Project commissioned by the Ministry of the Environment in 2021

FY2021 Commissioned Task for a City-to-City Collaboration Project for the Realization of a Zero-Carbon Society

（Project for realizing decarbonized transportation utilizing biofuel and developing a decarbonized city by the spread of renewable energy）

Report

March 2022

Japan NUS Co., Ltd.

Toyama City

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List of abbreviations

Abbreviation	English
ADB	Asian Development Bank
BOG	Boil off gas
BRT	Bus Rapid Transit
CNG	Compressed Natural Gas
EPC	Engineering, Procurement and Construction
FIT	Feed in Tariff
GHG	Greenhouse gas
DDF	Dual Diesel Fuel
IRDA	Iskandar Region Development Association
IRR	Internal Rate of Return
JANUS	Japan NUS Co., Ltd.
JCM	Joint Crediting Mechanism
KK	Kota Kinabalu City
LNG	Liquefied Natural Gas
LPG	Liquefied petroleum gas
LRT	Light Rail Transit
MRV	Measurement, Reporting and Verification
NDC	Nationally Determined Contributions
POME	Palm Oil Mill Effluent
SDGs	Sustainable Development Goals

Chapter 1. Background and Purpose of this Task

1. 1 Background of the task

In November 2016, the Paris Agreement came into effect, and in 2020, it was put into practice. The Malaysian government set a goal of reducing greenhouse gas emissions by 35% between 2005 and 2030 or 45% by enlisting international cooperation, as a nationally determined contribution (NDC). In 2019, they announced the “Malaysia Energy Supply 2.0 (MESI 2.0)” plan with a goal of increasing the ratio of renewable energy among fuel for power generation to 20% by 2025, energizing activities for reducing greenhouse gas emissions.

Among these circumstances, Toyama City, which is a futuristic city for SDGs, is recognized by the United Nations as the only “energy efficiency improving city” in Japan, as its efforts to develop a compact city based on public transportation and utilize renewable energy, including micro-hydroelectric power, by utilizing its regional characteristics. In order to fulfill its roles as an advanced environmentally friendly city, Toyama City concluded an agreement for cooperation in utilization of renewable energy and promotion of public transportation with Iskandar, which is located in Johor, Malaysia, and Kota Kinabalu, which is the state capital of Sabah in northern Borneo, to share the municipal and corporate technologies and know-how internationally for realizing a decarbonized society.

	
Scene of conclusion of an agreement with Iskandar	Scene of conclusion of an agreement with Kota Kinabalu

1. 2 Purpose of the task

The Paris Agreement stipulates that non-governmental bodies, including municipalities and cities, in addition to central governments should accelerate activities for coping with climate change. Cities and municipalities are key players when discussing and executing concrete measures and projects for coping with climate change. In order to realize a decarbonized global society, it is necessary to accelerate the trend of developing a low-carbon society to actualize a sustainable decarbonized society in Asia, whose economy is rapidly growing. Accordingly, there is the growth of support for urban initiatives around the globe, with the aim of decarbonizing cities and realizing low-carbon

cities, which support the advance of society and economy.

In this City-to-City collaboration project, we studied the feasibilities of an urban development project based on low-carbon public transportation utilizing biofuel and a project for distributing renewable energy based on micro-hydroelectric power generation in cooperation with Toyama City and enterprises that possess decarbonization technologies, selected candidate JCM deals while proposing JCM equipment support projects, and proposed and developed measures and systems for carrying out the project smoothly.

1.3 System for conducting the task

The system for conducting the task this fiscal year is as shown in **Figure1-1**. Under the framework for intercity collaboration, Toyama City, Iskandar, and Kota Kinabalu concluded an agreement for cooperation, and had discussions about the sharing of know-how for developing a compact city and support for policymaking for facilitating the project for urban development based on decarbonized transportation utilizing biofuel and the project for distributing renewable energy, which are the subjects of this research, while Iskandar Regional Development Authority (IRDA) and Kota Kinabalu served as liaisons.

To discuss commercialization, we cooperated with enterprises in Toyama City, including Hokusan Co., Ltd., which specializes in industrial gas services and has the experience of planning a JCM equipment support project (public transportation bus fuel change) for the City-to-City collaboration project in Indonesia, Hokuden Engineering Consultants Co., Ltd., which has the experience of planning a micro-hydroelectric power generation project and conducting engineering design, Nihon Kucho Hokuriku Co., Ltd., which has the experience of engineering design for solar power generation, Nissan Chemical Corporation, which possesses the technology for purifying exhaust gases from automobiles, etc., and JGC Holdings Corporation, which possesses the knowledge of biogas liquefaction technologies. In addition, Japan NUS Co., Ltd. managed the entire project by collecting information for intercity collaboration, supporting surveys, and coordinating communication among related institutions.

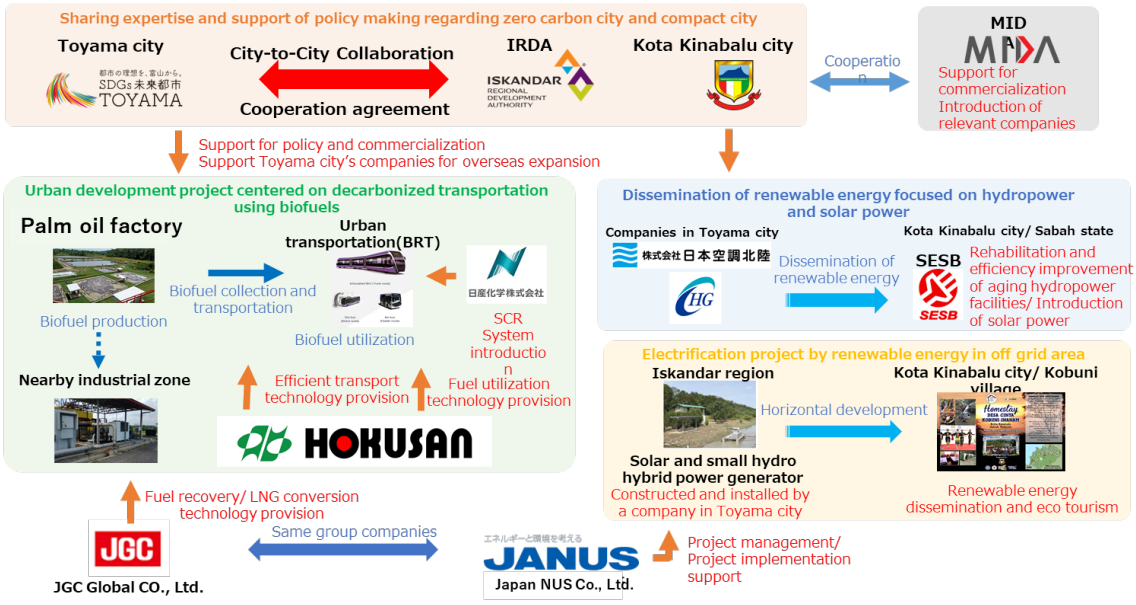


Figure1-1　Outline of this task and the implementation system

Chapter 2. Overview of the Results of the Survey in 2020

In the City-to-City collaboration project in 2020, we were not able to conduct an on-site survey due to the spread of COVID-19, but by holding online meetings, etc., we were able to collect necessary information for JCM monetization as initially planned.**Table2-1** shows the outcomes.

Table2-1 Summary of the outcomes of the City-to-City collaboration project in 2020

Project	Outcome
Urban development project centered on decarbonized transportation system using biofuel	・ Policy about biofuel utilization and public transportation (BRT system introduction project) has been confirmed. ・ Biofuel production potential has been assessed with the identification of the factories to be examined. ・ Biofuel transportation method has been considered, and the appropriate biofuel selling cost assumed from the production volume and transportation method. ・ The amount of biofuel demand expected at the BRT system introduction has been considered.
Dissemination of renewable energy focused on hydropower and solar power	・ Small hydropower plant location and output potential have been considered. ・ Small hybrid solar-hydropower generation equipment installed in Iskandar region have been presented ・ Kobuni village has been introduced to us as a renewable energy introduction project site aiming environmental education and it has been agreed that this consideration would be added into the survey the following fiscal year.
City-to-city Collaboration activities	・ At the kick-off meeting and workshop, Toyama City’s efforts and policies have been presented. ・ The will of continuing the city-to-city collaboration project on the following fiscal year has been confirmed.

Chapter 3. Decarbonized public transportation project utilizing biofuel

Malaysia produces the second largest volume of palm oil in the world (21,486,000 tons in 2014), Johor, where Iskandar is located, can purify the third largest volume of palm oil in the country (15.89 million tFFB [Full Fruit Bunches] in 2015), and Sabah, where Kota Kinabalu is located, can purify the largest volume of palm oil in the country (33.76 million tFFB in 2015). The water discharged from palm oil mills (palm oil mill effluent [POME]) includes a high concentration of organic pollutants, so the treatment of them is a long-standing issue. In Sabah, river water is used for drinking, bathing, etc. in daily life in some regions, where POME contaminates the river, and some health damage cases have been reported. To deal with this issue, the Malaysian government tightened environmental regulations for the palm oil industry and made it mandatory to treat POME appropriately by setting water discharge standards. Since then, palm oil mills had treated POME in unlined wastewater reservoirs, but methane gas, which is a greenhouse gas, was produced through fermentation, so it was recommended in National Key Economic Areas (NKEA) that methane gas, which is emitted during the treatment of POME, should be collected and reused by 2020. Following this recommendation, some enterprises installed equipment for collecting and using methane gas, but they are limited to large companies. Most enterprises discharge POME to rivers without treating it or merely treat it in lagoons, because the cost for installing equipment for collecting methane gas is large and it is impossible to find users or transportation enterprises of collected methane gas. This is a major factor in environmental pollution and global warming.

In this situation, we are discussing measures to collect and treat POME and effectively use methane gas as fuel in this project. In the project in 2020, we estimated the potential supply volume of biofuel from the locations and production outputs of palm oil mills in Iskandar and Kota Kinabalu. In addition, to research the demand side, we surveyed and summarized the potential consumption of biofuel in BRT, which is to be adopted in Iskandar, and discussed the business model shown in **Figure3-1**. The problems with this model are the augmentation of transportation costs due to the distance of transportation of collected biofuel and the shortage of biofuel to be used as fuel for BRT, which is scheduled to be adopted in Iskandar.

In the project this fiscal year, we discussed the technological details of necessary equipment for supplying and using biofuel with the aim of expanding the biofuel supply capacity. In addition to the technological discussion, we discussed urban development based on new public transportation and summarized the methods for municipal involvement with the adoption of public transportation, supportive policies, etc. in this project.

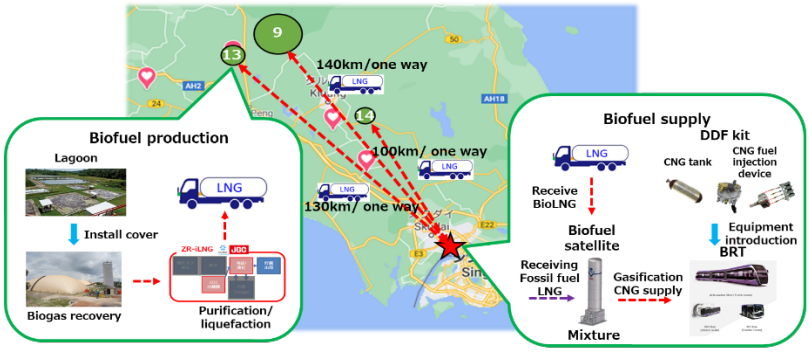


Figure3-1　Business model discussed in the project in 2020

3. 1　Discussion on technological details for actualizing a biofuel utilization project

3. 1 . 1　　Supply of biofuel

1) Discussion on the enhancement of the biofuel supply capacity

In the survey in 2020, we produced the list of palm oil mills and enterprises in Johor, where Iskandar is located, and Sabah, where Kota Kinabalu is located, by researching literature, interviewing MIDA, etc. On the other hand, it was found, as mentioned above, that the mills surveyed in the previous fiscal year have the problems with transportation distance and supply capacities. Accordingly, in the survey this fiscal year, we added new information sources regarding palm oil mills and produced a map of palm oil mills.

According to NNA ASIA (Asian economic news)[1], United States Customs and Border Protection (CBP) issued a withhold release order (WRO) against the palm oil and related products of FGV Holdings, which is a leading Malaysian company that operates palm plantations, because of forced labor on September 30, 2020. On December 30, 2020, the same order was issued against Sime Derby Plantation Bhd., which is the largest company in this field, and also enterprises that manage RSPO-certified facilities. In the past 2 years, this order has been issued against 7 enterprises. At present, the Malaysian government is discussing swift measures for solving problems with enterprises in order to make the WPO rescinded.

Against this backdrop, we added the palm oil mills that make transactions with Japanese enterprises, which are considered to take cautious measures for sustainability issues, including forced labor and environmental problems, in order to reduce risks in future business operation, as information sources (**Table3-1**).

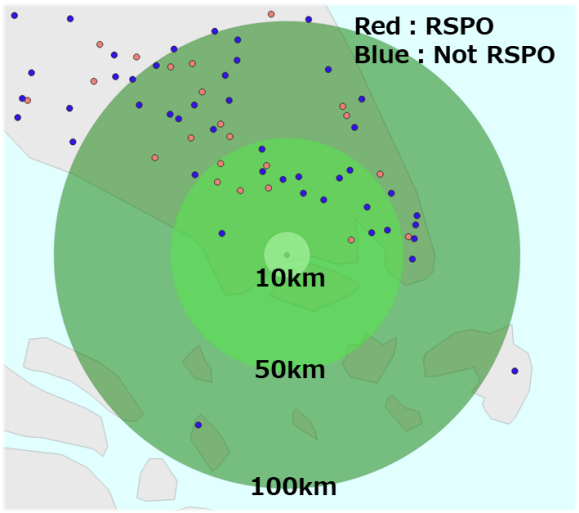
[1] https://www.nna.jp/news/show/2253373

Table3-1 Added information sources

No.	Name of information source	Remarks
1	Palm trading companies publicly announced by Kao[2]	Announcement of the presence or absence of RSPO certification
2	Palm trading companies publicly announced by Nisshin Oillio[3]	Announcement of the presence or absence of RSPO certification
3	Palm trading companies publicly announced by Fuji Oil[4]	Announcement of the presence or absence of RSPO certification
4	Palm trading companies publicly announced by Meiji[5]	-
5	Factories publicly announced by GLOBAL FOREST WATCH[6]	Announcement of the presence or absence of RSPO certification

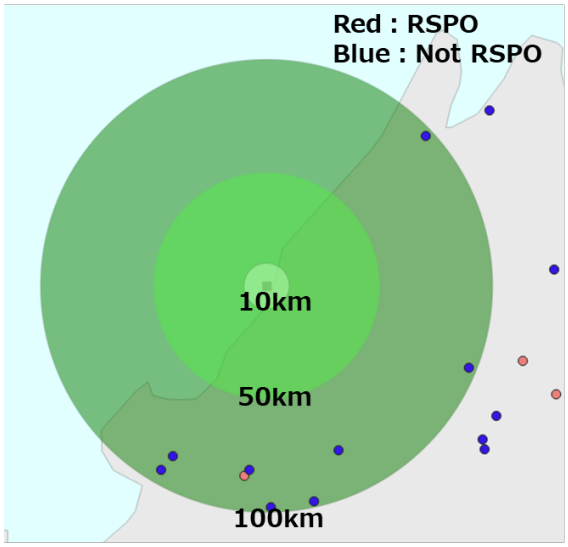
We summarized the information on locations of palm oil mills obtained through these information sources and produced a map with GIS software. In addition, we sorted palm oil mills by distance (10 km, 50 km, and 100 km) from the urban areas of Iskandar and Kota Kinabalu, which are candidate places for supplying biofuel, by using the functions of GIS software (**Figure3-2** and **Figure3-3**). The list of sorted palm oil mills are shown in **Table3-2** and **Table3-3**. It was clarified that in Iskandar, there are 18 mills within 50 km from the urban area and 31 mills within 100 km from the urban area, that is, a total of 49 mills, and in Kota Kinabalu, there are 9 mills within 100 km from the urban area.

[2] https://www.kao.com/content/dam/sites/kao/www-kao-com/jp/ja/corporate/sustainability/pdf/progress-2021-001.pdf
[3] https://www.nisshin-oillio.com/company/sustainability/sustain/pdf/Nisshin_OilliO_Group_Total_Mill_List.pdf?201130
[4] https://www.fujioilholdings.com/pdf/en/sustainability/supplychain_database/h2_2020_mill_list.pdf
[5] https://www.meiji.com/sustainability/procurement/pdf/mill_list.pdf
[6] https://www.globalforestwatch.org/



Distance	RSPO	Not RSPO
10km	0	0
50km	6	12
100km	11	20

Figure3-2　Map and number of palm oil mills (Iskandar)



Distance	RSPO	Not RSPO
10km	0	0
50km	0	0
100km	1	8

Figure3-3　Map and number of palm oil mills (Kota Kinabalu)

Table3-2 List of sorted palm oil mills (Iskandar)

Mills_name	Parent_Comp	RSPO	10km	50km	100km
TUNJUK LAUT	AWAN TIMUR GROUP	Not RSPO Certified			○
UNITED BELLL	BELL GROUP	Not RSPO Certified		○	○
TELOK SENGAT	BOUSTEAD PLANTATIONS BERHAD	Not RSPO Certified		○	○
PALM DISCOVERY / KULAI MAS	DUPONT & LEOSK ENTERPRISES	Not RSPO Certified		○	○
SEMENCHU	FGV HOLDINGS BERHAD	Not RSPO Certified		○	○
WA HA	FGV HOLDINGS BERHAD	RSPO Certified			○
LOK HENG	FGV HOLDINGS BERHAD	Not RSPO Certified			○
ADELA	FGV HOLDINGS BERHAD	RSPO Certified			○
BUKIT BESAR	FGV HOLDINGS BERHAD	Not RSPO Certified		○	○
KULAI	FGV HOLDINGS BERHAD	RSPO Certified		○	○
PENGGELI	FGV HOLDINGS BERHAD	RSPO Certified		○	○
BELITONG	FGV HOLDINGS BERHAD	RSPO Certified			○
KAHANG	FGV HOLDINGS BERHAD	Not RSPO Certified			○
AIR TAWAR	FGV HOLDINGS BERHAD	Not RSPO Certified		○	○
TENGGAROH	FGV HOLDINGS BERHAD	RSPO Certified			○
TENGGAROH TIMOR	FGV HOLDINGS BERHAD	Not RSPO Certified			○
SENINNG	FGV HOLDINGS BERHAD	Not RSPO Certified			○
GENTING AYER ITEM	GENTING PLANTATIONS	RSPO Certified			○
KLUANG	HOK HUAT GROUP SDN BHD	Not RSPO Certified			○
PAMOL KLUANG	IOI CORPORATION	RSPO Certified			○
MASAI	KECK SENG (M) BERHAD	RSPO Certified		○	○
CORONATION	KIAN HOE PLANTATIONS BHD	Not RSPO Certified			○
KIAN HOE PLANTATIONS	KIAN HOE PLANTATIONS BHD	Not RSPO Certified			○
KOTA TINGGI	KIM LOONG RESOURCES BERHAD	Not RSPO Certified		○	○
SUNGKIT ENTERPRISES SDN BHD	KIM LOONG RESOURCES BERHAD	Not RSPO Certified		○	○
KEKAYAAN	KUALA LUMPUR KEPONG (KLK)	RSPO Certified			○
PALOH KKS	KUALA LUMPUR KEPONG (KLK)	Not RSPO Certified			○
SEDENAK	KULIM (MALAYSIA) BERHAD	RSPO Certified		○	○
TEREH	KULIM (MALAYSIA) BERHAD	RSPO Certified			○
PASIR PANJANG	KULIM (MALAYSIA) BERHAD	RSPO Certified			○
SINDORA	KULIM (MALAYSIA) BERHAD	RSPO Certified			○
TAI TAK	LADANG TAI TAK (KOTA TINGGI) SDN BHD	Not RSPO Certified		○	○
PPNJ KAHANG	PERTUBUHAN PELADANG NEGERI JOHOR (PPNJ)	Not RSPO Certified			○
PH PALM EXPRESS	PH PALM EXPRESS CORPORATION	Not RSPO Certified			○
FRUIT EXPRESS	PH PALM EXPRESS CORPORATION	Not RSPO Certified			○
RISDA SG AMBAT	RISDA ESTATES SDN BHD	Not RSPO Certified			○
SUNGEI KAHANG	SAYONG PLANTATION SDN BHD	Not RSPO Certified			○
LADANG PADANG KAHANG	SEONG THYE PLANTATIONS SDN BHD	Not RSPO Certified			○
YONG PENG (SOU 19A)	SIME DARBY	Not RSPO Certified			○
BUKIT BENUT (SOU 22)	SIME DARBY	RSPO Certified			○
HADAPAN (SOU 24)	SIME DARBY	RSPO Certified		○	○
ULU REMIS (SOU 23)	SIME DARBY	RSPO Certified		○	○
BUKIT LAWIANG	TH PLANTATIONS BERHAD	Not RSPO Certified			○
SUNGAI KACHUR	TRADEWINDS PLANTATION BERHAD	Not RSPO Certified		○	○
ULU SEBOL	TRADEWINDS PLANTATION BERHAD	Not RSPO Certified		○	○
KILANG KELAPA SAWIT SIANG	UNKNOWN	Not RSPO Certified			○
AGRO MEKAR LESTARI	UNKNOWN	Not RSPO Certified			○
SOUTHERN MALAY	VICTORY ENGHOE PLANTATIONS SDN BHD	Not RSPO Certified			○
ALAF	YPJ PLANTATIONS SDN BHD	Not RSPO Certified		○	○

Table3-3 List of sorted palm oil mills (Kota Kinabalu)

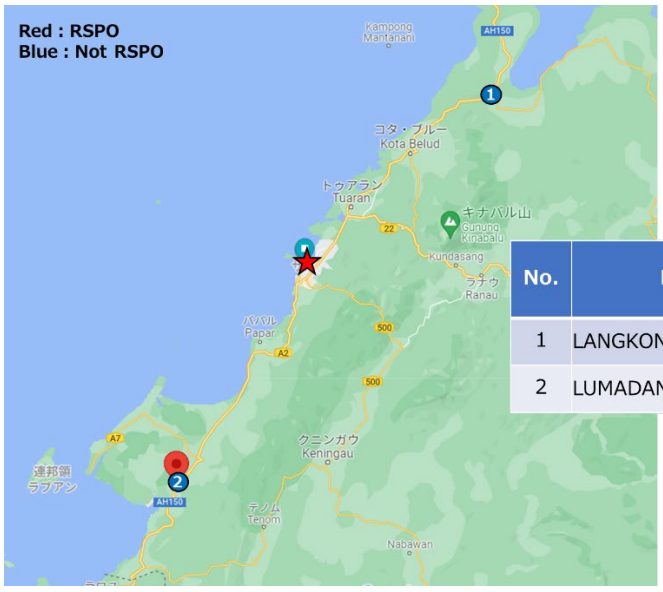
Mills_name	Parent_Comp	RSPO	10km	50km	100km
MELALAP (SOU 27)	SIME DARBY	RSPO Certified			○
BEAUFORT	NGIN KONG GROUP	Not RSPO Certified			○
LANGKON	SAWIT KINABALU SDN BHD	Not RSPO Certified			○
LUMADAN	SAWIT KINABALU SDN BHD	Not RSPO Certified			○
DESA KIM LOONG	KIM LOONG RESOURCES BERHAD	Not RSPO Certified			○
SOOK OIL MILL	CHELLAM PLANTATIONS	Not RSPO Certified			○
KENINGAU POM	SABAH LAND DEVELOPMENT BOARD	Not RSPO Certified			○
TANER R&D	TANER INDUSTRIAL TECHNOLOGY (M) SDN BHD	Not RSPO Certified			○
TOUPOS	TOUPOS PALM OIL MILL SDN BHD	Not RSPO Certified			○

Among 18 palm oil mills located within 50 km from the urban area of Iskandar, we can check the

FFB treatment amounts of 10 mills by studying literature and interviewing MIDA, and the potential biofuel supply amount estimated from the FFB treatment amounts is 21,400 tons per year (**Figure3-4**). In addition, among 9 palm oil mills located within 100 km from the urban area of Kota Kinabalu, we can check the FFB treatment amounts of 2 mills by studying literature and interviewing MIDA, and the potential biofuel supply amount estimated from the FFB treatment amounts is 4,200 tons per year (**Figure3-5**).

No.	Mill	Company	Bio-LNG Potential [ton/y]
1	TELOK SENGAT	BOUSTEAD TELOK SENGAT	1,900
2	SEMENCHU	FGV PALM INDUSTRIES	1,900
3	BUKIT BESAR	FGV PALM INDUSTRIES	1,300
4	KULAI	FGV PALM INDUSTRIES	1,400
5	PENGGELI	FGV PALM INDUSTRIES	2,600
6	MASAI	KECK SENG (M)	2,800
7	TAI TAK	LADANG TAI TAK (KOTA TINGGI)	2,000
8	HADAPAN (SOU 24)	SIME DARBY PLANTATION	2,800
9	ULU REMIS (SOU 23)	SIME DARBY PLANTATION	2,800
10	ALAF	YPJ PLANTATIONS	1,900

Figure3-4　Potential biofuel supply amount (Iskandar)



No.	Mill	Company	Bio-LNG Potential [ton/y]
1	LANGKON	SAWIT KINABALU	2,100
2	LUMADAN	SAWIT KINABALU	2,100

Figure3-5　Potential biofuel supply amount (Kota Kinabalu)

2) Estimation of costs for supplying biofuel

In the project in 2020, we estimated the costs for a value chain set in **Figure3-1** with a simple

method. In the project this fiscal year, we estimated the costs for supplying biofuel with an elaborate method.

① Estimation condition

The supply chain system discussed in this research is shown in **Figure3-6**.

The COD value of palm oil mill effluent (POME) discharged from the crude palm oil (CPO) production process is reduced through anaerobic fermentation in open lagoons in business as usual (BaU). At that time, the open lagoons emit biogas, which is composed of mainly methane and carbon dioxide, through anaerobic fermentation to the atmosphere as greenhouse gas. In this model, the anaerobic fermentation in open lagoons is changed to the anaerobic fermentation in the closed space of a continuous stirred tank reactor (CSTR), to which POME is transported, so that biogas is collected without emitting it to the atmosphere, and the collected methane gas is purified and separated to produce bio-methane. The produced methane gas is delivered to fuel consumers (factories and transportation) and consumed. It is assumed that compression equipment (for producing bio-CNG) or liquefaction equipment (for producing bio-LNG) will be installed for improving the efficiency of transportation of produced bio-methane.

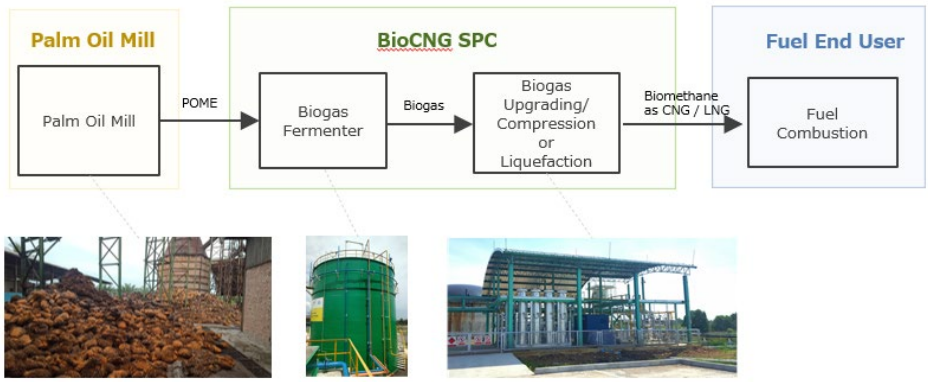


Figure3-6　Assumed supply chain

When the costs for equipment for bio-LNG and bio-CNG, which are the subjects of this research, were estimated, the following input conditions were assumed (**Table3-4**).

Assuming a palm oil mill (POM) that treats 60 ton-FFB/hr, biogas volume was estimated to be 3,000 ton-Biomethane/year. This biogas production volume was estimated by calculating the volume of methane gas derived from POME, which is emitted from POM that treats 60 ton-FFB/hr, from the mass balance information with reference to palm-related documents.

Table3-4　Assumed input conditions

Component	Design	Range	Remarks
Nitrogen	0.2 mol%	< 0.8 mol%	Basis of flash gas recycle, impact on capacity
Oxygen	0.1 mol%	< 0.5 mol%	Basis of liquefaction, Sulfur removal; note 3
CO_2	35 mol%	34 – 42 mol%	Design of membrane gas upgrading & LCO_2
Methane	64 mol%	58 – 66 mol%	Balance
Water	Saturated	10 - 40° C	At digester pressure of 50 mbarg
Ammonia	10 ppm	< 10 ppm vol	Determines need for scrubber
Hydrogen	50 ppm	< 100 ppm vol	Design of bleed system and LCO2 condenser
VOC's	900 ppm	< 900 ppm	See note 1)
Siloxanes	2.3 mg/Nm^3	< 5 mg/Nm^3	OEM limit, previously at 35 mg/Nm^3
H_2S	20 ppm	< 30 ppm mol	Design of Activated Carbon system
Sulfur compounds	50 ppm total S	< 50 ppm total S	See note 2), 50 ppm = 65 mg/Nm^3

Note 1) VOC's: total Volatile Organic Compounds
< 700 ppm p-cymene (4000 mg/Nm^3)
< 100 ppm; D-limonene
< 100 ppm; Benzene, Toluene, Xylene (BTX)
Mol mass of terpenes is about 135 g/mol; 1 ppm = 6 mg/Nm3; 900 ppm = 5400 mg/Nm3.
Note 2) Other organo-sulfur compounds like Mercaptans; DMS-DiMethyl Sulfide, THT-TetraHydro Thiofene.
Note 3) Sulfur removal by activated (impregnated) carbon requires O_2 to oxidise the H_2S to elemental Sulfur, which is adsorbed in the carbon pores.

Next, the specs of the final products of bio-LNG and bio-CNG, which are produced by treating the waste liquid discharged from FFB treatment (POME), are as shown in **Table3-5** and **Table3-6**.

Table3-5　Assumed product specs (bio-LNG)

Item	Value	Unit
Bio-LNG production amount	3,000	ton-Bio-LNG/year
Temperature	-150	deg.C
Pressure	atmospheric	-
Methane concentration	99	%>

Table3-6　Assumed product specs (bio-CNG)

Item	Value	Unit
Bio-CNG production amount	3,000	ton-BioLNG/year
Temperature	atmospheric	-
Pressure	20	MPa
Methane concentration	99	%>

Based on the above conditions, we discussed the composition of equipment for processing and

estimated the costs for equipment and operating it.

② Estimation results: Case of bio-CNG

The composition of equipment for producing bio-CNG from POME gas is shown in **Figure3-7**. POME is transported to CSTR, and methane fermentation is facilitated in a sealed system. The produced biogas is transported to a biogas upgrading unit, to be purified, separated, and used as bio-methane. The purified and separated bio-methane is compressed to 20 MPa, to produce bio-CNG.

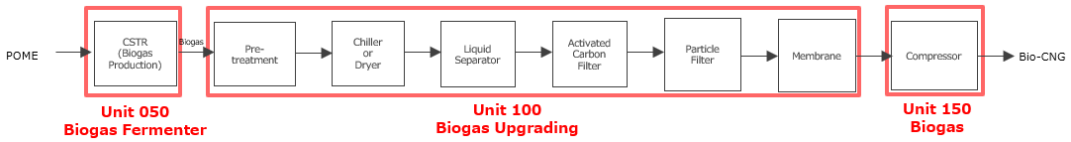


Figure3-7 Composition of equipment for producing bio-CNG from POME gas

For installing equipment for producing 3,000 tons of bio-CNG, it is necessary to invest about 190 million yen in CSTR (biogas fermentation tank) for collecting POME gas and about 370 million yen in the upgrading unit and the compressing unit, that is, a total of about 560 billion yen (assumed exchange rate: 1 US dollar = 110 yen).

CSTR and the compressing unit consume a lot of electricity, so electricity cost occupies a significant portion of the operating expenditure. We estimated personnel expenses based on the following assumption.

③Estimation results: Case of bio-LNG

The composition of equipment for producing bio-LNG from POME gas is shown in **Figure3-8**. POME is transported to CSTR, and methane fermentation is facilitated in a sealed system. The produced biogas is transported to a biogas upgrading unit, to be purified, separated, and used as bio-methane. The purified and separated bio-methane is transported to a liquefaction unit.

In this study, the ZR-iLNG process was assumed for the process in the liquefaction unit. The ZR-iLNG process is expected to have a cost advantage for a relatively compact liquefaction unit for bio-methane. **Figure3-9** compares the liquefaction process used often for ordinary large-scale LNG processes, including the C3MR process, and the ZR-iLNG process in block flow.

This process is an innovative one that does not require the removal of acid gas or the external storage of refrigerants in the existing biogas liquefaction process. By reducing the number of necessary devices and the necessary land area, it is expected to reduce the initial investment amount in a plant by 20-40%.

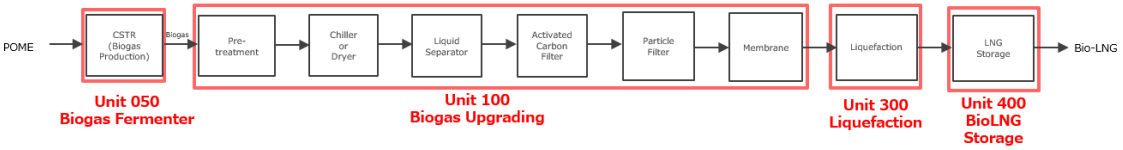


Figure3-8　Composition of equipment for producing bio-LNG from POME gas

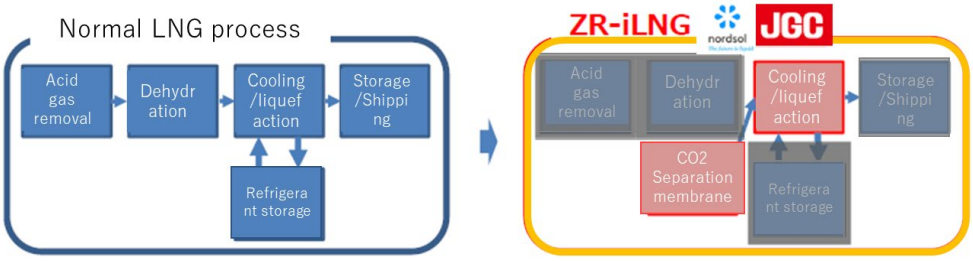


Figure3-9　Comparison between the ZR-iLNG process and the ordinary LNG liquefaction process

In the ZR-iLNG process, CO_2 in bio-methane that has passed the upgrading unit is separated by a three-phase separator, so that the CO_2 concentration of bio-LNG, which is the final product, is at the same level as ordinary LNG. Accordingly, it becomes possible to use a device such as a membrane separator and a pressure swing adsorption (PSA) device without investing a lot of money for installing an acid gas removal device for separating CO_2 in the upgrading unit. As a result, it would reduce the total cost for the equipment.

The components from the POME gas collection unit (CSTR) to the upgrading unit are the same as those of the equipment for producing bio-CNG from POME mentioned in Chapter 3, but the component downstream of the upgrading unit is changed from a compressor unit to a liquefaction unit.

Accordingly, more compressors, an aluminum plate fin heat exchanger, a three-phase separator, a special valve, etc. are added, so the overall cost for a liquefaction unit is larger than that for a compressor unit. As a result, the total cost for equipment was estimated to be about 2.18 billion yen.

The ZR-iLNG process is advantageous from the viewpoints of both equipment cost and operating expenditure. The operating expenditure for LNG equipment is attributable to mainly electricity charges, especially for operating rotary machines. The electric power consumption per unit mass of LNG equipment is called specific power [kWh/ton-LNG], and operating expenditure is generally evaluated from the aspect of power consumption while referring to specific power. **Figure3-10** compares the ZR-iLNG process and another compact liquefaction process in specific power.

The specific power of the ZR-iLNG process is expected to be about 14% lower than that of the

compact liquefaction process, so operating expenditure will be reduced. In a project aimed at decarbonization, a process that consumes less power should be highly evaluated also from the viewpoint of LCA.

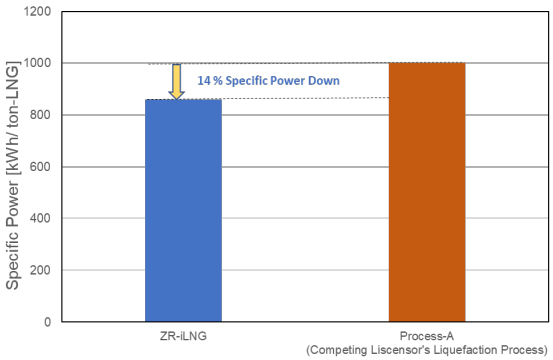


Figure3-10　Comparison between the ZR-iLNG process and another compact liquefaction process in specific power

Like CNG, electric power consumption is significant, so operating expenditure is attributable to mainly electricity charges. In addition, the costs include the license fee for adopting the innovative liquefaction process and the ZR-iLNG process of Nordsol. The assumed staffing plan is the same as that for CNG.

3)Discussion on reduction of costs for supplying biofuel

The high transportation efficiency of bio-LNG is advantageous, but the cost for equipment is relatively large. Therefore, we discussed the possibility of further cost reduction for the liquefaction unit, which accounts for a large portion of the cost for installing equipment for producing bio-LNG from POME gas. Since rotary equipment (compressor) accounts for a significant portion of costs for the liquefaction unit of bio-LNG production equipment, we discussed cost reduction for rotary equipment.

Table3-7 shows the types of compressors used for a liquefaction unit. The compressors used in a liquefaction unit for the ZR-iLNG process can be classified into the screw type, the reciprocating type, and the expander compressor type.

The gas treatment capacity of a compressor used in a bio-methane treatment plant in the scheme discussed here is significantly lower than that of a compressor used in a large-scale LNG plant.

Considering the above characteristics (compressor types) and processing conditions (input and output conditions of each compressor, especially gas treatment capacity), we looked for vendors that can deliver compressors that can satisfy the above conditions at low prices by asking trading houses,

etc., but they answered that it is unlikely that the cost for rotary machines will be reduced considerably.

Table3-7　Types of compressors used for a liquefaction unit

Equipment Name	Compressor Type
Biogas Compressor	Screw
Recycle Gas Compressor	Screw
Turbo Compressor Expander	Expander Compressor
Booster Compressor	Reciprocating

We also discussed cost reduction by packaging the freezing system, but it was concluded that cost reduction is difficult, because it is not suited for the bio-methane production volume of 3,000 tons per year and cooling temperature, which are discussed in this project.

In conclusion, it is very difficult to reduce capex considerably by curtailing the cost for each piece of equipment or packaging a system, and in order to improve economic performance, we should improve the supply chain, for example, by locating liquid nitrogen production equipment like a hub station and supplying the nitrogen refrigerant to each POM to liquefy bio-methane with liquid nitrogen at each POM, rather than reducing the cost for each piece of equipment.

3.1.2　Transportation of biofuel

In the project in 2020, the cost for biofuel transportation was estimated with a simple method for the value chain set in **Figure3-1**, like the supply of biofuel. In the project this fiscal year, we estimated the costs for transportation equipment and satellite equipment, while assuming that the transportation volumes of LNG and CNG are both 3,000 tons per year, according to the supply of biofuel.

1) Estimation of costs for biofuel transportation equipment

① Case of bio-CNG

In a case where 3,000 tons of bio-CNG is transported every year, it is realistic to utilize a 4,500-L or 6,000-L CNG tubing trailer (**Figure3-11**), assuming that it is transported 300 days per year.

Figure3-11　CNG tubing trailer

It would be possible to transport 3,000 tons of CNG per year by making 3 runs per day with a 4,500-L tubing trailer or by making 2 or 3 runs per day with a 6,000-L tubing trailer.

Equipment costs are as shown in **Table3-8**. The trailer and the tank would cost about 22-25 million yen, the tractor truck would cost about 15 million yen, and the total cost would be 37-40 million yen.

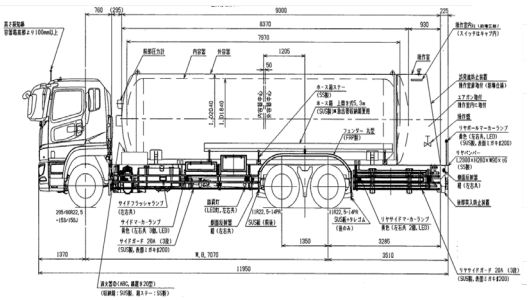
Table3-8　Costs for bio-CNG transportation equipment

Capacity	4,500L	6,000L
Trailer/Tank	22 million yen	25 million yen
Tractor truck	15 million yen	

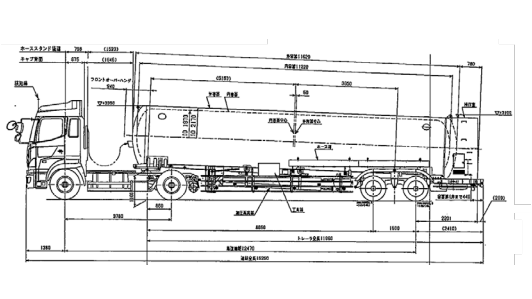
② Case of bio-LNG

In a case where 3,000 tons of bio-LNG is transported every year, it is realistic to utilize a 8.6-t or 14-t LNG trailer (**Figure3-12** and **Figure3-13**), assuming that it is transported 300 days per year.

Figure3-12　LNG trailer



8.6t trailer



14t trailer

Figure3-13　Schematic diagrams of LNG trailers

It would be possible to transport 3,000 tons of LNG per year by making 1 or 2 runs per day with an 8.6-t trailer or by making 1 run per day with a 14-t trailer.

Equipment costs are as shown in **Table3-8**. The trailer would cost about 15-20 million yen, the tank would cost 35-45 million yen, the tractor truck would cost 15 million yen, and the total cost would be about 65-80 million yen. Compared with CNG tubing trailers, the price of the tank is higher, so the total price nearly doubles, but the number of runs of transportation is smaller, so personnel expenses could be reduced.

Table3-9　Costs for bio-LNG transportation equipment

Capacity	8.6t	14t
Trailer	15 million yen	20 million yen
Tank	35 million yen	45 million yen
Tractor truck	15 million yen	

2) Estimation of costs for satellite equipment

Satellite equipment is required for using transported LNG. Satellite equipment for LNG has a structure that receives, stores, and discharges/gasifies the LNG transported by tanker truck and then produces and supplies gas whose heat quantity has been adjusted to satisfy the conditions for the heat quantity of supplied gas. It is composed of a storage tank, a vaporizer, a heat adjustment device, etc.

Actual satellite equipment is shown in **Figure3-14**, and equipment specs are shown in **Table3-10**. For receiving 3,000 tons of LNG per year, it is appropriate to install a storage tank with a capacity of 80 kL (maximum storage amount: 33 tons, effective usage: 25 tons) and two 500-kg/h LNG hot-water evaporators.

Figure3-14　Photo of satellite equipment for LNG

Table3-10　Specs of satellite equipment for bio-LNG

	構成機器	標準仕様	オプション例
設備仕様	受入設備	SUS製フレキシブルホース（1口）	
	貯　槽	竪型パーライト真空断熱金属二重殻貯槽	
	気化器	竪型温水式気化器（コイル式、貯槽加圧機能付）	空温式気化器
	温水供給設備	真空式温水ヒーター（燃料：天然ガス）	
	送ガス設備	自圧式減圧弁	熱量調整設備、付臭設備、流量計設備
	ローリー加圧器	なし（ローリー側で加圧蒸発器を積載）	ローリー加圧設備
	防消火設備	粉末消火器	貯水槽、散水設備
	照　明	防爆型照明	
	土木基礎	直接基礎	杭基礎工事、地盤改良工事
	窒素設備	パージ用及び弁操作用	
	ガス漏洩検知	保安電源付	
	動力制御盤	屋外自立式（非防爆）	遠隔監視システム

The layout and system diagram designed based on the above specs are shown in **Figure3-15** and **Figure3-16**. Equipment costs are as shown in **Table3-11**, and the total cost would be 115.5 million yen. In the case of LNG, it is possible to transport a larger volume at once, but satellite equipment is

required and the price of a tanker truck is higher than that for CNG, so it was considered that LNG is not advantageous except the case of superlong-distance transportation, such as international one.

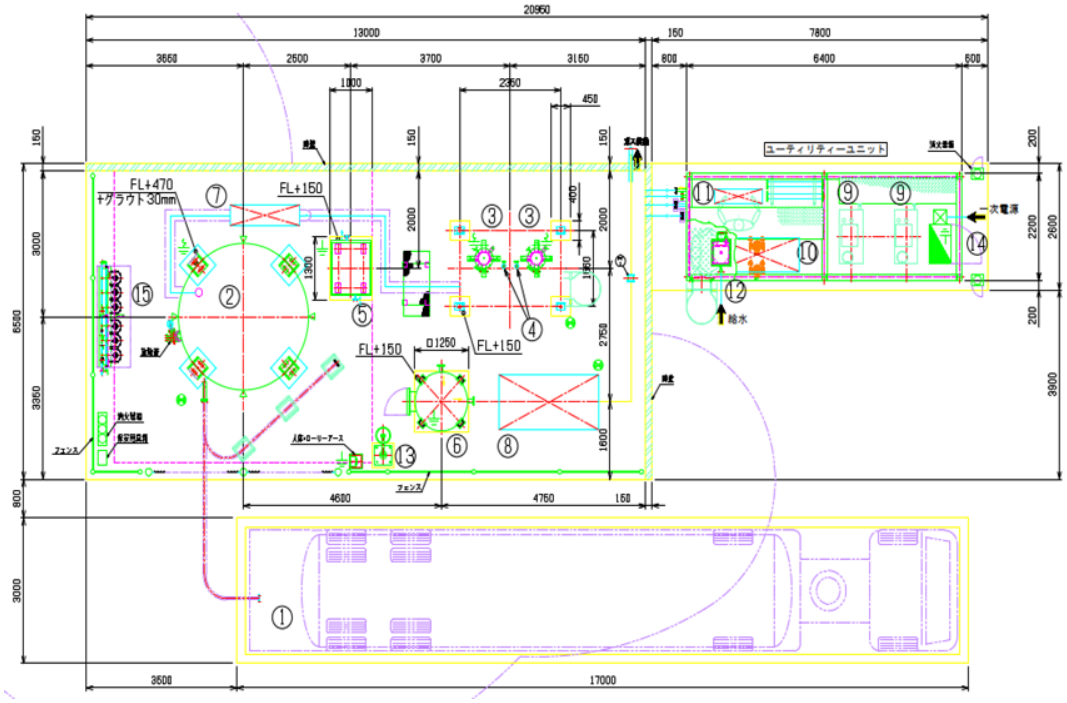


Figure3-15　Layout of satellite equipment for LNG

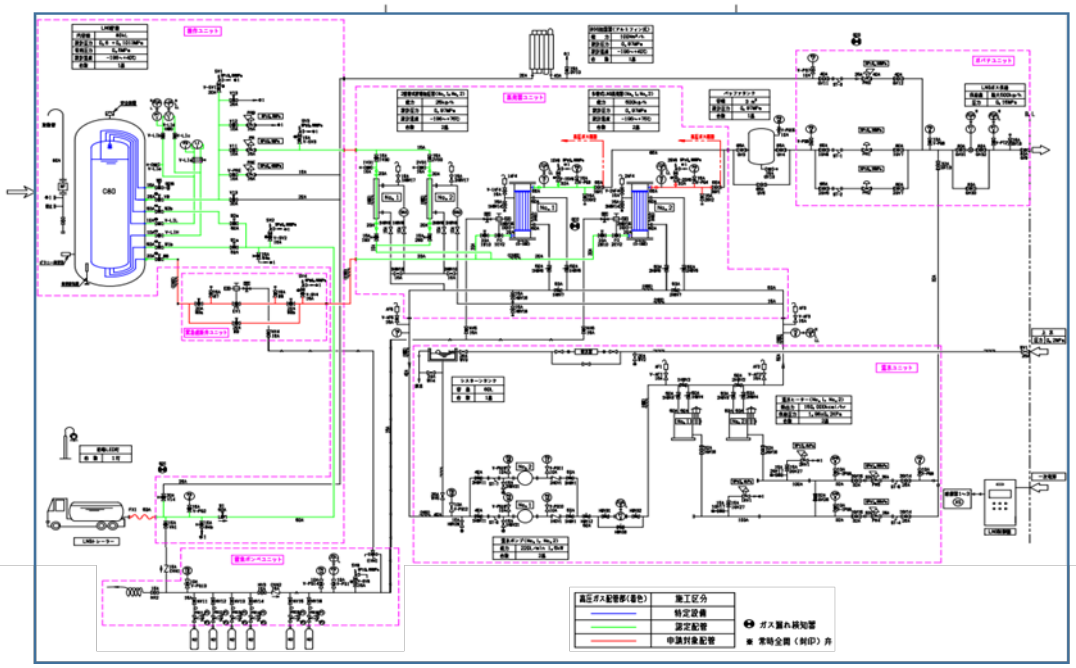


Figure3-16　System diagram of satellite equipment for LNG

Table3-11　Costs for satellite equipment for bio-LNG

Storage tank (80kL)	39 million yen
Two evaporators (500kg / h)	9.5 million yen
Hot water circulation equipment	21 million yen
Control panels	6 million yen
Valves	9 million yen
Storage tank transportation cost (* for Japan)	9 million yen
Construction fee (* for Japan)	22 million yen
Approximate total	115.5 million yen

3.1.3　Use of biofuel

In Iskandar, large-scale urban development has progressed recently in the course of an intensive regional development project implemented by the Malaysian government. In particular, the ratio of private car owners is projected from 300/1000 in 2010 to 800/1000 in 2025, so there is concern over traffic congestion, atmospheric pollution, and the rapid increase in greenhouse gas emissions. Accordingly, “a blueprint regarding transportation infrastructure in Malaysia Iskandar Development Region” was produced, and they plan to adopt public transportation systems, including the bus rapid transit (BRT) system, while aiming to realize an environmentally friendly public transportation network. They are discussing measures for reducing greenhouse gas and preventing atmospheric pollution by utilizing biofuel, etc.

In the project in 2020, we discussed the effects of fuel change while considering the current bus routes, the roughly estimated fuel consumption, etc. In the project this fiscal year, we identified target buses by interviewing IRDA and enterprises that own buses, etc., and discussed the economic and environmental performance after fuel change.

1) Fuel consumption and costs

Table3-12 shows the results of discussions with IRDA about target vehicles and other needs, while taking into account the results of the survey in 2020 and the workshop held in 2020. When IRDA reported the economic effects of the shift to biofuel estimated in the workshop held in 2020 to the existing enterprises that own buses, Causeway Link, Syarikat Pengangkutan Maju, and Transit Link showed interest in the shift to biofuel. Then, we received the data on travel distance, diesel fuel consumption, etc. in 2019 from the 3 companies, and analyzed economic and environmental performance.

Table3-12　Outline of the interview with IRDA (June 8, 2021)

Attendees	IRDA (6 people), Japan NUS (5 people)
Interview outline	・ After having shared the outcome of the workshop organized in Fiscal Year 2020, 3 companies namely Causeway Link, Syarikat Pengangkutan Maju and Transit Link showed interest in fuel conversion to biofuel. ・ Data of the above mentioned 3 companies such as driven distance and diesel consumption amount will be shared. ・ Regarding decarbonization technologies, electric vehicles and hydrogen technologies in addition to biofuels are being considered by the region. ・ Due to the impact of the Coronavirus, bus operation is about half of the usual traffic.

① Causeway Link

Causeway Link is the largest bus company in Iskandar, which owns a total of 462 buses. The bus routes are shown in **Table3-13**. There are many spots where people gather, such as colleges and shopping malls in Johor Bahru and routes that cross the national border with Singapore, and the length of each route is 10-50 km. The vehicles they own are shown in their website[7]. Since the start of operation in 2002, they have used mainly the vehicles of MAN (Germany) and Mercedes Benz (Germany), and since 2014, they have been using the models of Yutong (China) and Sksbus, a maker in Malaysia (**Figure3-17**). They also use the buses of Nissan Motor and Hino Motors (**Figure3-18**).

[7] https://businterchange.net/busphoto/operator.php?album=2104

Table3-13　Bus routes of Causeway Link

Route No.	Route	Route No.	Route
1B	JB Sentral ⇔ Bandar Selesa Jaya	LM1	JB Sentral ⇔ Gelang Patah
5B	Taman Universiti ⇔ JB Sentral	MV2	JB Sentral ⇔ Mid Valley Southkey
7B	JB Sentral ⇔ Kulai Terminal	P101	Larkin ⊃ Bandaraya Johor Bahru
10B	Taman Setia Indah ⇔ JB Sentral	P102	PPR Sri Stulang ⇔ Majlis Bandaraya Johor Bahru
52T	Pontian ⇔ Gelang Patah	P103	Larkin ⇔ PPR Sri Stulang
66	Larkin ⇔ Kota Tinggi	P201	Taman Universiti ⊃ Taman Pulai Indah
77B	JB Sentral ⇔ Kulai Terminal	P202	Taman Universiti ⊃ Taman Ungku Tun Aminah
111	JB Sentral ⇔ Taman Tan Sri Yaacob	P203	PPR Melana Indah ⇔ KIP Mart Tampoi
505	Taman Pulai Indah ⇔ JB Sentral	P211	Taman Universiti ⇔ Larkin
666	Larkin ⇔ Gelang Patah	P212	Perling Mall ⊃ TESCO Extra Mutiara Rini
777B	JB Sentral ⇔ Taman Puteri Kulai	P213	Taman Universiti ⇔ Gelang Patah
AA1	Larkin ⇔ Senai Airport	P214	Taman Universiti ⊃ Taman Setia Tropika
BET3	Taman Universiti ⇔ JB Sentral	P401	Kulai Terminal ⊃ Bandar Putra
CT1	JB Sentral ⊃ Bayu Puteri	P402	Econsave Senai ⊃ Taman Desa Idaman / Taman Aman
CW1	Larkin ⇔ Kranji MRT	P403	Econsave Senai ⊃ Skudai Parade
CW2	Larkin ⇔ Queen Street Terminal	P411	Kulai Terminal ⇔ Larkin
CW3	Perling Mall ⇔ Jurong East	P412	Kulai Terminal ⊃ Taman Scientex Kulai
CW3E	Larkin ⇔ CIQ 2nd Link	PM1	JB Sentral ⇔ Paradigm Mall
CW3L	Perling Mall ⇔ CIQ 2nd Link	S1	JB Sentral ⊃ KSL City
CW3S	Taman Ungku Tun Aminah ⇔ CIQ 2nd Link	TD1	Twin Danga Residence ⇔ JB Sentral
CW4	Pontian ⇔ Jurong East	8	Batu Pahat ⇔ Ayer Hitam
CW4G	GP Sentral ⇔ CIQ 2nd Link	503	Putrajaya ⇔ Puchong Utama
CW4S	Sutera Mall ⇔ Jurong East	601	Pasar Seni ⇔ Putra Perdana
CW5	CIQ Johor Bahru ⇔ Newton Circus	604	Pasar Seni ⇔ Saujana Puchong
CW6	Taman Nusa Bestari ⇔ Boon Lay	608	Pulau Meranti ⇔ IOI Mall Puchong
CW7	Hotel Ramada ⇔ Tuas Link	P701	Port Klang ⇔ Pasar Seni
CW7L	Hotel Ramada ⇔ CIQ 2nd Link	PJ05	Bandar Utama ⇔ LRT Taman Bahagia
CWL	Larkin ⇔ CIQ Johor Bahru	PJ06	Bandar Utama ⇔ Damansara Damai
IM05	GP Sentral ⇔ Pendas	T705	Port Klang ⇔ Bandar Sultan Sulaiman
JPO1	JB Sentral ⇔ Johor Premium Outlets	T706	Port Klang ⇔ Teluk Gong

Figure3-17　Bus owned by Causeway Link: Mercedes Benz

Figure3-18　Bus owned by Causeway Link: Nissan Motor

Table3-14 shows the data on travel distance, fuel consumption, fuel cost, and CO_2 emissions in each month in 2019 provided by IRDA. The 462 buses of Causeway Link traveled about 8.77 million km and consumed about 3.59 million L of diesel fuel in one year. The annual average travel distance per vehicle is about 19,000 km, and fuel efficiency is about 2.4 km/L, which is nearly equal to that of an ordinary large-sized bus (2-3 km/L). The cost for fuel consumption is 1.87 million US dollars per year, and it was clarified that fuel costs would augment operation costs. The CO_2 emissions from fuel consumption is about 12,700 t-CO_2 per year.

Table3-14　Bus operation data of Causeway Link (2019)

Bus Operator	Handal Ceria Sdn Bhd (Causeway link)			
Total Bus	462			
Bulan / month (2019)	Jumlah Jarak / Mileage (KM)	Jumlah Penggunaan Diesel / Total Diesel (litre)	CO2 emission(tCO2)	Total Amount (USD)
Jan	705,531	307,783	1,088	161,032
Feb	662,858	282,835	1,000	147,979
March	705,859	304,256	1,075	159,187
Apr	764,701	308,489	1,090	161,402
May	772,033	310,124	1,096	162,257
June	727,192	290,510	1,027	151,995
July	781,495	305,995	1,081	160,096
Aug	741,324	297,501	1,051	155,653
Sept	750,211	295,586	1,045	154,651
Oct	727,130	299,144	1,057	156,512
Nov	706,260	290,310	1,026	151,890
Dec	722,180	295,465	1,044	154,587
Grand Total	**8,766,773**	**3,587,998**	**12,681**	**1,877,241**

② Syarikat Pengangkutan Maju

Syarikat Pengangkutan Maju is a bus operator in Johor Bahru, which owns a total of 64 buses. The bus routes are shown in **Table3-15**. Their buses run mainly in Johor Bahru. Their vehicles are shown in the above-mentioned website, and include the vehicles produced by Higer and Bonluck in China (**Figure3-19**).

Table3-15　Bus routes of Syarikat Pengangkutan Maju

Route No.	Route
96	Larkin ⇔ Pontian
205	JB Sentral ⇔ Ulu Tiram
207	Senai Airport ⇔ Larkin
208	Larkin ⇔ Masai
224	Larkin ⇔ Pasir Gudang
227	Larkin ⇔ Kota Tinggi
229	JB Sentral ⇔ Kulai Terminal
BET2	JB Sentral ⇔ Ulu Tiram
IM17	JB Sentral ⊃ KSL City
P301	Pasir Gudang ⇔ Tesco Plentong
P302	Pasir Gudang ⇔ Taman Desa Rakyat Perdana
P303	Kota Masai ⇔ Pasir Gudang
P311	Pasir Gudang ⇔ JB Sentral
P312	Masai ⊃ Pasir Gudang
P313	Ulu Tiram ⇔ Kampung Felda Sungai Tiram
P314	Kota Masai ⊃ Kampung Cahaya Baru
272	Kota Tinggi ⇔ Bandar Penawar
KT3	Kota Tinggi ⇔ Air Terjun
MM01	Mersing ⊃ Taman Sri Pantai
MM02	Hab Taman Ehsan ⊃ Taman Sri Pantai
MM03	Mersing ⇔ Kampung Air Papan

Figure3-19　Bus owned by Syarikat Pengangkutan Maju: Higer

Table3-16 shows the data on travel distance, fuel consumption, fuel cost, and CO_2 emissions in each month in 2019 provided by IRDA. The 64 buses of Syarikat Pengangkutan Maju travel a total

of about 6.49 million km per year and consume about 2.59 million L of diesel fuel. The annual average travel distance per bus is about 101,000 km/bus, and travel distance per bus is nearly 5 times that of Causeway Link. Fuel efficiency is about 2.5 km/L, which is nearly equal to that of an ordinary large-sized bus (2-3 km/L). The cost for fuel consumption is 1.38 million US dollars per year, and the CO_2 emissions from fuel consumption is about 9,200 t-CO_2 per year.

Table3-16　Bus operation data of Syarikat Pengangkutan Maju (2019)

Bus Operator	Syarikat Pengangkutan Maju Bhd			
Total Bus	64			
Bulan / month (2019)	Jumlah Jarak / Mileage (KM)	Jumlah Penggunaan Diesel / Total Diesel (litre)	CO2 emission(tCO2)	Total Amount (USD)
Jan	551,456	220,582	780	115,409
Feb	491,044	196,418	694	102,766
March	528,826	211,530	748	110,672
Apr	525,391	210,156	743	109,954
May	568,831	227,532	804	119,045
June	492,026	196,810	696	102,971
July	525,739	210,296	743	110,027
Aug	525,413	209,365	740	109,540
Sept	570,601	228,240	807	119,415
Oct	598,061	239,224	845	125,162
Nov	551,078	220,431	779	115,329
Dec	560,920	224,368	793	117,389
Grand Total	**6,489,386**	**2,594,952**	**9,171**	**1,357,679**

③ Transit Link

Transit Link is a bus operator in Johor Bahru, which owns a total of 75 buses. Their bus routes are shown in **Table3-17**, which are composed of mainly popular routes across Johor Bahru. The vehicles they own are shown in the above-mentioned website, and include those of Mercedes Benz, Nissan Motor, and Hino Motors in Japan (**Figure3-20** and **Figure3-21**).

Table3-17　Bus routes of Transit Link

Route No.	Route
2	Larkin ⇔ Ayer Hitam
3	Larkin ⇔ Pontian
13	Larkin ➔ Kulai
15	JB Sentral ⇔ Bandar Selesa Jaya
39	Larkin ⇔ Masai
41	JB Sentral ⇔ Kota Tinggi
51	JB Sentral ⇔ Larkin
123	JB Sentral ⇔ Permas Jaya
133	JB Sentral ⇔ Kota Masai
188	JB Sentral ⇔ Ulu Tiram
331	Taman Universiti ⇔ JB Sentral

Figure3-20　Bus owned by Transit Link: Mercedes Benz

Figure3-21　Bus owned by Transit Link: Nissan Motor

Table3-18 shows the data on travel distance, fuel consumption, fuel cost, and CO_2 emissions in each month in 2019 provided by IRDA. The 75 buses of Transit Link travel a total of about 5.02 million km per year and consume about 1.18 million L of diesel fuel. The annual average travel distance per bus is about 67,000 km/bus, and fuel efficiency is about 4.3 km/L, which is better than the fuel efficiencies of the above two companies. The cost for fuel consumption is 0.618 million US dollars per year, and the CO_2 emissions from fuel consumption is about 4,200 t-CO_2 per year.

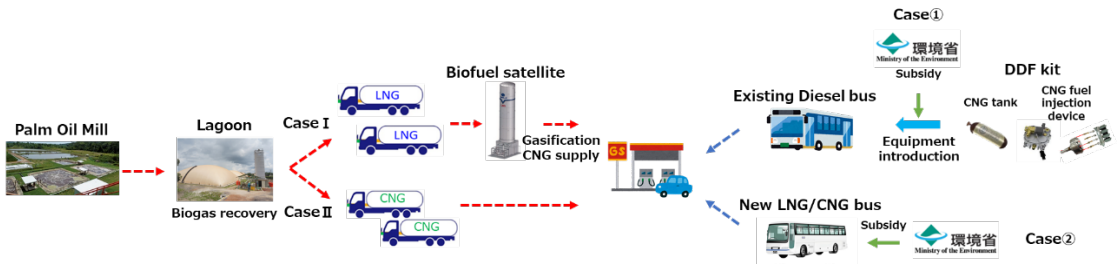
Table3-18　Bus operation data of Transit Link (2019)

Bus Operator Total Bus	Transit Link (Johor Baharu) Sdn Bhd 75			
Bulan / month (2019)	Jumlah Jarak / Mileage (KM)	Jumlah Penggunaan Diesel / Total Diesel (litre)	CO2 emission(tCO2)	Total Amount (USD)
Jan	402,749	107,878	381	56,442
Feb	388,425	95,121	336	49,767
March	415,915	102,652	363	53,708
Apr	389,523	93,538	331	48,939
May	406,111	98,030	346	51,289
June	399,835	94,895	335	49,649
July	448,521	101,888	360	53,308
Aug	438,454	101,240	358	52,969
Sept	420,934	96,580	341	50,531
Oct	454,953	101,088	357	52,889
Nov	427,494	92,902	328	48,606
Dec	422,720	95,636	338	50,037
Grand Total	**5,015,634**	**1,181,448**	**4,175**	**618,134**

2) Discussion on economic and environmental performance

In this section, we discussed economic and environmental performance, etc. after replacing the currently used diesel fuel with biofuel derived from POME, with reference to the bus operation data of each company in 2019 provided by IRDA. Estimation was conducted for each company under the following conditions.

- Image of fuel conversion project when using JCM equipment support subsidies is as follows



- Biofuel conversion rate is set from 0% to 100%
- Biofuel prices are based on the average selling price (36.42RM / MMBTU) of Gas Malaysia from October to December 2021 in the Malay Peninsula.
- In addition to the normal fuel conversion case, the fuel conversion project carried out in the previous fiscal year showed a fuel efficiency improvement effect of about 20%. Therefore, estimation has also been made for the case where the fuel efficiency improvement effect is 20%.

・ From the amount of CO_2 reduction due to fuel conversion, maximum subsidy amount (4,000 yen per ton of CO_2 reduced) that can be received when applying the JCM equipment support subsidy, and the subsidized cost per bus have been calculated.

Table3-19, **Table3-20**, and **Table3-21** show the results of estimation of economic and environmental performance after the shift to biofuel under the above conditions.

Table3-19 Results of estimation of economic and environmental performance after fuel change: Causeway Link

Simulation_Causeway Link					
Green LNG Rate[%]	0	25	50	75	100
Diesel [L]	3,587,998	2,690,999	1,793,999	897,000	0
Green LNG[t]	0	801	1,602	2,404	3,205
Cost Diesel[USD]	1,877,241	1,407,930	938,620	469,310	0
Cost Green LNG[USD]	0	350,201	700,401	1,050,602	1,400,802
Cost Total[USD]	1,877,241	1,758,131	1,639,021	1,519,912	1,400,802
CO2 [tCO2/year]	12,681	9,510	6,340	3,170	0
CO2 [tCO2/5year]	63,403	47,552	31,701	15,851	0
CO2 Reduction[tCO2/5year]	0	15,851	31,701	47,552	63,403
Subsidy [yen]	0	63,402,939	126,805,878	190,208,817	253,611,756
Subsidy [yen/bus]	0	137,236	274,472	411,707	548,943
Include Fuel economy improvement effect (20%)					
Green LNG[t]	0	641	1,282	1,923	2,564
Cost Green LNG[USD]	0	280,160	560,321	840,481	1,120,642
Cost Total[USD]	1,877,241	1,688,091	1,498,941	1,309,792	1,120,642

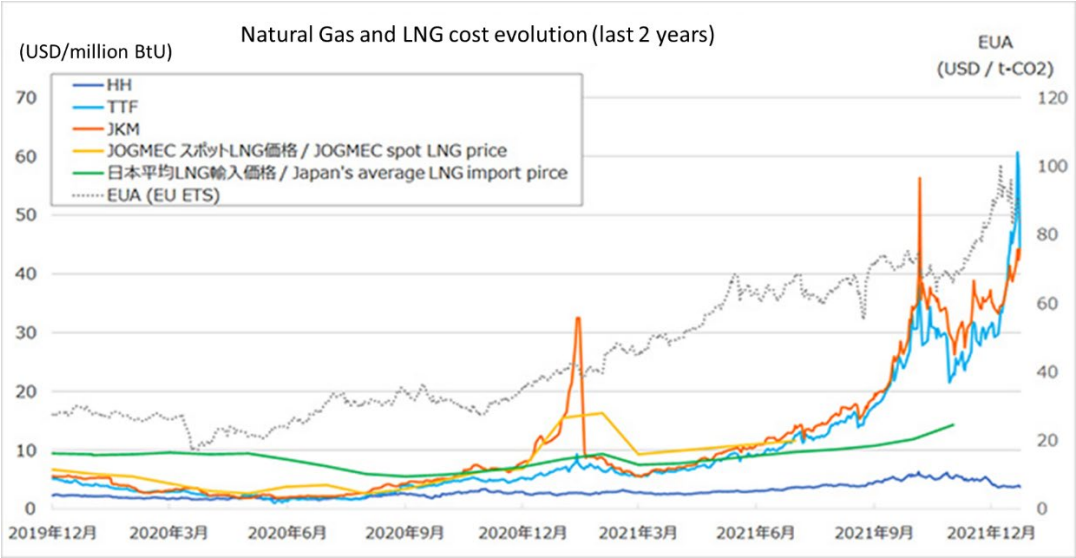
Table3-20 Results of estimation of economic and environmental performance after fuel change: Syarikat Pengangkutan Maju

Simulation_Syarikat Pengangkutan Maju Bhd					
Green LNG Rate[%]	0	25	50	75	100
Diesel [L]	2,594,952	1,946,214	1,297,476	648,738	0
Green LNG[t]	0	579	1,159	1,738	2,318
Cost Diesel[USD]	1,357,679	1,018,259	678,839	339,420	0
Cost Green LNG[USD]	0	253,276	506,552	759,828	1,013,104
Cost Total[USD]	1,357,679	1,271,535	1,185,391	1,099,248	1,013,104
CO2 [tCO2/year]	9,171	6,878	4,585	2,293	0
CO2 [tCO2/5year]	45,855	34,391	22,927	11,464	0
CO2 Reduction[tCO2/5year]	0	11,464	22,927	34,391	45,855
Subsidy [yen]	0	45,854,982	91,709,963	137,564,945	183,419,926
Subsidy [yen/bus]	0	716,484	1,432,968	2,149,452	2,865,936
Include Fuel economy improvement effect (20%)					
Green LNG[t]	0	464	927	1,391	1,854
Cost Green LNG[USD]	0	202,621	405,242	607,862	810,483
Cost Total[USD]	1,357,679	1,220,880	1,084,081	947,282	810,483

Table3-21 Results of estimation of economic and environmental performance after fuel change: Transit Link

Simulation_Transit Link (Johor Baharu) Sdn Bhd					
Green LNG Rate[%]	0	25	50	75	100
Diesel [L]	1,181,448	886,086	590,724	295,362	0
Green LNG[t]	0	264	528	791	1,055
Cost Diesel[USD]	618,134	463,600	309,067	154,533	0
Cost Green LNG[USD]	0	115,313	230,627	345,940	461,253
Cost Total[USD]	618,134	578,913	539,693	500,473	461,253
CO2 [tCO2/year]	4,175	3,132	2,088	1,044	0
CO2 [tCO2/5year]	20,877	15,658	10,439	5,219	0
CO2 Reduction[tCO2/5year]	0	5,219	10,439	15,658	20,877
Subsidy [yen]	0	20,877,179	41,754,357	62,631,536	83,508,714
Subsidy [yen/bus]	0	278,362	556,725	835,087	1,113,450
Include Fuel economy improvement effect (20%)					
Green LNG[GJ]	0	11,503	23,005	34,508	46,010
Cost Green LNG[USD]	0	92,251	184,501	276,752	369,002
Cost Total[USD]	618,134	555,851	493,568	431,285	369,002

The estimation results indicate that total fuel cost could be reduced if the three companies shift to biofuel. Furthermore, as the price of natural gas derived from fossil fuel skyrocketed due to the world affairs, etc. (**Figure3-22**), another merit of biofuel is the possibility of stabilizing business operation by supplying natural gas derived from POME stably.



Source: https://oilgas-info.jogmec.go.jp/nglng/1007905/1009222.html

Figure3-22 Variations in prices of natural gas and LNG (JKM: spot LNG price in Northeast Asia)

Assuming the use of the JCM equipment support project and the 100% shift to biofuel, the maximum subsidy per bus would be about 550,000 yen/bus for Causeway Link and about 2.87 million yen for Syarikat Pengangkutan Maju, showing a significant difference. This is attributable to

the about-5-time difference in fuel consumption per bus (CO_2 emissions per bus). Considering cost-effectiveness, we would choose the vehicles of Syarikat Pengangkutan Maju for promoting fuel change.

It was found that by using biofuel only, it is possible to reduce CO_2 emissions by 4,200 to 12,700t-CO_2 per year.

3) Policy for decarbonizing the public transportation system in Iskandar

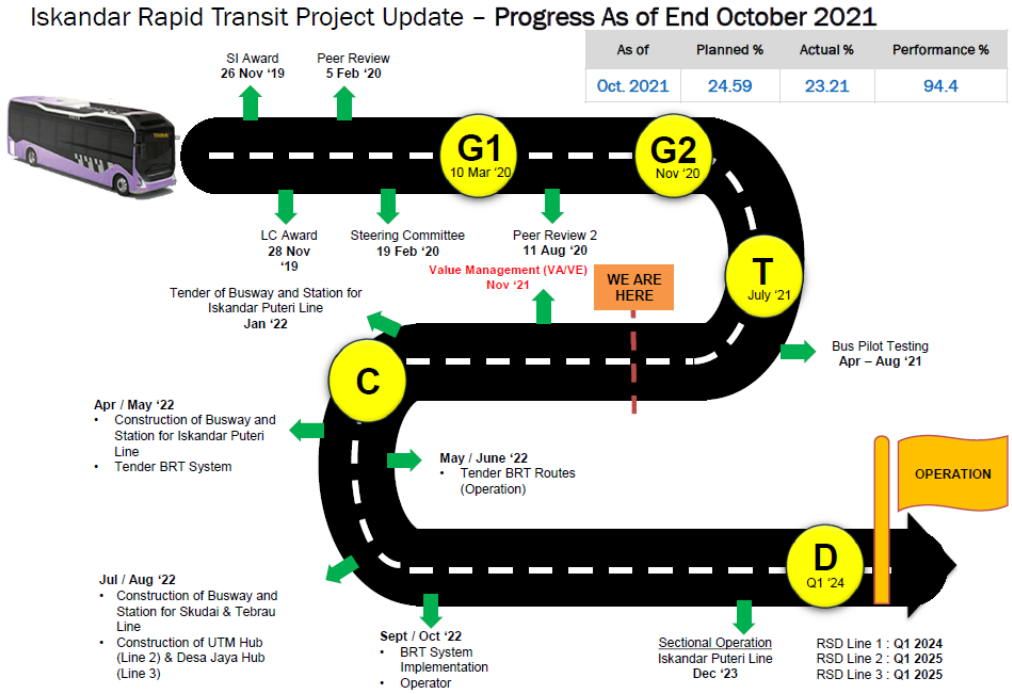
Table3-22 shows the results of discussions on the policy for decarbonizing the public transportation system in Iskandar, etc. while mentioning the merits of the shift to biofuel, etc. based on the estimation results, etc. in the previous section.

Table3-22 Results of discussions on the policy for decarbonizing public transportation (Nov. 15, 2021)

Attendees	IRDA (6 people), Japan NUS (5 people)
Interview Outline	・ Benefits of converting to biofuel is understood. ・ If fuel costs can be reduced and DDF equipment can be installed, it is attractive that the return on investment is expected in a few years. ・ On the other hand, the construction of a supply chain related to biofuel supply, especially the installation of stations necessary for biofuel supply, is a major issue. ・ In addition, when retrofitting a bus, warranty becomes an issue. ・ Currently, IRDA has conducted demonstration tests on 10 decarbonized buses, including electric buses and biodiesel. ・ Based on the results of the verification test, it was decided to prioritize the introduction of electric buses as a plan by 2030. ・ The plan is to switch half (270) of all vehicles to electric buses by 2030. ・ Currently, the remaining vehicles are planned to be operated with existing diesel vehicles, but if issues such as infrastructure equipment can be solved, it is possible to consider fuel conversion to biofuels. ・ At the same time, low-carbon technology utilizing hydrogen from NEUTO is also being considered. ・ It is understood that hydrogen infrastructure is being developed in Toyama City as well, so presentation of such technology at the workshop at the end of the fiscal year would be appreciated.

As mentioned in the outline of the interview, IRDA provided us with the updated information of

the BRT plan. The progress of the BRT plan is as shown in **Figure3-23**. A demonstration test of a new vehicle has ended, and they have determined routes and stations for BRT.



Source: IRDA

Figure3-23 Progress of the BRT plan

In demonstration tests for decarbonized vehicles, the 10 buses shown in **Table3-23** were tested, to study the travel distance, necessary time for refueling and recharging, noise level, use of electronic tickets, traveling performance, etc.

Table3-23 Decarbonized vehicles for which demonstration tests were carried out

No	Company Name	Bus Type	Date	Test Conducted
1	MOBILUS	ART 32m Ebus	April 8 – Aug 31	▪ Battery capacity & durability; ▪ Record during charging; ▪ Bus noise level; ▪ Use of QR tickets; and ▪ Drive along the proposed Iskandar Rapid Transit/SBST routes as direct and feeder.
2	CRRC ZHEJIANG ELECTRIC VEHICLE	10.6m Ebus	April 8 – May 8	
3	SCANIA	12m Ebus 10.7m Biodiesel B100	April 8 – April 15	
4	WISESTAR GROUP	8.5m Ebus	April 8 – April 30	
5	HYUNDAI CORPORATION	11m Ebus	April 8 – April 15	
6	SKS	9.7m Ebus	August 8 - 15	
7	VOLVO	10.8m Biodiesel B7	August 17	
8	GO AUTOMOBILE MANUFACTURING SDN BHD	12m Ebus 12m Euro5 (3 doors)	August 23 - 25	
9	WSH AUTOMOTIVE SDN BHD	12m Ebus	TBA / MCO	
10	HMH ELECTRIC TRANSPORT SDN BHD	Mini 6.3m Ebus	TBA / MCO	

Source: IRDA

Seeing the results of driving tests, IRDA has decided to adopt electrical buses on a priority basis in the BRT plan by 2030, for the following reasons:

- Infrastructure for green fuel, such as bio diesel fuel, is still to be developed.
- For adopting green fuel, governmental intervention is required for fuel procurement.
- The operation cost for electrical buses is lower.

Electrical buses will be adopted in accordance with the plan shown in **Table3-24**. They plan to have 270 electrical buses among 540 buses by 2030. In the interview, they said that the remaining 270 buses will be diesel ones for the foreseeable future, but they plan to decarbonize them. Regarding the utilization of POME-derived biofuel, which is discussed in this project, it has been confirmed that it would become a very effective means for decarbonization if infrastructure, such as fuel supply stations, is developed through the popularization of biofuel.

Table3-24　Plan for adopting electrical buses

	Package/ Number of Routes (Feeder and Direct)		2023	2024	2025	2026	2027	2028	2029	2030
			Target Percentage Rollout and Number of Routes by Package							
Route Package 1	Kulai		0%	20%	30%	40%	50%	70%	80%	100%
	BRT FEEDER	5	0	1	2	2	3	4	4	5
	BRT DIRECT	9	0	2	3	4	5	7	8	9
	Total	14	0	3	5	6	8	11	12	14
Route Package 2	Pulai		0%	20%	30%	40%	50%	70%	80%	100%
	BRT FEEDER	3	0	1	1	2	2	3	3	3
	BRT DIRECT	6	0	2	2	3	3	5	5	6
	Total	9	0	3	3	5	5	8	8	9
Route Package 3	Iskandar		20%	30%	40%	50%	70%	80%	90%	100%
	BRT FEEDER	8	2	3	4	4	6	7	8	8
	BRT DIRECT	9	2	3	4	5	7	8	9	9
	Total	17	4	6	8	9	13	15	17	17
Route Package 4	Johor Jaya		10%	20%	30%	40%	50%	70%	80%	100%
	BRT FEEDER	18	2	4	6	8	9	13	15	18
	BRT DIRECT	8	1	2	3	4	4	6	7	8
	Total	26	3	6	9	12	13	19	22	26
Route Package 5	Pasir Gudang		0%	20%	30%	40%	50%	70%	80%	100%
	BRT FEEDER	12	0	3	4	5	6	9	10	12
	BRT DIRECT	6	0	2	2	3	3	5	5	6
	Total	18	0	5	6	8	9	14	15	18
Route Package 6	Ulu Tiram		0%	20%	30%	40%	50%	70%	80%	100%
	BRT FEEDER	1	0	1	1	1	1	1	1	1
	BRT DIRECT	4	0	1	2	2	2	3	4	4
	Total	5	0	2	3	3	3	4	5	5
	Total Route	89	7	25	34	43	51	71	79	89
	Peak Vehicle Requirement	540	42	152	206	261	309	431	479	540
	Ebus % from PVR		20%	20.0%	25.0%	30.0%	35.0%	40.0%	45.0%	50.0%
	Ebus Qty		8	30	52	78	108	172	216	270

Source: IRDA

3.1.4　Discussions on fund procurement methods and business schemes

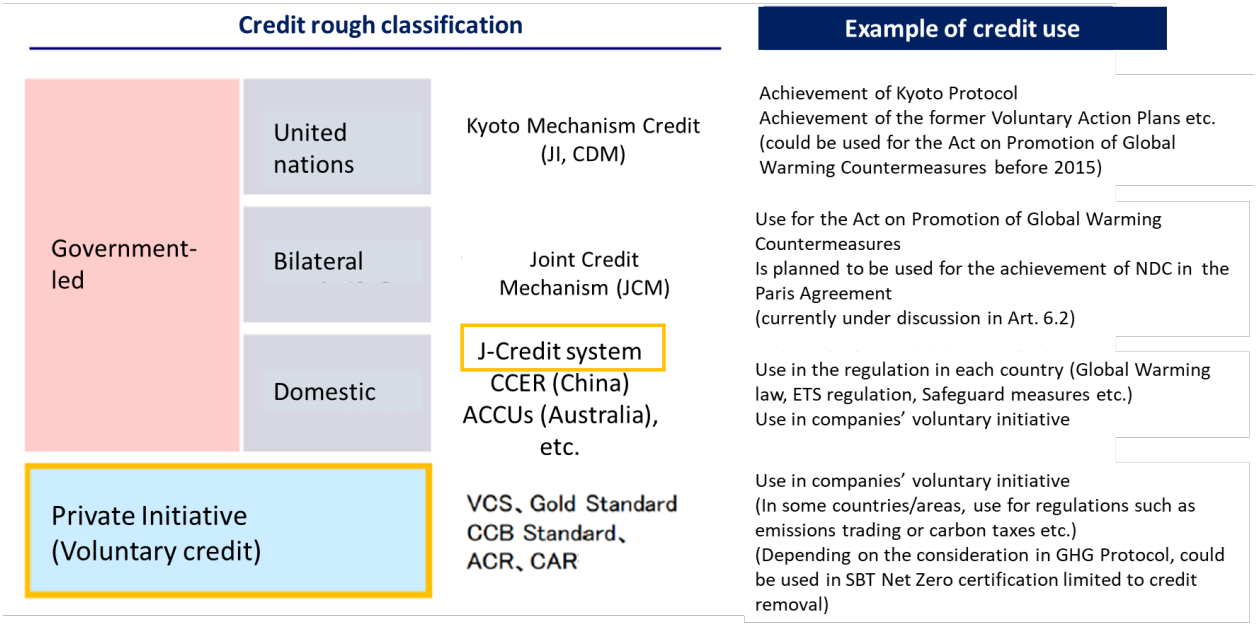
As of the end of Jan. 2022, Japan and Malaysia have not signed a JCM agreement. In addition, the previous section indicates that it is necessary to popularize biofuel in not only the transportation field, but also other fields and develop infrastructure, including refueling stations, in Malaysia, in order to utilize POME-derived biofuel for BRT, which is scheduled to be adopted in Iskandar.

Under these circumstances, it is necessary to consider the utilization of private voluntary credits when discussing a project for using POME-derived biofuel, so we will summarize the trend and methodology of voluntary credits and business schemes utilizing voluntary credits in the following section.

1)　Trend of major voluntary credits

Credits are classified into 4 kinds as shown in **Figure3-24**, and the methods for utilizing them are different from one another. The voluntary credit use by enterprises is assumed for voluntary credits. Nowadays, many enterprises set a goal of achieving carbon neutrality in response to the Japanese government's declaration of carbon neutrality by 2050, but there is a limit to the reduction of greenhouse gas emissions through the adoption of energy-saving and renewable energy systems, so

an increasing number of enterprises consider utilizing voluntary credits for attaining the goal. Furthermore, an increasing number of gas companies, which supply fuel, add carbon credits to fuel, such as natural gas derived from fossil fuel, and sell carbon-free fuel to enterprises that aim to realize carbon neutrality.



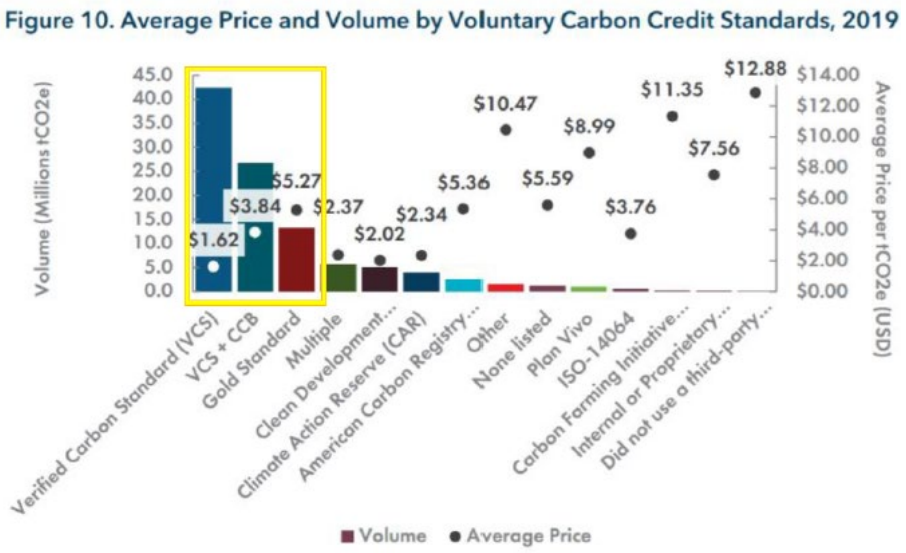
Source: Document 1 of the 3rd Study Group on Economic Methods for Realizing Carbon Neutrality in the World (Ministry of Economy, Trade and Industry, March 2021)

Figure3-24 Classification of credits

Among voluntary credits, international enterprises use mainly the following three credits. The transaction volumes and prices are as shown in **Figure3-25**. The prices are continuously rising, due to the recent trend of decarbonization.

- Verified Carbon Standard (VCS)
- Gold Standard
- CCB Standards

Among them, VCS is managed and developed by Verra, which is an international group for carbon offset standards. Approved projects include 11 kinds of projects in the fields of forestry, industry, agriculture, and livestock, and it is possible to propose the creation of environmental value with unique methodology. The Gold Standard was developed in 2003 and is managed by GS Office. Based on the Gold Standard, the degree of contribution to sustainable development is evaluated, so credits generated from approved projects will secure the contribution to sustainable development as well as the reduction of greenhouse gas emissions.

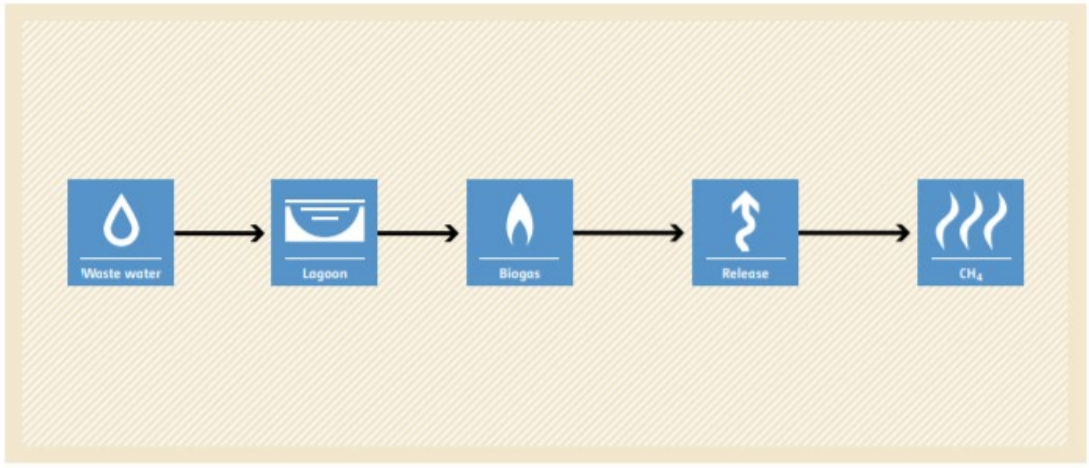


Source: Document 1 of the 3rd Study Group on Economic Methods for Realizing Carbon Neutrality in the World (Ministry of Economy, Trade and Industry, March 2021)

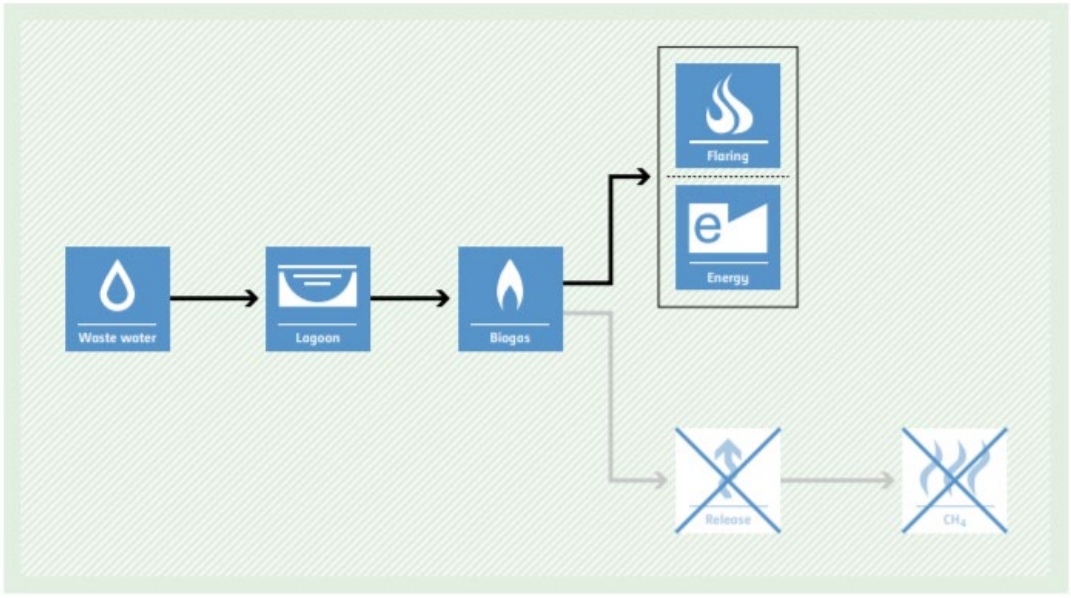
Figure3-25　Transaction volumes and prices of major voluntary credits

In most cases of major voluntary credits, CDM approval methodology is adopted as baseline and monitoring methods. For collecting methane gas from POME, “AMS-III.H: Methane recovery in wastewater treatment” was adopted in most cases, but “ACM0013: Construction and operation of new grid connected fossil fuel fired power plants using a less GHG intensive technology” was adopted in some cases. The former is introduced in the booklet[8], and the baseline and project scenarios are shown in **Figure3-26**. It is possible to count the collected methane as credits.

[8] https://cdm.unfccc.int/methodologies/documentation/meth_booklet.pdf#AMS_III_H



Baseline scenario



Project scenario

Source: CDM METHODOLOGY BOOKLET

Figure3-26　Scenario setting: AMS-III.H

For VCS and the Gold Standard, a lot of projects for collecting methane gas from POME have been already approved and registered, and the projects in Malaysia include “Methane recovery and utilisation project at United Plantations Berhad, Jendarata Palm Oil Mill, Malaysia[9].” In said project, 180,000 tons of FFB is handled per year, and the volume of discharged POME is 120,000m^3 per year. POME, which has been treated in open lagoons, will be treated in the closed tank of CSTR, to

[9] https://registry.verra.org/app/projectDetail/VCS/769

collect and use methane gas. The produced biomass will replace the fossil fuel used for steam boilers and/or thermal heaters of palm oil purification plants located next to palm oil mills. The approved credit in this project is 20,271 t-CO_2 per year.

2) Discussions on business schemes

Table3-25 shows assumed business schemes for utilizing methane gas derived from POME, including a business scheme utilizing voluntary credits. For the next fiscal year, we will discuss and compare business schemes in detail and promote activities for actualizing business and decarbonization.

Table3-25 Assumed business schemes

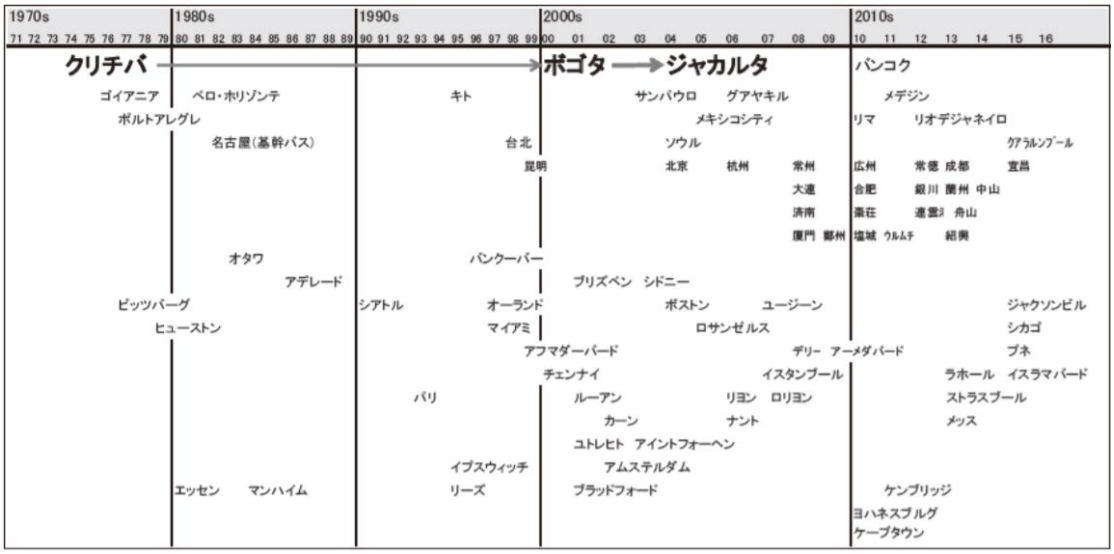
No.	Used mechanism	Outline
1	JCM	・ Recover biogas from POME and use it as a replacement for existing fossil-derived fuels in the transportation and industrial fields ・ On the biogas user side, utilize the JCM subsidy for equipment introduction required for fuel conversion.
2	Voluntary credits	・ Recover biogas from POME and use it as a replacement for existing fossil-derived fuels in the transportation and industrial fields ・ Apply voluntary credit certification to the biogas recovery portion from POME. ・ The acquired credits can be traded as carbon-free fuel by buying and selling in the market or by granting them to fuels derived from fossil fuels.
3	Other	・ Recover biogas from POME. ・ Export the recovered biofuel to Japan by ship, etc., and sell and use it as carbon-free (carbon-negative) fuel.
4	Other	・ Recover biogas from POME ・ The recovered biofuel is given a premium as carbon-free (carbon negative) fuel and traded with energy companies in Malaysia. ・ Direct supply to nearby gas pipelines

3. 2 Discussions on adoption of public transportation

As mentioned above, Iskandar aims to install a bus rapid transit (BRT) system as decarbonized public transportation, to reduce CO_2 emissions in the transportation field for urban development. In Kota Kinabalu, too, plans to adopt such public transportation. On the other hand, the staff of local municipalities mentioned that they hope to study previous cases inside and outside the country, including those in Toyama City, and discuss issues and countermeasures, at the online workshop held in the project in 2020 and the online tour of Toyama City held in the project this fiscal year. This section summarizes the previous cases of BRT, which has been already installed overseas.

Table3-26 shows the timeline of BRT adopted in urban areas and recently adopted plans. The oldest case is the adoption of BRT in Curitiba, Brazil in the 1970s, and recent cases include a case of Jakarta, Indonesia. BRT is often adopted in large cities in developing countries, mainly in Asia, in order to actualize punctual, rapid, advanced, low-cost public transportation, because BRT has the swift transportation capability comparable to that of railways.

Table3-26 Timeline of adoption of BRT



Source: https://www.nikkoken.or.jp/pdf/symposium/JRCTP201606.pdf

Year	City	Country	Urban population size (million people)	Line length (km)	Number of lines
2004	Jakarta	Indonesia	9.6 (2011)	207	12
2005	Mexico City	Mexico	8.85 (2010)	125	6
2006	Hangzhou	China	4.45 (2013)	55	3
2007	Istanbul	Turkey	14.16 (2014)	52	1
2008	Xiamen	China	1.91 (2013)	49	3
2009	Ahmedabad	India	5.72 (2010)	82	1
2010	Bangkok	Thailand	8.30 (2010)	16	1
2011	Medellin	Colombia	2.74 (2012)	18	2
2012	Changde	China	1.40 (2013)	19	1
2013	Lahore	Pakistan	7.13 (2010)	27	1
2014	Taichu	Taiwan	2.70 (2013)	17	1
2015	Subang Jaya	Malaysia	0.71 (2010)	5	1
2016	Daar El Salam	Tanzania	4.36 (2012)	21	1
2017	Hanoi	Vietnam	1.43 (2017)	15	1
under planning	Yangon	Myanmar	5.21 (2014)	245	11
under planning	Vientiane	Laos	0.76 (2015)	11	1
under planning	Cebu	Philippines	0.87 (2010)	25	1

Source: Study on Sustainable BRT in Developing Countries: Example of Bangkok BRT

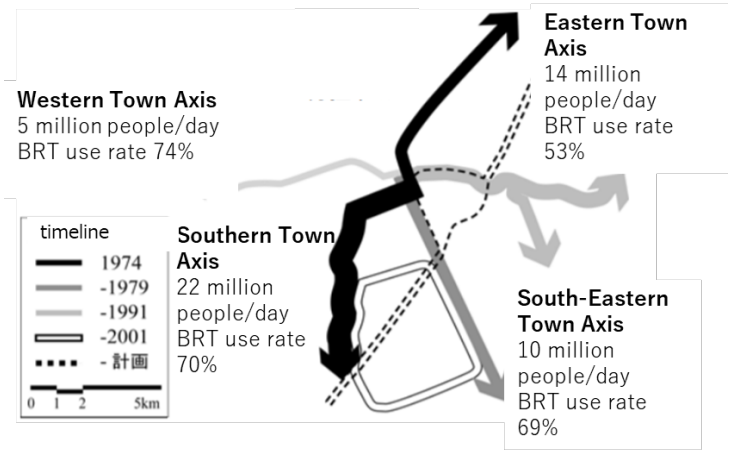
The following sections summarize the backgrounds of adoption of BRT, financial resources for BRT, operation, etc. in 3 cases of “Curitiba, Brazil,” “Bogotá, Colombia,” and “Jakarta, Indonesia” among a large number of previous cases, because we were able to obtain a great deal of information about them.

■ Curitiba, Brazil

Curitiba saw the worsening of traffic congestion in urban areas due to the rapid population growth from the 1950s, but there was no budget for constructing subways or technology for operating and managing them in Curitiba. In 1966, they established an urban planning research institute as a public institution for conducting surveys and research for promoting urban plans and proceeded with the

installation of BRT stepwise according to the growth of the urban axes.

As shown in **Figure3-27**, Curitiba has an urban structure constituted by 5 radial urban axes extending from the urban center. In parallel with the growth of the axes, they constructed the north-south traffic axis in 1974 and the east-west traffic axis in the 1980s, and adopted a bi-articulated bus (**Figure3-28**) and a tube-type bus in the 1990s, boosting their transportation capacity.



Source: Comparative analysis of planning, operation, and flight patterns in BRT introduction cases

Figure3-27 No. of bus passengers of each urban axis in Curitiba and the share of each direction

Source: https://www.hilife.or.jp/cities/data.php?p=1748

Figure3-28 Bi-articulated bus

Regarding the financial resources for installing BRT, the expenses for constructing facilities along the urban axes of Curitiba, terminals, bus stops for tube-type buses, etc. are paid by using aids from

advanced countries, loans of the World Bank, subsidies from the federal government of Brazil, and the municipal budget. BRT is operated by URBS established in 1963 in the third sector, but it is virtually managed by the city, because the city holds 98% of shares and the private sector holds 2% of shares. Based on the basic policy for urban planning set by the city, URBS designs a plan for the citywide traffic network; determines operation frequency, fares, vehicle specs, and bus timetables; sets and manages technical standards; and signs bus operation contracts with private bus operators. On the other hand, bus operation is carried out by private enterprises, while URBS provides 10 bus operators inside the city with the right to drive buses along the routes in each area. All revenues from fares are managed by URBS in a unified manner, and URBS pays remuneration to bus operators in proportion to travel distance rather than fares, in accordance with the contract. URBS can conduct a survey on bus passengers' satisfaction level, and if the service level of a bus operator turns out to be low, URBS can cancel the contract with that bus operator. This encourages bus operators to improve their services.

In order to change bus fares, it is necessary to obtain an approval of the city mayor. If URBS falls into the red, the city will compensate it. URBS buys all buses and owns about 2,500 buses. At present, the operation costs of bus operators and the purchase prices of buses can be fully covered by revenues from fares.

■ Bogotá, Colombia

In Bogotá, Colombia, buses used to be able to run along any routes until the 1990s, because bus operation was conducted by private enterprises. In addition, there were no bus stops, and there was a custom of raising your hand to stop a bus at a roadside. Therefore, there were many traffic accidents due to congestion, the sudden stop or lane change of buses, etc. Enterprises freely set and used bus routes according to residents' requests and abolished less profitable routes. The government left them uncontrolled. In order to improve that situation, Bogotá requested JICA to research means for transporting people smoothly, produced a master plan for urban transportation under the support of JICA in 1995, and planned to introduce an urban mass transportation system based on BRT. Then, feasibility research, etc. were conducted, roads exclusively for buses and terminals for changing buses were developed, and BRT was installed in 2000. As a result, bus passengers increased considerably, and about 70% of people use public transportation as a means of transportation.

One of the characteristics of the case of Bogotá is a bus stop. Each bus stop has a platform and an automatic ticket gate, so that fares are collected in advance. It is also equipped with platform screen doors, to protect wheelchair users, visually impaired people, and seniors. At terminals, passengers can get on not only BRT, but also a feeder bus. In addition, the salaries of BRT drivers relatively high, so the ratio of applications to job openings is over 10, and drivers are highly evaluated and considered as diligent, safe, and kind.

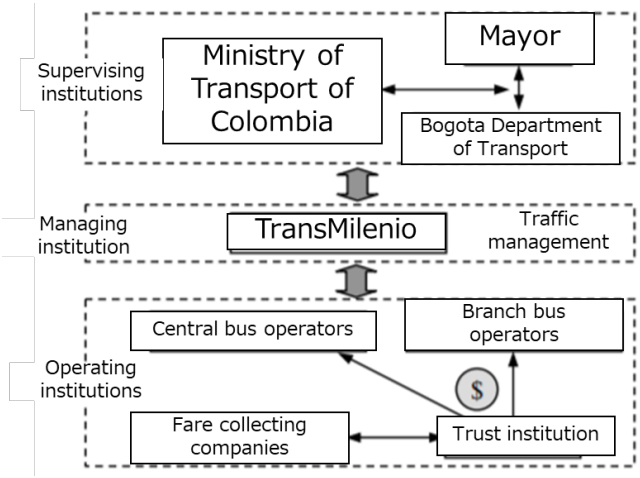
Source: https://www.mlit.go.jp/common/001020737.pdf

Figure3-29　Scenes of BRT in Bogotá

The cost for installing BRT in Bogotá is about 35 billion yen for the first phase, where the necessary expenses for developing infrastructure and establishing operation management systems amount to about 23 billion yen, and are borne by the government by using revenues from fuel charges in Bogotá, the general account budget of the city, subsidies from the Colombian government, loans from the World Bank, etc. On the other hand, the purchase of buses and the establishment of bus yards and fare collection systems were realized through the investment by multiple private companies via an overseas investment institution.

BRT is operated by TransMilenio, which was established with the investment by the government of Bogotá as shown in **Figure3-30**. It designs bus operation plans and manages real-time operations. Actual bus operation is carried out by private enterprises entrusted by TransMilenio, in accordance with each bus operation plan. The private enterprises include trunk line and feeder bus operators, companies that collect fares, and trust agencies that manage revenues from fares. The trust agencies pay operation expenses, etc. to each enterprise. As of now, trunk line bus operators, feeder bus operators, fare collecting companies, and TransMilenio receive 65%, 20%, 10%, and 4% of revenues from fares, respectively.

As the effects of the installation of BRT in Bogotá, the average time for transporting citizens was reduced by about 20 minutes, and as significant effects other than those on transportation time, air pollutants decreased, and carbon dioxide emissions from the entire system of CDM was reduced by 1.7 million tons between 2001 and 2009.



Source: https://www.mlit.go.jp/common/001020737.pdf

Figure3-30　Organizational form of TransMilenio

■ Jakarta, Indonesia

In Jakarta, the recovery from the economic crisis in the late 1990 and the increase in income allowed more individuals to use vehicles, motorcycles, etc., decreasing the frequency of use and quality of public transportation services, where problem emerged, including the severe traffic congestion in the morning and the evening along the radial roads extending from the urban center, atmospheric pollution, and noise. In order to solve such urban traffic problems, they invited engineers from Bogotá and installed BRT as an urban trunk transportation system, with reference to the proposal from JICA.

The BRT in Jakarta is a high-speed bus transportation system with two dedicated lanes in both directions at the center of each major trunk road. The first line was constructed and opened in 2004, and 8 lines (total length: about 97 km, length per line: 10-20 km) are currently in service, and about 200,000 people are using BRT per day. Its unified fare is 35 yen per ride, which can be said to be very low, if you change routes.

Source: https://www.mlit.go.jp/common/001020737.pdf

Figure3-31　Scene of BRT in Jakarta

BRT was installed by using the center-side lanes of existing wide roads and center medians as exclusive bus lanes. The total cost was about 2 billion yen, mainly for installing curbstones, pedestrian overpasses, facilities for getting on or off a bus (bus stops) and ticket checkers and purchasing vehicles, and it was fully covered by the general account budget of the traffic bureau of Jakarta.

For operation, Trans Jakarta was established as one of organizations of Jakarta, and it mainly maintains the facilities on exclusive bus lanes and outsources bus operation for BRT. Actual bus operation is carried out by a private company named Jakarta Express Transport (JET), which was established based on the joint investment by multiple bus companies, as it is entrusted by Trans Jakarta. The revenues from BRT fares are first collected by Bank Indonesia, and Trans Jakarta allocates them to bus operators, fare collecting private companies, and securities firms. Each bus operator receives about 6,000 rupiah (70 yen) per km according to bus travel distance. The bus operator (JET), the fare collecting company, the security firm, and Trans Jakarta receive 65%, 11%, 11%, and 11% of the revenues from fares, respectively.

Lastly, **Table3-27** compares the characteristics of BRT in overseas cities. In all of previous cases, public institutions, such as municipalities and the third sector, are in charge of planning, infrastructure development, and operation, and private enterprises operate BRT based on business licenses and outsourcing contracts under the strict supervision of municipalities, etc. In every case, private enterprises can earn revenues according to bus travel distance, so they make efforts to maximize profits by reducing costs while managing drivers and vehicles and maintaining their service level.

Table3-27　Table for comparing previous cases of installation of BRT

都市名 / 項目	ボゴタ（コロンビア）	ジャカルタ（インドネシア）	ソウル（韓国）	クリチバ（ブラジル）	日本 ※路線バスの典型例
計画立案	自治体	自治体	自治体	*IPPUC（公的機関）	事業者（民間・自治体）
インフラ整備	自治体	自治体	自治体	自治体	自治体
インフラ整備財源	・政府補助金 ・自治体燃料課徴金 ・世界銀行融資	・自治体の一般財源	・自治体の一般財源 ・交通誘発負担金 ・通行税	・政府補助金 ・自治体の一般財源 ・世界銀行融資	・道路特定財源 ・自治体の一般財源
運営	Transmilenio（市出資の公的機関）	TransJakarta（市出資の公的機関）	自治体	URBS（第3セクター）	事業者（民間・自治体）
運営財源	運賃収入	運賃収入	運賃収入＋市補助金	運賃収入	運賃収入（独立採算）
車両購入	民間事業者	自治体	民間事業者	URBS（第3セクター）	事業者（民間・自治体）
運行	民間事業者（委託）	民間事業者（委託）	民間事業者（委託）	民間事業者（委託）	事業者（民間・自治体）

*IPPUCは，市長直結の都市計画立案機関

Source: Comparative analysis of planning, operation, and flight patterns in BRT introduction cases

Chapter 4. Project for Distributing Renewable Energy based on Small-scale Hydropower Generation and Solar Power Generation

The distribution of renewable energy is viewed as one of the vital items on the policy agenda of Iskandar and Kota Kinabalu, with concrete measures for promoting the spread thereof being considered as well. Like Toyama City, which is surrounded by Tateyama Peaks and possesses abundant water resources, an abundance of water resources originating from the Mount Kinabalu, the highest mountain in Southeast Asia, etc. and many small-scale hydropower plants exist in Sabah, where Kota Kinabalu is located. On the other hand, their facilities all have low operating rates and do not function sufficiently compared to their potential, and this is an issue. This is because facility utilization rate decreased remarkably due to defects resulting from deterioration with age, etc. in some cases, while in other cases facility utilization rate has remained low because repairs were not realized as planned after damage was brought about by earthquakes, floods, etc. In addition, there are some facilities with low facility utilization rate from the very start of the facility operation. This is thought to be a state where the water turbine power generation equipment does not work according to the plan in incompatible hydraulic conditions as it was adopted without sufficiently considering installation conditions, such as the river flow rate, flow regime and geological features. Seeing that many facilities do not utilize their potential despite abundant water resources, this plan aims for replacing electricity generated by fossil fuels and reducing greenhouse gas emissions by recovering or increasing the power generated by small-scale hydropower plants in Sabah through the repair (rehabilitation) of small-scale hydropower plants with low facility utilization rate, or switching over to more efficient equipment produced in Japan.

In the project in 2020, we acquired data concerning the power generation facility specifications and changes in the amount of power generation from a total of 7 facilities (8.1MW) owned by public power companies and 2 facilities (6.5MW) owned by private operators. Since facility utilization rate is extremely low (around 20% on average) compared with the average values in Japan, it is suggested that it may be possible to increase the amount of power generation by implementing the project, but the data was not sufficient to identify concrete causes of the decrease in facility utilization rate.

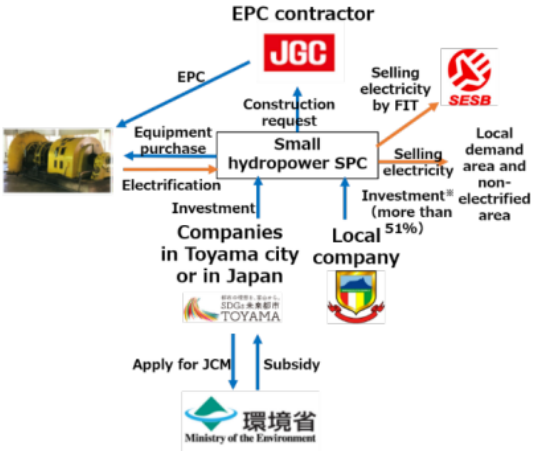
Under these circumstances, the project for this fiscal year consists of gathering information and performing diagnosis in order to discuss concrete measures while identifying causes of the facility utilization rate decrease.

In addition, the installation of facilities for generating a total of 100 MW from solar power in the city, including 56 school institutions, is aimed for in Kota Kinabalu as part of the aforementioned "Green City Action Plan: Kota Kinabalu.” Taking these circumstances into account, the potential of introducing solar power generation mainly in Kota Kinabalu was discussed.

4. 1　Permits, licenses, etc. required for the realization of power generation business using renewable energy

In the project in 2020, we organized information regarding electricity policies and policies pertaining to renewable energy in Malaysia, and the government-affiliated organizational frameworks which have a jurisdiction over these matters. In order to realize the project scheme discussed in the project in 2020 (**Table 4-1**), we confirmed the requirements for launching power generation business and performing the EPC in Sabah by consulting SESB, a public electricity corporation, and the Energy Commission, which have the jurisdiction over electricity business regulations, on detailed rules and the legal system in Sabah.

Table4-1　Schematic diagram of the commercialization and the implementation system

Business 1	Business 2
Case where only the installation of equipment, such as waterwheel, is conducted	Case where investment in small hydropower generation business is conducted
	

The agenda for the consultation with Energy Commission and SESB and the summary of their responses are shown in **Table5-2**.

Table4-2　Summary of the consultation with Energy Commission and SESB (January 28, 2022)

Attendees	Energy Commission (3 people), SESB (4 people), Japan NUS (2 people)
Consulted items	・ Possibility and conditions of participation of foreign companies in power generation projects ・ Conditions for participation of foreign EPC contractors ・ Application of FIT ・ Establishment of electricity selling charges

As seen below, we organized information regarding requirements for launching power generation business utilizing renewable energy, etc. in Sabah, and performing the EPC, based on the results of the consultation and study of reference material.

■ Participation of international companies in the power generation business

Regarding the participation of international companies in the power generation business, the upper limit for the investment is 49%, as a general rule. Moreover, as authorization by the Ministry of Energy and Natural Resources is required for launching power generation business, the business application procedure can be performed by submitting documents related to the Power Purchase Agreement (PPA). The Ministry shall then comment on the business and may present an opinion on the investment ratio of the operators on this occasion as well. This regulation is also mentioned in the law related to the Feed-in-Tariff (FIT), but the ratio for international investment in electricity business is up to 49% no matter whether FIT is adopted or not.

■ Participation of international companies in EPC

International EPC contractors often handle construction and especially the hydropower generation business has seen increasing participation of Chinese companies in recent years. However, regulations may temporarily become strict according to the timing of a project, etc. As there is a case in which it was impossible to bid for an EPC contract from abroad, in order to support domestic companies when the economic situation in the country worsened due to the coronavirus pandemic, it is necessary to confirm the latest situation at the timing of the business composition. Moreover, in order to perform EPC business, each company is required to acquire a license from the Malaysian Construction Industry Development Board[10].

■ FIT system, subsidy system for green energies

As of 2022, FIT has not yet been adopted in Sabah. The reason lies in the judgement that no further grants for the power generation business may be approved as SESB, a major electricity operator in Sabah, has been receiving a subsidy from the Malaysian central government and purchasing gas at a low price over many years, with approximately 70% of electricity in Sabah being covered by SESB's gas-powered electricity generation.

[10] http://mytraderepository.customs.gov.my/en/pia/Pages/mow.aspx

However, the sum granted in this subsidy system is scheduled to be reviewed in the near future, and as gas price is expected to be raised more than threefold (subsidy to be reduced), SESB is also in a situation which inevitably calls for proactive development of renewable energy power generation business as a power generation business other than gas-powered electricity generation. We have confirmed that especially hydropower generation is a field on which SESB is going to focus from now on.

4.2 Micro-hydroelectric power generation project

In the project in 2020, we obtained the specs of power generation equipment and data on annual change in power output regarding 7 power plants owned by SESB (8.1 MW) and 2 power plants owned by private enterprises (6.5 MW) in Kota Kinabalu and Sabah, as mentioned above. From them, it was found that equipment utilization rate is very low (around 20% on average) compared with the average in Japan, so it was indicated that it would be possible to increase power output through the project, but we were not able to clarify why equipment utilization rate is low.

Accordingly, in the project this fiscal year, we had discussions with SESB and local staff, selected the spots where project feasibility seems to be high, delved into literature and conducted on-site surveys via the Internet to seek the causes of the decline in equipment utilization rate, gathered information and conducted assessment for discussing concrete measures, and discussed policies for actualizing future projects.

4.2.1 Selection of Project Implementation Sites

Currently, SESB operates small hydropower plants at 7 locations in Sabah (**Table 4-3**). These power plants were all built and launched in the 1990s.

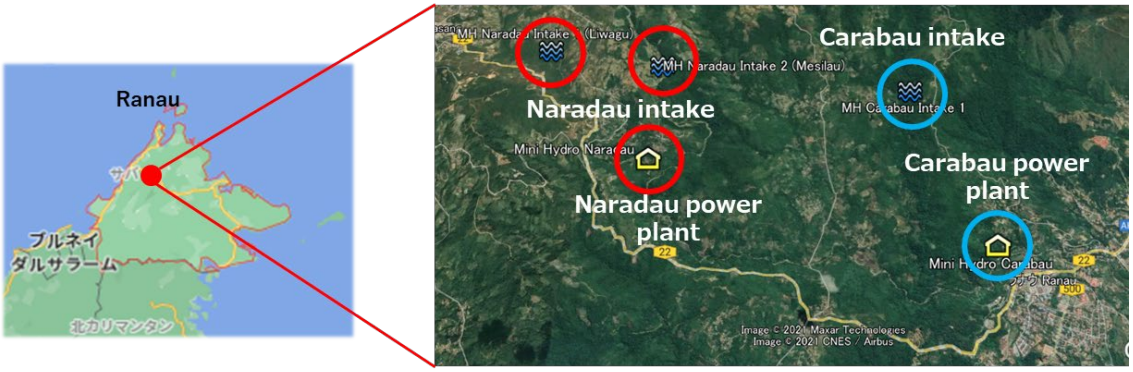
Table4-3 Hydropower Plants in Sabah

No.	発電所名	タービンと生産国	設備容量	運転開始年
1	Naradau, Ranau	WKV Turgo Turbine/ England	2*880kW	1999
2	Carabau, Ranau	Pelton Hidro Biwater/England	2*1,000kW	1991
3	Sayap, Kota Belud	Xian China – CJ-W-90/1 x 11/ China	2*500kW	1991
4	Melangkap, Kota Belud	Jyoti 600T-500 / India & Xian China – CJ-W-90/1 x 11/ China	2*500kW	1990 & 1992
5	Kiau, Kota Belud	Wassercraft TD50H 330-1	1*350kW	1994
6	Bombalai, Tawau	WKV-Turgo Implus TT-285-180-1	1*1,000kW	1996
7	Merotai, Tawau	Gilkes Hidro G-150 (Francis Turbine)	1*1,000kW	1992

With regard to these facilities, we've interviewed SESB about whether there were any facilities they wanted to improve on a priority basis and affirmed their intention to first discuss Carabau Power Plant and Naradau Power Plant, which have no plan or outlook on system improvements despite a significant decline in facility utilization rate. Based on these, this project selected both power plants for the system improvement plan, and studied and organized information to identify the cause of utilization rate drop, etc.

Both plants are located in Ranau District in western Sabah, about 3 hours by car from Kota Kinabalu, as shown in **Figure4-1** and several dozens of kilometers northwest of the central city of Ranau District, the City of Ranau.

The locations of the power station building and the water intake are as shown in **Table4-4**, and because the distance between the water intake and the power station building is several kilometers, transportation by car is required. Also, Naradau Power Plant is a distinctive facility having 2 water intake points.



Source: Google Maps

Figure4-1 Locations of Carabau and Naradau Hydropower Plant

Table4-4 Latitudes and Longitudes of Carabau and Naradau Hydropower Plant

		Latitude	Longitude
Carabau power plant	Water intake	5°58'43.16"N	116°38'45.98"E
	Building	5°57'22.28"N	116°39'30.34"E
Naradau power plant	Liwagu river intake	5°58'47.10"N	116°36'34.30"E
	Mesilou river intake	5°58'53.31"N	116°35'33.38"E
	Building	5°57'55.56"N	116°36'33.29"E

Further, the power output at both plants since 2013 is shown in **Table4-5**.

According to the interview with SESB, the output at Carabau Power Plant in 2014 and 2015 was not recorded due to the mudslide that occurred around penstock. Also, it suffered from frequent

overheating caused by a turbine malfunction even though the water flow had been low. After that, its power production has dropped rapidly since 2016.

With regard to Naradau Power Plant, due to the earthquake that hit Sabah in 2015, its water intake got damaged (details will be described later), which led the power output to decline. Furthermore, it suffered from a nozzle failure in 2020, the suspended water intake caused by mudslides during the monsoon season, and also the general inspection. They caused its output to drop considerably from the previous year.

Table4-5　Output at the Two Plants Since 2013 (kWh)

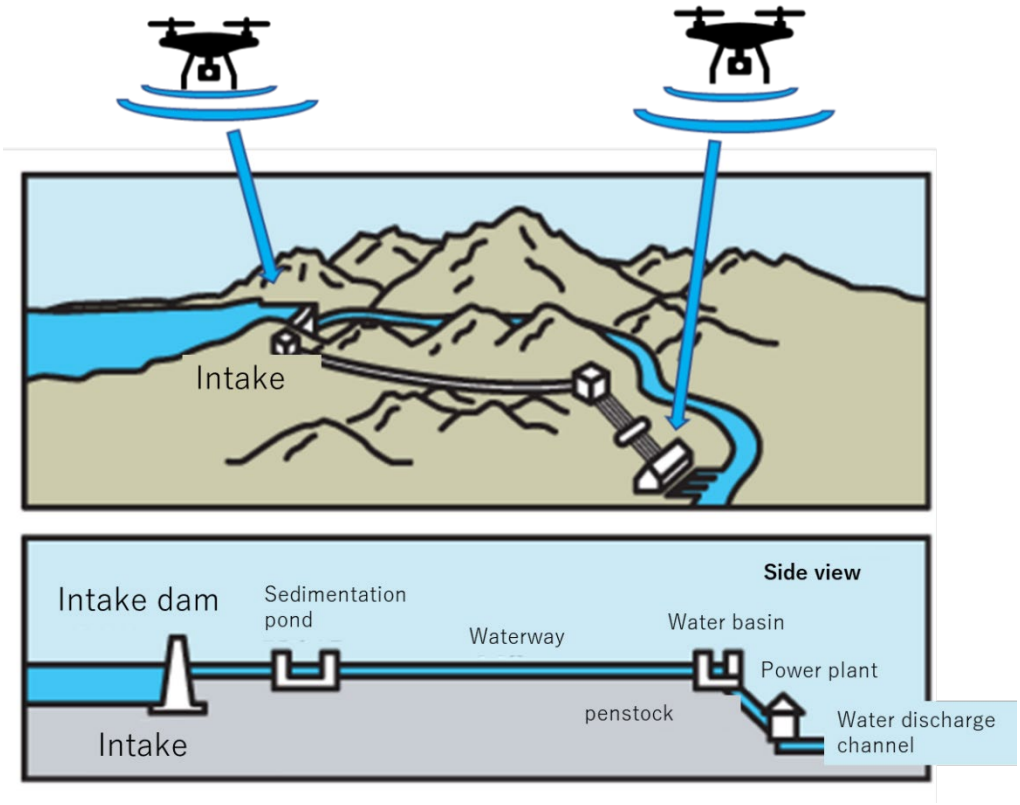
	2013	2014	2015	2016	2017	2018	2019	2020	2021*
Carabau	4,875,683	-	-	60,400	3,759,020	241,950	382,520	621,230	1,860,734
Naradau	9,805,929	9,385,730	8,456,188	4,035,744	5,959,392	5,830,432	5,756,160	4,292,640	2,131,307

* Regarding 2021data, only January to May is included

Also, after our literature research, it became evident that a survey on the small hydroelectric development plan was conducted with respect to Naradau Power Plant by the Japan International Cooperation Agency (currently JICA) in October 1992. This survey report[11] shows that the organization verified the estimated power production and its schematic design, and also summarizes problems with Naradau Power Plant, which was launched ahead of Naradau Power Plant. In addition to our literature research and interview with SESB, we worked with HIS, a travel agency that has a branch in the City of Kota Kinabalu, to conduct an online field survey to shed light on more realistic challenges. This online field survey was conducted on December 6, 2021, on Naradau Power Plant (including the water intake), then on December 8, 2021, on Carabau Power Plant. The procedure of the online field survey included, as shown in **Figure4-2**, taking photos focusing on the main system of each plant such as the water intake, the sedimentation tank, the penstock (when it's a land pipeline), the power station building and relevant systems (the turbine, the flood bypass entrance etc.), as well as utilizing drones to take aerial photos to understand the whole picture of the systems and their positional relationship. Also, on the day of the field survey, we connected online as much as possible with concerned parties on site and shared information to witness the situation from Japan on a real-time basis.

In the next section, we summarized the online on-site survey results of both plants.

[11] https://openjicareport.jica.go.jp/643/643/643_113_11009966.html



Source: https://enechange.jp/articles/hydroelectric-power-generation

Figure4-2　Schematic Diagram of the Online Field Survey

4.2.2　Carabau Power Plant

■ Water Intake

A part of the drawing obtained during our field survey is shown in **Figure4-3**. Carabau Power Plant uses a water intake method, which takes in water from the bottom of the river. A bar screen was installed at the water intake, to eliminate obstacles such as large stones. After the water is taken in, it goes through the sedimentation tank located several meters away from the water intake to deposit gravels, then is sent to the head tank. Also note that this online field survey was conducted during the monsoon season with larger river flows.

	
Water intake	Aerial view of water intake
	
Aerial view of sedimentation pond	Waterway between water intake and sedimentation pond

Figure4-3 Appearance of Water Intake at Carabau Power Plant

■ Head Tank

Water withdrawn at the intake is sent to the head tank shown in **Figure4-4** before it is sent to the power station building. The head tank is located about 20 minutes away by car from the water intake location. Head tank dimension is with the area of 3 m × 9.5 m, about 15m of the water depth, and made of cement. According to the interview with SESB personnel, sand and clay that did not deposit in the sedimentation tank accumulate on the bottom of the head tank, therefore, they conduct cleaning to remove those deposits every 6 to 8 months. There is a waterway for excess water to be released to avoid overflow, which is also used to remove the deposits.

Water in the head tank is sent to the power station building in the Carabau Power Plant. There is an about 1.8 km distance between the head tank and the power station building, with a drop of about 200 m, at a water pressure of about 35 bar. There is a covered deck built on the left side of the head tank that has a bulb, which controls the flow volume to the power station building.

	
Aerial view of head tank	Land view of head tank
	
Regulating valve of head tank	Penstock switching valve

Figure4-4　Head Tank of Carabau Power Plant

■　Power Station Building

Water sent from the head tank goes to the power station building shown in**Figure4-5**. Carabau Power Plant has two 1000kW-level Pelton Turbines.

On the other hand, according to the interview with SESB, water supply volume is small, and only one of the two turbines is in operation. Therefore, under the current situation, we were not able to identify the reason why water supply remains small, and thus, we need to find it out by studying the current operation method (an operation manual) and from the actual field survey.

Water that went through the power generator is then guided toward outside of the power station to be released to the waterway eventually. Also, the generated power goes through the power transformer unit on site before being delivered to consumers.

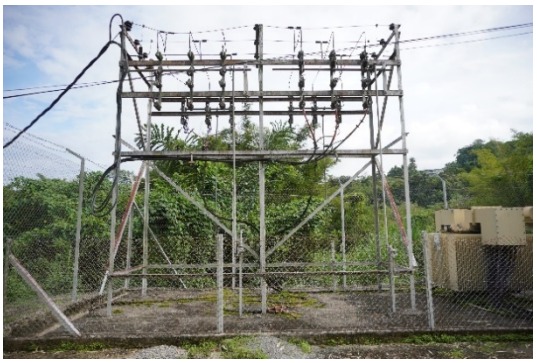
	
Carabau power plant building (from outside)	Carabau power plant building (from inside, turbine)
	
Turbine of Carabau power plant	Turbine of Carabau power plant
	
Carabau power plant discharge outlet	Carabau power plant switchyard

Figure4-5　Carabu Power Station Building and Surrounding Facilities

4.2.3 Naradau Power Plant

■ Water Intake

As described previously, Naradau Power Plant withdraws water from two rivers, the Liwagu River and the Mesilou River.

The location of the water intake at the Liwagu River is as shown in **Figure4-6**, which fundamentally withdraws water with the same way as Carabau Power Plant, with a screen set on the bottom of the river. The water withdrawn goes through the sedimentation tank built in parallel to the river to deposit gravels.

	
Liwagu River intake	Liwagu River sedimentation pond

Figure4-6 Liwagu River Water Intake Area of Naradau Power Plant

However, the water intake at the Mesilou River was badly damaged by the earthquake that hit in 2015, as shown in **Figure4-7**, which cannot operate to withdraw water under the current conditions. At present, a restoration work on the water intake is discussed by SESB.

Both water intakes have a bulb that is built to control the water flow to the power station building, which will be closed so that it won't withdraw water when there is a flood caused by the heavy rain, in order to avoid any damage to the water intake screen.

	
Mesilou River damaged intake (side)	Mesilou River damaged intake (aerial)

	
Mesilou River sedimentation pond	Waterway from Mesilou River sedimentation pond

Figure4-7　Mesilou River Water Intake Area of Naradau Power Plant

■　Power Station Building

Water withdrawn from the Liwagu River and the Mesilou River meet at a location several hundred of meters south from each water intake point, then is sent to the waterway to be delivered to Naradau Power Plant at a water pressure of about 35 bar (**Figure4-8**). Naradau Power Plant has two hydro turbines. As previously described, presently, one of the 2 existing water intakes is too damaged to withdraw any water, which leads to less water flow to the power station, as only one of the two systems is operating.

Water that went through the power generator is guided out of the building, then is released to the waterway eventually.

	
Gathering point of Liwagu and Mesilou Rivers' waterways	Naradau power plant building (from outside)

	
Naradau power plant building (turbine)	Naradau power plant (turbine)
	
Naradau power plant discharge outlet	Naradau power plant control board

Figure4-8　Naradau Power Plant Building and Peripheral Facilities

4.2.4　Challenges and Project Road Map

Based on the online field survey mentioned above and the literature research, as well as on the information such as the outcome of the interview with SESB, we identified the challenges each plant bears, and summarized the examined solutions to those challenges in the following **Table4-6**.

Table4-6　Challenges in Both Plants and Proposed Solutions

	Issues	Proposed solution
Equipment side	Insufficient power generation compared to the scale of installed equipment	・ Since there is a possibility of water leakage or spillage from the water intake, etc., a functional survey of the water intake facility will be conducted, and repairs will be made as necessary. ・ Measure the flow rate onsite to see if there is any water leakage from the water pipes, etc., and repair if necessary.

	Issues	Proposed solution
		・ Check that the location and structure of the equipment are installed correctly and collect them if necessary.
	The sedimentation function of the sand basin is reduced or insufficient.	・ Improve the sedimentation function according to the actual conditions such as flood frequency.
	The turbine is not performing as it should.	・ If there is a problem with the durability of the turbine, replace the turbine.
	There is no automatic flow rate adjustment function	・ Communication control equipment will be installed between the head tank and the power plant to automate the flow rate adjustment.
Operational aspect	The amount of power generation is insufficient for the flow rate that can be confirmed by the online survey.	・ Check whether the operation manual exists, and if it exists, whether it is the correct operation, and if necessary, support the development of a manual on gate and valve operation conditions based on the operation results in Japan. ・ Hold a workshop on Japanese operation methods and problem solving and share knowledge with SESB.
Maintenance	Insufficient frequency and method of periodic inspection and maintenance of equipment	・ Check the equipment inspection manual and frequency and support the development of manuals if needed. ・ Hold a workshop on Japanese operation methods and problem solving and share knowledge with SESB. ・ Through field surveys, confirm and instruct how to carry out maintenance of water intake facilities and power generation facilities.
data	Lack of data on layout, specifications, structural dimensions and soundness of major structures	・ Check if the conceptual diagram in Fig. 4-9 is consistent with the actual situation.**Figure4-9** ・ After confirming the height of the top of each structure, assume the water adjustment operation of the power plant in the head tank, and investigate the water level to the specified water volume.

	Issues	Proposed solution
	It is unknown whether the operating conditions meet the demand	・ Confirmation of local electricity demand

As shown in the table above, both plants share a common challenge that, because only one of the two turbines is working, power output is significantly short for the size of the plants' installed systems. For Carabau Power Plant, we can think of multiple factors as a cause of this challenge, such as a turbine malfunction and a lack of water intake and water flow. While, for Naradau Power Plant, the cause of the issue is because only one of the two water intakes is in operation due to the damage to one intake. At present, a restoration work on the intake is planned, and once the restoration work completes, we can expect the level of power output to recover to the level before the earthquake, when two turbines are in operation. On the other hand, based on the online field survey result, we identified challenges like a leak and a sediment deposition like in Carabau Power Plant, thus, we could expect a further increase in power output.

To discuss and estimate an appropriate level of power output, we drafted the conceptual diagram for Carabau Power Plant based on the information obtained from our online field survey and literature research, taking some assumptions into consideration, and calculated power output based on the anticipated water volume. Our current conceptual diagram is shown in**Figure4-9**. By the way, Naradau Power Plant withdraws water from two rivers, but for this purpose, we can apply the same conceptual diagram assuming that it uses only one water intake. Moreover, the length and diameter of the waterway connecting the water intake and the head tank, and those of the penstocks connecting the head tank and hydro turbines were generated based on the data provided from the local site, however, we decided to verify the entire water level (EL) and water consumption level (WL) on the water intake weir, the water intake, the sedimentation tank, and the head tank respectively, so that we can input accurate values for each items.

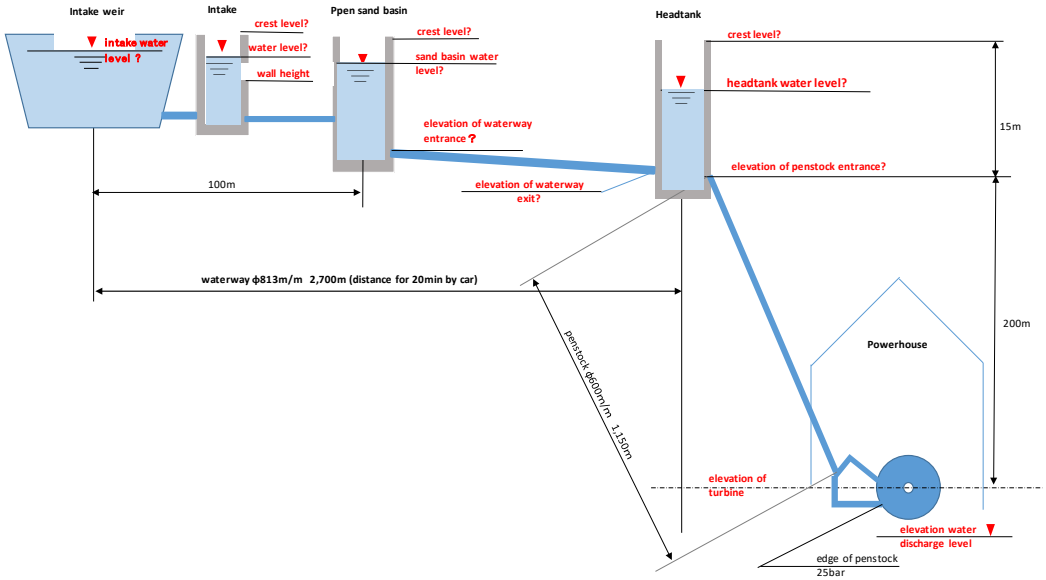


Figure4-9 Conceptual diagram of Carabau Power Plant

Also, we set up the specifications for the waterway and the penstock as shown in **Table4-7**, and based on them, we calculated in-pipe flow velocity and friction loss in the waterway and the penstock with respect to the water consumption volume (water intake volume) shown in **Table4-8**.

Table4-7 Calculation of Loss Factors

Parameters	Unit	Waterway specifications	Penstock specifications
n: Roughness coefficient (welded steel pipe)	-	0.011	0.011
D: Waterway/penstock diameter	m	0.813	0.600
L: Waterway/penstock length	m	2,700	1,150
2g	m/s^2	19.60	19.60
f: Loss coefficient	-	0.016	0.018

Table4-8 In-pipe Flow Velocity and Friction Loss in the Waterway and the Penstock with respect to Water Consumption Volume

Amount of water used	Waterway (water intake to head tank)		Penstock (head tank to turbine)	
	In-pipe flow velocity	Friction loss hf1	In-pipe flow velocity	Friction loss hf2
m^3/s	m/s	m	m/s	m
0.100	0.193	0.101	0.354	0.221
0.200	0.385	0.402	0.707	0.880
0.300	0.578	0.906	1.061	1.981
0.400	0.771	1.612	1.415	3.524
0.500	0.963	2.514	1.768	5.502
0.600	1.156	3.623	2.122	7.926
0.700	1.348	4.926	2.476	10.791
0.800	1.541	6.438	2.829	14.087
0.900	1.734	8.151	3.183	17.833
1.000	1.926	10.057	3.537	22.021
1.100	2.119	12.173	3.890	26.636
1.200	2.312	14.491	4.244	31.704
1.300	2.504	16.998	4.598	37.214
1.400	2.697	19.720	4.951	43.147
1.500	2.889	22.627	5.305	49.537
1.600	3.082	25.751	5.659	56.369
1.700	3.275	29.078	6.013	63.642
1.800	3.467	32.587	6.366	71.334
1.900	3.660	36.316	6.720	79.488
2.000	3.853	40.247	7.074	88.083

We include the friction loss at the waterway and the penstock in the calculation, and we assume that the head drop is about 2%. The total head drop is about 220 m, so we can calculate effective head drop as shown below. Furthermore, we can estimate the output shown in the table below with the assumption that synthesis efficiency is 70%.

Output = Gravitational acceleration (9.8) x Effective head x Overall efficiency (0.7)

Table4-9 Estimated Output with respect to Water Consumption

Amount of water used	Total loss head	Effective head	Output
m^3/s	m	m	kW
0.100	0.328	219.672	151
0.200	1.308	218.692	300
0.300	**2.945**	**217.055**	**447**
0.400	5.239	214.761	589
0.500	8.176	211.824	727
0.600	11.780	208.220	857
0.700	16.031	203.969	979
0.800	20.936	199.064	1,092
0.900	26.504	193.496	1,195
1.000	32.720	187.280	1,285
1.100	**39.585**	**180.415**	**1,361**
1.200	47.119	172.881	1,423
1.300	55.296	164.704	1,469
1.400	64.124	155.876	1,497
1.500	73.607	146.393	1,506
1.600	83.762	136.238	1,495
1.700	94.574	125.426	1,463
1.800	105.999	114.001	1,408
1.900	118.120	101.880	1,328
2.000	130.897	89.103	1,222

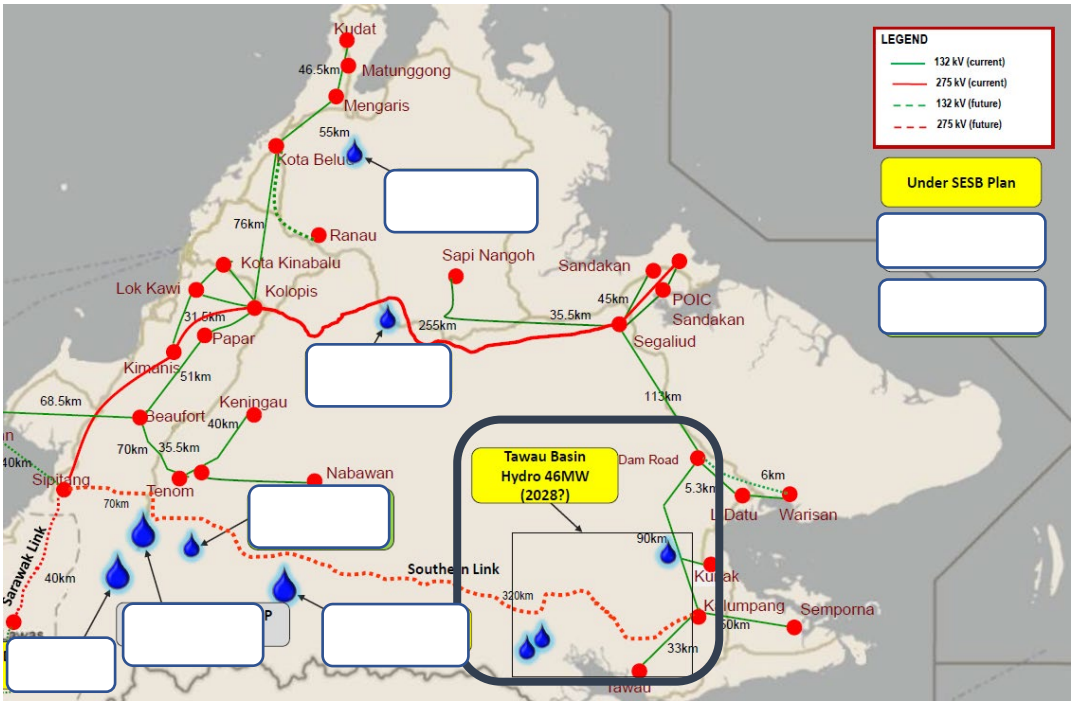
Moving forward, we plan to conduct a more in-depth examination to verify the possible water intake amount and check the performance of the hydraulic turbines, as well as the actual on-site survey, and then, while utilizing the table above, we plan to have discussions with SESB and make a final decision on the rehabilitation plan for the power plants. Regarding the restoration of the water intake at Naradau Power Plant, we assume the possibility of a disaster of the same level as the earthquake in 2015 to occur in the future, and we expect to propose and support the design of the penstock as well as the selection of materials based on the design/operation performance record in Japan.

In addition, this fiscal year's survey indicated that facility utilization rate might have been declining not only because of tangible factors like system improvement/replacement/arrangement,

but also intangible factors such as operation management and system inspection/maintenance. For the next fiscal year, on top of the assistance to draft an operation manual and a maintenance/inspection manual based on the operation performance record and know-how in Japan, we can possibly implement quick and effective measures by holding workshops for local concerned parties.

For the next fiscal year, while working with SESB on the challenges and solutions mentioned above, we plan to embody the efforts from both tangible and intangible aspects, while checking and confirming their intentions at the same time.

Moreover, as previously mentioned, SESB foresees the subsidy on their natural gas purchase to be allocated to the renewable energy project in the near future. As such, SESB is considering to start a new hydroelectric project along with the improvement/upgrade of small hydropower generation systems. Under the current circumstances, since the 46MW-level hydroelectric project utilizing Tawau water zone in central eastern Sabah, as shown in**Figure4-10**, is underway, we plan to work on collecting information and building relationships with local concerned parties, while applying JCM to the project.



Source: SESB

Figure4-10　Tawau Water Area and Proposed Location of New Hydropower Plant

4. 3　Solar Power Generation

In Malaysia, because of the abundant amount of incoming solar radiation, solar power generation

was nominated as one of the highly possible options to adopt renewable energy. Also, a report shows that Sabah has a very large amount of incoming solar radiation in Malaysia, and literature indicates an annual average of around 180 kW/m^2 of solar radiation can be expected there[12]. For this reason, installing solar panels on public facility buildings is included as part of the project related to the city's energy sector in "Green City Action Plan: Kota Kinabalu" published in 2019 by the City of Kota Kinabalu, and is also considered as a high priority project (**Table4-10**).

Table4-10　Priority Business Projects in Energy Area set out by Kota Kinabalu

Project plan	Priority
Soft planning	
Formulation of efficient strategies and implementation plans at the city level	High
Hard planning	
Building a solar system connected to the grid	High
Installation of 5-15kW solar panels in various public facilities in the city	High
Installation of solar panels in elementary schools (56 locations)	High
Replacement of conventional power by introducing a solar system with an inverter and replenishment during average power distribution	Intermediate
Introduction of water heaters in hospitals, hotels and restaurants	High
Replacement of liquefied petroleum gas (LPG) with a solar cooker	Intermediate
Introducing steam cookers in schools, hotels and restaurants	High
Installation of energy efficient air conditioners, refrigerators, water pumps and ceiling fans	High

Source: Green City Action Plan: Kota Kinabalu, 2019.

Based on these, as part of this project, an interview was conducted to find out the progress of Kota Kinabalu's effort for this project, as well as to receive opinions and requests toward the implementation of renewable energy projects including the solar power project. A summary of the interview to the City of Kota Kinabalu（**Table4-11**) and their responses are as shown below.

[12] F.M Markos and J. Sentian, Potential of Solar Energy in Kota Kinabalu, Sabah: An estimate using a Photovoltaic System Model, Journal of Physics, 2016. (doi: 10.1088/1742-6596/710/1/012032)

Table4-11 Summary of the interview with the City of Kota Kinabalu (September 13, 2021)

Attendees	Kota Kinabalu City (3 people), Sustainable Energy Development Agency (SEDA) (1 person), SESB (1 person), Japan NUS (3 people)
Interview outline	・ Explanation of intercity cooperation project and JCM scheme ・ Progress of "Green City Action Plan: Kota Kinabalu" ・ Intention to introduce solar power generation equipment for private consumption in public facilities

■ Progress of “Green City Action Plan: Kota Kinabalu”

At the time of the interview, there was no solar power system installed by the City of Kota Kinabalu as a primary operating entity. This is because FIT is not available to apply in Sabah, which only leaves the options either to negotiate with off-takers to sell the power directly, or to plan to set up a system for personal consumption. Also, as it stands now, since a large amount of subsidy has been allotted to LNG owned by SESB, solar power generation is recognized as comparatively expensive in terms of power generation cost, and thus, the city is not looking to carry out any large-size solar power system installation projects. On the other hand, in the future, when the subsidy towards LNG is revised, solar power generation may become less expensive.

Moreover, the City of Kota Kinabalu once considered a project to supply the power for the streetlights in the city by using solar power generation, however, the project required to have power storage units such as batteries for night-time use, which would lead to high cost, therefore, this project, too, got cancelled.

4.3.1 Selection of Potential Sites for Installing Solar Power Systems

According to the interview above, the installation of commercial solar power generation systems led by the City of Kota Kinabalu would be difficult, however, we prioritized the installation of a solar power generation system for personal consumption on public facilities and studied it. In the above-mentioned interview, among the facilities and parking spaces that are owned or operated by the City of Kota Kinabalu, we interviewed them about those facilities that are expected to have daytime energy consumption considering personal consumption, and eventually, we selected 3 locations shown in **Figure4-11** as potential installation sites based on the discussion with the staff of Kota Kinabalu City Hall. The following sections will describe the results of estimation of the possible capacity and annual power output at each site.

To estimate power output, we used resources such as Google Earth to obtain aerial photos to find out the possible area for installation, then asked Nihon Kucho Hokuriku Co., Ltd. to design the layout for panels and estimate power output.

Source: Google Maps

Figure4-11　Potential Sites for Solar Power System Installation

1) Kota Kinabalu City Hall

As shown in **Figure 4-12**, Kota Kinabalu City Hall consists of multiple buildings. Among them, the roof of the main building, which was built relatively recently and is located the closest from the entrance, is a potential site. The building is visited by many local civilians because of the nature of the building being a City Hall, therefore, it is expected to have the most profound effect for disseminating its decarbonization effort. Furthermore, since there is a flat parking lot next to the building, installing carports with a built-in solar power system can also be considered.

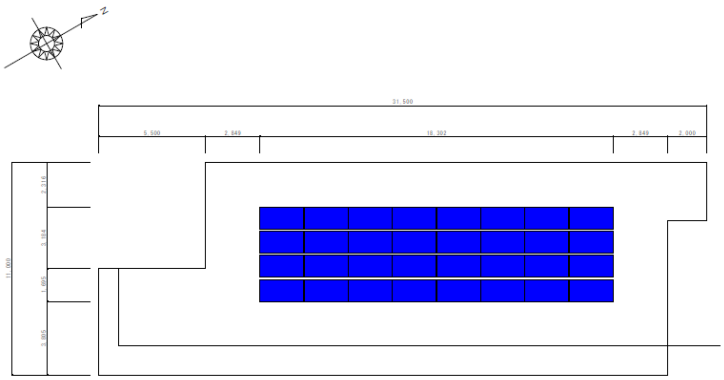
	
Entrance of Kota Kinabalu City Hall	Aerial view

Source: Google maps

Figure 4-12　Appearance of Kota Kinabalu City Hall

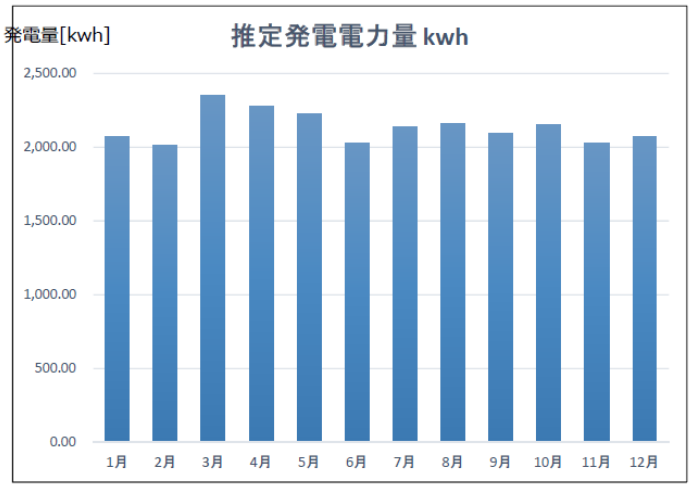
The panel layout is as shown in **Figure 4-13**, and it became evident that we can install a system

for generating a total of 17.28kW by placing thirty-two 540W-panels. Also, this system is expected to generate the power shown in **Figure 4-14**, which is 25,615 kWh per year (capacity factor: 16.9%).



Source: Nihon Kucho Hokuriku Co., Ltd.

Figure 4-13　Solar Panel Layout: Kota Kinabalu City Hall



Source: Nihon Kucho Hokuriku Co., Ltd.

Figure 4-14　Estimated Power Output: Kota Kinabalu City Hall

2) Pasar Tanjung Aru

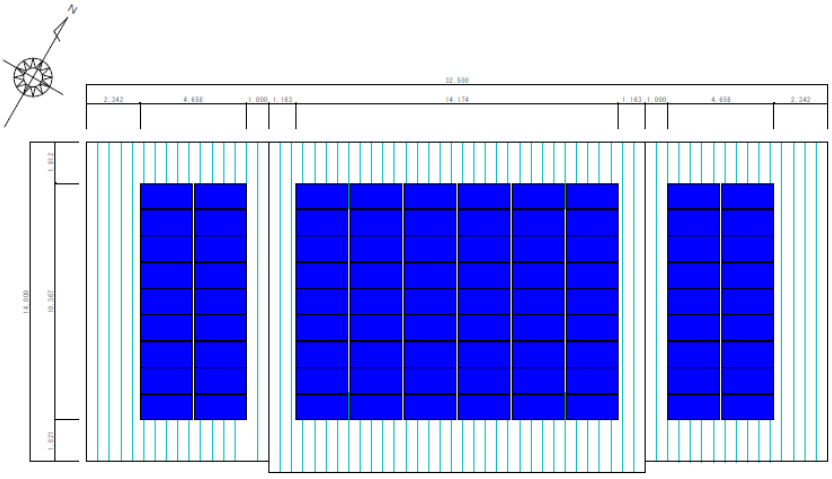
Pasar Tanjung Aru is a market with restaurants, as shown in **Figure4-15**, with frequent daytime use by local civilians. This building was built relatively recently and its roof is flat, so we can expect significant incoming solar radiation and output.

	
View from outside	Aerial view

Source: Google Maps

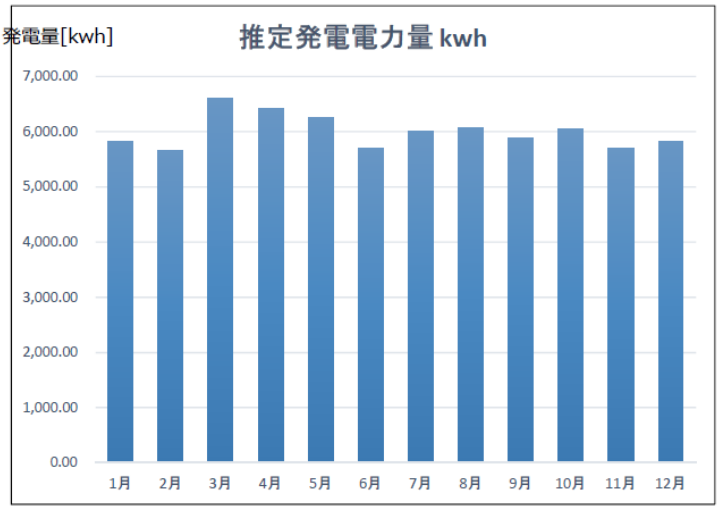
Figure4-15　Appearance of Pasar Tanjung Aru

The panel layout is shown in **Figure4-16**, and it became clear that we can install a system for generating a total of 48.6kW by placing ninety 540W-panels. Also, this system is expected to generate the power shown in **Figure4-17**, which is 72,042 kWh per year (capacity factor: 16.9%).



Source: Nihon Kucho Hokuriku Co., Ltd.

Figure4-16　Solar Power Panel Layout: Pasar Tanjung Aru



Source: Nihon Kucho Hokuriku Co., Ltd.

Figure4-17　Estimated Power Output: Pasar Tanjung Aru

3)Anjung Selera

Anjung Selera is also a supermarket that is frequently used by local civilians, as shown in **Figure4-18**. Although we still need to check the site to confirm whether the installation is actually feasible because it has a potential salt damage issue as it is facing the ocean and it has a uniquely shaped roof, we would be able to install many more systems than others because of its relatively larger area.

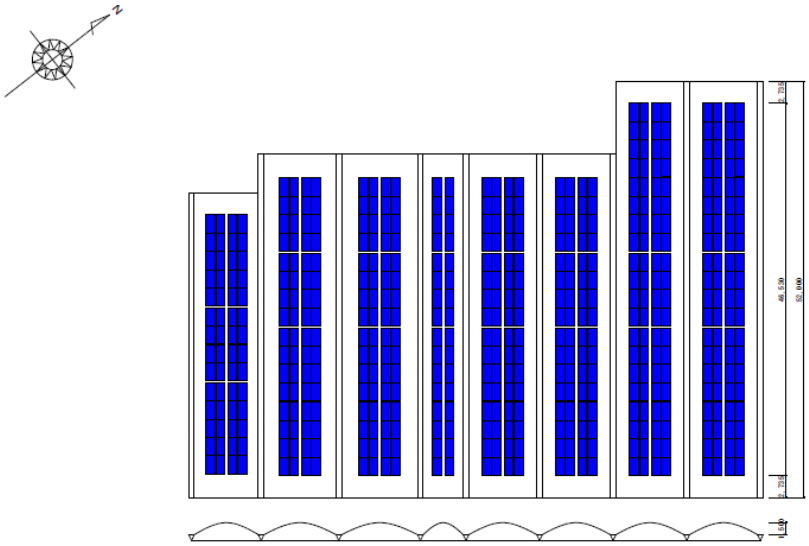
View from outside

Aerial view

Source: Google Maps

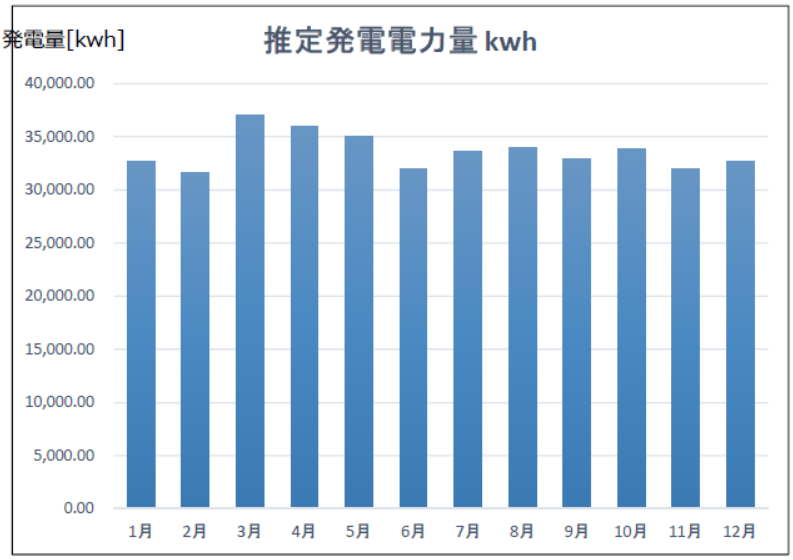
Figure4-18　Appearance of Anjung Selera

The panel layout is shown in **Figure4-19**, and it is now evident that we can install a system for generating a total of 272.16kW by placing 504 540W-panels. Also, this system is expected to generate the power shown in **Figure4-20**, which is 403,439 kWh per year (capacity factor: 16.9%).



Source: Nihon Kucho Hokuriku Co., Ltd.

Figure4-19　Solar Power Panel Layout: Anjung Selera



Source: Nihon Kucho Hokuriku Co., Ltd.

Figure4-20　Estimated Power Output: Anjung Selera

The volume of reduceable greenhouse gas emissions expected by the installation of each system is shown in **Table4-12**, which indicates the possibility of reducing emissions by up to 3,656t-CO2 in the 17 legal durable years.

Table4-12　CO_2 Emissions Reduction Expected by Solar Power Generation Business

Candidate site	Greenhouse gas reduction amount t-CO2 / year]	Greenhouse gas reduction amount t-CO2 / 17 years]
Kota Kinabalu City Hall	13.65	232.10
Pasar Tanjung Aru	38.40	652.78
Anjung Selera	215.03	3,655.56

4.3.2　Project roadmap

According to the reference material published by SESB, the power consumption cost in Sabah is set as shown in **Table4-13**, there is no minimum charge, and the charge increases according to the power consumption level.

Table4-13　Power Consumption Costs in Sabah

Power consumption amount [kWh / month]	Price [RM/kWh]	Price [JPY/kWh]
From 1 to 100kWh	0.175	4.73
From 101 to 200kWh	0.185	5.00
From 201 to 300kWh	0.330	8.91
From 301 to 500kWh	0.445	12.02
From 501 to 1,000kWh	0.450	12.15
1,001kWh or more	0.470	12.69

Source: Tariff Booklet January 2014[13]

When we researched the annual power consumption level consumed by Kota Kinabalu City Hall in order to examine the merit of adopting solar power generation, it turned out to be around 177,000 kWh per year. It is 14,750 kWh/month, which means they are paying about 191,000 yen every month, or about 2,292,000 yen per annum, based on our aforementioned formula. Our assumption above shows it is possible for the 17.28kW system to generate 25,615kWh per year at Kota Kinabalu City Hall, thus, if they consume all the power it generated on its own, about 15% of their current power consumption level can be covered by the solar power generation. If we convert it to the annual reduceable energy cost, it would be about 344,000 yen to be reduced annually. As such, if we take the 17 legal durable years into consideration, the cost will be 5,850,000 yen, therefore, it

[13] https://www.sesb.com.my/getattachment/835e4583-b2ee-4fa9-ad76-0ea303991620/Tariff-Booklet-(English).pdf

became evident that there will be the merit of the implementation if we can keep the system installation cost, including maintenance costs, under 5.85 million yen. The cost for installing a rooftop solar power system in Japan is estimated at around 300,000 yen/kW, so if we assume the cost would be at the same level, which is about 5.2 million yen, we can expect to see the merit of the adoption.

Also, as it is difficult to apply JCM Equipment Subsidy Project at the size of our current plan, we can consider an option to carry out the project together with an energy storage or a system that can provide some sort of benefit to the demand side (e.g. a water purification system), to plan our future business development.

Furthermore, we discussed with a focus on adopting solar power systems inside the city of Kota Kinabalu for this year's project, however, our interview with potential biofuel off-takers in the Malay Peninsula revealed that there were multiple companies positively considering to install rooftop solar power systems while studying the biofuel utilization business discussed in the previous Chapter, and thus, we will also envisage making approaches to such business entities for the next year and on.

Chapter 5. Project to Electrify Non-Electrified Areas Using Renewable Energy

While Kota Kinabalu is the largest city in East Malaysia, some rural areas in the region fall behind on electrification. The states of Sabah and Sarawak are working on electrifying such areas through the Rural Electricity Supply (BELB) Programme that is aimed at raising the electrification rate in the areas. The program proposes the following two means of electrification: to connect the existing electricity lines and grids to the rural areas, and to directly build power facilities there. Generally, the latter is chosen in most cases because non-electrified areas are far from electricity grids and the cost effectiveness in connecting the existing grids is not high. The electrification rate in the state of Sabah as a whole went up to 90.81% at the end of 2021 through the program, but there are still a certain number of non-electrified areas.

In our project, therefore, we discussed a model project to electrify non-electrified areas. Specifically, we held a discussion about Kobuni, which is a non-electrified village located about 20 km from the center of Kota Kinabalu. While moving ahead with negotiations with Kota Kinabalu in the project we carried out in fiscal year 2020, we received a request for helping electrify the village. With the population being slightly less than 300 people, the village has poor access to the city area and is afflicted with frequent power outages due to unstable electricity supply. On the other hand, Kobuni is famous as an ecotourism spot for their traditional lifestyle and rich tourism resources, such as tropical rain forests and waterfalls. Looking ahead to development of ecotourism, including environmental education, the government of Kota Kinabalu is planning to make the village a model area by combining renewable energy with electrification and setting up a system that fulfills demand for energy essential for the life of the residents while paying respect to the traditional lifestyle there.

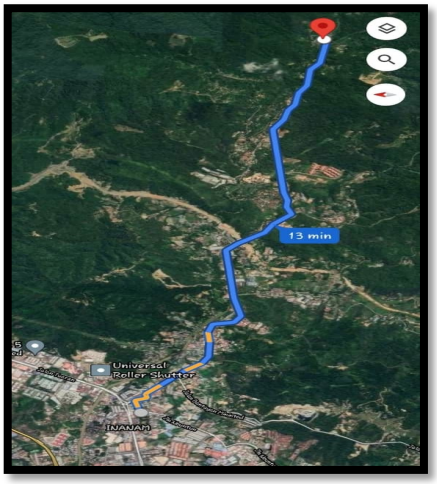
This City-to-City collaboration project, thus, targets Kobuni Village and discusses an electrification project in combination with such renewable energy sources as micro hydropower and solar power according to demand for electricity. Promotion of electrification is expected to improve the educational environment and the environment of such medical facilities as hospitals, create a more proper gender balance, and prevent population outflow to cities, and this initiative is meaningful from the perspective of the Sustainable Development Goals (SDGs).

5. 1 Overview of Kobuni Village

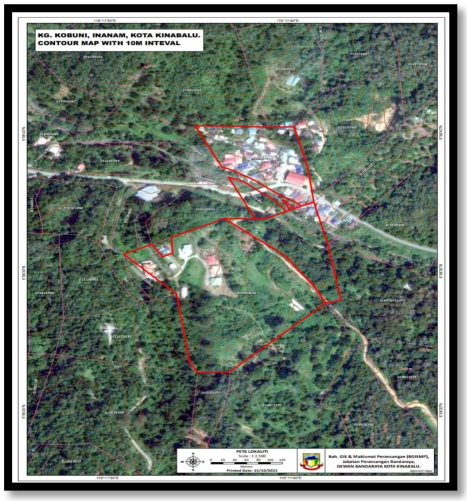
The village of Kobuni is located about 20 km east of Kota Kinabalu, the capital of the state of Sabah, and it takes about 30 minutes by car from the capital to the village (**Figure5-1**). The area is approximately 28,000 m^2, the population is about 300, and 82 households live there. With two rivers, which are Kobuni River and Inanam River whose headwaters are found in Mount Kinabalu, the largest mountain in Southeast Asia, being running in Kobuni, the village proactively welcomes tourists, including students for home stay programs, by taking advantage of the beauty of nature and

its unique culture (**Figure5-2**).

Kobuni Village is currently restricted from accepting people for home stay programs due to the impact of the novel coronavirus infection; however, based on the policy of Kota Kinabalu that has jurisdiction over the village, Kobuni continues to focus on setting up environmental education programs by utilizing the richness of nature and promoting ecotourism that has been gaining popularity recently.



Location of Kobuni Village



Borderline

Source: shared by local stakeholders

Figure5-1 Location of Kobuni Village

Source: shared by local stakeholders

Figure5-2 Leaflet of Home Stay Program

5. 2 Identification of issues regarding electricity use

Kobuni Village has the facilities shown in **Table5-1** because the village hosts home stay programs and other events while 82 households live there as mentioned above:

Table5-1 List of Facilities in Kobuni Village

No.	Facilities	No.	Facilities
1	Mosque	11	Public hall
2	Surau	12	Bus stop
3	Non-Muslim Workship place	13	Police station
4	Community hall	14	Playground
5	Clinic	15	Football field
6	Deputy pos	16	Game court
7	Facilities/Banking agents	17	Graveyard
8	Library	18	Street light
9	ICT center/Computer center	19	Public Phone
10	Operational room	20	Recycle facilities

Source: shared by local stakeholders

Meanwhile, as the village of Kobuni is located far from the urban areas, the electricity grids are weak and electricity supply is unstable.

In this project, therefore, we interviewed local parties concerned via the Internet with the aim of identifying issues related to use of electricity. The results of the interview are summarized in **Table5-2**. The interview has revealed that while electricity is provided to Kobuni to a certain extent in the amount necessary for the residents to lead everyday life, electricity supply to public facilities used for events for the residents and home stay activities is inadequate and electricity is lost at times.

Table5-2 Summary of the Interview with Parties Concerned in Kobuni Village (Aug. 12, 2021)

Attendees	Kota Kinabalu City Hall (1 person), local officials from Kobuni Village (4 people), Japan NUS (3 people)
Hearing summary	・ Currently, Kobuni Village uses electricity supplied by the local power company SESB. ・ As for the power supply situation, the power supply necessary for the living of the residents is covered to some extent, and although power outages occur occasionally, the rate of occurrence is not high.

	・ On the other hand, public facilities such as community halls and soccer courts (Nos. 4 and 15 in Table 5-1) are also used for events such as weddings, and the utilization rate is high, and the amount of electricity used is also important.**Table5-1** ・ If renewable energy can be installed, supply to those public facilities would be beneficial. ・ Also, while accepting homestays, users often point out the lack of streetlights. There are some bridges in the village because of the river flowing through it, but if there are few streetlights, there is a risk of injury because of low sight on feet. Therefore, increasing the number of streetlights is considered. ・ Water rights are not an issue when introducing equipment to rivers flowing through the village of Kobni.

5. 3 Basic survey for drawing up a commercialization plan

Taking into account the results of the interview with the local parties concerned, this survey examined the situation of electricity use at the public facilities and places that are expected to have potential in terms of adoption of renewable energy sources, such as solar power and micro hydropower.

5. 3 . 1 Situation of electricity use

We examined the situation of electricity use targeting the football field, the community hall, the mosque, and the school (**Figure5-3**) based on the results of the interview with the local parties concerned.

	
Soccer court	Community Hall

Mosque

School

Position of each facility (Google Maps image edited)

Source: shared by local stakeholders

Figure5-3　Appearance of the Facilities Examined

The results of the interview regarding the amount of electricity used and major purposes of electricity use at each of the facilities are shown in **Table5-3**. The mosque and the school together have signed a contract for electricity supply. The facility where the largest amount of electricity was used was the mosque and the school combined in September 2021 with the amount used standing at 288 kWh for a month while the total amount of power usage at the four facilities was 337 kWh in September 2021. The primary use was for lighting, and other purposes of electricity use included air conditioning at indoor facilities, such as the community hall. According to the summary of the results of the fact-finding survey on carbon dioxide emissions from households in 2020

(preliminary)[14] published by the Ministry of the Environment, the annual amount of electricity consumed per household in Japan was 4,258 kWh, which was approximately 355 kWh when calculated per month, and the total amount of electricity used at the four facilities in Kobuni Village was almost equivalent to the amount of electricity consumed per household in Japan. This indicates that large renewable energy power generation equipment is not necessarily required.

The amount of electricity used decreased in March 2021 due to the travel and other restrictions imposed in Malaysia amid the Covid-19 pandemic. Consequently, this forced Kobuni to refrain from providing home stay programs; however, when the village is allowed to host people for home stay programs again, the amount of electricity used will be larger than the total amount in September 2021.

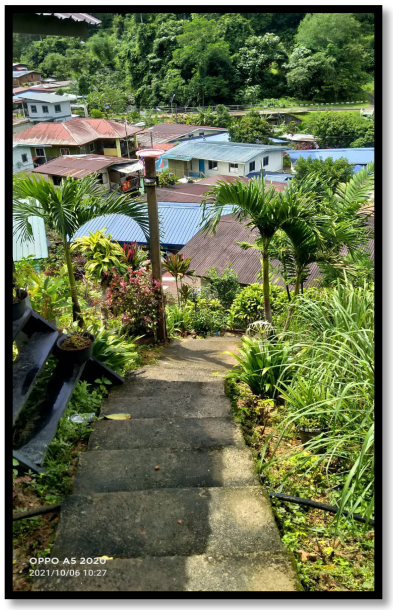
Table5-3 Amounts of Electricity Used and Primary Uses at Each Facility

No.	Name of facility	Date / power consumption (kWh)		Power purpose
①	Soccer court	September 2021 / 26.00		• Lights
② + ③	Mosque, school	March 2021 / 99.00	September 2021 / 288.00	• Lights • For prayer Speaker broadcasting (5 times a day)
④	Community hall	March 2021 / 18.00	September 2021 / 23.00	• Lights • Computer • Air conditioner

Source: shared by local stakeholders

Regarding candidate places for street lights installation, we received requests through the interview with the local parties concerned for installing lights near the stairs and bridges as shown in **Figure5-4**.

[14] https://www.env.go.jp/earth/ondanka/ghg/03_R2kateiCO2kekkagaiyou_sokuhou.pdf

	
Stairs in Kobuni vikkage	Bridge across river

Source: shared by local stakeholders

Figure5-4　Candidate Places for Installing Street Lights

5.3.2　Potential in terms of adoption of renewable energy

As stated above, the amount of electricity demanded in the village of Kobuni is around 500 kWh per month at most. The amount demanded in Kobuni will be almost equivalent to the amount consumed at two households in Japan even when the amount of power consumed for street lights are included. This means that large-scale power generation equipment need not be installed, and the demand for electricity can be satisfied with solar power generation equipment with a capacity of 10 kW or less in the case of roof-top solar panels or micro-hydropower generation equipment with a capacity of 2 kW or less. Given the time of the day when electricity is consumed, it will be effective to establish a hybrid power generation system by installing rooftop solar panels for public facilities that are usually used during the day and adopting micro-hydropower for street lights that are used in the nighttime, and this survey has identified places with potential regarding installation of power generation equipment based on our interviews with local parties concerned and local investigations via the Internet using photographs and videos taken with the smartphones of the local parties concerned.

1) Solar power generation

According to the aerial photographs provided by Google Maps, the facility that has the largest roof area in the village of Kobuni is the aforementioned football field, with the area being 680 m^2

(**Figure5-5**). Here, the rooftop solar panel (NQ-254BM[15]) for home use offered by Sharp Corporation can produce electricity of 254 W per panel, meaning that 40 panels will be required if power generation equipment with a capacity of 10 kW is installed. Furthermore, the size of the panel is 1,265 x 1,055 x 46 mm and the area required for installing 40 panels will be 53.4 m^2, which indicates that the area of the roof of the football field is large enough to install them. The amount of electricity generated is estimated at 15,000 kWh annually based on the data on the insolation amount in Kota Kinabalu (**Figure5-6**), suggesting that the amount of electricity demanded will be adequately covered.

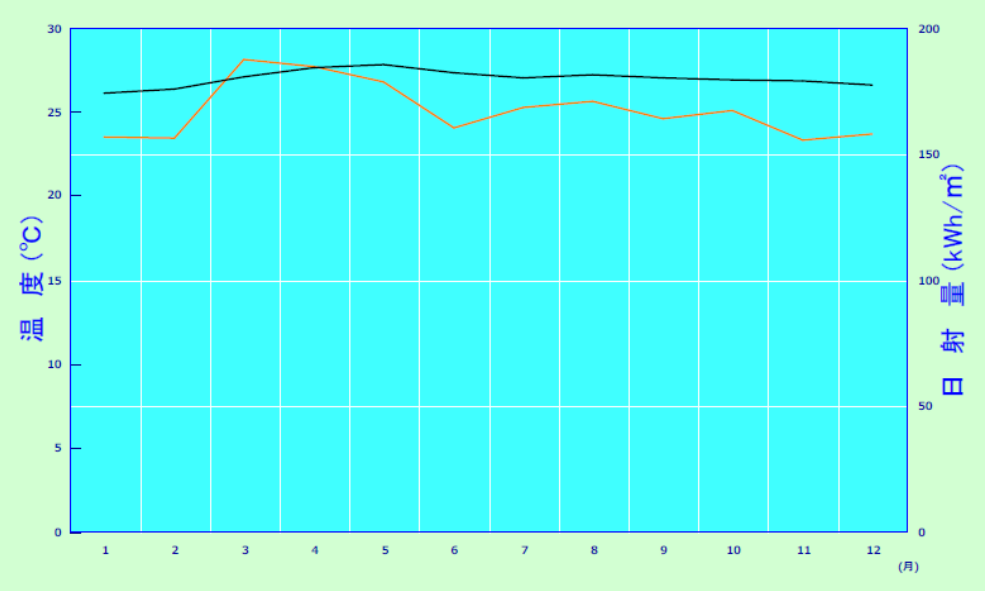
Meanwhile, the strength and load-bearing capacity of the roof and building are vital factors in installation of solar power generation equipment. In this case, the weight of the panel is 16.5 kg and 40 panels weigh 660 kg in total. We need to confirm whether the football field can carry the load by actually visiting the place for field surveys because design drawings and specifications have not been organized at the moment.

	
Soccer court	Roof of soccer court (surface: around 680m^2)

Source: ：Google Maps and local stakeholders

Figure5-5 Site with Potential in Terms of Solar Power Generation: Football Field

[15] https://jp.sharp/sunvista/products/module/254bm/spec/



Source: Nihon Kucho Hokuriku Co., Ltd.

Figure5-6　Data on Insolation Amount in Kota Kinabalu

2)Micro-hydropower generation

As mentioned earlier, two rivers, which are Kobuni River and Inanam River, are running in the village of Kobuni. Our interview with the local parties concerned has found that the flow rate of Inanam River is above a certain level throughout the year while the flow rate of Kobuni River declines to almost zero during the dry season. In this survey, thus, we have chosen Inanam River as a site with potential in terms of adoption of micro-hydropower.

The photographs of Inanam River are given in **Figure5-7**. Generally, data on the flow rate and the effective head are required for quantitatively understanding the potential regarding adoption of micro-hydropower generation; however, no data was amassed in the past and it was difficult to conduct field surveys due to the impact of the Covid-19 crisis, and therefore, we explored possibilities for installing micro-hydropower generation equipment with a capacity of 2 kW, which is necessary for covering the amount of electricity needed, through an interview with J-WatER that promotes and develops micro-hydropower use and carries out research studies in regard to use of micro-hydropower based on the photographs and videos that we received from the local parties concerned. The summary of the interview is as shown in **Table5-4**. According to the results of the interview, the flow rate of Inanam River is adequate enough to install power generation equipment with a capacity of around 2 kW. Surveys at the site are required for more detailed equipment design.

Source: shared by local stakeholders

Figure5-7　Pictures of the Inanam River

Table5-4　Summary of the Interview with J-WatER (November 22, 2021)

Attendees	National Small Hydropower Utilization Promotion Council (1 person), Japan NUS (2 people)
Interview outline	・ In the past, when JICA implemented ODA /projects in a village in Myanmar, 1kW was enough to supply electricity for the entire village. Currently, Kobuni village seems to have a slightly higher standard of living than Myanmar village. ・ As long as you look at the pictures of the Inanam River, it can be seen that the rocks in the river are splashing. From this, it can be assumed that there is a head of about 10 cm, and since there are three places within the range that can be confirmed in the photograph, it can be assumed that there is a head of about 30 cm. ・ Since the flow rate is estimated to be about 1 m^3 / s from the picture, it is considered that a power generation facility of about 2 kW can be installed sufficiently. ・ In the future, when estimating more detailed data, if there is data such as annual rainfall data of the area, calculation of the catchment area of the water source, frequency of rain and stop, the flow rate and the installed capacity can be determined more accurately.

	・ In addition, when installing streetlights, it is necessary to consider transmission lines and utility poles separately, which is expected to be an issue. In Myanmar, a simple utility pole was created using local bamboo.

5.4 Formulation of a business model plan

As remarked earlier, the amount of electricity demanded in Kobuni Village is almost equivalent to the amount consumed at two households in Japan, from which it is obvious that the scale of this project is small for launching a business utilizing the JCM equipment assistance project. Meanwhile, our literature surveys and interviews with Kota Kinabalu have revealed that the state of Sabah has a number of areas with poor electrical grid connection, like Kobuni, due to such factors as their locations that are far from the urban areas, and some of such areas even do not have electricity adequate enough to allow the residents to lead a daily life. From this perspective, if the village of Kobuni is set as a model area that is electrically self-reliant using renewable energy and the model is adopted to other areas, then large-scale promotion of renewable energy will be possible. In addition, in the state of Sabah, the responsibility for delivering electricity to areas far from the urban areas will be taken by Sabah Electricity Sdn, Berhad (SESB), an electricity power company, and various relevant factors, such as the cost of connecting electricity grids, will have a significant impact on the company's business; however, use of renewable energy sources and no reliance on electricity grids will bring an advantage of lowering the cost incurred on SESB.

Furthermore, although some restrictions, including travel restrictions, have currently been imposed due to the impact of the novel coronavirus infection, Kobuni Village has attracted a host of tourists, including students who do home stays. Addition of environmental education programs using renewable energy to home stay programs, therefore, is expected to help raise global awareness about use of renewable energy.

For these reasons, we believe that this project is meaningful because it significantly contributes to achieving Goal 4 (Quality Education), Goal 7 (Affordable and Clean Energy), Goal 11 (Sustainable Cities and Communities), Goal 13 (Climate Action), and Goal 17 (Partnerships for the Goals) of the SDGs. This section, thus, discusses similar projects previously conducted and the future policies on carrying out this project.

5.4.1 Similar projects previously conducted

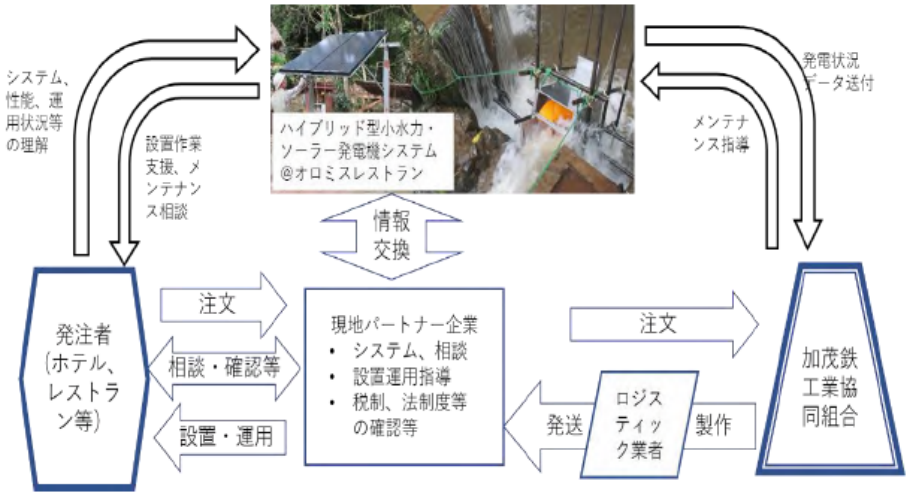
1) Survey on electricity supply with a spiral-type micro-hydroelectric power generator in Cambodia (Japan International Cooperation Agency (JICA), January of 2018)[16]

According to the report on survey results, issues regarding development of Senmonorom, the

[16] https://openjicareport.jica.go.jp/pdf/12303285.pdf

capital of the province of Mondulkiri, Cambodia, are chronic power shortages and non-electrified villages with no connection to electricity lines. Most of the areas far from the urban areas and mountainous villages where ethnic minorities live have not been electrified while electricity supplied through the electricity network is expanding in Senmonorom, and the issue was how to deliver electricity to such rural areas. The survey was performed in hopes of making contributions to regional industries through electricity supply using such renewable energy sources as micro hydropower, including not only improvement in the quality of life through installation of lights, but promotion of local industries, such as coffee and pepper, promotion of ecotourism propelled forward by the city of Senmonorom, and expansion of employment related to the electricity industry.

In the survey, the Kamo Iron Industries Cooperative Association and the Kamo Chamber of Commerce and Industry cooperated with each other in organizing “Tech x Tech KAMO,” and a project of developing and verifying micro hydropower generators is conducted with the aim of establishing a regional-distribution energy supply system shown in **Figure5-9** in collaboration with Ishikawa Prefectural University (the structure of the project implementation: **Figure5-8**).



Source: above cited survey

Figure5-8　Diagram of the Project Implementation Structure

Source: above cited survey

Figure5-9　Decentralized Energy Supply System

The survey employed spiral-type micro-hydropower generators as a hydropower generation technology (**Figure5-10**). The power generation equipment actually adopted was an upgraded version hybridized with solar power generation equipment, and has the following characteristics:

1) Capability of generating electricity more effectively even at a low head and low water volume than other companies' products

2) Spiral-shaped blades that let garbage easily flow down and allow easy maintenance

3) Excellent portability thanks to the light weight of 100 kg or less, and no need of large-scale installation works

4) Capability to generate electricity day and night, and regardless of whether it is a dry season or a rainy season, thanks to hybridization with solar power

	
Spiral-type micro-hydropower facility	Installed solar power generation facility

Source: above cited survey

Figure5-10　Power Generation Equipment Installed

The results report states that the total cost including the costs of shipping and installation works is 1,240,000 yen and it requires over 30 years to recoup the investment while the actual amount of electricity produced is 1.085 kWh per day for micro-hydropower generation and 0.306 kWh per day for solar power generation, which amounts to 1.391 kWh per day in total. On the other hand, the report mentions that potential effects brought about through the project include promotion of ecotourism for environmentally conscious tourists and resultant expansion of the local economy.

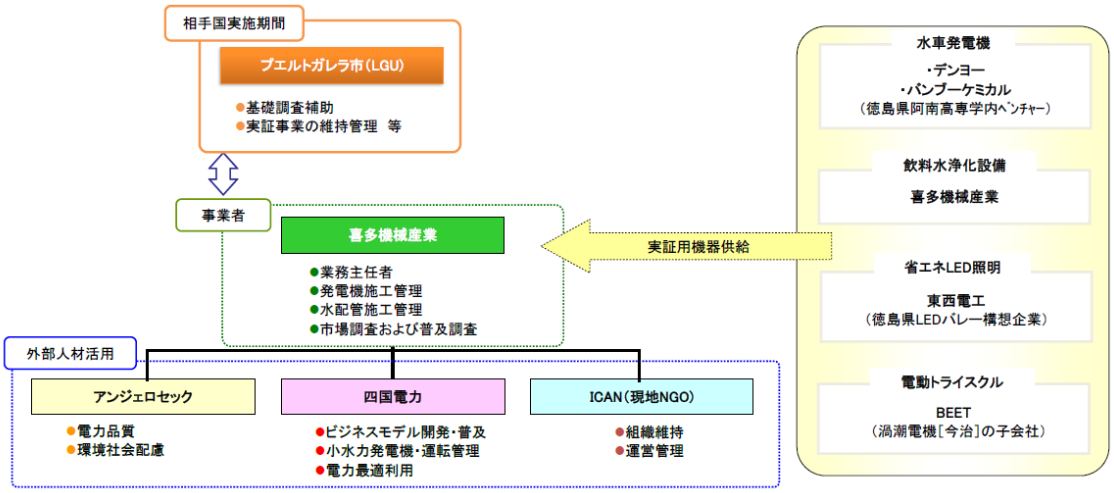
2)Pilot Survey for Disseminating Small and Medium Enterprises Technologies for Developing Non-Electrified Community by Using Micro Hydro Power [17] (Japan International Cooperation Agency (JICA), June of 2016)

According to the results report of the pilot survey, the Philippines have high mountain districts and abundant rainfalls, which are geographically and climatically excellent for hydropower generation, and with the Province of Oriental Mindoro set as a model site, the project was intended to develop the community with the aim of improving the sanitary and traffic environments and promoting tourism there by delivering electricity to non-electrified areas through adoption of micro hydropower generation, supplying drinking water to the model site that has no water supply service using surplus electricity, and installing lighting facilities and introducing low-emission electric transportation equipment in tourist spots.

In order to attain the aforementioned objectives, the project adopted a small-scale drinking water purification system, energy-saving LED lights, and electric tricycles, in addition to micro-hydropower generators (2 units) and conducted a verification project including effective use of energy on the demand side.

KITAKIKAI SANGYOU took a pivotal role in the project in cooperation with the Chugoku Electric Power Company, Incorporated, International Children's Action Network (ICAN), and INGÉROSEC Corporation, and purchased equipment from various suppliers and carried out the project (**Figure5-11**).

[17] https://openjicareport.jica.go.jp/pdf/12261830.pdf



Source: above cited survey

Figure5-11 Diagram of the Project Implementation Structure

The products adopted in the project and their characteristics are as follows according to the report on the results of the pilot survey, and their photographs are given in **Figure5-12**:

1) Micro-hydropower generator made by a venture company of the National Institute of Technology, Anan College

This is a horizontal-axis, propeller water turbine with a capacity of 1 kW, and can generate electricity with the propeller turbine set under running water. It can be installed easily because it produces power at a low head and a low flow rate and does not require civil engineering works for installation in most cases. It costs around 3,500,000 yen.

2) Micro hydropower generator made by Denyo Co., Ltd.

This is a crossflow water turbine with a capacity of 5 kW and can be adopted for a low flow rate (0.02 to 0.04 m^3/s) and a medium head (10 to 30 m). Its power generation system can be composed of such components as the main unit, a water tank, and a vinyl chloride conduit, and it costs about 3,000,000 yen, which is less expensive than products with equivalent specifications.

3) Small-scale drinking water purification system made by KITAKIKAI SANGYOU

This is a rapid-filtration water purification device and capable of purifying 5 liters of water per minute. It can be used for a long period of time because it comes with a function of cleaning the filter medium. It costs approximately 2,200,000 yen.

4) Energy-saving LED light made by Tozai Electric Industry Co., Ltd.

This light has a long service life of 60,000 hours (about 16 years) and consumes about 75% less

energy than regular mercury lamps. It costs approximately 330,000 yen for 10 units of such products as spotlights, streetlights, and security lights.

5) Electric tricycle made by BEMAC Corporation

This is an electric three-wheeled vehicle with a riding capacity of 6 people. It is strong enough to withstand rough roads and can travel a long distance. It costs about 2,350,000 yen.

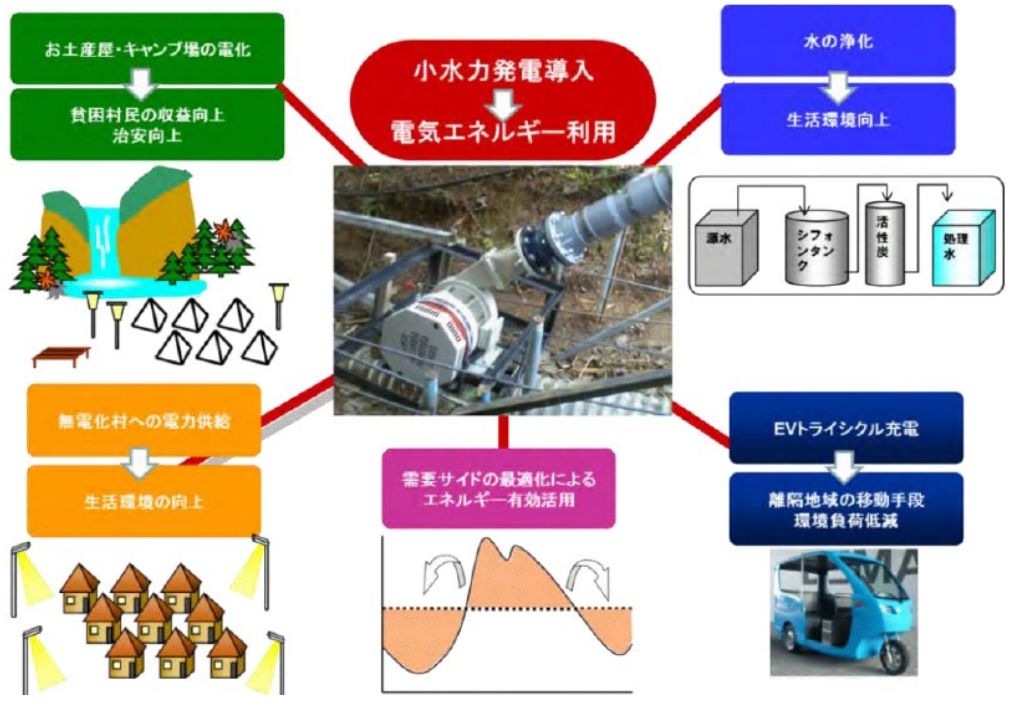
	
Small hydropower turbine made by Anan college of technology	Small hydropower turbine made by Denyo Corporation
	
Drinking water purification system by Kitakikai Sangyo Corporation	Energy saving LED light by Tozai Denko Corporation

Electrical tricycle by BEMAC Corporation

Source: above cited survey

Figure5-12　Products Adopted

As just described, the project is characterized by its aim of disseminating SME technologies and developing non-electrified communities through a proposal of a unified system (**Figure5-13**), for the purpose of settling local issues, including the user side of electricity generated, and verifying it.

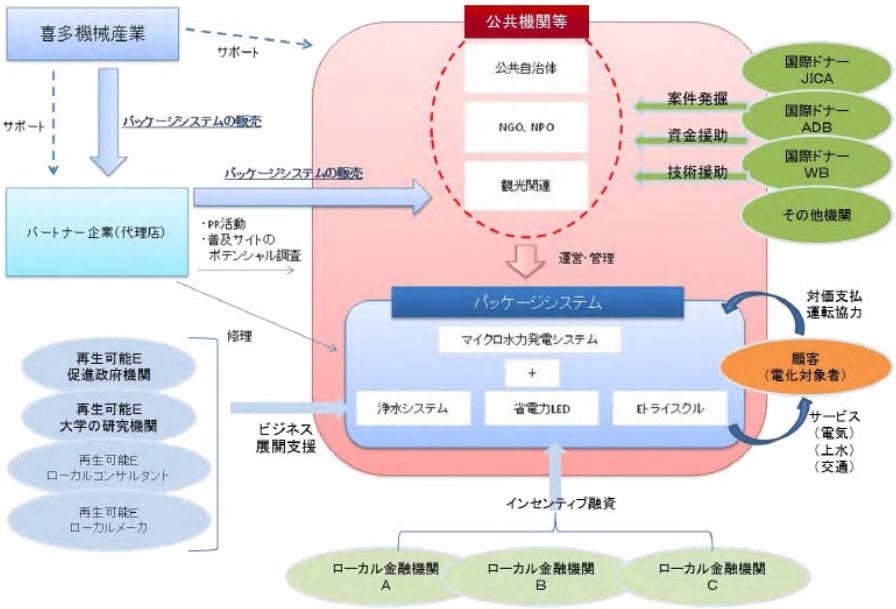


Source: above cited survey

Figure5-13　Schematic Diagram of Adoption of the Packaged System Proposed in the Project

Furthermore, the model shown in **Figure5-14** was proposed for transforming it into a business, including financing by international fund providers, such as JICA, the Asian Development Bank

(ADB), and the World Bank.



Source: above cited survey

Figure5-14　Business Model Proposed in the Project

5.4.2　Policies on project implementation

Taking into account the characteristics of the previous projects given in the above section, the following points will be issues to be solved for realization of our electrification project using renewable energy in the village of Kobuni:

・Adoption of a system capable of generating electricity at a low flow rate and a low head, and development of power generation equipment

・Easiness of works and construction related to installation of power generation equipment

・Easy maintenance

・Proposal for a system including how to use electricity produced

・Promotional activities in collaboration with local industries and products

・Promotion of the project while involving local residents and companies

Given these points, from the next fiscal year onward, we will strive to develop a project aimed at resolving other issues than the issue of local electricity supply in cooperation with Toyama University of International Studies (TUINS), a university located in Toyama City and focuses on promoting renewable energy sources, such as micro-hydropower. Specifically, as shown in **Figure5-15**, we will aim to install power generation equipment in fiscal year 2024 by discussing places to use electricity generated in order to settle local issues, promotional activities including development of environmental education programs, and how to adopt power generation equipment

to other areas while focusing on expanding use of such renewable energy sources as micro-hydropower and solar power.

In an effort to launch the project in or after the next fiscal year, we held a workshop on March 2, 2022 together with Kobuni Village, which two people from TUINS attended (see Chapter 6 for details). The people from TUINS presented the details of the international cooperation program held at the university in the past and we shared the policies on conducting the project in the next fiscal year or coming fiscal years, through which we have confirmed that the local parties concerned is in agreement on the project.

Figure5-15　Schematic Diagram of Implementation of the Project

Chapter 6. City-to-City collaboration Activities

6.1 Overview of the City-to-City collaboration activities

The overview of the City-to-City collaboration activities in the project carried out this fiscal year is as shown in **Table6-1**. This fiscal year, as we were unable to visit the actual places for field surveys and interviews due to the COVID-19 pandemic, we conducted all the collaborative activities with the local municipality, related organizations, and relevant companies via the Internet.

Table6-1 Overview of the City-to-City collaboration Activities

Event date	Participants (Project proponents)	Related topic	Agenda
September 6, 2021	OECC, JGC, JANUS	Biofuel	Interview about the credit system
September 6, 2021	Kobuni Village, JANUS	Electrification	Interview about power usage
September 13, 2021	Kota Kinabalu City, JANUS	Solar power	Interview about candidate sites for solar power generation
October 18, 2021	Malaysian Embassy, Toyama City, JANUS	Common	Introduction of to-City Collaboration Project, cooperation request
October 22, 2021	Kobuni Village, JANUS	Electrification	Discussions on power usage and renewable energy potential
October 25, 2021	SESB, JANUS	Small hydropower	Discussion on how to proceed with business this year
November 10, 2021	Kota Kinabalu City, JANUS	Solar power	Interview about candidate sites for solar power generation
November 15, 2021	IRDA, JANUS	Biofuel	Interview about the progress of the BRT plan
November 30, 2021	Kobuni Village, JANUS	Electrification	Introduction of precedent cases regarding renewable energy electrification
December 6, 2021- December 7, 2021	SESB, HIS, JANUS	Small hydropower	Online field survey
December 9, 2021	IRDA, Kota Kinabalu City, Kobuni Village, SESB, Toyama City, JANUS	Common	Online tour (Toyama)
December 13, 2021	IRDA, NEUTO, JANUS	Biofuel	Discussion on policies for realization of decarbonized public transportation, introduction of hydrogen utilization technology
December 20, 2021	FGV, JANUS	Biofuel	Introduction of biofuel utilization project

Event date	Participants (Project proponents)	Related topic	Agenda
January 27, 2022	SESB, Energy Commission, JANUS	Renewable energy	Interview of policies and systems related to renewable energy business
February 17, 2022	IRDA, Kota Kinabalu City, Toyama City, Nihonkucho Hokuriku, Hokuden, Hokuden Engineering Consultants, JANUS	Common	Workshop
February 17, 2022	Kota Kinabalu City, IRDA, Toyama City, Nihonkucho Hokuriku, Hokuden, Hokuden Engineering Consultants, JANUS	Common	Workshop
March 2, 2022	Kota Kinabalu City, Kobuni Village, Toyama City, Toyama University of International Studies, JANUS	Electrification	Workshop

6.2 Seminars

As mentioned above, following the second year of the project, we were unable to travel to the site due to the influence of the new coronavirus, so we held online workshop seminars with each of the Iskandar region and Kota Kinabalu city as follows

6.2.1 Workshop seminar with the IRDA (February 17, 2022)

The minutes of the workshop are summarized in **Table6-2**.

Table6-2 Summary of the Minutes of the Workshop Seminar with the IRDA

Date	Thursday, February 17, 2020 from 15:00 to 17:00	
Plac	Web conference (ZOOM)	
Attendees	Malaysia	IRDA, Neuto group
	Japan	Toyama city, Hokusan, Hokuden Engineering Consulting, Nihonkucho Hokuriku, JANUS

Contents of proceedings	**1. Opening Remarks** In the opening remarks, Mr. Kobayashi, Project Director of the Environmental Policy Division of Toyama City, introduced the background of the city-to-city cooperation project, Toyama City's Zero Carbon City Declaration, and Japan's 2050 Carbon Neutral Declaration. **2. Special Remarks** As opening greetings, Mr. IRDA Rudy Azhar mentioned the intention to continue the survey and to materialize the project in 2024, and the request from Toyama City to pass on know-how including not only the hardware aspect but also the software aspect (auality of life improvement etc.). **3. Study Report** Yamase of Japan NUS Co., Ltd. explained the survey results and cooperation requests for FY2021. Q&As are described below. ・ IRDA Kamisah Mohd Ghazali) Both Curitiba and Bogotá have been benchmarks since 2009 when we started considering the introduction of BRT at IRDA. I have had many interviews with the mayor of Bogotá. I've always seen TransMilenio as a success story. And these projects have been referred to in Malaysia Transportation Blueprint as well. (Reference: Comments in the chat section) Great! Curitiba and Bogota have been our benchmarking cities when we conceptualize BRT in 2009. We met the man behind the successful BRT system in Bogota --the then Mayor Mr Enrique Penalosa. The model of TransMilenio is also also the basis of our business model for BRT (refer to Iskandar Malaysia Transportation Blueprint 2010-2030.)

4. Technology introduction

M. Andy Low of Neuto group introduced the hydrogen related project.

- IRDA Kamisah Mohd Ghazali) Are there any data or references available on the performance of the NEUTO H2 EEV in commercial vehicles? (How is the performance of the NEUTO H2EEV on commercial vehicles, any report for reference?)
- Hamizah) How does hydrogen decarbonize the engine? Are there any by-products or waste generated in this process? (How does the hydrogen decarbonized the engine? is there any by product or waste generated from this process?)

* The above question will be answered by Mr. Andy Low at a later date.

Mr. Kurokawa of Hokusan introduced a hydrogen-related project.

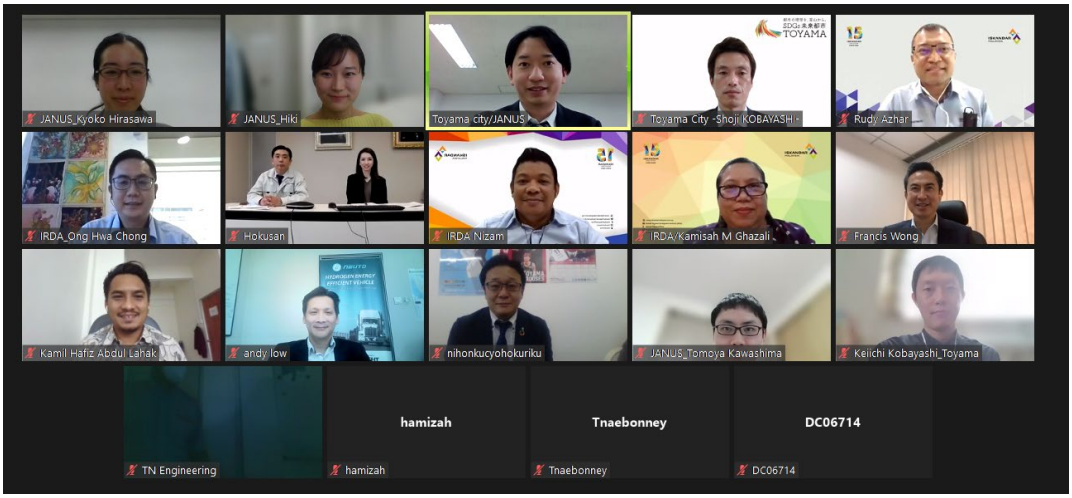
5. Comments and Discussion

- IRDA Ong Hva Chong) What are your thoughts on the next steps in this study? → JANUS Yamase) Regarding biofuels, we will consider industrial use in the future. After introducing the electric bus, I would like to combine the remaining 270 buses with Neuto and Hokusan technologies.

- IRDA Ong Hva Chong) What do you think about the availability of hydrogen? → JANUS Yamase) It is necessary to consider which technology is suitable in the future. Since "Simple Fuel" is a compact device, it does not require a large-scale infrastructure, and we believe that it is easy to consider economic efficiency. → Mr. Kurokawa, Kita Acid) I think it is better to install it in each area, taking advantage of its self-supporting and compact characteristics.

- JANUS Yamase) Is the introduction of hydrogen in Iskandar under consideration? → IRDA Ong Hva Chong) There is no specific policy regarding hydrogen. The Malaysian central government is making rules, but it will be completed after 2030. We are also in talks with a bus operator to introduce Neuto's technology. I think it is a very useful technology if the understanding of the bus operator is obtained.

- IRDA Nizam) One of the means to reduce the amount of diesel used is the introduction of electric buses. However, the introduction cost of electric buses is very high, and we plan to introduce them in stages over eight years. Technologies other than electric buses are welcome as long as they can achieve decarbonization. Please tell us how to cover supply and utilization in all technologies. I would like to deepen my understanding of hydrogen, Neuto, and Hokusan technologies. → JANUS Yamase) As you pointed out, infrastructure development is an issue. In order to solve this problem, we would like to first consider measures to widely

	spread biofuels. At the same time, we would like to consider hydrogen-related technologies. **6. Closing** Closing remarks were given by Mr. Kobayashi, Project Director of the Environmental Policy Division, Toyama City.
Photo	

6.2.2 Workshop seminar with Kota Kinabalu (February 17, 2022)

The minutes of the workshop are summarized in **Table6-3**.

Table6-3 Summary of the Minutes of the Workshop Seminar with Kota Kinabalu

Date	Thursday, February 17, 2022 10: 00-12: 10	
Plac	Web conference (ZOOM)	
Attendees	Malaysia	Kota Kinabalu City Hall, SESB
	Japan	Toyama city, Hokusan, Hokuden Engineering Consultants, Nihonkucho Hokuriku, JANUS
Agenda	1. Opening Remarks-Toyama City 2. Special Remarks-IRDA 3. Study Report 4. Initiatives Introduction 5. Comments and Discussion 6. Closing	

Agenda	**1. Opening Remarks** In the opening remarks, Mr. Kobayashi, Project Director of the Environmental Policy Division of Toyama City, introduced the background of cooperation with Kota Kinabalu City, Toyama City's Zero Carbon City Declaration, and Japan's 2050 Carbon Neutral Declaration. **2. Special Remarks** In a speech made by Mr. Jack Lo of Kota Kinabalu City Hall, intention to utilize Kota Kinabalu's renewable energy resources (wind power, hydropower, solar power) and expectations for horizontal expansion to other regions of Sabah were mentioned. **3. Study Report** Yamase of Japan NUS Co., Ltd. introduced the survey results for the FY2021. Q&As are described below. ・ Mr. Jack Lo, Kota Kinabalu City) I understand that the cost calculated this time is the introduction cost, but how much is the maintenance cost? → JANUS Yamase) No large-scale maintenance would be required for this power generation scale. About 10 years after the introduction, it costs about 100,000 yen to replace the equipment. ・ Mr. Jack Lo, Kota Kinabalu City) The building in Kota Kinabalu City is old, and it is necessary to consider the weight of the equipment in the future. → JANUS Yamase) The building currently under consideration is relatively new, but we will pay attention to the weight of the equipment and the durability of the building in the future. ・ Mr. Jack Lo, Kota Kinabalu City) Is it possible to relocate solar panels if the Kota Kinabalu City Hall is rebuilt? → Nihon Kucho Hokuriku Yoshino) It is possible to relocate, but it costs money to remove and relocate.

4. Initiatives Introduction

SESB Terrence Kouju introduced his commitment to decarbonization as SESB. Q&As are described below.

- Mr. Jack Lo, Kota Kinabalu City) What are the merits of the SELCO project introduced after 2017? → SESB Terrence Kouju) Installing solar power generation for private power generation has the advantage of being able to purchase power at a lower cost than grit connection. It is not a subsidies system.

- Mr. Jack Lo, Kota Kinabalu City) Why is the introduction rate of solar power generation limited to 20%? → SESB Terrence Kouju) It is important to maintain a balance between supply and demand for electric power. Since sunlight is unstable and uncontrollable, other power generation technologies need to be introduced. When the ratio of solar power generation was calculated, it was 20%. In addition to stable hydropower, it can also be controlled according to demand. Biomass varies depending on the nature of the raw material.

- Mr. Jack Lo, Kota Kinabalu City) What is the factor for the low emission factor in Sarawak and the high emission factor in the Malay Peninsula? → SESB Terrence Kouju) This is the difference due to the energy mix. Half of the Malay Peninsula is coal-fired and the rest is hydro and gas-fired. On the other hand, Sarawak has 80% hydropower.

- Mr. Jack Lo, Kota Kinabalu City) I would like to know about the licensing procedure when installing solar power generation equipment at Kota Kinabalu City Hall. → SESB Terrence Kouju) If you contact SESB, we will respond. We will provide guidelines later. You also need to apply to the Energy Committee.

- JANUS Hirasawa) Before proceeding to the licensing procedure, let's complete the survey in the city-to-city cooperation project. → Mr. Jack Lo, Kota Kinabalu City) Please note that a new permit may be required if an EPC contractor from Japan is planned.

5. Comments and Discussion

- JANUS Yamase) I would like to confirm the intention to introduce solar power generation equipment to Kota Kinabalu City Hall. Also, what do you think about the introduction to school roofs? → Mr. Jack Lo, Kota Kinabalu City) The introduction to

Kota Kinabalu City Hall is attractive, but the problem is that the initial investment is high. I want to get a subsidy from the government. Also, the building is old and there are concerns about its stability. When applying for a subsidy to the government, the possibility of relocation is likely to be pointed out, so I asked the previous question. For the two potential sites other than the city hall, large amounts of power generation are expected, and I feel that further investigation could be carried out. In addition, the wastewater treatment facility consumes a large amount of electricity, and there are no problems with the durability and installation area of the building, so I think it should be a candidate. → JANUS Yamase) Kota Kinabalu City Hall is too small to apply the JCM equipment subsidy project. If you have introduced the idea of a small hydroelectric power plant, there is a possibility that the Japanese government can subsidize it by 50%. I would like to consider it in the future.

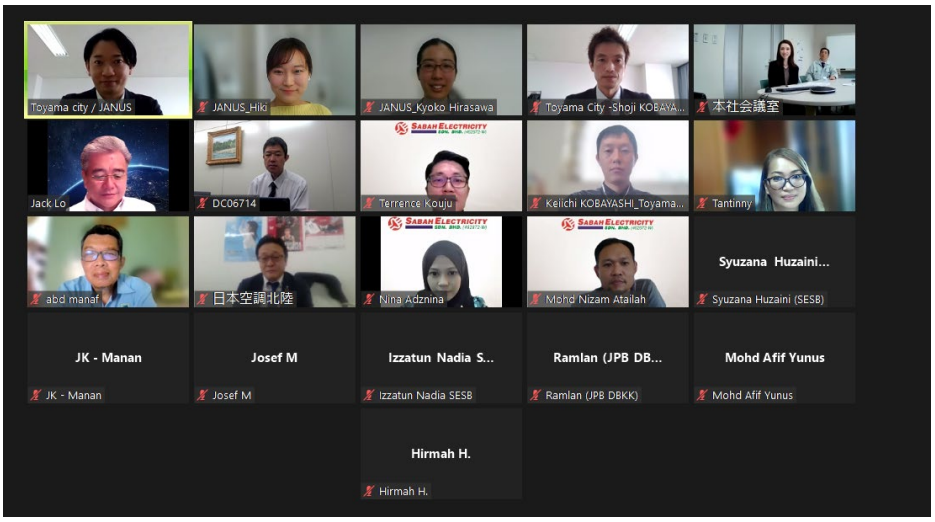
- Hokuden Technology Consulting) Is it possible to provide materials such as drawings of small hydroelectric power plants? → SESB Terrence Kouju) It is a fairly old plant, and it is difficult to provide drawings. Is it possible to proceed with the investigation as it is? → Hokuden Technology Consultant) Personally, I have a track record of being in charge of projects in other regions such as Vietnam and Laos, and I am very interested in it, so I would love to cooperate.

- Mr. Yoshino, Nihonkucho Hokuriku) I feel that the wastewater treatment plant in Kota Kinabalu has high potential. It is very encouraging to have SESB support for the introduction of solar power generation equipment. We would like to continue discussions with the SESB regarding the calculation of initial costs.

6. Closing

Closing remarks were given by Mr. Kobayashi, Project Director of Environmental Policy Division, Toyama City, and Mr. Jack Lo, Kota Kinabalu City.

Mr. Jack Lo of Kota Kinabalu City shared his hopes that this survey would serve as a model case and encourage other projects to proceed with the project.

Photo	

6. 3 Online tour

In this fiscal year's project as well, due to the impact of the new coronavirus, it was difficult to accept local officials from Japan, which had been implemented in the previous intercity collaboration project. On the other hand, because there was a request to observe the activities related to decarbonization of Toyama City, HIS, a major travel agency, planned the organization of a virtual tour that expanded the service triggered by the Corona disaster, and Japan NUS and Toyama City. The tour was held online on December 9, 2021 for 5 cities in 3 countries. On the day of the event, we introduced the environmental technology of Toyama City using videos taken in advance according to the timetable shown in**Table6-4** and exchanged opinions on each theme (**Figure6-1**). **Table6-5** summarizes the attendees and opinions from Malaysia. We were able to have lively discussions not only on renewable energies such as small hydropower and solar power, but also on hydrogen and waste

Table6-4 Timetable of the Online Tour

Japan time	Contents	Speaker
16:00	Explanation of the purpose of the event	JANUS
16:10	Greetings from the Ministry of the Environment	Ms. Inoue, International Cooperation and Environmental Infrastructure Strategy Office, International Cooperation Division, Ministry of the Environment
16:15	Opening remarks (VTR)	Mayor Fujii, Toyama City
16:20	To Achieve global Carbon Neutrality --International Cooperation (VTR)	
16:30	Introducing LRT (VTR)	
16:35	Q & A	Everyone
16:45	Introduction of solar power plant and supply effluent sanitary equipment construction site (Nihonkucho Hokuriku Co., Ltd.) (VTR)	
16:50	Q & A	Everyone
17:00	Introduction of hydrogen station (Hokusan Co., Ltd.) (VTR)	
17:05	Q & A	All
17:15	Introduction of small hydroelectric power plants (Tsunenishi Park, Higashimachi / Higashimachi Public Hall small hydroelectric power plants) (VTR)	
17:20	Q & A	All
17:30	Introduction of food recycling equipment (Toyama Green Food Recycle Co., Ltd.)	
17:35	Q & A	All
17:45	Comments from each region	Participants in each region (Male, Bali, Semarang, Iskandar, Kota Kinabalu)
18:00	Closing remarks	Toyama City Environment Department Environmental Policy Divisio, Project Director, Mr. Kobayashi

Table6-5　Summary of the Participants from Malaysia and Opinions Exchanged

Participants (honorific titles omitted)	
IRDA	Ong Hwa Chong, Muhanmad Nizam
Kota Kinabalu City Hall	Jack Lo, Linda Manahan, Tantinny Fung, Fauzaahton ag samad
Kobuni Village	Emalia Rabin
SESB	Adznina Eberahim, Mohd Afif Bin Yunus, Terrence Kouju
Borneo Organization	Boyd D jouman

Summary of opinions from Malaysian participants

■ LRT

・ What is Toyama City's policy for introducing LRT? When introducing it to Malaysia, I feel that it is difficult to combine it with existing means of transportation such as automobiles because there is no policy. What kind of policy would be appropriate if it could be incorporated into Malaysia? Please tell us about the introduction results in Malaysia. (IRDA)
→ Toyama City has a compact city policy and aims to increase the population by revitalizing public transportation. We are taking policy measures in anticipation of the issues facing Toyama City's aging population and declining population. (Toyama City)

・ What is the price of the share cycle? Also, who runs it? (IRDA)
→ If you use it within 30 minutes, you can use it only with a registration fee of 500 yen a month, and it is operated by a private project. Toyama City provides subsidies for the maintenance of hardware (installation of cycle stations) to provide lateral support. (Toyama City)

■ Solar power

・ When installing solar panels, is there a standard for the installation location, and in the case of roof-mounted sunlight, how much area is required for installation? How much is the price? (IRDA)
→ There is no problem with the location as long as the sun is shining. Many places are installed on the roofs and vacant lots of buildings. Also, it is better that the place where electricity is used is near. Since there are various sizes, it is considered possible to handle it. Prices also change depending on the location, so we would appreciate it if you could provide information on the installation location. (Nihonkucho Hokuriku)

・ Even in Malaysia, there are some spare places on the premises, so I would be grateful if we could utilize it in that way. (IRDA)

■ Hydrogen station

- Malaysia is currently implementing a project to utilize hydrogen as fuel for automobiles, but it is not being utilized in Malaysia due to the problem that the equipment for filling becomes large. Was the use of hydrogen in Toyama City subsidized by the government? (Kota Kinabalu City)

  → The hydrogen station was installed with the assistance of the hydrogen station Toyama METI and Toyama City, and the hydrogen station derived from renewable energy (H2OneST unit) was installed with the assistance of MOE and Toyama City. (North acid)
- Are there any safety issues when using hydrogen? (IRDA)

  → In Japan, there is the High Pressure Gas Safety Act, which is installed in accordance with it. The law is very strict and maintenance is carried out once every three days to ensure safety.

■ Small hydropower

- What is the price of electricity generated from small hydropower facilities when FIT is introduced? (SESB)

  → Approximately 0.30 USD / kWh (JANUS)
- A flow of water is required when introducing hydroelectric power generation equipment. There is a place where water springs up and flows into the land. In that case, is it possible to introduce a hydroelectric power generation facility by doing some construction work? Water is originally flowing out from a high place, and we plan to carry out agriculture in the surrounding area. (IRDA)

  → The requirements for hydroelectric power generation are determined by multiplying the head x flow rate x gravitational acceleration. Therefore, it is considered possible to install it by carrying out civil engineering work and creating a head. Design appropriately according to the situation of the site. Agriculture using irrigation canals is also popular in Toyama City, so I would like to introduce an example. It is a theme that also leads to the target of SDGs. (JANUS)

■ Food recycling equipment

- Are there any examples of utilizing gas generated from sewage? (Kota Kinabalu City)

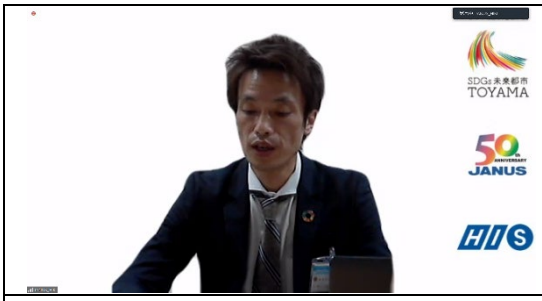
  → There is an example of using gas from sewage to generate electricity at a sewage treatment plant in Toyama City. (Toyama City)

■ summary

- An intercity collaboration project with Toyama City has been implemented since 2020. He introduced various low-carbon technologies and is currently focusing on the bus (BRT)

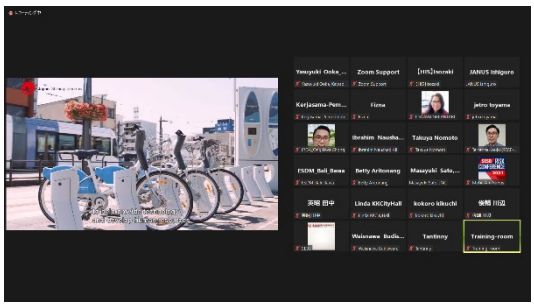
remodeling project. There is a policy in IRDA, but it is difficult to realize the policy, so I would like to refer to the policy of Toyama City. I was also very interested in small hydropower plants. Currently, we want to turn 310 acres of land into an agricultural area, and we would like to consider a system that combines agricultural water and small hydropower. Today's online tour was very helpful. (IRDA)

- The mayor of Kota Kinabalu is also proud of the intercity collaboration project. Kota Kinabalu is included in Sabah, but since Sabah has abundant water and long hours of sunshine, we would like to utilize natural resources to promote the spread of renewable energy. (Kota Kinabalu City)



Opening remarks by Toyama City Project Director, Mr. Kobayashi

Greetings from Mayor Fujii of Toyama City



During the movie screening

Members on the day

Figure6-1　Pictures of the Online Tour

Chapter 7. Conclusions

7. 1 Outcomes of the City-to-City collaboration project this fiscal year

In the City-to-City collaboration project this fiscal year, although we could not conduct field surveys due to the spread of COVID-19, we successfully collected information needed for transforming the project into a business based on the Joint Credit Mechanism (JCM) as we expected using such tools as online meetings. What we have achieved, including these results, are summarized in **Table7-1**.

Table7-1 Summary of the Achievements in the City-to-City Collaboration Project This Fiscal Year

Project	Outcome
Decarbonized transportation system using biofuel	・ To expand the biofuel supply site, palm factories near the Iskandar area and Kota Kinabalu city have been identified and potential amount have been surveyed. ・ Palm oil manufacturers have been contacted toward realization of the biofuel supply project. ・ Technical study on biofuel supply equipment and transportation equipment, and refined equipment costs and operating costs has been conducted. ・ Regarding biofuel use in the BRT system, lobbying of locals toward fuel conversion has been performed based on the understanding of the benefits of implementing such as project. ・ To realize the biofuel utilization project, multiple business schemes, including the utilization of voluntary credit have been considered. ・ After investigating precedent cases regarding the introduction of public transportation (BRT), the contents and issues were shared at the workshop.
Renewable energy promotion project centered on small hydropower generation and solar power generation	・ Candidate sites for small hydropower generation have been identified/ ・ An online field survey was conducted to understand the cause of the decrease in capacity factor. ・ From the results of the online field survey and literature survey, the factors and issues of the decrease in capacity factor were extracted, and the solutions to the problems were considered from both the hardware and software aspects. ・ Institutional and regulatory issues related to the project of renewable energy have been identified. ・ Potential sites for solar power generation have been identified in public facilities, and panel installation drawings and estimation of power generation have been performed.
Electrification project in non-electrified areas utilizing renewable	・ Power usage issues in Kobuni Village have been identified and information on basic information such as power usage have been collected.

energy	・ Future action line was organized from the precedent cases related to the electrification project in non-electrified areas.
City-to-City collaboration activities	・ At the workshop, efforts and policies of Toyama City have been presented. ・ Through an online tour of Toyama City, efforts of Toyama City and companies in the city have been shared.

7. 2 Policies on the City-to-City collaboration project next fiscal year

■ Biofuel-based decarbonized public transportation sector

We successfully found sites with significant potential for palm oil factories regarding biofuel supply in the project this fiscal year. Meanwhile, with regard to the use of biofuel, the IRDA intends to decarbonize the transportation sector mainly by utilizing electric buses for the bus rapid transit (BRT) for the time being, and it is obviously required to develop infrastructure necessary for using biofuel while encouraging biofuel use in other sectors than the transportation sector. In addition, at the moment, an agreement for the JCM has not been concluded yet with Malaysia, and several biofuel production projects using voluntary credits were conducted in the past, which means that we can clearly discuss some business schemes besides utilization of the JCM equipment assistance program.

Given these circumstances, in our project, we will begin with discovering places to use biofuel in industrial fields on a priority basis in order to realize decarbonized transport systems in the next fiscal year or coming fiscal years as shown in **Figure7-1**. Furthermore, we have forged relationships with all the relevant stakeholders, and we will continue our approach to going into the business while presenting several business schemes.

At the same time, because the BRT system will be fully adopted in the transportation sector, we will continue our software-related support and push forward with adoption of decarbonized public transport systems by taking advantage of the knowhow in adopting public transport systems that Toyama City has been working on. Furthermore, concerning adopting electric busses as discussed by the IRDA, we will endeavor to realize decarbonized transport systems at a more accelerating rate by proposing decarbonization of electricity needed for electric bus adoption while asking whether it is possible to apply such programs as the JCM equipment assistance program.

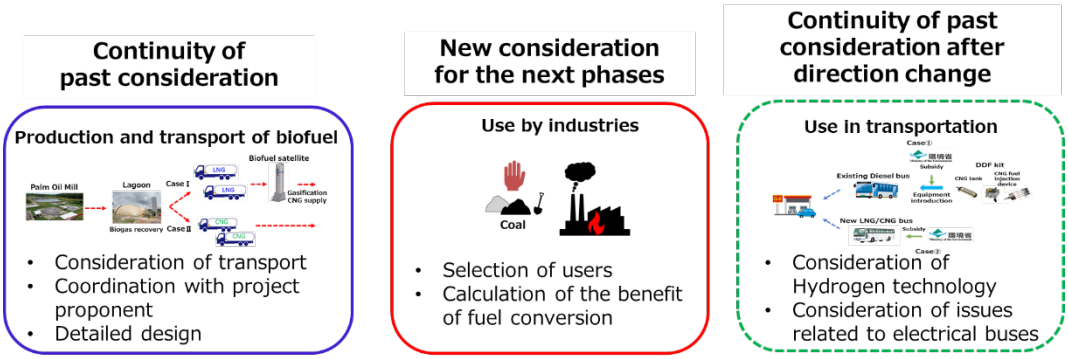


Figure7-1　Policies on Future Discussion

■　Renewable energy field centering on micro hydropower and solar power generation

In the project this fiscal year, we obtained information that are more detailed than ever before regarding micro hydropower by conducting online field surveys after selecting places to discuss on a priority basis; however, it is essential to conduct field surveys by actually vising the places for full design of power generation equipment. We will perform field surveys while sharing and discussing various matters, including the achievements in the project this fiscal year, with SESB for the next fiscal year, and crystalize and design a rehabilitation plan. In addition, we will discuss whether or not the JCM program can be applied to the project to newly build micro hydropower generation equipment discussed by SESB.

With regard to solar power generation, it has been indicated that installation of solar panels on the roof of the city hall in Kota Kinabalu will bring cost benefits to a certain extent, and we plan to create a more detailed engineering design through field surveys as required while grasping such information as in-detail electricity use situation (demand curve). Furthermore, in order to utilize the JCM equipment assistance program, we will suggest to local parties concerned that they develop business by coming up with new business models in combination with equipment that will help resolve local issues from the perspective of decarbonization and the SDGs because the project to adopt the power generation equipment only is considerably small in scale.

■　Field of electrifying non-electrified areas using renewable energy

The following points will be issues toward realization of the electrification project using renewable energy in Kobuni Village:

・Adoption of a system capable of generating electricity at a low flow rate and a low head, and development of power generation equipment

・Easiness of works and construction related to installation of power generation equipment

・Easy maintenance

・Proposal for systems including how to use electricity generated

・Promotional activities in collaboration with local industries and products

・Promotion of the project by involving local residents and companies

In order to resolve these issues, from the next fiscal year onward, we will strive to develop a project aimed at settling other issues than the issue of local electricity supply in cooperation with Toyama University of International Studies (TUINS), a university located in Toyama City and focuses on promoting renewable energy sources, such as micro hydropower. Specifically, we will aim to install power generation equipment in fiscal year 2024 by discussing places to use electricity generated for settling local issues, promotional activities including development of environmental

education programs, and how to adopt power generation equipment to other areas while focusing on expanding use of such renewable energy sources as micro hydropower and solar power.

■ City-to-City collaboration activities

We successfully crystalized the concept of transforming the project into a business through an event that has never been done before, an online tour of Toyama City targeting local parties concerned, in the project this fiscal year. In addition, besides the project that we are currently discussing, we got opinions that will help develop new decarbonization projects, including utilization of hydrogen and decarbonization of the agricultural sector.

In the next fiscal year, while continuing the approaches that we have taken, we intend to declare a policy statement that follows the zero-carbon city declaration by Toyama City and continuously share our efforts, past knowhow, and achievements, which will help the statement take shape, with local parties concerned