FY2018 Project for Ministry of the Environment Japan

FY2018
City-to-City Collaboration Programme for Low-carbon Society

City-to-City Collaboration between Yangon and Kawasaki
(Utilization of Energy and Energy Saving in Fruits and Vegetables Wholesale Market)

Report

February 2019

Nippon Koei Co., Ltd.
Kawasaki City
Hitachi Zosen Corporation

FY2018
City-to-City Collaboration Programme for Low-carbon Society
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(Utilization of Energy and Energy Saving in Fruits and Vegetables Wholesale Market)

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Abbreviations

Abbreviation	Definition
BEMS	Building Energy Management System
CAPEX	Capital Expenditure
COP	Conference of Parties
EPC	Engineering, Procurement and Construction
GHG	Greenhouse Gases
FS	Feasibility Study
FY	Fiscal Year
IRR	Internal Rate of Return
JCM	Joint Crediting Mechanism
JICA	Japan International Cooperation Agency
MAEX	Myanmar Agro Exchange Public Ltd.
MCCSAP	Myanmar Climate Change Strategy and Action Plan
MMK	Myanmar Kyat
MOU	Memorandum of Understanding
MRV	Monitoring, Reporting and Verification
NAPA	National Adaptation Programmes of Action
NSDS	National Sustainable Development Strategy
PCCD	Pollution Control and Cleaning Department
USD	United States Dollars
UNFCCC	United Nations Framework Convention on Climate Change
WTM	Water-needless Two-phase Methanation System
YCDC	Yangon City Development Committee

CHAPTER 1 BACKGROUND AND PURPOSE

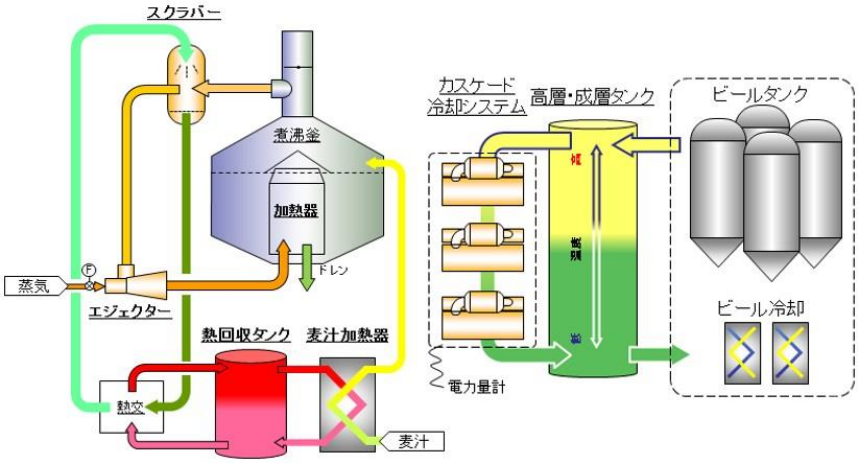
1.1 BACKGROUND

In December 2015, all countries participated in 21st Conference of the Parties (COP21) in Paris, France. The COP21 Paris Agreement was adopted as the legal framework of fair and practical countermeasures to combat climate change after 2020. Paris Agreement aims at keeping global warming below 2 degrees Celsius above pre-industrial level, Also, it requires efforts to keep below 1.5 degree Celsius by promoting activities for decarbonization. In addition, it was decided that activities by non-state actors including cities and efforts by all non-governmental entities (cities and other local governments etc.) are acknowledged and encouraged to be scaled up in COP21. Cities are the places to support social and economic growth since a lot of people live there. Although the total area of urban areas is only 2% of all land in the world, approximately half of the world's population live in urban areas and the percentage is predicted to increase to 70% by 2050. Also, it is estimated that more than 70% of global CO2 emission emitted from cities as of 2006. Thus, cities have important roles for mitigation of climate change. Thus, implementation of countermeasures to climate change and greenhouse gas (GHG) emission reduction in cities are vital for achievement of goal of Paris Protocol.

Yangon City is the old capital of Republic of the Union of Myanmar and the largest city with population of 5 million. The city is rapidly urbanizing by foreign funds and public development because of recent democratization. While urban development and infrastructure development are proceeding, supply shortage as one of the issues that is arising due to dramatic increase in demand for electricity. A result, importance of saving energy and low-carbon development increased and 'Project for formulation of JCM model project through city-to-city collaboration in Yangon' was implemented through City-to-City Collaboration between Kawasaki City and Yangon City in 2015.

Since the project in FY 2015, collaboration between Yangon City and Kawasaki City has continued and in March 2016, they concluded a Memorandum of Understanding (MOU). Since then, the project of the second year, FY 2016, was implemented with themes of 'Installation of high efficiency once-through boiler to food processing factory' and 'Introduction of Solar PV into Yangon city facility' and 'Introduction of One-through Boiler in food factory' Then, 'Introduction of High-efficiency Pumps into Existing Pumping Station' and 'Low Carbonization of Waste Management' were themes of the project in FY 2017

Attachment 1 presents the chronology of this city-to-city activities. The main achievements of the city-to-city collaboration are shown below.

Output I Conclusion of MOU The MOU between Kawasaki city and Yangon city was concluded on the end of March 2016.	
Output II JCM model project Introduction of saving energy system into Beer factory Estimated GHG emission reduction 2,841 tCO_2/year	
Output III JCM model project Introduction of high efficiency boiler into food factory Estimated GHG emission reduction 674 tCO_2/year	

Source: Nippon Koei

Figure 1-1 Achievements of the city-to-city collaboration

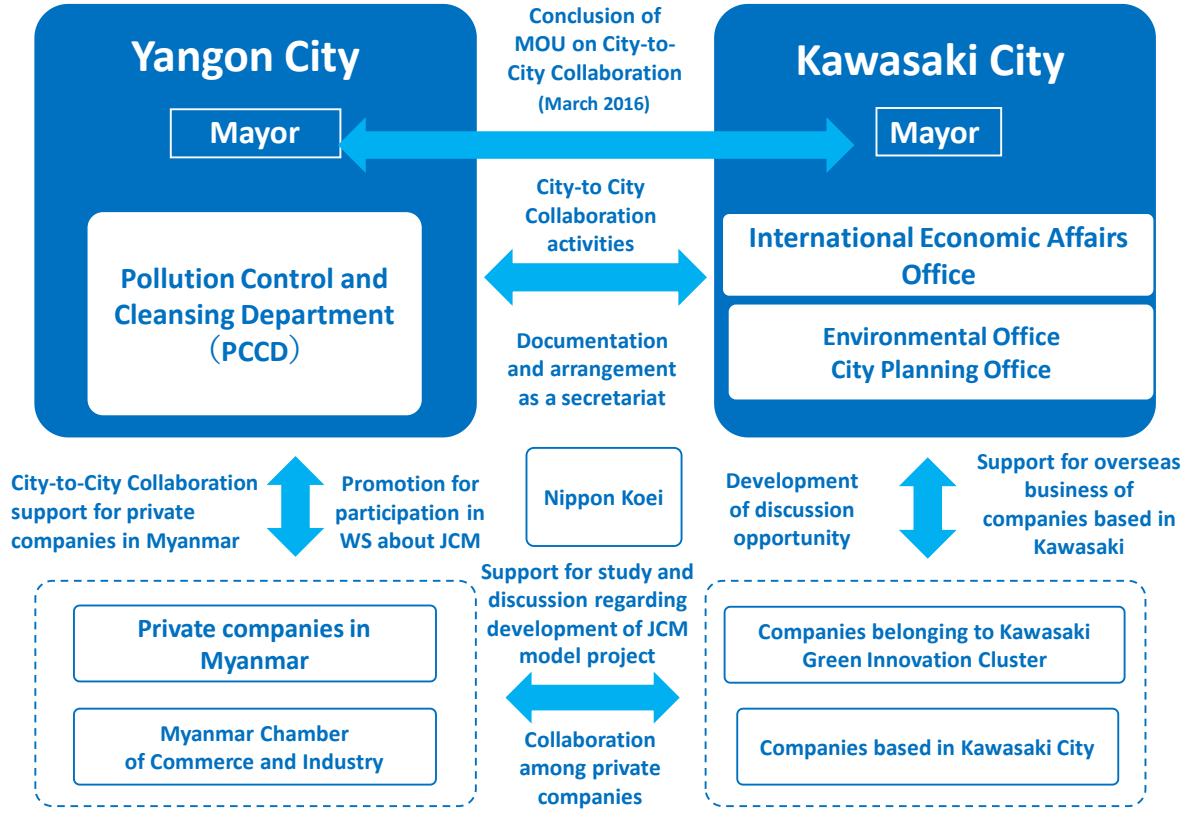
1.2 PURPOSE

This project of city-to-city collaboration between Kawasaki City and Yangon City is in its 4th year. The purpose of this project is that Kawasaki City, which has knowledge regarding formulation of low-carbon society, discusses urban issues of Yangon City such as waste management and consider direction for solving the issues with Yangon City. Also, for project formulation regarding low-carbon society, FS for installation of biogas electricity generation facility at fruit and vegetable market in Yangon by using waste generated by the market was implemented, in consideration of JCM.

1.3 IMPLEMENTATION STRUTURE OF THIS PROJECT

In this project, policies and technologies for low-carbon society were proposed to local counterpart, Yangon City Development Committee (YCDC). For this city-to-city collaboration in the last FY, Pollution Control & Cleaning Department (PCCD) and Engineering Department of Water and Sanitation was the main counterparts of Yangon City side. However, in this FY, PCCD was mainly counterpart.

For Kawasaki City side, as well as project in the past year, its International Economic Affairs Office participated and implemented activities for the city-to-city collaboration with cooperation with environmental office and City Planning Office. As a support of Kawasaki City for proposed candidate JCM model project, partner companies of Kawasaki Green Innovation Cluster, which is an association of companies based in Kawasaki and owning environmental technologies, cooperated for this project and helped JCM model project formulation with support for institution development for promoting implementation of JCM model project and for technical capacity building of local enterprises for sustainable development.



Source: Nippon Koei

Figure 1-2 Implementation structure

1.4 SCHEDULE

Schedule of this project is as follows.

Study items	2018									2019	
	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
1. Consideration of JCM model project formulation											
1) Consideration of specification of installed technology	→	→	→	→	→	→	→	→	→		
2) Planning for gasification and energy generation						→	→	→	→	→	
3) Consideration of business and financial planning			→	→	→	→	→	→	→	→	→
4) Consideration of monitoring plan			→	→	→	→	→	→	→	→	→
5) Arrangement for contract for international consortium								→	→	→	→
2. City-to-city collaboration activities											
1) Discussion about waste management in Yangon			→	→	→	→	→	→	→	→	→
2) Invitation to Japan（Site visit, discussion etc.）							△				
3. Documentation of final report											
1) Documentation of final report											△
4. Others											
1) Site study at Myanmer			▲		▲	▲			▲		
2) JCM City-to-City Collaboration Seminer										△	

▲：carried out at Myanmer △：carried out at Japan

Source: Nippon Koei

Figure 1-3 Project Schedule

CHAPTER 2 COUNTERMEASURES FOR CLIMATE CHANGE IN MYANMAR

2.1 OVERVIEW OF COUNTERMEASURE FOR CLIMATE CHANGE IN MYANMAR

Myanmar ratified UNFCCC in November 25, 1994 and Kyoto protocol in August 13, 2003. The national policy on global warming is summarized in the following table. In 2016, Myanmar Climate Change Strategy and Action Plan (MCCSAP) 2016-2030 were formulated in order to precede action plan for global warming.

Table 2-1 National Countermeasures for Climate Change

Action	Year	Summary
National Environment Policy in Myanmar	1994	- Environmental protection and prevention of deterioration - Promotion of economic development - Achievement of sustainable development in priority of environmental protection - Harmony between environment and development
Myanmar・Agenda21	1997	- Use of natural resource for sustainable development - Development of society, economy, and institution
National Sustainable Development Strategy (NSDS)	2009	- Strategy for sustainable development in three sectors such as society, economy and environment
Environment Protection Law	2012	- Management of natural resource - Promotion of social awareness - Cooperation to environmental program
National Adaptation Plan for Action (NAPA)	2012	- Selection of 32 priority actions from 8 sectors - Implementation of adaptation action for global warming
Participation to Joint Crediting Mechanism	2015	- Conclusion of JCM
Myanmar Climate Change Strategy and Action Plan (MCCSAP) 2016-2030	2016	- Target year is 2030 and plans to implement 6 priority projects for global warming policy

Source: prepared by Nippon Koei based on 11th Workshop on GHG inventories in Asia and the published Information by the UN prepared by the JICA Study Team

The Myanmar Climate Change Strategy and Action Plan 2016-2030 is summarized below.

Table 2-2 Summary of CCSAP

Vision	The action plan aims to implement low carbon development in order to pursue sustainable development of Myanmar
Goal	Goal of the plan is low carbon development and adaptation of climate change with the target year of 2030
Priority Action Area	Basic action plan a) Conter masure for climate change is reflected into development plan b) Development of organization and institution for cilmage change strategy c) Preparation of budget for climage change strategy d) Consideration of techniqhes for climate change strategy e) Developmetn of knowledge and organization for cliamge change f) Promotion of cooperation with several organizations for project investment Priority action plan are selected from the following sectors. 1)Agriculture and Fishery, 2) Environment, 3) Energy, Transportation and industry, 4) Urban city, 5) Welfare, 6) Education

Source: Myanmar Climate Change Strategy and Action Plan2016

2.2 COUNTERMEASURES FOR CLIMATE CHANGE AND WASTE MANAGEMNT IN YANGON CITY

2.2.1 Countermeasures for climate change

Although Yangon is rapidly urbanizing, there is no policy regarding climate change. That is why, Draft Low Carbon Action Plan (LCAP) was prepared in FY2016 in cooperation with Kawasaki city which has knowledge and experience for low carbon plan's development and the basic policy. Basic concept of LCAP is to contribute for development of sustainable and low carbon society of Yangon city based on i) harmonization of green environment and economy and ii) creation of their good cycle, so that the good natural environment can be maintained for the next generation and basic policies for 8 sectors described below ware set.

Table 2-3 Basic Policy for Low Carbon Action Plan

Sector	Needs and Basic policy
Industry	Yangon city has existing industrial parks and a plan of development of industrial parks in the city. Existing industrial parks have issues on renewal of aged facilities.
Energy	Population growth and development of industry cause increase of demand of electricity and frequent electric outage. It is important to provide stable electric supply.
Urban City	Urban development in the city center is increased because of private investment from domestic and international entities. It is expected that such commercial development will be more promoted since government also actively call for investment.
Transportation	Traffic congestion is one of issues to be solved in the city. It is necessary to consider counter measure for traffic congestion.
Waste Management	The main issue of waste management is increase of cost for garbage collection, needs for incineration facility and recycling system because of increase of waste materials. The total amount of wastes is exceeding 2000t per day and it is necessary to consider counter measure to the issue.

Sector	Needs and Basic policy
Education	It is necessary to improve understanding of citizens about recycling system and saving energy in order to archive low carbon society.
International Cooperation	Regarding low carbon and sustainable development, needs for introduction of leading technology from domestic and international courtiers is necessary.
MRV (Monitoring, reporting and verification)	It is important to introduce monitoring system for air pollution, and water contamination, and promotion of saving energy project.

Source: Nippon Koei

2.2.2 Countermeasures for waste management

In Yangon, due to recent rapid urbanization, the amount of generated waste has been increasing dramatically and currently reached at approximately 2,500 ton/day. However, its disposal is only open dumpling at reclaimed lands located at the boundaries with next cities. Moreover, management of the reclaimed lands is insufficient, which leads to high risks of deterioration of public health, water pollution and fire.

Yangon City developed Law for Private Development in Yangon in 2013 and launched monitoring for promotion of waste separation. Then, they newly employed 4,220 people for waste collection and disposal in 2015. However, countermeasures by construction of infrastructure such as disposal facility has not been implemented sufficiently because of lack of finance and technical knowledge so waste management is still one of the main issues Yangon City is facing.

2.2.3 Current situation of JCM model project in Myanmar

In Myanmar, seven JCM model projects have been adopted to date (Table 2-4). All local partner entities of projects in Yangon City and Thilawa Special Economic Zone (SEZ) are local subsidiary or same group company of Japanese representative entity excluding YCDC for Introduction of Waste to Energy Plant in Yangon City. This means that JCM is not well disseminated to local companies. The main reason could be cheap price of electricity and installation of energy-saving and electricity generation technologies are not attractive to local entities excluding factories with greater dependence on fuels rather than electricity.

On the other hand, shortage of electricity supply is a huge issue in Ayeyarwady Region and Mandalay Region. Local companies with large needs, such as local partner companies, are implementing Rice Husk Power Generation in Rice Mill Factory in Ayeyarwady and Introduction of 8.8MW Power Generation System by Waste Heat Recovery for Cement Plant.

Also, Introduction of Waste to Energy Plant in Yangon City is another project which has needs waste management mentioned above as one of the issues in Yangon.

These trends show that for JCM model project formulation in Myanmar, it is necessary to understand local situation and issues exactly and consider and propose installation of Japanese high technologies suited for needs in the area.

Table 2-4 JCM model projects in Myanmar

FY	Representative Entity	Partner company	Project site	Name of project	Type of Technology	Estimated GHG reduction (tCO2/year)
2015	JFE Engineering	YCDC	Yangon City	Introduction of Waste to Energy Plant in Yangon City	Waste management	2,358
2016	Kirin Holdings	Myanmar Brewery	Yangon City	Introduction of Energy Saving Brewing Systems to Beer Factory	Energy saving	2,841
2016	Acecook	Aceccook Myanmar	Thilawa SEZ	Introduction of High-efficiency Once-through Boiler in Instant Noodle Factory	Energy saving	674
2016	Fujita	Myanmar Agribusiness Public Corporation	Ayeyarwady Region	Rice Husk Power Generation in Rice Mill Factory in Ayeyarwady	Renewable energy	2,750
2016	Ryobi Holdings	Ryobi Myanmar Distribution Service	Thilawa SEZ	Introduction of Energy Efficient Refrigeration System in Logistics Center	Energy saving	125
2018	Global Engineering	Shwe Taung Cement	Mandalay Region	Introduction of 8.8MW Power Generation System by Waste Heat Recovery for Cement Plant	Renewable energy	19,241
2018	Kirin Holdings	Myanmar Brewery	Yangon City	Introdiction of Biomass Boiler and Waste Heat Recovery System to Beer Factory	Energy saving	3,508

Source: Nippon Koei

CHAPTER 3 FORMULATION OF JCM PROJECT

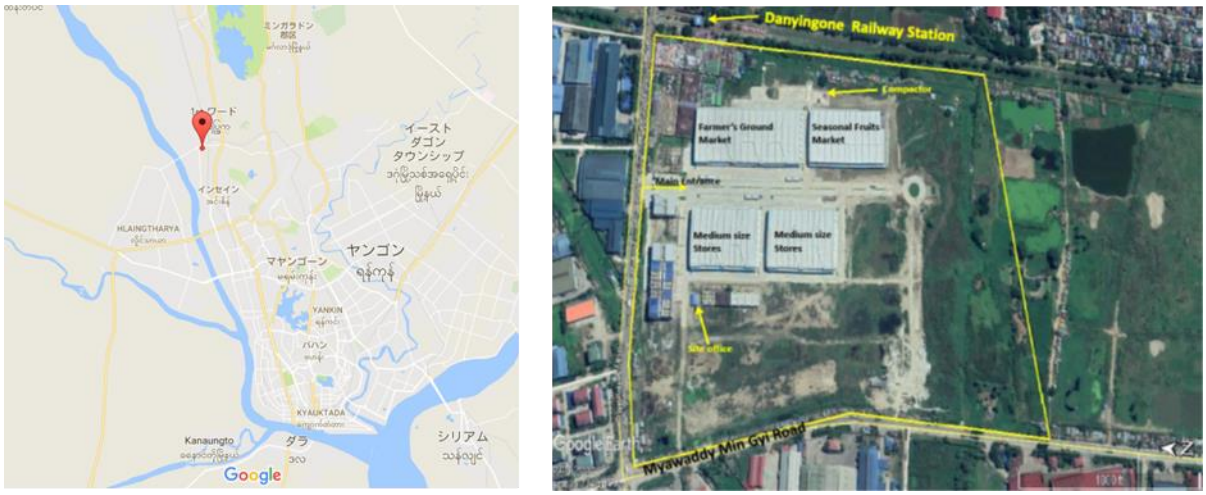
3.1 THE PROJECT INTRODUCING BIOGAS POWER GENERATION FACILITY INTO A FLUIT AND VEGETABLE MARKET

Outline of the fruits and vegetables market where introduction of biogas power generation facility was considered is described below.

Table 3-1 Outline of the Fruits and Vegetables Market

Item	Description
Name	Danyingone Fruits and Vegetables Wholesale Market
Operator	Myanmar Agro Exchange Public LTD. (Share: Dagon International Limited (45%) and YCDC (55%)
Address	Corner of Kayae Pin Road and Myawaddy Min Gyi Road, Insein Township, Yangon, Yangon Region (refer to figure 3-1)
Operation Schedule	Start of construction: April 2015 Start of partial operation: December 2017 Completion of construction: Beginning of 2022

Source: Dagon International Limited



Source: Nippon Koei

Figure 3-1 Location of the Fruit and Vegetable Market

In late FY2017 for Feasibility Study of Joint Crediting Mechanism Project by City to City Collaboration in Yangon Phase-3, the Project team had a meeting with Myanmar Agro Exchange Public LTD. (MAEX) that operate Danyingone Fruit and Vegetable Wholesale Market and Dagon International Limited that is a parent company of MAEX. CAPEX of the facility that the Project team recommended to introduce at that time had higher specifications, and it did not meet to their needs. However, Dagon International Limited has been interested in JCM model project. Dagon International Limited tried to use a scheme with solar power generation about two years ago, but gave up due to lack of economic effect. If economic effect is a certain level (IRR 10 – 15), the enterprise is willing to use the JCM scheme. Therefore, the feasibility study on introduction of waste-to-energy project with biogas generation facility started in FY2018.

The study result for consideration of JCM project formulation is described in this Chapter.

3.1.1 Solid Waste Survey/ Interview Survey

(1) Basic Information Survey for Considering Business Plan

In the beginning of the study period, basic information to calculate cost and effect of biogas power generation as JCM model project was collected through the discussion with PCCD and Dagon group.

Discussion with PCCD

Discussion with Dagon group

The resulting basic information is presented below.

Table 3-2 Basic Information for Consideration of Business Plan

Item	Unit	Price
Diesel	MMK/l	840
LPG	MMK/kg	1500
Water unit price	MMK/t	110
Labor (Admin)	MMK/year	(position wise) 101,640,000 Kyats per year- 10 person (Incld. Mgt level staff)
Labor (Worker)	MMK/year	(position wise) 11,448,000 Kyats per year- 99 person (Include. 50 Cleaners)
Labor (Electricity Generator)	MMK/year	(position wise) 6,600,000 Kyats per year- 2 persons
Efficiency of diesel generator	Litter/hour	200 KVA: 22.5 L per hour 700 KVA: 45 L per hour
Cost of electric generation	MMK/kWh	426
Daily electric generation	kWh/day	1,067
Electric consumption	kWh/day	12,000 Average usage (70% National Grid: 30% Generator)
Electricity Selling Price to Grid	MMK/kWh	177
Electricity unit price	MMK/kWh	141
Tipping fee of waste	MMK/ton	13,125

Source: Dagon International Limited

(2) Waste Composition Survey at the Wholesale Market

In order to precisely understand biogas and energy generation by the waste of Danyingone Fruit and Vegetable Wholesale Market, the Study conducted waste sampling at the market and waste composition analysis at a laboratory.

Overview of Target Market

Sampling Vegetable Waste

The result of waste composition analysis is shown in Table 3-3.

Table 3-3 Result of Waste Composition Analysis at the Wholesale Market

Sampling location: Danyingone Wholesale Market

Sampling date: 4 June 2018

Parameters		Wet basis	Dry basis	Parameters		Wet basis	Dry basis
pH	-	5.24	-	NO_2^-	mg/kg	<0.035	-
TS	%	13.13	-	NO_3^-	mg/kg	648	4,935
VTS	%	10.69	-	T-P	mg/kg	431	3,283
SS	%	8.61	-	Oil and Grease	mg/kg	7,000	53,313
VSS	%	7.27	-	TOC	%	4.10	31.23
CODcr	%	12.60	95.96	Na	mg/kg	1,920	14,623
T-N	mg/kg	4,400	33,511	K	mg/kg	1,258	9,581
NH_3-N	mg/kg	342	2,605	Ca	mg/kg	4,080	31,074
NH_4^+	mg/kg	1,280	9,749	Mg	mg/kg	1,200	9,139

Source: Hitachi Zosen

Using the above result, the Study calculated biogas and energy generation as follows. Biogas generation efficiency was a little higher than the estimated efficiency in the project proposal.

[Conditions]
- ■Capacity: 40 ton-organics /day
- ■Methane conc.: 60 %
- ■Calorie of CH4 [*2]: 36.39 MJ /Nm3
- ■Energy conversion factor: 3.6 MJ /kWh
- ■Power generator efficiency: 37 %

【Calculation】

1. Biogas yield: 58.5 m3 /ton-organics
2. Biogas volume: 40 ton /day×58.5 m3 /ton-organics = 2,340 m3 /day
3. Power generation: 2,340 m3 /day x 60 % x 36.39 MJ /Nm3 x 37 %÷3.6 MJ /kWh = 5,250 kWh /day
4. Generator capacity: 5,250 kWh÷24 hours = 219 kW

(3) Survey of High Calorie Waste

As is stated in section 3.1.2(2), electricity demand from diesel generation at the market became smaller than what was mentioned by Dagon International Limited last fiscal year, through the detail estimation. Therefore, assuming selling excess electricity, the Study surveyed volume and availability of high calorie waste that has high biogas generation efficiency at hotels and factories in Yangon.

<table>
<tr><td>  </td><td>  </td></tr>
<tr><td>Waste from Ever Sunny Industrial</td><td>Waste from Top Food Manufacturing</td></tr>
<tr><td>  </td><td>  </td></tr>
<tr><td>Waste from Yangon Aerodrome</td><td>Waste from Lotte Hotel</td></tr>
</table>

The survey was started by the Project team with a staff of Dagon International Limited; later Dagon International Limited continued the survey by themselves. The result is shown in Table 3-3. The volume of food waste that is suitable for biogas generation is small at factories in general. Large hotels produce some amount of food waste, and segregation is properly carried out. However, the volume is still 1-2 tons/day/hotel (see appendix-1). As a result of the survey, the Project team recognized that available food waste from hotels and factories is 10 ton/day. The Project team sampled at Lotte Hotel, which produces food waste of about 2 ton/day, and conducted waste composition analysis. The result is shown below.

Table 3-4 Results of Waste Composition Analysis at the Lotte Hotel

Sampling location: LOTTE Hotel & Serviced apartment

Sampling date: 17 October 2018

Parameters		Wet Basis	Dry basis	Parameters		Wet basis	Dry basis
pH	-	4.83	-	NO_2^-	mg/kg	<0.035	-
TS	%	26.33	-	NO_3^-	mg/kg	<0.067	-
VTS	%	25.54	-	T-P	mg/kg	423	1,607
SS	%	18.59	-	Oil and Grease	mg/kg	3,210	12,191
VSS	%	18.49	-	TOC	%	8.4	31.9
CODcr	%	39.1	148.5	Na	mg/kg	1,782	6,768
T-N	mg/kg	4,000	15,192	K	mg/kg	602	2,286
NH_3-N	mg/kg	144	547	Ca	mg/kg	4,500	17,091
NH_4^+	mg/kg	2,620	9,951	Mg	mg/kg	1,200	4,558

Source: Hitachi Zosen

The Study calculated biogas and energy generation as follows. Biogas generation efficiency was about three times that of the fruit and vegetable market.

[Conditions]

■Capacity: 10 ton-organics /day
■Methane conc.: 60 %
■Calorie of CH4 [*2]: 36.39 MJ /Nm3
■Power generator efficiency: 37 %
■Energy conversion factor: 3.6 MJ /kWh

[Calculation]

1. Biogas yield: 181.4 m3 /ton-organics
2. Biogas volume: 10 ton /day x 181.4 m3 /ton-organics = 1,814 m3 /day
3. Power generation: 1,814 m3 /day x 60 % x 36.39 MJ /Nm3 x 37 %÷3.6 MJ /kWh = 4,071 kWh /day
4. Generator capacity: 4,071 kWh÷24 hours = 170 kW

3.1.2 Considerations of Specification of Introducing Facilities

(1) Consumed in the Market (Alternative Electricity from Diesel Generation)

According to the interview survey to Dagon International Limited and MAEX last fiscal year, electricity demand of the Market after completion of construction was expected as about 12,000 kWh/day, and 30% of the electricity would be generated by diesel generator. Therefore, the Study assumed that electricity from biogas would be used to alternate with the electricity from diesel. Meanwhile, biogas could be stored and used for electricity generation on demand, since it is easy to alternate diesel generation electricity demand during power outages comparing to biomass energy generation.

The outline of facilities considering introduction are as follows.

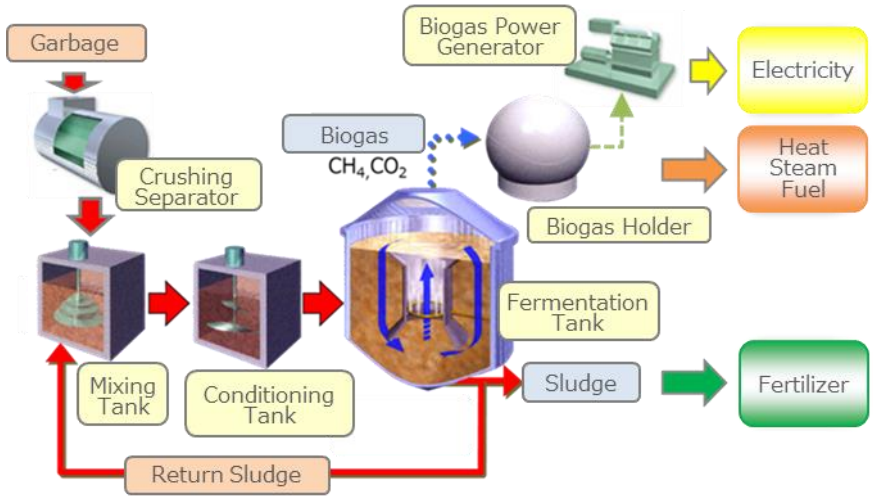
【Water-needless Two-phase Methanation System】

Methane fermentation process is composed of an acid genic process and a methanogenic process under different condition for each process. Each process is controlled with two reactor tanks for processing each reaction effectively. WTM system, Water-needless Two-phase Methanation system, is a unique anaerobic digestion system that will generate biogas with high production rate by effective acid genic reaction and methanogenic reaction. WTM doesn't require additive dilution water due to adjusting total solid concentration by returning digested sludge. The mixture slurry of organic waste and return sludge will be decomposed to small size molecule such as organic acids or alcohol under around 55 degrees Celsius condition. After that, the decomposed slurry will be converted to biogas in a mesophilic fermentation tank. The mesophilic condition is less subject to an ammonia inhibition even if an organic load was high. WTM has high biogas production rate with this combined digestion process.

【WTM features】

The organic waste will digest in a methane fermentation tank with mesophilic condition after hydrolysis and acid genesis process in a conditioning tank. In the fermentation tank, it can keep high concentration of microorganism without dilution water because mesophilic fermentation is less subject to an ammonia inhibition. Thus, high biogas production can be achieved.

- WTM system required less heating energy for fermentation process since WTM doesn't need dilution water. WTM system consists of small power equipment. Thus, energy requirement is smaller.
- WTM plant need less operating cost such as machine maintenance cost and energy cost than incineration plant because the plant has less equipment and it uses less power.
- Target materials of WTM are high moisture organic waste from household and/or food processing factory that is unsuitable for incineration plant.



Source: Hitachi Zosen

Figure 3-2 Image of WTM System

(2) Electric Power Selling

The Project team presented the above plan to Dagon International Limited in October 2018. However, Dagon International Limited mentioned that they would like to assume that the diesel generation demand is considerably smaller than the plan, because GRID electricity supply tends to be stable recently and electric power demand in the market is at the moment low (as many facilities such as cold storage have not operated). Thus, the Project team considered the case of electric power selling to GRID raising electricity generation efficiency with mixing high calorie waste from hotels and factories in Yangon. The specification of facilities is the same as above paragraph "(1) Consumed in the Market".

3.1.3 JCM Model Project Formulation

(1) Project Plan

The plan is to generate biogas from 40 ton/day of waste in the fruit and vegetable market and generate electric power to alternate diesel power generation. According to the result in section 3.1.1(2) above, 5,250 kWh/day could be generated, and annual CO2 reduction would be 1,470 tCO2. CAPEX is estimated as 5,221,140 USD, and subsidy calculated as about 800,000 USD (in case cost-effectiveness is restricted to less than 4000 Yen/tCO2).

Table 3-5 CO2 Reduction and Subsidy (Alternate Diesel Power Generation, 40 ton/day）

No	Item	Amount	Unit	Calculation
1	Waste	40	ton	
2	Annual	1,838	MWh	=5.250kWh/dayx350
3	CAPEX	5,221,140	USD	
4	Emission Factor	0.80000	tCO2/MWh	
5	Annual CO2 reduction	1,470	tCO2	=1838x0.8
6	Legal durable years	15	Year	
7	Total CO2 reduction	22,050	tCO2	=1470x15
8	Cost effectiveness	36.23	USD/tCO2	=(5,221,140x0.153)/22,050
9	Subsidy	798,834	USD	=(5,221,140x0.153)

Source: Nippon Koei

The project plan is as follows.

Construction	2	years		
Operation	15	years		
Capacity	40	ton/day		
Da Nyin Gone Market	40	ton/day		
Operation day	350	days/year		
Sales price				
Electricity selling price	0.11	USD/kWh	177	MMK/kWh
Waste treatment fee				
Da Nyin Gone Market	8.5	USD/ton	13,125	MMK/ton

Power generation cost	0.27	USD/kWh	426	MMK/kWh

* Note: Reduced cost by alternating the fuel for private power generation from diesel oil to biogas.

Generated biogas	2,340	m3/day
Methane gas	1,404	m3/day
CO2	936	m3/day
Generated electricity	5,251	kWh/day
	1,837,850	kWh/year
Income 615,220 USD/year		
Waste treatment fee	119,000	USD/year
Reduced cost of diesel oil	496,220	USD/year
Methane concentration	60	%
Biogas generator efficiency	37	%
CAPEX	5,221,140	USD
Civil and Building work	854,748	USD
Piping and electric work	268,957	USD
Machinery	2,790,136	USD
Engineering fee	1,307,300	USD

(2) Financial Plan and Project Evaluation

Dagon International Limited is a member of a big business group in Yangon, investing to several projects; therefore, funding ability is enough. Mr. Thurane Aung, CEO of Dagon International Limited, is one of directors in the group, and has authority of decision making in investment by Dagon International Limited. Hence, there is no problem that Dagon International Limited invests to MAEX for the JCM project with its own funds.

For the investment, profitability of the project must be considered as a private company, and Mr. Thurane Aung conditioned the investment to the project with IRR 15% during the meeting between the Project team and Dagon International Limited. After the consideration of the project formulation in the market, even alternating diesel energy generation became only 8.27% with subsidy (payback period is 8.4 years) due to the low tipping fee and low electric rate. Thus, it doesn't satisfy the condition of Dagon International Limited. During the third-year study (last fiscal year), Dagon International Limited gave diesel generation cost as 2,330MMK/kWh, and same cost was given to the Project team in the beginning of this year. However, when the Project team presented the detail calculation result of this fiscal year in October 2018 (IRR 30% approx.), they said that the diesel generation cost is too high. After the presentation, Dagon International Limited scrutinized the cost and replied as 426MMK/kWh that is extremely lower cost than the first information. The Project team requested to review it, though, it hasn't been done. Eventually, IRR has been lowered though Hitachi Zosen reduced Capex.

Furthermore, although Dagon International Limited explained in FY 2018 that the market used diesel generation power as 30% of total electricity demand, it has been modified to 1%.

It made original plan difficult, and an alternative plan is necessary in order to make a JCM project.

(3) Alternative Plan

The Project team considered selling electricity to grid as an alternative plan. Since the market waste doesn't generate large amount of biogas, the Project team planned to collect about 10 ton/day of food waste from hotels and factories (refer to section 3.1.1(3)) and use for biogas power generation. The total waste volume is 50 ton/day (40 ton/day from the market and 10 ton/day from hotels and factories), so electric power would be 9,322 kWh/day, and CO2 reduction would be 2,610 tCO2/year, as shown in Table 3-5.

Table 3-6 CO2 Reduction and Subsidy (Selling Electricity, 50ton/day)

No	Item	Amount	Unit	Calculation
1	Waste	50	Ton	
2	Annual	3,262	MWh	=9,322kWh/dayx350
3	CAPEX	6,546,508	USD	
4	Emission Factor	0.80000	tCO2/MWh	
5	Annual CO2 reduction	2,610	tCO2	=3,262x0.8
6	Legal durable years	15	Year	
7	Total CO2 reduction	39,144	tCO2	=2,610x15
8	Cost effectiveness	35.96	USD/tCO2	=(6,546,508x0.215)/39,144
9	Subsidy	1,407,499	USD	=(6,546,508x0.215)

Source: Nippon Koei

The alternative project plan is as follows.

Construction:	2	year
Operation:	15	year
Capacity:	50	ton/day
Da Nyin Gone Market:	40	ton/day
Hotels:	10	ton/day
Operation day:	350	day/year
Sales price		
Electricity selling price:	0.11	USD/kWh
Waste treatment fee		
Da Nyin Gone Market:	8.5	USD/ton
Hotels:	6.5	USD/ton
Power generation cost:	0.27	USD/kWh
Generated biogas:	4,154	m3/day
Methane gas:	2,492	m3/day
CO2:	1,662	m3/day
Generated electricity:	9,322	kWh/day
	3,263	MWh/year

Income:	515,079	USD/year
Waste treatment fee:	141,750	USD/year
Electricity selling	349,649	USD/year
Reduction cost of diesel oil:	22,680	USD/year
Methane concentration:	60	%
Biogas generator efficiency:	37	%
CAPEX:	6,546,508	USD
Civil and building works:	948,469	USD
Piping and electric work:	518,375	USD
Machinery:	3,772,364	USD
Utilities cost:	1,307,300	USD

In this case, IRR is 3.82% (payback period is 11.3 years) with subsidy, and it doesn't satisfy the condition of Dagon International Limited as well as the original plan. Dagon International Limited is considering the project with cautious stance as of February 2019.

(4) Consideration of Implementation Structure towards Application to JCM Model Project

The study considered project implementation structure with Dagon International Limited as shown in Figure 3-2. Detail discussion on establishment of international consortium has not been implemented since sufficient economic effect with the project has not been reached.

International Consortium would be formed for the application and implementation of JCM Model Project. Myanmar Agro Exchange Public Limited (MAEX) invested by Dagon International Limited would be partner participant, and a trading company, a member company of Green Innovation Cluste promoted by Kawasaki city, would be representative participant, and Subsidiary of a company in Kawasaki City would undertake an EPC contractor. In order to reduce the cost of the project, the Project team and Dagon International Limited had looked for a local company in Yangon, but so far have not found a candidate. The roles of such a company are listed below.

Table 3-7 Implementation Structure and Responsibility

Party	Responsibility
Representative Participant of International Consortium <A trading company>	● Consideration of JCM Model Project with Waste-to-Energy ● Application of JCM Model Project ● Project management, supervision and reporting
Partner Participant ＜MAEX＞	● Implementation of Waste-to-Energy ● Arrangement of location ● Daily maintenance, management and monitoring
EPC Contractor <Subsidiary of a Company in Kawasaki City>	● Equipment procurement and delivery ● Equipment installation

Source: Nippon Koei

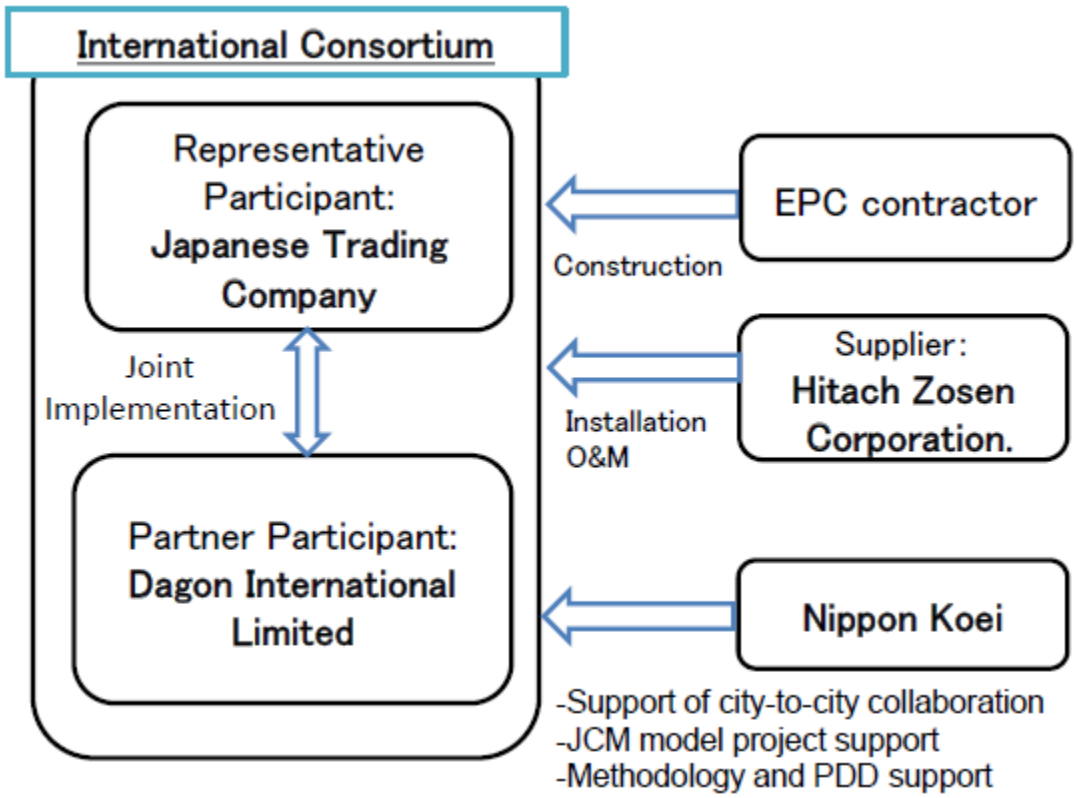
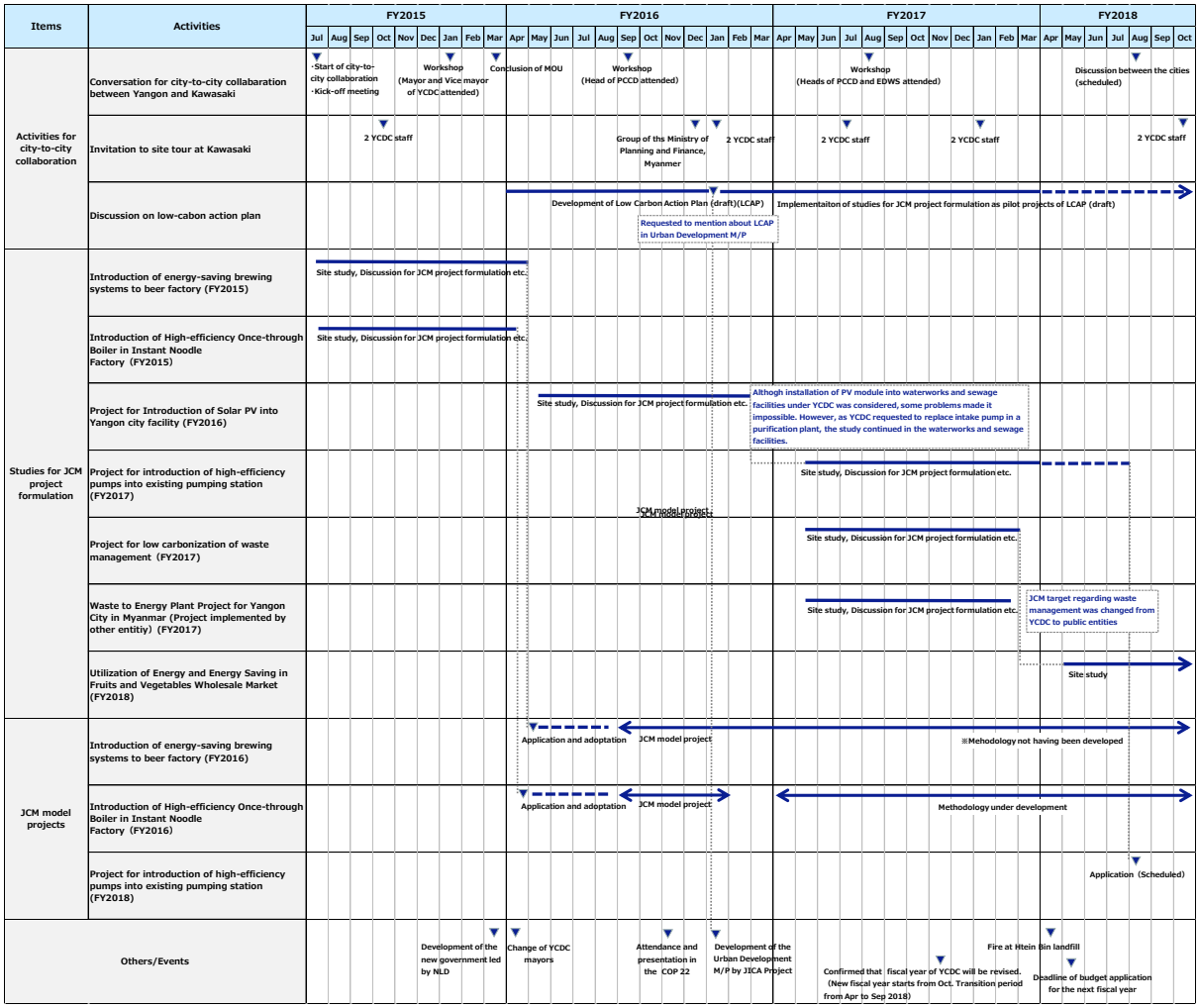


Figure 3-3 Project Implementation Structure (Draft)

CHAPTER 4 CITY-TO-CITY COLLABORATION

4.1 CHRONOLOGY

JCM city-to-city collaboration has commenced since July 2015 in order to grasp the energy saving potential in Yangon city and share Kawasaki's know-how of low carbon society. Chronology of the collaboration, which states the major activities and JCM feasibility study, is presented in the table below and Attachment 1.



Source: Nippon koei

Figure 4-1 Chronology of City-to-City Collaboration

As for the collaboration since FY 2015, the following priority topics were selected and shared with Yangon city.

1) Supports on the preparation of low carbon action plan in Yangon city
2) Feasibility study on solar PV system in the land of Yangon city
3) Feasibility study on energy saving on water supply facility
4) Knowledge sharing on solid waste management

Currently Yangon city has struggled with some issues due to rapid urbanization. Hence, the collaboration has conducted consideration of (i) proper solid waste management and (ii) its project formulation through JCM scheme, aiming to low carbon society.

4.2 DISCUSSION ON CITY TO CITY COLLABORATION

Yangon city produces domestic waste of approximately 2,500 to 2,700 ton per day. Then, it is conveyed to final disposal site without incineration. Due to the increase in the waste, the disposal site will soon reach full capacity. It is likely that Yangon city will face crucial issues on final disposal site in the near future. In addition to the above, Yangon city has some issues to solve. To this point, the city-to-city collaboration has tried to pick up several issues which high level of interest in Yangon city since FY 2015 are. Major activities are presented in the table below.

Table 4-1 Activities on City-to-City Collaboration in this year

Activities	Period	Description
Discussions on consideration of solid waste management in the final disposal site	Aug 2018	In May 2018, there was a fire in the Htein Bin and it was extinction of a fire. To this occasion, Kawasaki city shared the information and know-how on solid waste management. Details will be described in the Subsection 4.3 below.
Information sharing of Japanese advance technologies through JCM seminar	Oct 2018	Through the JCM seminar held in Yokohama city, information of existing JCM activities and Japanese advanced technologies were shared to the participants. Also, YCDC participants has visited Kawasaki facilities which described in the Sub-section 4.5 below.
Discussions on further collaboration between Yangon and Kawasaki	Dec 2018	To pursuit the low carbon society, the further collaboration was discussed based on the results of the collaboration and the current issues in Yangon city.

Source: Nippon Koei

In FY 2018, a Kawasaki city officer has visited Yangon city in August and December. In August, Kawasaki and Yangon cities discussed on proper solid waste management. Also, the officer made site survey to the Htein Bin final disposal site. In December, Yangon city and Kawasaki city have exchanged the opinions on further collaboration with Yangon city.

Aero photo of final disposal site

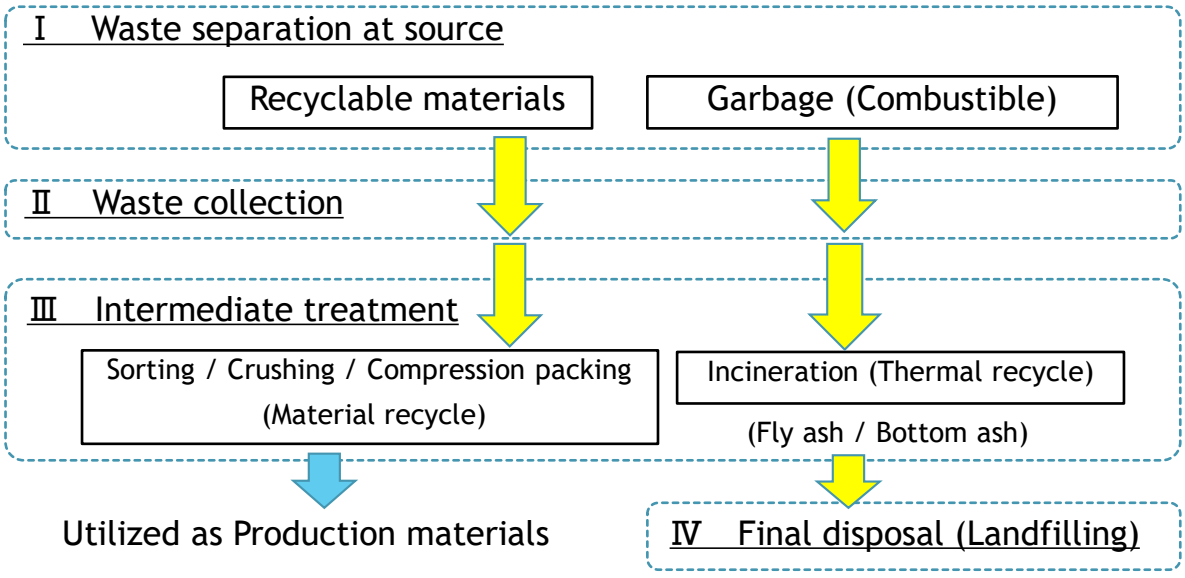
Final disposal site

	
Discussion of YCDC	Discussion with YCDC

4.3 CONSIDERATION OF SOLID WASTE MANAGEMENT

In Yangon city, domestic waste is normally collected and controlled by the person appointed by YCDC. The waste is collected by push cart, three-wheeler and conveyed to intermediate garbage collection point. Then it was transported from each district to the final disposal site by trucks.

As a part of knowledge sharing, Kawasaki city explained their activity/management on solid waste management. The following figure shows ways of collection on domestic waste management as a part of presentation material by Kawasaki city. Garbage is separated into two categories: normal and recycle. Normal garbage (combustible) is conveyed to incinerator plant and final disposal site. The recycle material is conveyed to intermediate depot and separated as production materials. Also, Kawasaki city explained the activity on separate collection with community residents.

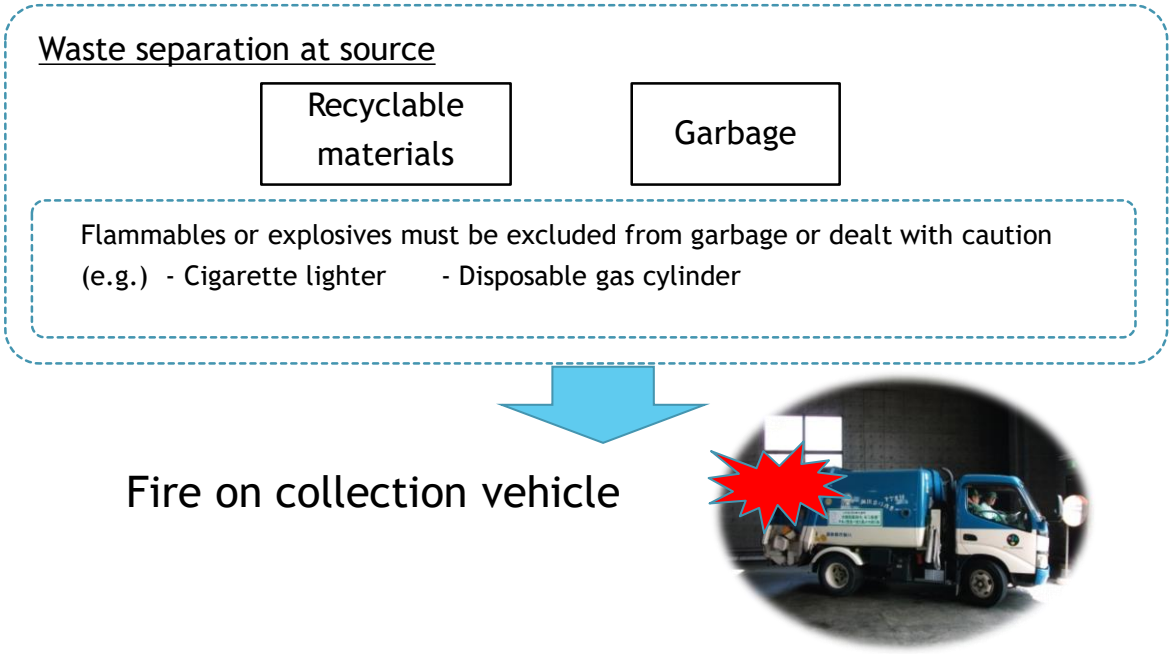


Source: Kawasaki city

Figure 4-2 Collection Flow on Solid Waste Management, Case of Kawasaki City

To respond to fire in Yangon final disposal site May 2018, Kawasaki city explained sharing the risk management of solid waste collection and other ways of avoidance. (See the figure below)

Fire hazards are included in normal domestic waste. To avoid an explosion, waste separation at source is indispensable. According to the Kawasaki officer, fire and explosion tends to happen in the collection vehicle. It is therefore necessary to manage the waste separation properly at the source by the community residents.



Source: Kawasaki city

Figure 4-3 Risks on Solid Waste Management, Case of Kawasaki City

Through the discussions and knowledge exchanges, the following items are considered in fostering better city-to-city collaboration. From now on, the items will be for better collaboration between the two cities.

1) Through the JICA grassroot project, the following activities will be supported.
   - Segregation of domestic waste
   - Fire protection in solid waste management
   - Establishment of integrated solid waste management system

2) Capacity building on medical and hazardous waste management

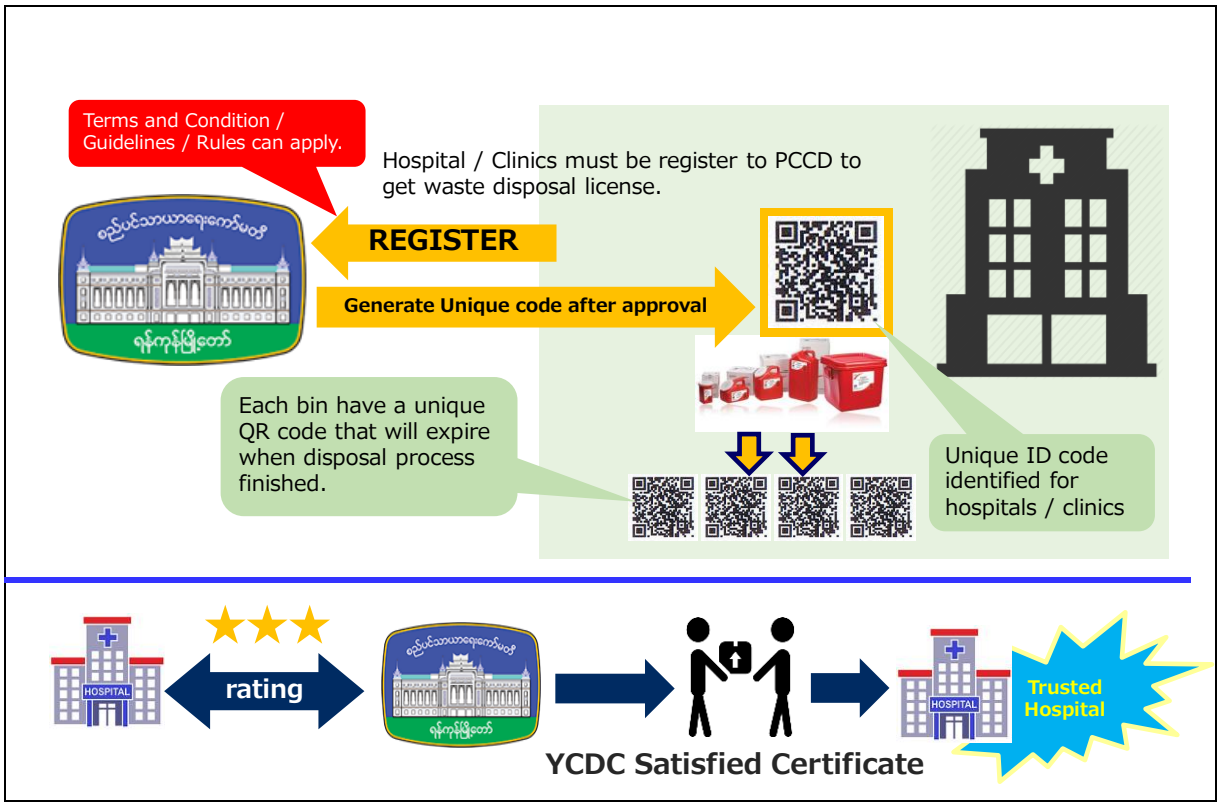
3) Project for solid waste management planning in Yangon city

4.4 PROPOSAL FOR OPITIMAL COLLECTING SYSTEM OF MEDICAL WASTE

At the wrap-up meeting of the city to city collaboration in January 2018 in Yangon (last fiscal year), iSGM which is subsidiary company of NEC's affiliated, introduced their optimal management system of medical waste from hospitals in Yangon city. However, it was not accepted by PCCD at the time because there was not sufficient budget to introduce the new system and the proposed technology seemed to have higher specification than they expected.

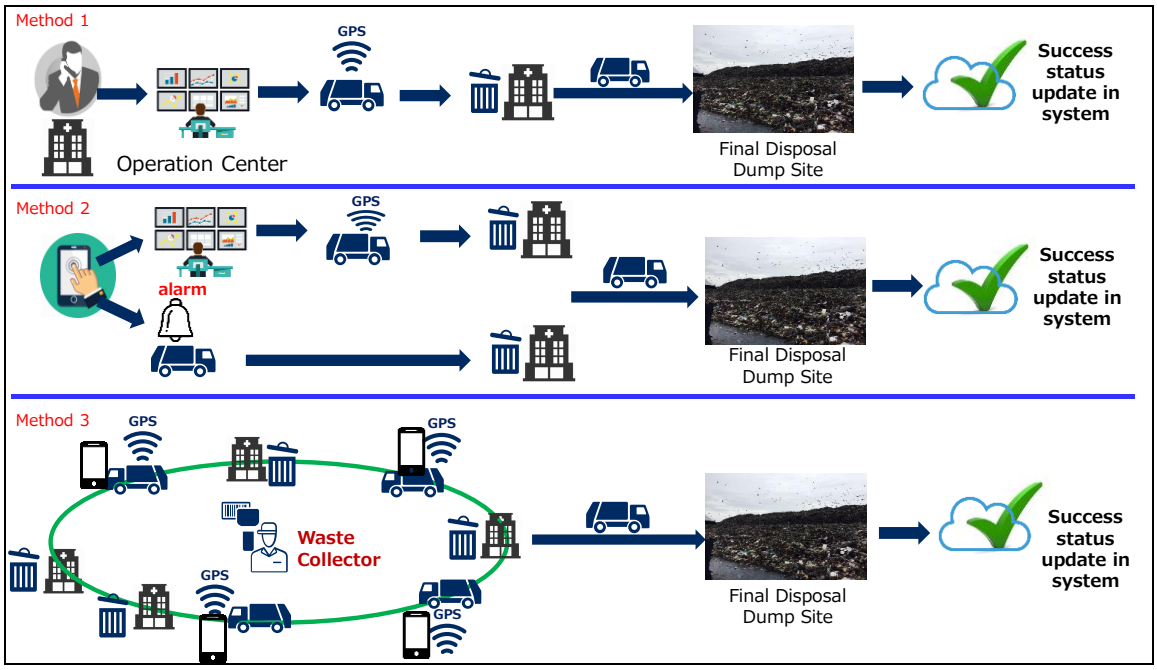
In June 2018, iSGM proposed some options of medical waste collection method at kick off meeting in Yangon, but it could not match the PCCD requirement (simple and reasonable system).

On the other hand, the proposed system is not suitable for JCM model project because it does not directly contribute GHG emission reduction by saving fuel of garbage trucks with the efficient system. Therefore, it would be necessary to consider suitable project scheme instead of JCM.



Source: iSGM

Figure 4-4 Image of Certification System for Hospital based on Safety Management of Medical Waste using QR Cord



Source: iSGM

Figure 4-5 Image of optimal collection system for medical waste using GPS

In other to promote the optimal collection system of medical waste using advanced technology in Yangon, a subsidiary of NEC had an interest in the JICA scheme which support technical transfer to the abroad by Japanese entities. After consideration, it did not realize project because lack of information to decide budget and level of technology, and implementation structure was not feasible.

It is clear that proper treatment and management of medical waste in Yangon city is strongly recommended from the view of public health. It is necessary to introduce both system and capacity development. YCDC/PCCD is responsible to decide policy and budget for the activities and Kawasaki city is expected to support for project implementation continually.

4.5 CITY-TO-CITY COLLABORATION SEMINAR AND 3R CONFERENCE FOR ASIAN LOCAL GOVERNMENTS

On October 23 and 24 of 2018, the 11th “3R Conference for Asian Local Governments” was held by Japan Environmental Sanitation Center (JESC) and on October 25 and 26 of 2018, “Seminar on City-to-City Collaboration for Creating Low-carbon Society” was held by IGES/MOE. Both events were held in Yokohama, and the following two staff from YCDC were invited.

	Name	Position/Organization
1	Mr. Zaw Nyunt	Deputy Head of Production Department/ YCDC
2	Mr. Tin Myo Htwe	Supervisor of Pollution Control and Cleansing Department (PCCD)/YCDC

During the seminar and conference, Mr.Zaw Nyunt, deputy head of PCCD had made presentations about current situation/issues of waste management in Yangon city and activities under the city to city collaboration with Kawasaki city.

It became a good opportunity to share information with local governments from Asian countries which have participated in City to City Collaboration. During site visit in Yokohama (Green building) and Tokyo (Incineration plant), invitees were able to obtain various technology and knowledge introduced to the public facilities.

<table>
<tr><td> 
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<tr><td>Presentation of YGCD at 3R conference (Mr.Zaw Nyunt)</td><td>Presentation of YCDC at City to City Collaboration seminar</td></tr>
<tr><td>  </td><td>  </td></tr>
<tr><td>Overview of Yokohama City Action Plan for Global Warming Countermeasures</td><td>Site visit for Green Building in Yokohama</td></tr>
<tr><td>  </td><td>  </td></tr>
<tr><td>Site visit for Green Building in Yokohama</td><td>Site visit of Incineration plant in Tokyo</td></tr>
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CHAPTER 5 ISSUES AND PROPOSAL ON JCM CITY TO CITY COLLABORATION PROJECT

5.1 CHALLENGES FOR THE FUTURE

5.1.1 JCM Model Project (BIOGAS DIGESTER)

In case private companies execute biogas power generation projects, it is difficult to ensure economic effect because of low GRID electricity price, no FIT, and low tipping fee. In order to improve the economic effect, proportion of high calorie food waste must be increased. For example, if 40 ton/day of food waste from hotels is used to generate biogas, power generation with the system of Hitachi Zosen would be 16,283 kWh, and it is triple of the power generation with fruit and vegetable waste. In this case, subsidy would be more than 200 million USD and IRR would be 16.83% (payback period 5.4 years).

Besides, as power generation from biogas is generally so efficient, improvement of economic effect with heat utilization such as biogas boiler is worth considering.

5.1.2 Review of City to City Collaboration

Kawasaki city and Yangon city has implemented the JCM city-to-city collaboration since FY 2015 (July 2015). So far, two cities have achieved several results, such as the conclusion of minutes of understanding toward the low carbon society, JCM project formulation and knowledge sharing/discussions aiming to low carbon society.

The following table states the major activities through the JCM City-to-City Collaboration between Yangon city and Kawasaki city.

Table 5-1 Major Activities in Yangon-Kawasaki JCM City-to-City Collaboration

Fiscal year	Outlines
2015	・ JCM feasibility study on Introduction of High-efficiency Once-through Boiler in Instant Noodle Factory ・ Conclusion of minutes of understanding on low carbon society development between Yangon city and Kawasaki city.
2016	・ Project formulation of two JCM projects: - Introduction of High-efficiency Once-through Boiler in Instant Noodle Factory - Introduction of Energy Saving Brewing Systems to Beer Factory ・ JCM feasibility study on solar PV system in Nyaung Hnit WTP ・ Discussions on preparation of low carbon action plan
2017	・ JCM feasibility study on high efficiency pump replacement in existing pump station ・ JCM feasibility study on solid waste treatment ・ Discussions on solid waste management in Yangon city

Fiscal year	Outlines
2018	・ JCM feasibility study on biogas power generation in vegetable market ・ Discussions on solid waste management

There was no relationship between Yangon city and Kawasaki city before FY2015. However, both cities have several outcomes, which have contributed to countermeasure of Yangon's critical issues, until now. Through the collaboration, the following items are identified as critical issues to aiming to the materialization of low carbon society including JCM project formulation.

1) City-to-city collaboration

・ It is necessary to implement continuous support to Yangon city to materialize fruitful support. There however is a limitation of the city-to-city collaboration in terms of input from Kawasaki city in the scope of the JCM city-to-city collaboration project.
[Countermeasures]
Detailed action plan which consists of proper implementation body, financial support etc. is necessary to prepare. In reference to JCM annual activities (JCM seminar etc.), the plan shall be committed by Yangon city as beneficiary. Also, other supporting scheme should be utilized as support of next steps.

・ It is necessary to study various issues under YCDC's control items.
[Countermeasure]
To share Kawasaki's experience and identify Yangon's issues effectively, exchange of opinions is necessary to held with YCDC's support.

2) JCM model project

・ There is a bottleneck that low emission factor (0.3 tCO2/MWh) and low power tariff In terms of JCM project formulation in Myanmar.
[Countermeasure]
Taking the current situation into consideration, another option should be studied. As a new approach to this matter, it is necessary to investigate fuel switch potential in addition to energy efficiency/saving project.

・ It is necessary to contact with not only public sector but also private sector in order to promote JCM model project in Yangon city.
[Countermeasure]
Through discussion with YCDC, it seems that public relations on JCM scheme is effective.

- To plan the public JCM project with YCDC, it is necessary to check YCDC's procurement process and budget preparation process.
  [Countermeasure]
  In the discussion on the city-to-city collaboration, it is preferable that YCDC's procurement and budget preparation processes will be shared.

It is necessary to implement the collaboration step-by-step taking the above descriptions into account.

5.2 FURTHER PROPOSAL

5.2.1 Formulation of JCM Model Project

According to section 3.1.1(3), there is limitation of amount waste from hotels and factories. In the discussion with PCCD in this fiscal year, PCCD proposed the possibility of cooking gas project made from waste from 10,000 households in the southern part of Yangon City through anaerobic fermentation. It is necessary to separate general waste but there is an opportunity to formulate JCM model project by reconsidering usage of row waste. Additionally, there is another possibility of JCM model project to utilize biogas heat as mentioned in section 5.1.1

As a reference case, the project of biogas boiler at Myanmar Brewery has been adopted as JCM model project in this fiscal year. It is expected that high efficiency biogas boiler is suitable for JCM scheme because of GHG reduction and economic efficiency.

5.2.2 Proposal in FY 2019

To deepen a committed relationship between Yangon city and Kawasaki city, the following points will be considered based on the previous experiences.

1) City-to-city collaboration

- Currently Yangon city has received various kinds of assistance/proposals from the international community after cancellation of the economic blockade. To differentiate from them, the city-to-city collaboration should be considered or focused on bilateral cooperation based on the city level point of view.

- After identification of the support items from Kawasaki to Yangon, approach/ways of the collaboration also considered based on the discussions among the stakeholders in terms of implementation structure, schedule, etc.

2) JCM model project

- Taking the power supply situation into consideration, cost effectiveness of JCM project should be considered. However, there are some difficulties on the formulation of the project with regard to the following issues.

- Low grid emission factor
- Low power tariff

In this context, fuel switch is potential activity on JCM project formulation.

- Yangon city has confronted serious issues, such as insufficient final disposal site, chronic traffic jams, etc. These are potential and urgent issues. After identification of the project, feasibility of the project should be checked in terms of financial aspect, schedule, applicable technology, etc. In case of the public project, i.e. work with YCDC, harmonization of the JCM scheme is necessary to consider for the smooth implementation.

In addition, YCDC (PCCD) gave the possibility of JCM project inside/outside of Yangon city as the interest of JCM project formulation.

Table 5-2 Ideas of JCM model projects in Yangon

Project idea	Description
1) Biogas project on utilization of domestic waste	Currently, Yangon city is considering the project which produces biogas from domestic waste by anaerobic fermentation process and utilize as the household energy. Taking the biogas project experience into consideration, the project feasibility will be checked.
2) Small hydropower project	To meet with the power demand in Yangon city, renewable energy project is one of the solutions to this situation. According to the YCDC officer, there are some potential site for mini hydropower inside and nearby Yangon city.

Yangon city is one of the most rapidly growing cities in Asian region and it has big opportunity for business expansion of private entities. The city is however facing environmental issues, such as insufficient final disposal site, chronic traffic jams, etc.

To this situation, public and private partnership, in other words the city-to-city collaboration, is a hopeful solution or a trigger that satisfy with the expectation of both Yangon city and Japanese private companies.