitchen (Segregaed into food waste, paper, metal and glass)

Methane fermentation facility

Solar panel

Plastic-free amenities

Figure 3-56 Conditions in Reethi Faru

As mentioned above, although some resorts are working on waste treatment and resource recycling on resort islands, such as methane fermentation equipment and composting equipment for organic waste, there are still problems with waste treatment. In addition, such resorts are only a few. The reality is that most of the resorts dispose of waste by transporting and dumping it at waste islands such as the Thilafushi Island or into the ocean.

(3) Waste Management Plan

a) Legal system related to waste

The law governing environmental protection in the Maldives is the Environmental Protection and Preservation Act (EPPA) in 1993 (Act No. 4/93), which sets out principles for maintaining and expanding the environmental benefits of the Maldives, including waste management. The law authorizes the Ministry of the Environment to develop regulations and policies for environmental protection and conservation. Section 7 of the Act provides regulations for waste disposal and management of petroleum and toxic substances, while Section 8 provides regulations for the management of hazardous/toxic or nuclear waste and sets out waste management policies.

The National Solid Waste Management Policy was formulated in 2008 by the Environmental Research Centre of the then Ministry of Environment and Energy (now EPA) with the support of the United Nations Development Programme (UNDP) and was subsequently revised in 2015. The policy begins with an analysis of the current state of waste management, which clarified the lack of a national approach to waste management in the Maldives and inequities in governance and resources, both in terms of capacity and infrastructure. The lack of leadership on waste management is also a challenge, as there is no clear role or responsibility for waste management not only at the national

level, but also at the regional, atoll and island levels. In addition to a lack of awareness of the waste problem, there are no provisions on incentives or punitive measures to encourage active waste management.

In addition, the Strategy Action Plan states that the goals for waste to be achieved by 2023 include "selection of cost-effective technologies to generate profit from waste which are appropriate for the situation in the Maldives" and "evaluation of the mechanism by which waste-derived fuel is generated." Specifically, the following policies, strategies, and actions have been presented.

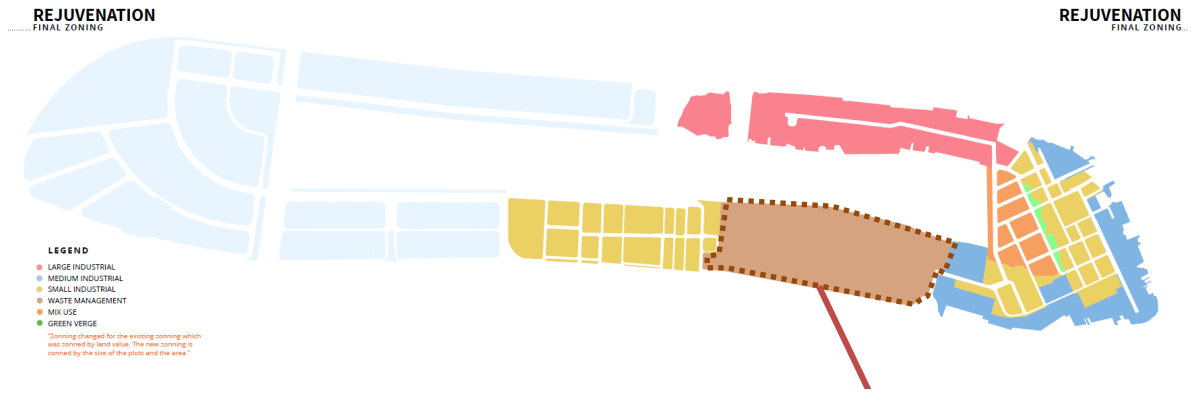
Policy 1: To promote the use of waste as a valuable source of revenue generation

- Strategy 1.3: To establish a mechanism for the collection, storage and management of waste at the island level
  - ✧ Action 1.3f: To provide guidance to the Island Council to integrate waste collection as part of the government's integrated utility service offering
- Strategy 1.4: To strengthen waste collection and management in the Greater Malé region
  - ✧ Action 1.4a: To develop a scheme for separating household waste
- Strategy 1.5: To strengthen waste management through evidence-based policies
  - ✧ Action 1.5a: To conduct comprehensive waste assessment on all islands to identify the volume of various waste flows and set reduction targets
- Strategy 1.7: To expand and implement the conversion of waste into energy and expand efforts in local communities to convert waste into resources
  - ✧ Action 1.7a: To conduct research to identify cost-effective technologies to generate profit from waste which are appropriate for the situation in the Maldives.

b) Future Waste Management Plan

The construction of the final disposal site on the Thilafushi Island began in 1992, but it has been in a state of open dumping as no pollution control measures have been implemented since the beginning, leading to serious public health and environmental impacts. Smoke from spontaneous combustion causes air pollution, and uncontrolled waste leachate may lead to marine environmental pollution.

Thilafushi Island



Masterplan for Thilafushi Island
(Source: HDC)

Figure 3-57 Conditions of Thilafushi Island

In light of this situation, in order to optimize the disposal of 836 t/day of waste generated in Zone 3 and to promote energy use as well as waste disposal, the ADB agreed with the Maldivian government in August 2020 regarding waste disposal optimization and infrastructure development, to gradually phase in the development of waste power generation infrastructure by combining it with the following four initiatives [36].

(i) Improvements to the venous chain for solid waste, including collection and waste container transportation

(ii) Implementation of temporary measures, such as the storage of urban solid waste, as an interim solution to stop the illegal dumping and incineration of Thilafushi Island until a modern solid waste treatment and disposal facility becomes operational

(iii) Collection and treatment of construction and demolition waste

(iv) Strengthening institutional capacity and public awareness to provide sustainable SWM services

The project has been approved as the "Greater Malé Waste-to-Energy Project" utilizing the Japan Fund for the Joint Crediting Mechanism of the Asian Development Bank. The target is a waste power plant with a capacity of 500 t/day, and the expected emission reduction is about 40,417 t CO_2/year.

In this project, based on the above-mentioned waste power generation project, the target will be the organic waste in the Hulhumalé district. Due to the high water content of organic waste, the treatment of organic waste in the "Greater Malé Waste-to-Energy Project" planned for the Thilafushi Island may lead to a decrease in heat generated, resulting in a decrease in power generation efficiency or a corresponding increase in fuel consumption.

[36] ADB Project data sheet" Maldives: Greater Male Waste-to-Energy Project 2020.
URL: https://www.adb.org/projects/51077-003/main#project-pds

At present, in the Malé metropolitan area, waste is not separated at the source, and unseparated waste is being collected for all household waste, business waste, commercial waste, etc. Waste separation at the source is being planned in preparation for the start of operation of the waste power plant. The 5th amendment to the Waste Management Act was announced in August 2021, under which the separation of waste into two types - dry waste and wet waste, is scheduled to start. According to an interview with the Waste Management Corporation Limited (WAMCO), wet waste will mean organic waste such as food waste, and dry waste will mean all other types of waste. Sorting is scheduled to begin in June 2022, and full-scale waste management will begin when the waste power generation facility starts operation from 2023 to 2024. In addition, in an interview with the Ministry of the Environment of the Maldives, it was informed that waste generated after December 2021 would be disposed of at the waste power generation facility, and that it would be stored under a veil until the completion of the facility.

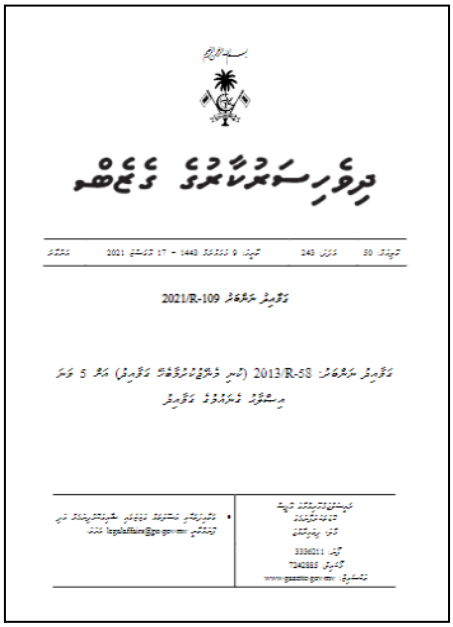


Figure 3-58　5th Amendment to the Waste Management Act (Cover) [37]

Under the current plan, only dry waste will be transported to the Thilafushi Island to be used as fuel for waste-to-energy generation. Dry garbage collected on the Thilafushi Island is sorted into end-of-life vehicles (ELV), construction waste, etc. by using sorting equipment installed on the island. As for plastic waste, PARLEY, which is an international NGO that aims to reduce marine waste worldwide, is discussing the collection and recycling of plastic waste. The company is working with Adidas and other companies to reduce plastic waste. In the Maldives, plastic bottle compression facilities have been installed on the Malé Island and the Thilafushi Island. In the future, the Maldives intend to install additional resource recovery bags at the sorting and collection site on the Thilafushi

[37] 5th Amendment to Waste Management Regulation
https://www.environment.gov.mv/v2/en/download/12347

Island. To promote the recovery of resources other than plastic bottles, the Maldives is also considering the construction of a new resource selection facility on the Thilafushi Island.

Wet waste, on the other hand, will not be transported to the Thilafushi Island, but will remain on the source island. There is no current plan for the treatment of wet waste or organic waste, and if no method of utilization is found, there is a concern that it may be dumped in the ocean and cause marine pollution with the plastics included in the waste.

There are also plans for sorting dry waste, but the movement toward recycling after sorting has not been integrated in the Maldives, and a domestic resource recycling model has yet to be drawn up.

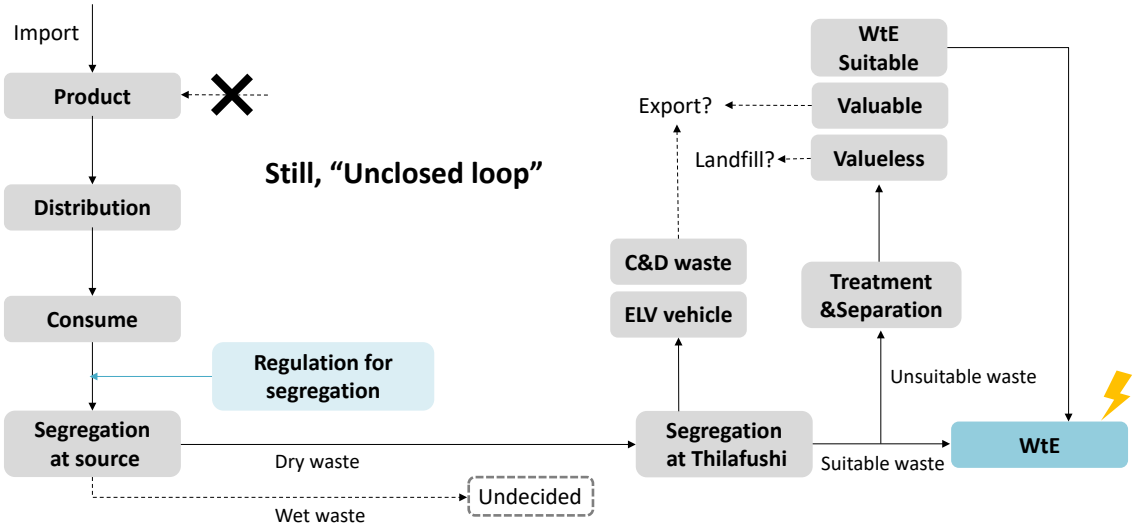


Figure 3-59 Planned waste flow

Source: Prepared by JAPAN NUS CO., LTD. with reference to a report of the Ministry of the Environment of the Maldives[39]

In recent years, the concept of "Circular Economy" has been proposed mainly in Europe. The circular economy is an approach that aims for sustainable economic growth by considering waste as a resource and making the most effective use of it. In Japan, the "Circular Economy Vision 2020 [38]" includes a list of policies for a circular economy. In particular, in the Maldives, where almost all resources are imported from overseas, it is desirable to realize a circular economy that makes the most effective use of resources in the region. In the Maldives, a model can be devised in which waste is collected on the Thilafushi Island, where a waste power plant is located, and resources are allocated to a waste power plant or a recycling facility after sorting.

[38] METI: “Recycling Economy Vision 2020” 2020 (https://www.meti.go.jp/press/2020/05/20200522004/20200522004.html)

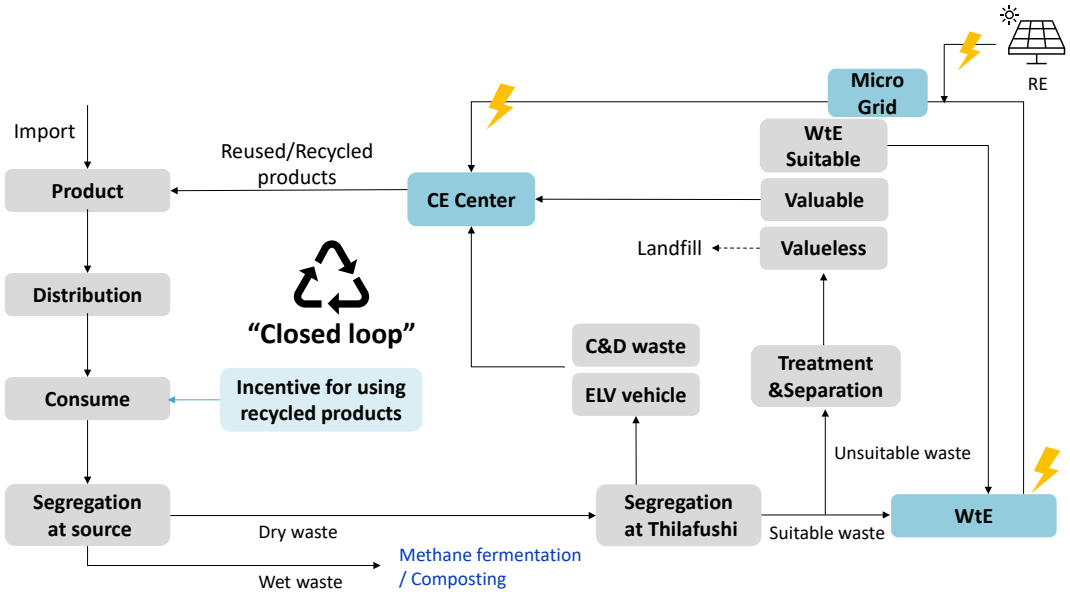
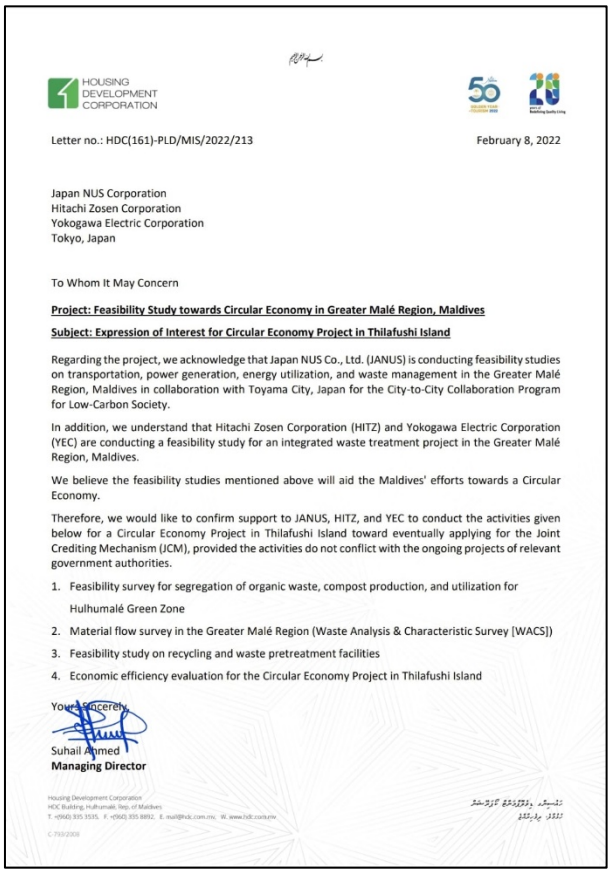


Figure 3-60 Waste flow for a circular economy

In this way, we proposed the concept of achieving a circular economy starting from the waste power plant on the Thilafushi Island to the HDC. Then, they showed great interest, and we received a letter from them expressing their interest regarding a feasibility study.

The recycling of organic waste under consideration in this project can also be regarded as part of this circular economy concept. The Hulhumalé district needs compost to maintain roadside trees, parks and green space, and currently imports about $500,000 worth of compost annually from overseas. Imported compost could possibly be sourced from domestic waste. The consideration of the material balance and economy is key to the feasibility study. The results of these studies are presented in the next section.



HOUSING DEVELOPMENT CORPORATION

Letter no.: HDC(161)-PLD/MIS/2022/213 February 8, 2022

Japan NUS Corporation
Hitachi Zosen Corporation
Yokogawa Electric Corporation
Tokyo, Japan

To Whom It May Concern

Project: Feasibility Study towards Circular Economy in Greater Malé Region, Maldives

Subject: Expression of Interest for Circular Economy Project in Thilafushi Island

Regarding the project, we acknowledge that Japan NUS Co., Ltd. (JANUS) is conducting feasibility studies on transportation, power generation, energy utilization, and waste management in the Greater Malé Region, Maldives in collaboration with Toyama City, Japan for the City-to-City Collaboration Program for Low-Carbon Society.

In addition, we understand that Hitachi Zosen Corporation (HITZ) and Yokogawa Electric Corporation (YEC) are conducting a feasibility study for an integrated waste treatment project in the Greater Malé Region, Maldives.

We believe the feasibility studies mentioned above will aid the Maldives' efforts towards a Circular Economy.

Therefore, we would like to confirm support to JANUS, HITZ, and YEC to conduct the activities given below for a Circular Economy Project in Thilafushi Island toward eventually applying for the Joint Crediting Mechanism (JCM), provided the activities do not conflict with the ongoing projects of relevant government authorities.

1. Feasibility survey for segregation of organic waste, compost production, and utilization for Hulhumalé Green Zone
2. Material flow survey in the Greater Malé Region (Waste Analysis & Characteristic Survey [WACS])
3. Feasibility study on recycling and waste pretreatment facilities
4. Economic efficiency evaluation for the Circular Economy Project in Thilafushi Island

Yours sincerely,

Suhail Ahmed
Managing Director

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C-793/2008

Figure 3-61 Letter from the HDC expressing their interest regarding a feasibility study for the Circular Economy Project in the Thilafushi Island

(4) Amount and composition of waste produced

According to HDC, the survey conducted last fiscal year showed that the amounts of waste generated in *Hulhumalé* were 1,643 t/year of sewage sludge, 1,825 t/year of organic waste (garden waste) such as plants, and 405 t/year of kitchen waste, which amounted to 3,873 t/year in total. Regarding the composition of the waste, we have obtained the results of the survey performed in 2016 from the report published in 2017 by the Ministry of Environment and Energy of the Republic of Maldives [39].

[39] Ministry of Environment and Energy, "Consultancy Services for Feasibility Study for an Integrated Solid Waste Management System for Zone III (including Greater Male') and Preparation of Engineering Design of the Regional Waste Management Facility at Thilafushi FEASIBILITY REPORT," 2017

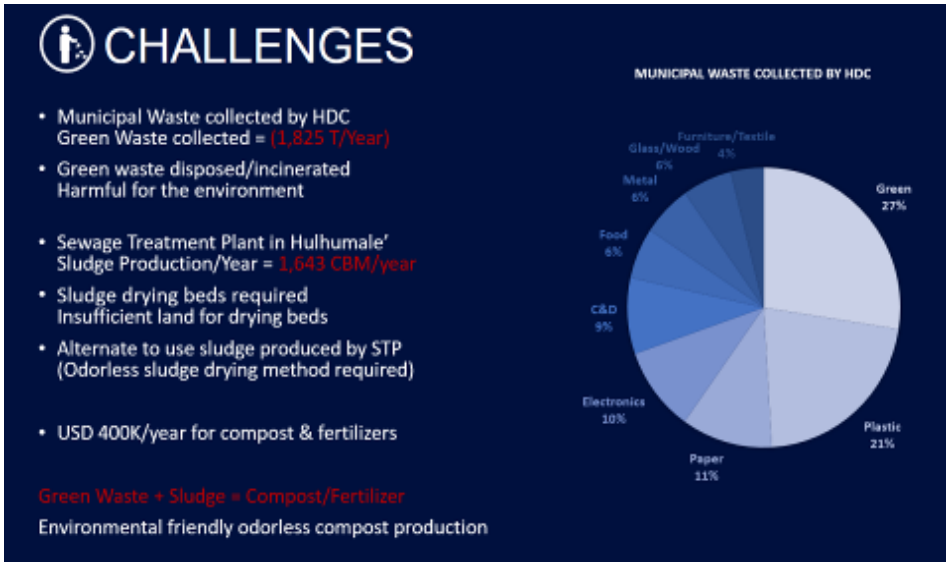

Figure 3-62 Amount and proportion of organic waste produced in Hulhumalé

Source: Material provided by HDC

Table 3-9 Composition of household waste

Waste composition	%	Trend
Organics	60%	constant
Garden waste	*10%*	
Kitchen waste	*40%*	
other organics	*10%*	
Paper & cardboard	10%	constant
Glass	3%	decrease by 1%
Plastics	10%	increase in the next years probably by 1-2 %
Metals	4%	constant
Hazardous wastes (including clinical)	3%	constant
Other (inert & dust)/mixed waste	10%	decrease
Total	100%	

Source: Ministry of Environment and Energy[39]

Although we strived to collect more detailed information on these data this fiscal year, we found out that there are no official monitoring data, except for the results of the survey carried out last fiscal year. Our interviews with the Ministry of National Planning, Housing and Infrastructure, and Male' Water and Sewerage Company (MWSC) have revealed that nether Male' nor Hulhumalé has any sewage treatment plants, and no sewage sludge has been produced currently. According to the

interview with MWSC, a sewage treatment plant would be built in Hulhumalé through the Maldives Urban Development and Resilience Project by the World Bank [40], the project was at a bidding stage at the time, and construction would start in February 2021. MWSC will be in charge of the operation for three years and the Ministry of National Planning, Housing and Infrastructure will be responsible for the project as a whole, and information on the amount and quality of sewage sludge will become available through inquiries to the relevant organizations as they have made some progress with the project.

In this survey, therefore, we have estimated the amount of waste created based on the population using the estimates given by the World Bank (the amount of waste produced: 1.8 kg/person/day in the urban areas, 0.8 kg/person/day in the residential islands). With regard to the composition of waste, we enlisted the cooperation of Hitachi Zosen Corporation that participates in this project and referred to part of the results of the survey on waste composition that Hitachi Zosen conducted in the Integrated Waste Management Business in Greater Male' Capital Region, Maldives under the program to support carbon dioxide emissions reduction through strategic international expansion of Japan's circulation industries in 2021. We will amass information on the amount of sewage sludge generated as progress has been made with the project.

To begin with, the population and the amount of waste (estimate) are as shown in the table below for the residential islands in Zone 3 that includes the Greater Male' Capital Region. The values have been estimated based on the population (the statistics in 2014) using the estimates provided by the World Bank (the amount of waste produced: 1.8 kg/person/day in the urban area and 0.8 kg/person/day in the residential islands) as described earlier, with the estimated amount standing at 28 t/day in Hulhumalé and 228 t/day in Male'.

Table 3-10 Population and amount of waste (estimate) of each island in Zone 3

Name - Administrative Statu			Population (2014)	Waste gereration (estimated amount, kg/day)
Kaafu Atoll	Dhihffushi	Island	1,053	842
	Gaafaru	Island	1,066	853
	Himmafushi	Island	1,725	1,380
	Hulhumale'	Island	15,769	28,384
	Huraa	Island	1,300	1,040

[40] Project ID: P163957, "Maldives Urban Development and Resilience Project"
The details of the project are as follows:
(1) Resilient infrastructure and strengthening of emergency response systems, (2) sustainable urban planning, development, and management, and (3) project implementation, management, and reporting. (https://projects.worldbank.org/en/projects-operations/project-detail/P163957)

	Kaashidhoo	Island	1,865	1,492
	Male'	City	127,079	228,742
	Thulusdhoo	Island	1,408	1,126
	Vilin'gili	Island	7,790	6,232
	Gulhi	Island	912	730
	Guraidhoo	Island	1,738	1,390
	Maafushi	Island	3,025	2,420
Kaafu Atoll			164,730	274,632
Vaavu Atoll	Felidhoo	Island	506	405
	Fulidhoo	Island	372	298
	Keyodhoo	Island	675	540
	Rakeedhoo	Island	106	85
	Thinadhoo	Island	152	122
Vaavu Atoll			1,811	1,449
Alifu Dhaalu Atoll	Dhan'gethi	Island	824	659
	Dhigurah	Island	610	488
	Dhihdhoo	Island	153	122
	Fenfushi	Island	837	670
	Hangnaameedhoo	Island	517	414
	Kun'burudhoo	Island	462	370
	Maamigili	Island	2,359	1,887
	Mahibadhoo	Island	2,074	1,659
	Mandhoo	Island	367	294
	Omadhoo	Island	883	706
Alifu Dhaalu Atoll			9,086	7,269
Alifu Alifu Atoll	Bodufolhudhoo	Island	608	486
	Feridhoo	Island	441	353
	Himandhoo	Island	724	579
	Maalhos	Island	434	347
	Mathiveri	Island	662	530
	Rasdhoo	Island	1,067	854
	Thoddoo	Island	1,534	1,227

	Ukulhas	Island	1,005	804
Alifu Alifu Atoll			6,475	5,180
ZoneⅢ			182,102	288,530

*The estimates have been made with Male' and Hulhumalé being considered as urban areas and others as residential islands based on the estimates given by the World Bank (the amount of waste produced: 1.8 kg/person/day in the urban areas and 0.8 kg/person/day in the residential islands).

As shown in the table above, most of waste is generated in Male' and Hulhumalé, and the total volume of waste in the two islands accounts for nearly 90% of the waste created in Zone 3. The Maldives Bureau of Statistics published demographic statistics only up to 2014, and thus we had to make estimates as given above; however, the population has been growing since 2014 and the amount of waste produced is expected to increase accordingly. The population of Hulhumalé has already reached 65,000 in Phase I and 30,000 people will reportedly move into Hulhumalé soon in Phase II. Given that the population stands at 100,000 as of 2022, the amount of waste produced in Hulhumalé is 180 t/day.

Then, concerning the composition of waste, we referred to part of the results of the waste composition survey by Hitachi Zosen Corporation as mentioned earlier. The types and sources of waste carried into Thilafushi Island are as follows, and the waste composition survey was performed targeting the waste collected in Male':

【Classification (sources) of waste carried into the Thilafushi Island】
- From Male' (twice a day)
- From Hulhumalé (once a day)
- From Villingili Island (once a week)
- From Resort Island (via small boats (Dhonis))

【Classification (types) of waste dumped in the Thilafushi Island】
- Household waste (collected by WAMCO or other authorized companies)
- Commercial waste (such as waste generated in shops, restaurants, and commercial facilities)
- Construction waste (waste collected mainly by private operators and carried into the shipping bases of WAMCO)
- Medical waste produced in hospitals in Male' (collected by WAMCO or other authorized companies)

According to the table below, kitchen waste accounts for 21% and garden waste makes up 5%.

Table 3-11 Results of waste composition survey

Type of waste	Percent
Inseparable mixed waste	27.05
Kitchen waste	21.13

Packaging Plastics	11.86
Paper and cardboard	10.14
Garden waste	4.96
Rags &Textiles	4.30
PET bottles	4.23
Diapers and sanitary pads	4.07
Glass	3.23
Industrial Plastics	3.09
Metals	2.71
Rubbers, Leathers	0.99
Others	0.96
Other organics	0.71
Hazardous waste	0.57
Incombustibles (Inert, dust, etc.)	0.00

Based on these pieces of information, the volume of waste generated in Hulhumalé is estimated at 180 t/day given that the population is 100,000. Out of the waste, kitchen waste and garden waste that can be raw material for farmyard compost will amount to 38 t/day (21%) and 9 t/day (5%), respectively, according to the results of the waste composition survey, and it is expected that a total of 47 t/day will be created as raw material for compost production.

3.4.2. Discussion about a possibility to adopt organic waste-based compost and survey on sales networks

The Maldives relies on imports for most of resources, and compost is no exception. HDC imports compost from Singapore for the greening of Hulhumale Island, which costs about 400,000 USD per year. In this project, with an eye to the composting of organic wastes (food and green wastes), the properties and prices of compost currently available in the Maldives were surveyed on the web. A survey of online stores for the Maldives revealed that compost are imported from a wide range of countries, such as USA, UAE, UK, and India. The table below shows the information on compost made from food and green wastes, which is similar to the content of this project, although the raw materials of compost include food, green wastes such as branches and leaves, and livestock manure (chicken manure and cow manure).

Table 3-12 Compst available in Maldives via online store [41]

Product name	Import source	Price	Amount	Rate	Ingredients
Blue Ribbon Organics OMRI Certified Natural	USA	2649 MVR	820L	3.2 MVR/L	Food waste, Green waste

[41] https://maldives.desertcart.com/brand/compost

Premium Organic Compost for Plants					
Shalimar Vegetarian Bio Organic Compost	UAE	1,269 MVR	50L	25 MVR/L	Tea leaves
Green Rich Bio Organic Compost	UAE	1,179 MVR	50L	24 MVR/L	Green waste
Plant Based Powder Form Fertilizer Compost	UAE	1,999 MVR	25 kg	80 MVR/kg	Green waste
Coir Brick 650g x 4 | Compressed Soil for Gardening	UK	1,199 MVR	9L	133 MVR/L	Coconut shell

As mentioned above, compost made from food and green wastes is available in the Maldives and may be purchased by citizens for gardening. In the organic waste composting business, the issue is that the demand for compost is generally low and sufficient sales revenue cannot be obtained. On the other hand, in the Maldives, most of the land is sandy soil, and compost is necessary for greening. In addition to large-scale urban greening, demand from citizens is also expected. In site survey, we saw plastic containers placed under the eaves of houses to grow plants, and guesthouse owners was laying soil on their premises to create green areas. When considering specific candidate technologies to be introduced in Greater Male region in the future, the properties of the compost and its applicability to the Maldives will be investigated in more detail.

In addition, since the selling price of compost varies depending on the product as shown in the table above, we will consider setting a competitive price by referring to the price range of these imported products.

Villingiri Island

Green area in the guesthouse in Thulusdhoo Island

Figure 3-63 Greening in Greater Male region

3.4.3. Discussion about an operational plan, business feasibility assessment, and business structure

(1) How to utilize organic waste and candidate equipment

Organic waste provides methane as energy through a methane fermentation treatment process and residue of the fermentation process as farmyard compost, and these recycling efforts will contribute to settling waste-related issues and decarbonizing society. Toyama City has a plant for recycling

kitchen refuse and pruned branches that is operated by a company called TOYAMA GREEN FOOD RECYCLE, and the plant consists of a facility for methane fermentation treatment of food waste and a facility for transforming pruned branches and grass clippings into compost. The plant has adopted a system of recycling organic waste called Metacless and operates an environmental plant system, which decomposes such organic waste as kitchen refuse with the fixed-bed, high-temperature methane fermentation technology using microorganisms, collects biogas generated, and obtains electricity and heat. In the project last fiscal year, we explored possibilities for installing methane fermentation equipment through interviews with TOYAMA GREEN FOOD RECYCLE and got survey results suggesting that it is realistic to treat kitchen waste and sewage sludge at a methane fermentation facility and recycle garden waste as compost after crushing it and then mixing it with methane fermentation residue at a compost production facility. Furthermore, given the current cost of importing farmyard compost, an economical potential has been demonstrated even though it costs money to adopt methane fermentation equipment. The following figure shows an operational plan in Hulhumalé when both methane fermentation equipment and composting equipment are installed:

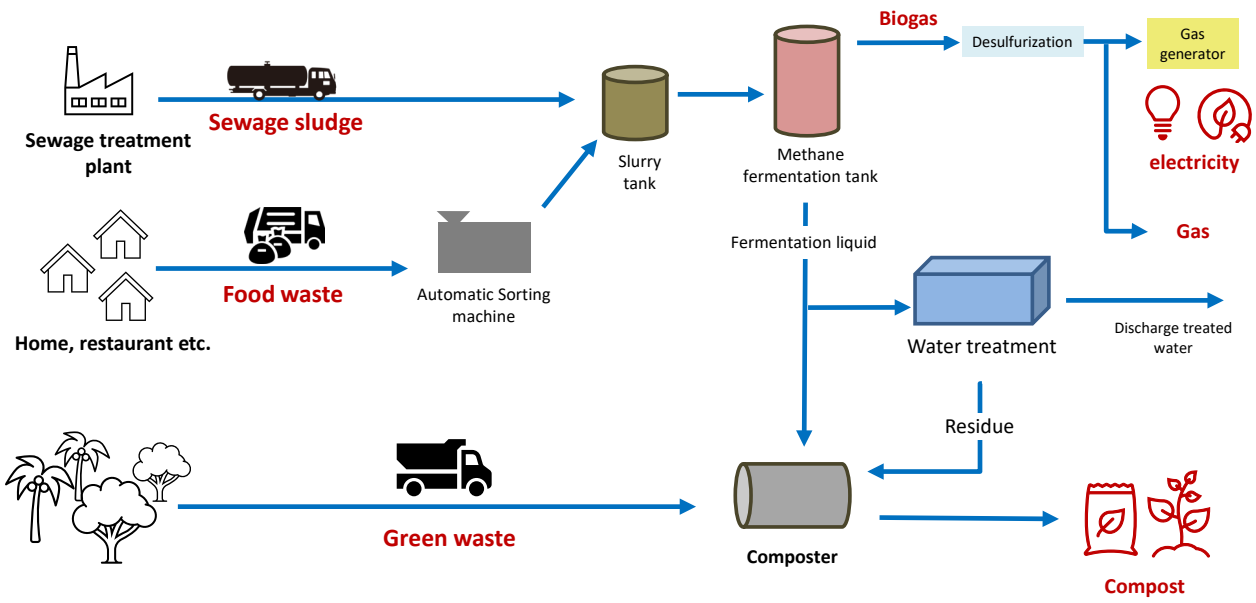

Figure 3-64 A proposed system that combines methane fermentation equipment with composting equipment

While the aforementioned system that combines methane fermentation with composting is an ideal system that generates energy and compost and enables maximum utilization of organic waste as resources, a tiny number of engineers in the Maldives will be an obstacle to the operation of methane fermentation equipment in no small part because it requires expert knowledge for stable operation. In addition, the former ambassador Keiko Yanai of the Embassy of Japan in the Maldives told us that the minister Aminath Shauna of the Ministry of Environment and Energy expressed great interest in recycling organic waste as compost and said that they wanted to adopt not labor-intensive, but automatic composting equipment during their opinion exchange.

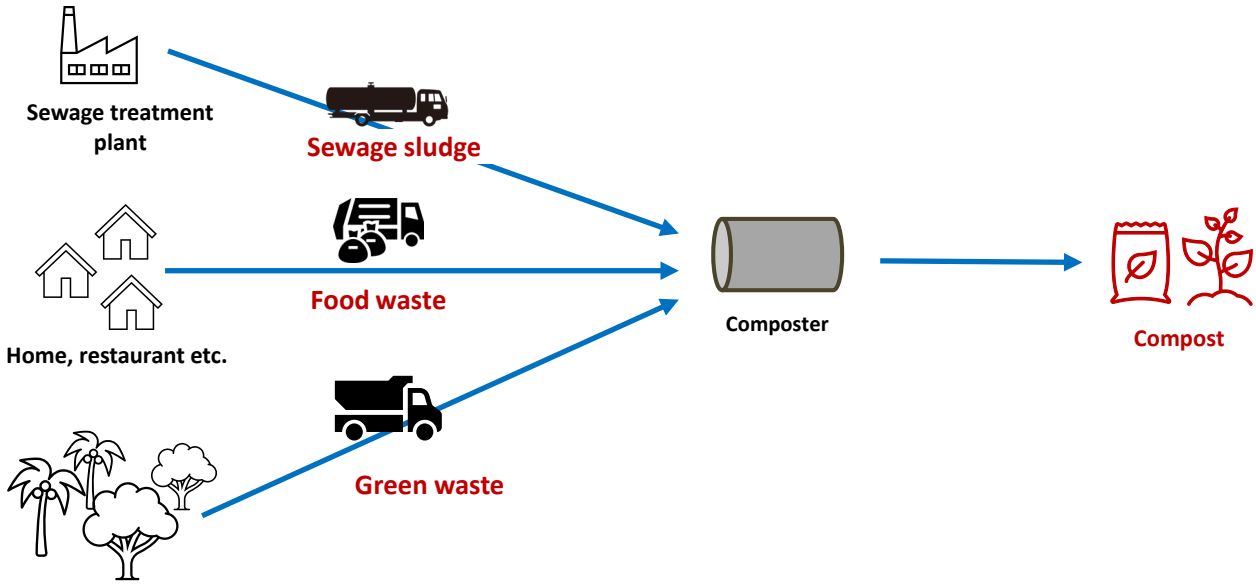

Figure 3-65　A proposed system when only composting equipment is installed

Conventionally, the composting process is divided into two phases, which are primary fermentation during which easily degradable organic matters are mainly decomposed, and secondary fermentation during which decomposition and humification of degradable organic matters proceed together. Compost must be moved for the secondary fermentation process after primary fermentation. Furthermore, technology associated with composting is essential, besides labor power, for manufacturing quality compost because it is required to appropriately record and manage such factors as the air flow rate, temperature, frequency of stirring and turning compost, fermentation period, and moisture.

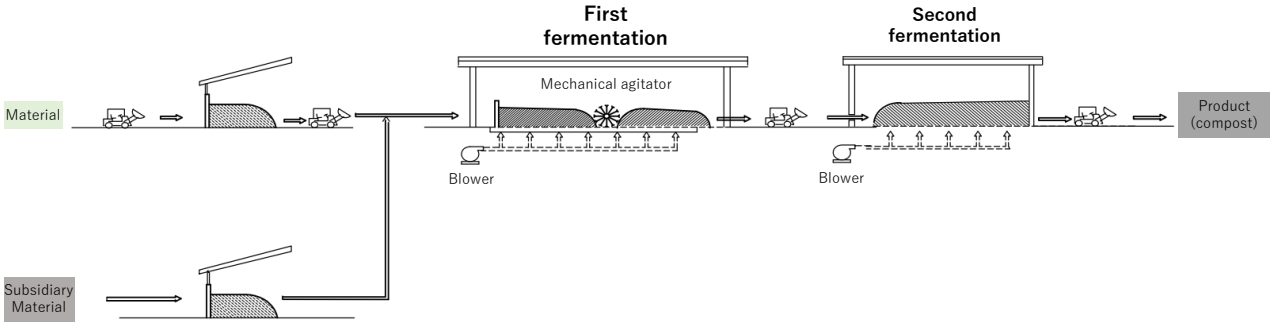

Figure 3-66　Flow chart of conventional compost production process

Source: Material given by Minamiboso City [42]

Equipment that can be maintained relatively easily and operated without specialized knowledge is

[42] Compost production method by Minamicboso City（49fab7d9005.pdf (city.minamiboso.chiba.jp)）

desirable to realize stable compost production in the Maldives. One of the candidate technologies is "YM Himawari-kun (an encapsulated composting equipment)" developed by Kyowa Kako Co., Ltd. as fully automatic composting equipment. The equipment is capable of executing all the processes fully automatically, ranging from putting biomass, the raw material, into it to carrying out resultant products, and the schedule of composting can be easily managed with the controller-based automatic management system [43], meaning that it can possibly be adopted in the Maldives that has only a few engineers.

Mix food waste and compost

Fermentation for 1 month in fermentation tank
Humidity: 85%

Input into YM composter for 7 days

Packing

Free distribution to residents

Figure 3-67 Case of adoption of YM Himawari-kun in Mashiko Town, Tochigi Prefecture

Source: Website of Kyowa Kako Co., Ltd. [44]

(2) Business feasibility assessment

As stated earlier, the volume of waste generated in Hulhumalé will be 180 t/day with the population considered to be 100,000. Of the waste, based on the results of the waste composition survey, kitchen waste that serves as raw material for compost is 38 t/day (21%) and garden waste is 9 t/day (5%), resulting in raw material for compost production of 47 t/day in total. That is, a total of 17,155 t/year of the raw material will be created.

An example of business feasibility assessment is Eco☆West, a facility for reducing volumes of

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[43] Website of Kyowa Kako Co., Ltd. (https://kyowa-kako.co.jp/business/ym-composter/)

[44] Mashiko Office of Kyowa Kako Co., Ltd in the list of institutions on the website of Kyowa Kako (https://kyowa-kako.co.jp/institution/composting/mashikojigyousho/

raw waste operated by Kumagaya Cleaning Company, although the scale of the facility is a little small. With the waste treatment capacity being 20 t/day, the facility treated 7,458 t of raw waste (from May 2014 when the company began operation of the facility to February 2016) and produced 373 t of compost. The initial cost was 296,877,500 yen according to the table blow.

Table 3-13 Initial cost of Eco☆West (composting equipment)

Facility summary	Site area		2,907.76 m^2
	Building area		1,703.36 m^2
	Capacity		20t/day
Initial cost	Building		220,000,000 yen
	Facility	Self-propelled agitator	20,000,000yen
		Crushing and separating machine	5,000,000 yen
		Wheel loader	4,000,000 yen
		Sieving machine	3,000,000 yen
		Deodorizer	20,000,000 yen
		Truck scale (30t)	2,500,000
		Aeration facility	5,000,000 yen
		Bacterial cell	15,600,000 yen
	Total		296,877,500 yen

Source: Report on verification through demonstration tests for a raw waste volume reduction (HDM system) and composting project by Kuki-Miyashiro Eisei Kumiai (2017) [45]

Given that a similar type of equipment is adopted, compost generated can be used for roadside trees and gardens in Hulhumalé, and based on a simple calculation, the initial investment can be recouped in the seventh year of the adoption with the expenditure of 400,000 US dollars (about 40 million yen) currently used for importing compost considered to be revenue.

The estimated amount of compost produced is 10,220 t annually based on the data suggesting that the decomposition rate of raw waste through composting treatment is 70% and that of pruned branches is 20% [46]. These amounts are larger than the volume of compost used in Hulhumalé, and revenue can possibly be yielded through sale of compost to other islands in the Greater Male' Capital Region.

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[45] Report on verification through verification tests for a raw material volume reduction (HDM system) and compost production project by Kuki-Miyashiro Eisei Kumiai, 2017 (http://www.crt-kuki.miyashiro.saitama.jp/pdf/hdmhoukokusyo.pdf)

[46] Research and analysis on compost production and methane fermentation equipment targeting various types of organic waste by Laboratory of Solid Waste Disposal Engineering, Graduate School of Engineering, Hokkaido University, 2011 (https://www.eng.hokudai.ac.jp/labo/waste/wp-content/uploads/2014/03/report3.pdf)

This analysis, however, does not include such matters as the interest on financing related to equipment installation, cost of land acquisition, inflation rate, and operational cost. It is necessary to identify stakeholders and discuss economic potential including these costs, as well as obtain estimates of waste volumes and detailed information on the composition and amount of waste and forge ahead with in-detail design with the local situation taken into consideration.

3.4.4. Decarbonization effects of composting equipment and discussion about transformation of the project into a JCM-based business

Decarbonization through adoption of composting equipment helps prevent methane from being emitted from anaerobic fermentation at organic waste treatment plants. Meanwhile, the composting processes also release greenhouse gas. Organic waste is generally transformed into compost under aerobic conditions, which produces almost no methane; however, methane will be generated when the volume of oxygen supplied is not adequate because insufficient oxygen will provoke anaerobic reactions. The methane so produced will be oxidized and become carbon dioxide under an aerobic environment, but part of the methane will be released into the air as it is. The amount of dinitrogen monoxide produced will be according to the percentage of nitrogen contained in the volume of organic waste that will be transformed into compost [47].

To begin with, we used the IPCC Waste Model [48], which is the guidelines offered by the IPCC in 2006, for calculating a reference emission amount, the amount of methane emission avoidance through anaerobic fermentation at organic waste treatment plants. Candidate legal useful lives of composting equipment are seven years for agricultural equipment and ten years for equipment for manufacturing beverages, cigarettes, or feed based on the list of the useful lives of depreciable assets, and we decided to employ ten years for equipment for manufacturing beverages, cigarettes, or feed because we consider this project to be a compost manufacturing project. The methane emission avoidance volume through anaerobic fermentation of waste generated in *Hulhumal*é with an estimated population of 100,000 (with kitchen waste standing at 13,882 t/year and garden waste amounting to 3,259 t/year) (reference emission volume) will be 2,120 t-CH_4 in total, which will be 44,512 t-CO_2 when converted into an amount of CO_2 using 21 that is the global warming potential of methane.

Table 3-14 Reference emission amount (avoidance amount of methane emitted from anaerobic fermentation)

avoidance amount of methane emitted from anaerobic fermentation

Year	Food waste[Gg]	Green waste[Gg]

[47] Website of the Ministry of the Environment "5. Field of Waste | Detailed information on how to calculate the amount of greenhouse gas emitted and absorbed, 5.B.1 Composting" (https://www.env.go.jp/earth/ondanka/ghg-mrv/methodology/material/methodology_5B1_2020.pdf)

[48] 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 5 Waste, IPCC Waste Model (MS Excel) (https://www.ipcc-nggip.iges.or.jp/public/2006gl/vol5.html)

1	0.000	0.000
2	0.073	0.018
3	0.122	0.034
4	0.155	0.047
5	0.177	0.058
6	0.192	0.067
7	0.202	0.075
8	0.209	0.082
9	0.213	0.087
10	0.216	0.092

	Food waste	Green waste
Methane emission (t-CH4)	1,560	560
Methane emission（t-CO2）	32,755	11,756

Reference emission （t-CO2）	44,512

Then, we calculate an amount of greenhouse gas released through compost production, which is a project emission amount. We calculated the volumes of CH_4 and N_2O emitted from the process of transforming organic waste into compost using the method described in Chapter 4: Biological Treatment of Solid Waste in the IPCC guidelines published in 2006.

CH_4 emission by biological treatment

$$CH_4\ Emissions = \sum (M_i \bullet EF_i) \bullet 10^{-3} - R$$

CH_4 Emissions: CH_4 emission（$GgCH_4$）
M_i: Amount of input of "organic waste (i) "（Gg）
EF: Emission factor（gCH_4/kg waste treated）

N_2O emission by biological treatment

$$N_2O\ Emissions = \sum_i (M_i \bullet EF_i) \bullet 10^{-3}$$

N_2O Emissions: N_2O emission（GgN_2O）
M_i: Amount of input of "organic waste (i) "（Gg）
EF: Emission Factor (gN_2O/kg waste treated）

For EF, the default values based on wet weight of IPCC guidelines (CH_4 : 4 gCH_4/kg waste treated, N_2O : 0.24 gN_2O/kg waste treated) were used.

Figure 3-68 Equations for calculating the amounts of CH_4 and N_2O emitted from biological treatment

Source: IPCC Guidelines published in 2006, Volume 5 Waste, Chapter 4 Biological Treatment of Solid Waste

Consequently, the volume of greenhouse gas emitted from the process of transforming organic waste into compost was 27,152 t-CO_2. Although electricity consumed and fuel used for composting equipment must actually be included as the project emission amount, the volumes are unclear at the moment and we consider 27,152 t-CO_2 so calculated as the project emission amount.

Table 3-15 Project emission amount (volumes of CH_4 and N_2O released from the composting process (as converted into an amount of CO_2))

	CH_4 emission	N_2O emission
Food waste (t-CO_2/year)	1,166	1,033
Green waste (t-CO_2/year)	274	242
Annual emission (t-CO_2/year)	2,715	
Project emission (t-CO_2)	27,152	

The amount of cutbacks is a value calculated by subtracting the project emission amount from the reference emission amount, which is 17,360 t-CO_2.

As mentioned earlier, the JCM equipment assistance program adopts 50% of the equipment that contributes to cutting back on CO_2 emissions or 4,000 yen/t-CO_2, a rough indication of an emission reduction cost, whichever is less, for the first project in a relevant country. The upper limit of a subsidy (when the subsidy rate is 50% or less) will be 69.44 million yen if it is calculated backwards using the rough indication of an emission reduction cost of 4,000 yen/t-CO_2. Equipment that costs 138.88 million yen can be installed when the subsidy is rebated at the subsidy rate of 50%. We will organize our thoughts on specific candidate technologies by using this value as a reference next fiscal year.

No composting project has been registered for either the Clean Development Mechanism (CDM) or the JCM at the moment, and a Measurement, Reporting, and Verification (MRV) methodology must be developed from scratch for setting up business. For instance, if composting equipment is installed in Hulhumalé, the cutbacks of the vessel fuel conventionally required for carrying waste into the Thilafushi Island can possibly be added to the reference emission amount. Meanwhile, the amount used for bringing organic waste to composting equipment may be added to the project emission amount, and it is necessary to discuss the implementation structure, including places to install composting equipment, and carefully examine resultant amounts of cutbacks in the next fiscal year.

3.4.5. Implementation structure

Regarding the implementation structure, we discuss a plan to form an international consortium with HDC and Waste Management Corporation Ltd. (WAMCO) with a company based in Toyama City, which takes interest in the composting project, serving as the representative operator. When installing composting equipment, we need to confirm whether there is demand that is commensurate with the volume of compost generated, but stable operation of the equipment will be possible with HDC playing the roles of both the equipment owner and the off-taker of compost. Furthermore, although it is expected that securing land for building composting equipment will go through difficulties due to territorial limitations in the Greater Male' Capital Region, HDC has an authority over the use of land in the region and we expect smooth coordination, including securing land for construction. In addition, greening activities in other places than Hulhumalé are expected to contribute to compost use. For WAMCO, too, proper separation and collection of organic waste can result in not only production of high-quality compost, but increased revenue, and this can give WAMCO incentives to manage waste.

When the utilization of sewage sludge becomes possible, we plan to cooperate with Male Water and Sewage Company (MWSC) in carrying sewage sludge. We will also discuss how to effectively collect organic waste not only from household garbage, but from such places as restaurants, food processing plants, and markets and potential of using them because the properties of such waste are considered to be uniform to a certain extent.

We will amass more information on various matters, including plans to collect moist garbage and progress in other waste-related projects, and move ahead with in-detail discussion about places to install composting equipment, selection of equipment to install, and other relevant matters. Regarding places for equipment isntallation, in particular, although we are currently considering the Thilafushi Island and Hulhumalé as candidate sites together with HDC, ongoing and profound discussion with the local parties concerned will be required because the impact on the local waste flow is significant. A concept and project of recycling waste centering on construction of a waste-based power plant are discussed in the Thilafushi Island, and this is an item for discussion because gathering venous industries in the Thilafushi Island can result in effective waste management.

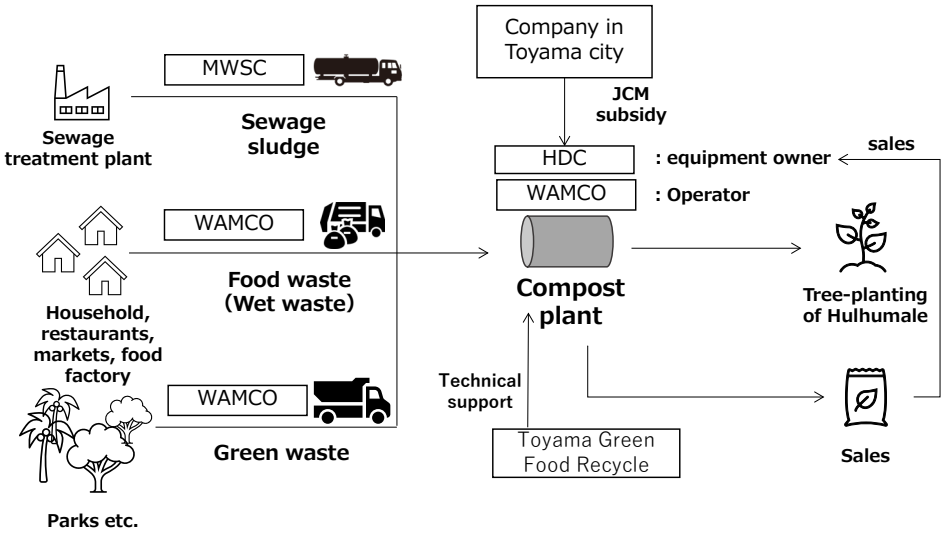


Figure 3-69 Plan of implementation structure in using organic waste as compost

4. Intercity collaboration to realize a low-carbon society (invitation of local stakeholders and workshops)

4.1. Overview of intercity collaboration activities

The impact of the spread of the novel coronavirus continued during this fiscal year's city-to-city collaboration project, but even though the major meetings were held online, field surveys were conducted from October 26 to November 9, when the status of the infection in both countries was relatively stable. Through online tools such as remote meetings and e-mail, as well as face-to-face meetings when traveling to the Maldives, we gained the understanding of the survey contents and activities from the local parties concerned and have been working to gather information in cooperation with local counterparts, the Embassy of Japan in the Maldives, the JICA office and other organizations for the survey. The main activities are summarized below.

Table 4-1 Major activities

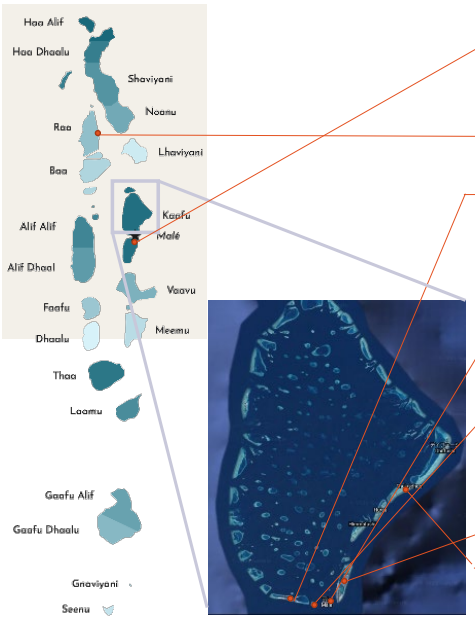
Date	Activity	Participating organizations
September 6th, 2021	Kick-off meeting with HDC, request for information	HDC, JANUS
September 7th, 2021	Report of survey results in FY2020 to the Embassy of Maldives in Tokyo, exchange of opinions	Toyama City, Embassy of Japan in Maldives, JANUS
September 7th, 2021	Exchange of opinions with Mr. Nakagawa, Transportation Policy Supervisor of Toyama city	Toyama City, Nippon Engineering Consultants Co., Ltd., JANUS
September 16th, 2021	Consultation on SATREPS application to JICA Maldives	JICA Maldives, Nippon Engineering Consultants Co., Ltd., JANUS
September 21st, 2021	Explaining the outline of the project to the Maldives National University and discussing the possibility of cooperation in the survey for formulating a public transport master plan	Maldives National University, HDC, JANUS
September 22nd, 2021	Discussion on the content of proposals to resort development companies	HITZ, NIKKU, JANUS
September 28th, 2021	Discussions on activities this year in the field of public transportation	Sato Kogyo Co., Ltd., Kawada Industries, Inc., Nippon Engineering Consultants Co., Ltd., JANUS.
September 30th, 2021	Kick-off meeting with the Ministry of the Environment	Toyama City, NIKKU, Sato Kogyo Co., Ltd., Kawada Industries, Inc., Nippon Engineering Consultants Co., Ltd., HITZ, Hokusan, JANUS
October 7th, 2021	Discussion with Renewable Energy Maldives on order details	Renewable Energy Maldives, JANUS
October 19th, 2021	Discussions with Hulhumale Development Corporation regarding the	HDC, JANUS

	process of field survey	
October 26th-November 9th, 2021	Field survey 27th Oct.: Crossroad Island 28th Oct: HDC, Embassy of Japan in Maldives 29th to 30th Oct.: Visit to Reethi Faru Resort 31st Oct.: STELCO, visit to Thilafushi Island 1st Nov.: Meeting (HDC, Maldives National University, MWSC, WAMCO, GeotechMaldives) 2nd Nov.: Meeting (BISON, MTCC) 3rd Nov.: Meeting (Geotech Maldives, Renewable Energy Maldives) 4th Nov.: (Ministry of the Environment, Waste Management department of Ministry of the Environment, Ministry of Planning, Housing &Infrastructure, Ministry of Transport and Civil Aviation) 6th Nov.: Visit to Thulusdhoo Island	JANUS
November 15th, 2021	Business trip report to Nihonkucho Hokuriku Co., Ltd. and future activity discussions	NIKKU, JANUS
November 16th, 2021	Business trip report to Hokusan Co., Ltd. and future activity discussions	Hokusan, JANUS
November 17th, 2021	Report on business trips to Kawada Industries, Inc., Sato Kogyo Co., Ltd., and Nippon Engineering Consultants Co., Ltd. and discuss future activities	Kawada Industries, Inc., Sato Kogyo Co., Ltd., Nippon Engineering Consultants Co., Ltd., JANUS
November 18th, 2021	Business trip report to Toyama City and future activity discussions	Toyama City, JANUS
November 19th, 2021	Exchange of views with Chi Energie on the introduction of LNG infrastructure in the Maldives	Chi Energie, Japan NUS Co., Ltd.
December 9th, 2021	Toyama online inspection tour	Toyama City, related Japanese companies, people involved in intercity collaboration projects in Indonesia, Malaysia, and Maldives, JANUS
December 27th, 2021	Ministry of the Environment Interim Report Meeting	Ministry of Environment Japan, Toyama City, Hokusan, JANUS
December 28th, 2021	Opinion exchange regarding to waste management with the Dhigurah Island Council	Dhigurah Island Council, Embassy of Japan in Maldives, JANUS
28th February, 2022	Workshop (Webinar on the Joint Crediting Mechanism (JCM) Implementation in Republic of Maldives - Innovation for Carbon Neutrality	Ministry of the Environment Maldives, Ministry of Tourism Maldives, STELCO, FENAKA, GEC, ADB,

	through JCM)	Embassy of Japan in Maldives, Ministry of Environment Japan, HITZ, Hokusan, JANUS

4.2. Field survey (October 26 to November 9)

An attempt was made to travel between October 26 and November 9 when the status of the infection improved. The destinations and schedule are shown below.



Date	Flight	Time	Country	Action	Schedule Schedule.
Oct 25 (Mon)	QR807	22:30	JAPAN	Move	Narita Airport
		04:00	Qatar	Move	Doha Airport
Oct 26 (Tue)	QR674	08:30	Qatar	Move	Doha Airport
		15:20	Maldives	Move	Male Airport
		17:00	Maldives	meeting	HDC greeting
Oct 27 (Wed)		11:00	Maldives	Visit (resort)	Visit to Aquidneck Island
Oct 28 (Thu)		11:00	Maldives	meeting	HDC President Interview
		12:30	Maldives	meeting	Greetings from Ambassador Yanai, Embassy of Japan in Maldives, Director of JICA Kawasaki Branch
		18:00	Maldives	meeting	Dinner reception at the Embassy of Japan in Maldives
Oct 29 (Fri)		09:00	Maldives	Visit (resort)	Visit to Reethi Faru Resort (accompanied by the ambassador)
Oct 30 (Sat)		16:00	Maldives	Visit (resort)	Visit to Reethi Faru Resort (accompanied by the ambassador)
Oct 31 (Sun)		10:30	Maldives	meeting	STELCO meeting
		14:00	Maldives	meeting	MWSC meeting
		15:30	Maldives	Inspection (male area)	Visit to Thilafushi Island
		18:00	Maldives	meeting	Renewable Energy Maldives Dinner Meeting
Nov 1 (Mon)		10:00 10:00	Maldives	meeting	WAMCO meeting
		11:30	Maldives	meeting	Geotech Maldives Meeting
		13:00	Maldives	meeting	HDC Business Development Department Meeting
		14:30	Maldives	meeting	Maldives National University Meeting
		15:00	Maldives	meeting	Embassy of Japan in Maldives Meeting
Nov 2 (Tues)		10:30	Maldives	meeting	MTCC meeting
		14:00	Maldives	meeting	BISON meeting
		15:00	Maldives	Inspection (male area)	Visit to Male Island
		19:00	Maldives	meeting	Mr.Adam dinner meeting
Nov 3 (Wed)		09:00	Maldives	meeting	Geotech Maldives, Hitachi Zosen Meeting
		11:00	Maldives	meeting	Renewable Energy Maldives Meeting
		13:00	Maldives	Inspection (male area)	Visit to Billingili Island
Nov 4 (Thu)		09:00	Maldives	meeting	Ministry of Environment and Energy Meeting
		10:00	Maldives	meeting	National Planning and Housing Infrastructure Ministry Meeting
		14:30	Maldives	meeting	Ministry of Transport and Civil Aviation Meeting
		15:00	Maldives	meeting	Ministry of Environment and Energy Waste Department Meeting
		16:30	Maldives	meeting	Greetings from HIS Iishi
Nov 5 (Fri)		09:00	Maldives	Inspection (male area)	Visit to Hulhumale and Male islands
		20:00	Maldives	meeting	Mr. and Mrs. Adam Dinner Meeting
Nov 6 (Sat)		09:00	Maldives	Inspection (male area)	Visit to Thulusdhoo Island
Nov 7 (Sun)		12:00	Maldives	meeting	HDC follow-up meeting
	QR675	20:25	Maldives	Move	Male Airport
		23:15	Qatar	Move	Doha Airport
Nov 8 (Mon)	QR806	02:00	Qatar	Move	Doha Airport
		17:55	JAPAN	Move	Narita Airport

Figure 4-1 Field survey schedule and destinations

The contents of the individual discussions and surveys are as described in the relevant sections of this report. This section presents the contents of the discussions with the HDC concerning the overall work and the exchange of views with the Embassy of Japan.

(1) Discussions with the HDC

On October 28, 2021, discussions were held with President Suhail Ahmed of HDC. The meeting started off with an explanation on how the political situation had become complicated due to friction with the central government after the opposition party won the Malé mayoral election in April 2021. However, even in such a situation, the policy toward decarbonization is being pushed forward by both parties.

In addition, while there are clear differences in diplomatic relations between the ruling party, which has close ties with India, and the opposition party, which has close ties with China, Japan has built up relations with the Maldives from a neutral position, so we were able to confirm that we will continue the Intercity Collaboration.

On the other hand, in terms of the authority and role of the HDC and the city of Malé, while the HDC has authority over social services, coordination with the city of Malé is becoming complicated.

Under these circumstances, based on the authority and role of the HDC in the formulation of the city master plan, Toyama City conveyed that it intends to continue to promote Intercity Collaboration project through the HDC.

Cooperation with the central government and other state-owned enterprises tends to be vertically segmented, and certain details of the overall project are not fully understood. For example, during the formulation of the land use plan and the implementation plan by the HDC, we received advice that there is a division of roles with MTCC in charge of public transportation, STELCO in charge of power generation, and WAMCO in charge of waste materials, and that their confirmation and coordination are necessary in the project plan. The HDC has been promised an arrangement for such coordination and consultation with relevant organizations as a counterpart of the Intercity Collaboration project.

HDC President Suhail Ahmed is being interviewed every day for an article in the Asia Business Report and he has talked about the Intercity Collaboration with Toyama City in the article.


毎日アジアビジネス研究所
毎日アジアビジネスレポート
2021年8月号
動き始めたインド洋の真珠
モルディブ
動き始めたインド洋の真珠モルディブ　フルマーレプロジェクト
フルマーレ開発担う住宅開発公社（HDC）
スハリ・アフメド社長に聞く
首都の過密解消めざす人工島
モルディブ最大の開発プロジェクト
日本の最新技術に期待
投資家との対話を歓迎

Figure 4-2　Article of the interview with HDC [49]

Source: Mainichi Asia Business Report Aug. 2021 Issue

(2) Exchange of opinions with the Japanese Embassy

We have been receiving a great deal of support from the Embassy of Japan in conducting the previous year's work and launching this Intercity Collaboration project, with the support of former Japanese Ambassador to the Maldives, Keiko Yanai.

In the field survey, multiple discussions were held with the Ambassador, and we obtained advice regarding the survey, commercialization and the promotion of decarbonization measures.

During the exchange of opinions, based on the challenges and needs in the Maldives, including

[49] Mainichi Asia Business Research Institute: "Mainichi Asia Business Report－the Maldives, a pearl in the Indian Ocean, starts to move," Aug. 2021 (https://mainichi.asia/%e6%af%8e%e6%97%a5%e3%82%a2%e3%82%b8%e3%82%a2%e3%83%93%e3%82%b8%e3%83%8d%e3%82%b9%e3%83%ac%e3%83%9d%e3%83%bc%e3%83%88%ef%bc%92%ef%bc%90%ef%bc%92%ef%bc%91%e5%b9%b4%ef%bc%98%e6%9c%88%e5%8f%b7%ef%bc%88/)

those in the Malé Metropolitan Area, we received requests for proposals on ideas for establishing more effective assistance projects by coordinating the programs of Japanese donors such as the Embassy, JICA, and the Ministry of the Environment.

Therefore, we proposed several business ideas for the local needs obtained from this project and the operations under consideration in this project, in cooperation with not only companies in Toyama City, but also Japanese companies such as Hitachi Zosen Corporation, which were looking for business opportunities in the Maldives. Intending to utilize the grant aid budget of the Ministry of Foreign Affairs, we intend to further consider the possibility of exchanging opinions with embassies and conducting joint projects.

Proposal 0: Providing carbon-neutral drinking water (solar water production equipmen

Field: Decarbonization of water supply

Business difficulty: low
(There is a package technology, and in addition to the infrastructure (water services) development that leads to the utilization of the technology, there is a possibility that the Japanese company side can take charge of management and operation, so the probability of business sustainability is high.)

Local needs

In Maldives, where water resources are scarce, drinking water is produced by seawater desalination equipment using RO membranes. Areas without this facility and water distribution facility will be supplied with water using PET bottles. In order to popularize renewable energy and reduce plastics, it is expected that water production and water supply facilities will be popularized and decarbonized. However, since seawater desalination facilities generally require a stable power source, renewable energy is expected. There are challenges in driving at 100%.

Solution by Japanese technology

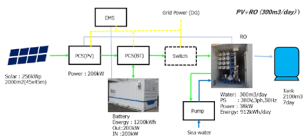
Hitachi Zosen Corporation can provide 100% renewable energy water production facilities that combine RO seawater desalination equipment, energy management systems, storage batteries, and solar power generation with a full turnkey. In addition to selling out, the company is also considering selling under a Water Purchase Agreement (WPA) contract, in which the company owns and manages the equipment and obtains a return by selling the water produced.

Introduction image

Although it is possible to develop as a normal business in resorts with financial power, there is room for consideration in residents' islands where costs such as initial investment cannot be paid. On Thulusdhoo Island near Male, a factory of Coca-Cola is located and the company's water can be purchased, but investment such as water pipes is required on the user side, and the water usage fee is high. Therefore, the council wants to introduce its own water production equipment. With the WPA contract, there is no initial investment burden for the RO system itself, including sunlight, but the problem is that costs will be incurred for the installation of water networks, etc.

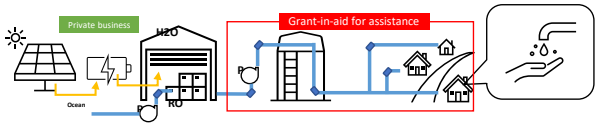
Reference case

Hitachi Zosen Corporation possesses seawater desalination equipment technology using RO membranes, develops packages that integrate with peripheral equipment such as solar power, batteries, and EMS, and is at the stage of commercial deployment.



Synergistic effect with other projects

An approach that maximizes the effect of introduction can be considered by making water production facilities a private business and laying water networks, etc. on specific islands within the framework of grant-in-aid for aid.



Proposal 13: Rationalization of power usage by measures against heat island

Field: Energy saving

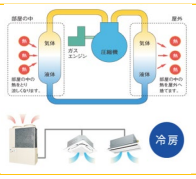
Business difficulty: Medium
(In order to improve the efficiency of air conditioning, it is important to select an appropriate site because the building materials and airtightness are also related, and it is also important that the facility is planned to be constructed in the future. It is also necessary to keep in mind that the development of gas infrastructure, etc. is awaited because gas utilization, etc. will be considered for the conversion.)

Local needs

According to STELCO, it is characterized by the fact that air conditioning accounts for a very large proportion of the electricity consumption in the Male metropolitan area, and it is pointed out that energy saving is also important. Full male has a wide gap between buildings and is well ventilated, so it consumes less electricity per person than male, and it consumes 20% less electricity on rainy days than on sunny days. In Male, where the buildings are dense and poorly ventilated, the temperature rise due to the heat island phenomenon seems to affect power consumption.

Solution by Japanese technology

In Japan, we have advanced technology for designing and introducing the optimum air conditioning system based on the airtightness of the building and the characteristics of the building, switching from individual air conditioning to more efficient central air conditioning, and optimizing the heat source. It is possible to make proposals for improving efficiency through air conditioning.



Introduction image

As one of the highly efficient air conditioning systems, it is possible to consider the introduction of high efficiency equipment by introducing GHP (gas heat pump) technology. GHP is a highly efficient system that drives a compressor with a gas engine that uses natural gas as fuel to recover and utilize waste heat. In shopping malls, office buildings, hospitals, hotels, etc., more efficient air conditioning than electric type Can be realized. If the use of LNG, etc., which is expected to be supported by India, is progressing, it can be proposed as a means of gas use.

Reference case

For high-efficiency air conditioning, there is an air conditioning equipment manufacturer that is expanding worldwide, led by Daikin Industries, Ltd., and construction companies and air conditioning equipment construction companies design and introduce the optimum air conditioning system according to the characteristics of the facility to which it is installed. Is common. It has been introduced in buildings constructed by Japanese companies overseas as well as in various parts of Japan.

Synergistic effect with other projects

Toyama City and Male City are underway in the "Intercity Collaboration Project for Building a Decarbonized Society", which is a project of the Ministry of the Environment of Japan. It is possible to carry out studies and proposals related to the introduction of efficient air conditioning. Since it contributes to decarbonization, it is possible to use JCM equipment assistance, and cooperation can be considered.

Proposal 5: Decarbonization of large-scale electricity consumers by using ENE-FARM

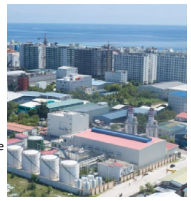
Field: Electricity decarbonization

Business difficulty: Medium

It is a combination of technologies possessed by Japanese companies, and while there are few issues regarding introduction, there are issues regarding selection of target facilities and economic efficiency (including introduction costs).

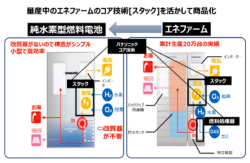
Local needs

In office buildings, hotels, condominiums, factories, and other facilities that consume large amounts of electricity, stable supply is required, and there is a problem in achieving 100% renewable energy with an unstable power source such as sunlight alone. It is expected that "green buildings," which aim for 100% renewable energy in buildings and other facilities alone, will become widespread, but there is a problem in terms of efficiency because electricity storage by batteries and the like is required.



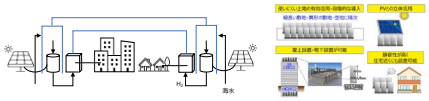
Solution by Japanese technology

ENE-FARM, which was developed by Panasonic and is becoming more widespread, is a system that separates hydrogen from city gas (natural gas) and supplies electricity and heat. By combining the power generated by solar power and the water electrolysis hydrogen production equipment and using the equipment as a human hydrogen type fuel cell, it is possible to make a highly efficient combined heat and power supply a stable supply system using hydrogen as a livestock energy source. can.



Introduction image

For large-scale consumer equipment, a solar panel, electrolyzed hydrogen production equipment, and energy farm will be installed, and hydrogen will be used as an energy carrier to supply heat and electricity to develop an energy-independent facility, which will be used as a model. To spread as.



Case study

Enefarm has a cumulative production record of 200,000 units, and Japanese companies such as Toshiba and Hitachi have already commercialized water-electrolyzed hydrogen production equipment that uses sunlight as an energy source. The introduction is at a stage where it can withstand commercialization.

Synergistic effect with other projects

A project between Toyama City and Male City is underway in the "Intercity Collaboration Project for Building a Decarbonized Society", which is a project of the Ministry of the Environment of Japan, and the feasibility of a similar project is under consideration. It is possible to consider a combination with the JCM equipment subsidy project, and to consider operational cooperation with Hokushi Co., Ltd. (Toyama City), which has a track record of hydrogen utilization and operational technology. Furthermore, Hitachi Zosen Corporation, which plans to introduce solar water production equipment, owns the technology for water electrolysis hydrogen production equipment, and it is possible to consider cooperation.

Figure 4-3　Projects proposed to the Embassy of Japan in Maldives (excerpt)

In December 2021, on the occasion of the appointment of Ambassador Midori Takeuchi as the new Japanese Ambassador to the Maldives, we paid a courtesy call together with Mr. Sugitani, Environment Minister of the Ministry of the Environment of Toyama City, and Manager Kobayashi. The outline of the Intercity Collaboration project in Toyama City was introduced, and future cooperation was confirmed.

Figure 4-4　Courtesy visit from the new ambassador Takeuchi (at the Foreign Ministry on December 15, 2021)

(From left: the chief Kobayashi of Environmental Policy Division, Environmental Section, Toyama City, the head Sugitani of Environmental Section, the new ambassador Midori Takeuchi, the president Chikamoto of Japan NUS Co., Ltd., Ishiguro, and Hiki)

4.3. Online tour

While the field survey by the Japanese investigation team was successfully implemented as described above, it was difficult for the local team, including the HDC, to accept the project in Japan. Therefore, it was necessary to effectively introduce the decarbonization activities of Toyama City.

For this reason, HIS, a major travel agency, planned the application of virtual tours with expanded services in the wake of the novel coronavirus pandemic, and this plan was implemented with the support of HIS Maldives among others.

The virtual tour was held on December 9, 2021, in five cities in three countries that are related to JAPAN NUS CO., LTD. and Toyama City. Attendees from the Maldives were as follows.

Table 4-2　Online tour participants from the Maldives

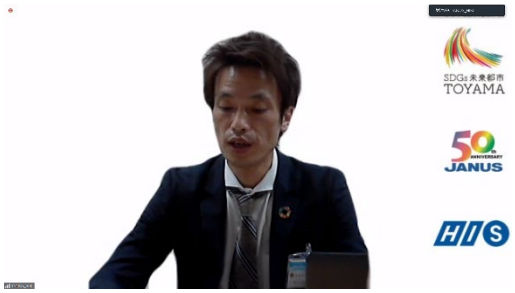
Affiliation	Name
Housing Development Corporation Ltd	Ibrahim Naushad Ali Ahmed Shahud Zuhair
GeoTech Maldives	Mohamed Shumais Mahmood.riyaz
STELCO	Hassan Hasin Hussain
Maldives National University	Zeeniya Kamil Wadheea Thoufeeq
Male' Water & Sewerage Company pvt ltd.	Abdul Hameed Hussain Muhsina Mohamed

On the day of the tour, we introduced the environmental technology of Toyama City using videos taken in advance and exchanged opinions on each theme. The timetable is shown below.

Table 4-3 Online tour timetable

Time	Agenda	Speaker
12:00	Introduction	JANUS
12:10	Opening remarks from MOEJ	MOEJ
12:15	Opening remarks from Toyama city (video contents)	Mr. Fujii, The Mayor of Toyama city
12:20	To Achieve global Carbon Neutrality - International Cooperation (video contents)	
12:30	**LRT** ride experience (LRT; Light Rail Transit) (video contents)	
12:35	QA session	All participants
12:45	Introduction of **Solar power plant and construction site** of NIKKU (Nihon Kucho Hokuriku) (video contents)	
12:50	QA session	All participants
13:00	Introduction of **Hydrogen station** of HOKUSAN (video contents)	
13:05	QA session	All participants
13:15	Introduction of **Small Hydropower Plant** in Toyama city (video contents)	
13:20	QA session	All participants
13:30	**Food waste recycling facility** of Toyama Green Food Recycle Co. (video contents)	
13:35	QA session	All participants
13:45	Comments from each city	Participants from each city (Bali, Semarang, Iskandar, Kota Kinabalu, Male)
14:00	Closing remarks	Toyama city official

During the comments from each region, the Maldives provided an explanation of the outline and progress of the Intercity Collaboration project by the HDC. They commented that they are interested in various technologies introduced in this online tour, such as public transportation and waste recycling, and that they would like to consider the implementation of technologies suitable to the Maldives.



Opening remarks by project director of Toyama cityr

Special remarks by the mayor of Toyama city

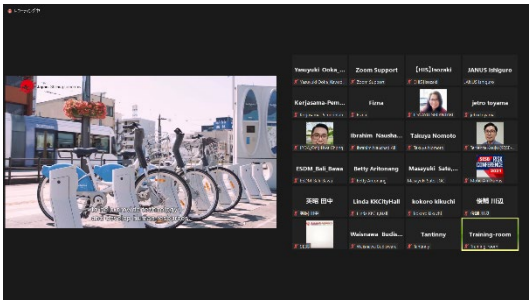


Figure 4-5 Scenes of the online tour

4.4. Workshop

On February 28, 2022, the Ministry of Environment Japan and the Ministry of Environment Maldives jointly held a webinar titled " Webinar on the Joint Crediting Mechanism (JCM) Implementation in Republic of Maldives - Innovation for Carbon Neutrality through JCM ", where Toyama City and JANUS made a presentation on this project. The webinar was held mainly for government officials and private companies in both Maldives and Japan to share the outline and achievements of the project, which is being implemented by the Ministry of Environment Japan and the Asian Development Bank to disseminate decarbonization technologies. The purpose of the webinar was to share the outline and achievements of the project with government officials and private companies in both countries, and to introduce the policies of the Maldives in the areas of climate change, tourism, and electricity. An overview of the webinar is provided below.

In addition to inviting the participation of the counterpart, HDC, related organizations of this projectsuch as the Ministry of Environment of Maldives, Ministry of Tourism, and STELCO also participated in the webinar, and presented Toyama City's policies, efforts in international collaboration projects, and the results of this project to show the will for further collaboration in the future.

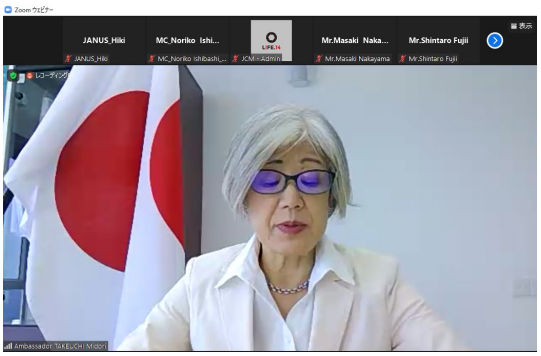
Agenda of JCM Webiner

Date and Time : Monday 28 February 2022 at 10:00-12:00 (Maldives Time), 14:00-16:00 (Japan Time)

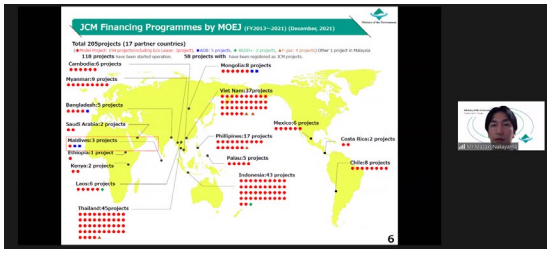
Venue : Online (Zoom)

Organizers : Ministry of Environment, Climate Change and Technology, Republic of Maldives, Ministry of the Environment, Government of Japan
Language : English
Moderator : Pacific Consultants Co., Ltd.
Agenda:

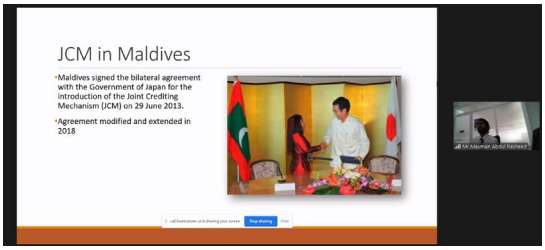
10:00-10:10	Opening Remarks Ms. Midori Takeuchi, Ambassador, Embassy of Japan in the Republic of Maldives
Session 1. State of Climate Change in Maldives and opportunities for the JCM	
10:10-10:20	Climate Change Policy and Focusing Renewable Technologies Ms. Aishath Mohamed Thaufeeq, Programme Officer, Climate Change Department, Ministry of Environment, Climate Change and Technology, Maldives
10:20-10:30	Recent Development of the JCM Mr. Masaki Nakayama, Researcher, Ministry of the Environment, Government of Japan
10:30-10:45	Financing Programme for JCM Model Projects and JCM Global Match Mr. Satoru Tango, Senior Manager, Financing Programme Group, Tokyo Office, Global Environment Centre Foundation (GEC)
10:45-10:55	Recent development of Japan Fund for the JCM (JFJCM) Mr. Shintaro Fujii, Environment and Climate Change Specialist, Climate Change and Disaster Risk Management Division, Sustainable Development and Climate Change Department, Asian Development Bank (ADB)
Session 2. Renewable energy opportunities in Maldives	
10:55-11:05	Recent Situation of Tourism in Maldives Ms. Malaka Abdul Hameed, Director, Security and Crisis Management, Ministry of Tourism Maldives
11:05-11:15	Strategies for Electricity in Maldives (Greater Male) Ms. Mariyam Mooha Midhath, Assistant Engineer, Projects Planning & Development Department, State Electric Company Limited
11:15-11:25	Strategies for Electricity in Maldives (Remote islands) Ms. Mariyam Layal Shakir, Engineer, Technical Service & Green Energy Department, FENAKA Corporation Limited
11:25-11:35	Male-Toyama City-to-City Collaboration for Low-Carbon Society Mr. Shoji Kobayashi, Project Director, Environmental Policy Division, Environmental Department, Toyama City, Japan Mr. Hidenori Ishiguro, Consultant, Environment Consulting Department, International Business Unit, Japan NUS Co., Ltd.
11:35-11:45	Q&A
11:45-11:50	Closing address Ms. Khadeeja Naseem, Minister of State, Ministry of Environment, Climate Change and Technology, Maldives



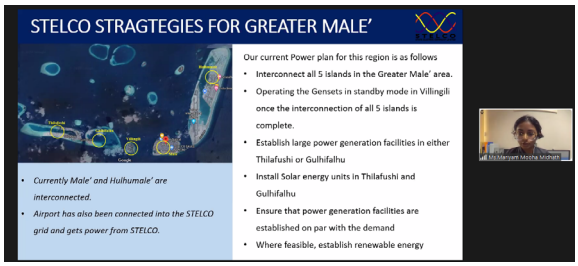
Opening remarks by Ambassador Takeuchi of Ebassy of Japan in Maldives



Presentation by MOE Japan



Presentation by MOE Maldives



Presentation by STELCO

5. Summary

5.1. Outcomes in the current fiscal year

In this fiscal year, despite the ongoing travel restrictions due to the novel coronavirus, field surveys were carried out once the status of the infection improved, which greatly contributed to the deepening of relationships with each project and local stakeholders. As the project took shape, issues related to the project implementation system, economic efficiency, and requirements for JCM facility subsidy projects were highlighted. Considering the resolution of these issues will lead to the creation of a decarbonization project, an agreement has been reached on a policy of working together on a breakthrough plan in collaboration with the Maldives. The results of this fiscal year are shown below.

Table 5-1 Summary of outcomes

Candidate project	Resolts
Public transportation	・ Agreed on two approaches to be considered: long-term measures and short-term measures. ・ As a long-term measure, it was confirmed that a master plan for public transportation would be developed in conjunction with the dynamic survey. Establishment of a system towards proposals to the SATREPS project. ・ As a short-term measure, the introduction of EV buses in the GEF project and the conversion of existing public buses operated by MTCC to EVs will be considered. ・ Confirmed issues of CO2 emission reductions and subsidy effects in the application of the JCM equipment subsidy project. ・ Formulated a policy for future detailed studies and establishment of a system.
Fuel conversion for power generation facility	・ Expression of interest from related organizations for utilization of hydrogen ・ Survey about applicable technologies and models for hydrogen use. ・ Obtain information on natural gas utilization plans and policies. ・ Conducted a comparative study of ammonia, hydrogen, and natural gas in the supply chain, and formulated a policy for hydrogen use based on the idea of autonomous and decentralized use of hydrogen from renewable energy sources in the Maldives.
Dissemination of renewable energy	・ Proposal solar power generation system for resort owner ・ Collaboration with HITZ for their desalination system ・ Basic design, estimated caliculation ・ Possibility of expansion in other resort and residensial island
Utilization of organic waste	・ Information gathering about waste composition and waste management plan ・ Waste management and issues in cities, residensial islands and resort island. ・ Caliculation of CO2 emission reduction and expected amount of subsidy ・ Expression of interest for circular economy conception from related organizations
Others	・ Introduction of proble-solving technologies in Japan to the Embassy of Japan in Maldides ・ Strengthen collaboration with Japanese companies
City-to-City collaboration activities	・ Policy recommendation (Introduction of Toyama city's effort regarding public transportation , hydrogen usage and eco-town etc..) ・ Introduction of decarbonization declaration of Toyama city and explanation of our expectation for decarbonization declaration of Male city

Over the course of this fiscal year's activities, we have noticed mutual relationships and interconnectedness in various themes such as public transportation, energy, and waste. For example, there is a possibility that the use of EVs in public transportation can be linked to solar power generation systems discussed in the theme of renewable energy promotion, and a relationship has been found with the use of hydrogen in the sense that the power from the solar power generation systems can be assumed in the production of hydrogen through water electrolysis.

In addition, the effects of linkage with other F/S undertaken by Japanese companies were

hypothesized while considering waste materials. Specifically, this is the "FY2021 Overseas CO_2 Reduction Support Project through Strategic International Expansion of Japan's Circulation Industry: Integrated Waste Management Project in the Malé Metropolitan Area of the Republic of Maldives" by Hitachi Zosen Corporation, a project to investigate the actual situation of waste matter in the Malé Metropolitan Area, focused on the waste power generation project that the company is engaged in.

Upon receiving the status of the survey on the left, as a result of exchanging opinions with Hitachi Zosen Corporation, we came to realize that in the Maldives, the venous industries, which include separation and reuse, are weak and that incineration by waste power generation alone cannot solve the entire waste problem.

Under these circumstances, the use of organic waste as compost under consideration in the Intercity Collaboration project could be an effective recycling model, but there were also problems in collection and separation, and it was assumed that the feasibility of the project would depend on the establishment of a route, a system, and the provision of technology for the effective use of waste other than organic waste.

Therefore, referring to the Eco-Town Project that the city has been working on since 2002, the city proposed to the HDC, WAMCO, and the Ministry of the Environment of the Maldives measures to promote the separation and effective use of waste by integrating recycling industries.

Assuming that the projects centered on the waste-to-energy project which are currently being considered by the ADB and the Government of Maldives were a one-way street from the perspective of resources recycling, we applied the concept of the circular economy in order to realize sustainable resource recycling and proposed to strengthen the recycling industry through the implementation of various recycling technologies along with a decarbonization concept which uses renewable energy as the energy sources required for the industry.

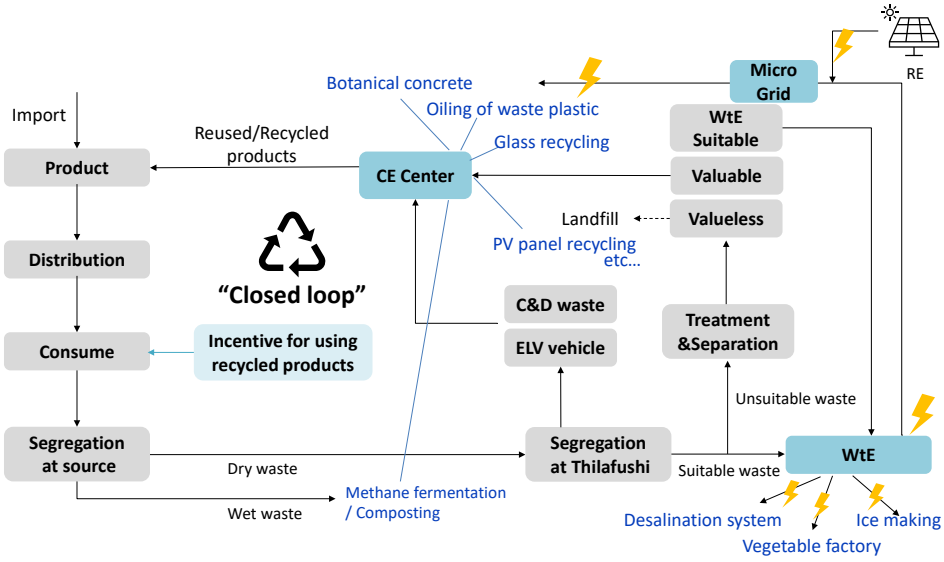


Figure 5-1 Concept of the proposal to the Ministry of the Environment, HDC, WAMCO and STELCO

In response to the above proposal, we have received expressions of interest from relevant

organizations, and have decided to proceed with further concrete discussions with Hitachi Zosen Corporation and Yokogawa Electric Corporation, which is cooperating with us in the F/S business, in the Intercity Collaboration project for the next fiscal year.

5.2. JCM Equipment Project candidates and challenges in implementation

In this survey, the subjects of the JCM equipment subsidy projects were assumed to be (1) public transportation, (2) diesel-powered fuel conversion, (3) the spread of renewable energy, and (4) the recycling of organic waste.

As mentioned above, we were able to make concrete progress on each of these themes in this fiscal year, but there are still some issues that need to be addressed when it comes to turning the themes into proposals.

The JCM equipment support projects assumed from each theme and their challenges are summarized below.

Table 5-2 JCM project candidates, issues, and countermeasures

Project	Facility	Issues	Countermeasures
(1)Public transportation	e-bus	・GEF project are not cost effective in JCM project ・MTCC projects are also not covered all facilities by JCM project. It's realistic to limite to solar power generation facilities for EV buses.	・Utilize projects other than JCM and consider methodologies suitable for transportation projects, and consider project proposals that meet local needs as much as possible.
(2)Fuel conversion for power generation facility	・Hydrogen utilization	・Identification of installation site and limitation of land ・Cost is still high	・Identification of potential site with HDC ・Advance demonstrations through demonstration projects
	・Gas conversion	・Dependent on governmental policy for gas utilization	・Monitor the status of local policy decisions.
（3）Dissemination	・PV+RO system	・ Dependent of decision making by resort ownwer	・ Making proposal with existing data of

of renewable energy			othe resorts ・ Acquisition of competitiveness through the JCM project and consideration of business scheme
（4）Utilization of organic waste	・Composting facility	・Uncertainty in sorting and collection scheme of organic waste ・Land shortage ・ Availability of sewage sludge is unknown.	・Monitor on the latest waste management plan and policy reccomendation ・Identification of candidate site with HDC ・Information gathering by MWSC

5.3. Intercity Collaboration Project in the next fiscal year and future proposals

In the next fiscal year, the survey items corresponding to "Countermeasures" shown in Table 5.2 above will be implemented. The next fiscal year will be the third fiscal year of the three-year project, and since this is the final fiscal year of the project, the focus will be on preparations for the proposals of JCM facility subsidy projects in each theme.

At the same time, based on the authority and role of the HDC, we will aim to make it a good example of a decarbonization domino by obtaining a declaration similar to the Decarbonization Declaration, in cooperation with Toyama City.

In addition to the JCM facility subsidy project, the Government will continue to prepare for the development of demonstration projects and research projects, with the aim of using this Intercity Collaboration project as an opportunity to achieve results.

Although this fiscal year's field survey was conducted, due to the impact of the spread of the novel coronavirus, the survey team, which included Toyama City officials and cooperating companies, could not sufficiently check the site and consult with stakeholders, which is essential for creating a project.

In order to make decisions and create projects, both of which are essential for commercialization, methods are being devised, including the use of online tools and appointment of local coordinators, and it is expected that the parties concerned will visit the site whenever they see an opportunity.

From the next fiscal year onward, we will devise survey options and build a system that will lead to the creation of proposals for each theme, based on the assumption that travel restrictions will continue.

Additionally, in order to achieve effective business proposals and synergies as a Japanese

company, we will further strengthen cooperation not only with the Embassy and JICA, but also with Japanese consultants, manufacturers, trading companies, and other parties involved in activities in the Maldives, and will continue to promote activities towards decarbonization in the Maldives through the establishment of the JCM equipment subsidy project.