MOEJ

Final Report

City to City
Collaboration for
Zero-carbon Society in FY2021

Zero-carbon Society Development
in Bandung City
through Energy Saving and Improvement of
Transportation Infrastructure System

March 2022

Oriental Consultants Co., Ltd.
Kawasaki City

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List of Abbreviations

Abbreviation	Meaning
BEMS	Building and Energy Management System
BRT	Bus Rapid Transit
CCTV	Closed Circuit Television
COP	Coefficient of Performance
GHG	Greenhouse Gas
IEA	International Energy Agency
JCM	Joint Crediting Mechanism
MEPS	Minimum Energy Performance Standard
TOD	Transit Oriented Development
ZEB	Net Zero Energy Buildings
ZEH	Net Zero Energy House

Chapter 1 Project Overview

1.1 Project Objective

The Paris Agreement came into force in November 2016, and the year 2020 represents the implementation stage of the Paris Agreement. This agreement cites that central governments as well as local governments, cities and non-governmental organizations should accelerate measures against climate change. At the "Online Platform Ministerial Meeting on Recovery from the New Coronavirus and Climate Change/Environmental Measures" held in September 2020, it was confirmed that decarbonization policies are necessary for local governments that engage in activities directly related to communities, and that local community-led development approaches are important. In Japan, it has been declared that the country aims to achieve a decarbonized society with zero greenhouse gas emissions as a whole by 2050, and the number of municipalities declaring virtually zero carbon dioxide (CO2) emissions has rapidly increased to over 300.

As described above, the role of cities and local governments is becoming more important in considering and implementing specific regional climate change countermeasures and projects. In order to realize a global decarbonized society, it is necessary to accelerate the movement toward building a sustainable decarbonized society, especially in Asia, where economic growth is remarkable, and it is a place for activities that support socio-economic development. The movement to support the efforts of cities is being strengthened internationally toward the decarbonization and low carbonization of cities.

In addition, in the current situation of the spread of the COVID-19 infection, cities are under pressure to address issues related to the spread of infection and at the same time readjust and consider new measures to achieve sustainable development. It is extremely important to build a new method and a new city through cooperation between cities.

In this project, Japanese research institutes, private companies, universities, etc., together with Japanese cities that have experience and know-how regarding the development of zero/low-carbon societies, will conduct a research project to support the efforts of overseas local governments to form a zero/low-carbon society and the introduction of facilities that contributes to the formation of a zero/low-carbon society.

1.2 Project Overview

Entrusted Project Name:	City to City Collaboration for Zero-carbon Society in FY2021 Zero-carbon Society Development in Bandung City through Energy Saving and Improvement of Transportation Infrastructure System
Implementation Period:	September 1, 2021, to March 10, 2022
Ordering Party:	International Cooperation / Environmental Infrastructure Strategy Section, Global Environment Bureau, Ministry of the Environment
Consignee:	Oriental Consultants Co., Ltd.

1.3 Implementation Structure

The implementation of this project was initiated by Kawasaki City, the International Cooperation

Sub-Division, the Environmental and Cleanliness Department and the Transportation Department of the City Government of Bandung. Since participating in the 3rd Asia-Pacific Eco-Business Forum held by Kawasaki City in 2007, the cities of Kawasaki and Bandung have continued exchanging information on advanced environmental technologies and domestic and overseas environmental measures. They also implemented Feasibility Studies on a Large-Scale JCM Project for Realizing Low-Carbon Development in Asia in FY 2014 and FY 2015 to survey the adoption of energy management in buildings, LED street lighting and an energy management system for waste management and commercial facilities. In February 2016, both cities concluded "Memorandum of Understandings concerning a city-to-city collaboration to build a low-carbon and sustainable city" and implemented capacity development for a project to manage waste and boost river water quality among others; leveraging a JICA grassroots project and programs of the Ministry of the Environment. Kawasaki City has also promoted efforts to revitalize the regional economy and make an international contribution by leveraging the city's environmental technologies and industries under the Kawasaki Green Innovation Cluster. Likewise, this project has also involved sharing technological insights into an energy-saving system in cooperation with its member companies. In February 2020, both cities concluded new memorandum of understandings to further promote collaboration to build a sustainable city, targeting efforts to promote air quality management alongside conventional efforts in waste and water environmental management.

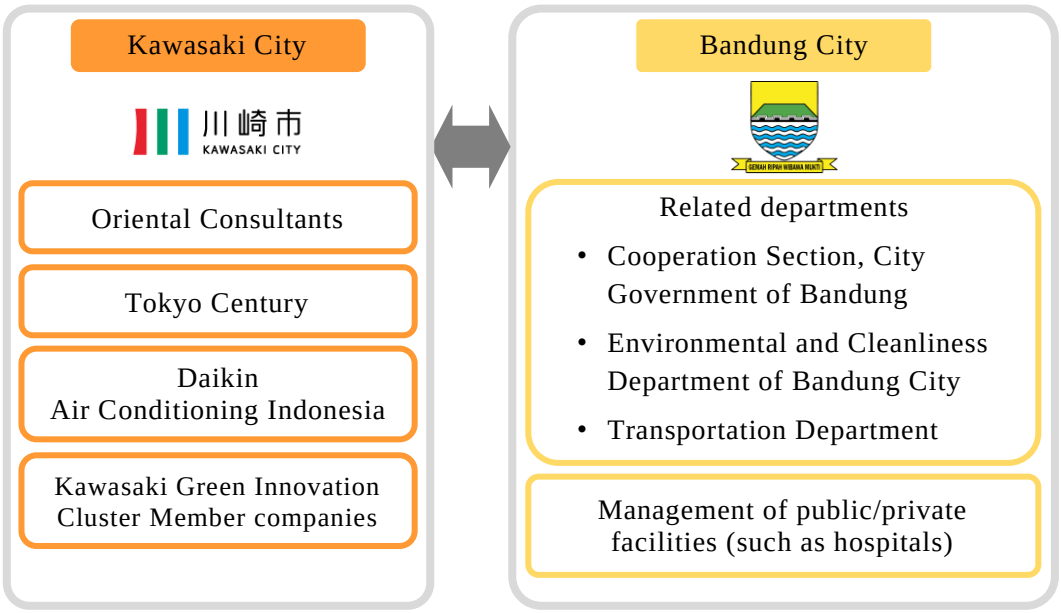


Figure 1-1 Implementation Structure

1.4 Project Implementation Plan and Project Implementation Process in FY 2022

The project was implemented as the first year of a three-year plan formulated in FY 2021.The project conducts a survey which will help mitigate traffic congestion and introduce an air quality monitoring system examining the causes of air pollution, improvement of which has yet to get underway among other activities set out in the memorandum of understandings. Moreover, the project also provides support, mainly for converting to a high-efficiency air-conditioning system, adopting LED streetlights and promoting green buildings as priority areas, with GHG emissions expected, to help realize a decarbonized society.

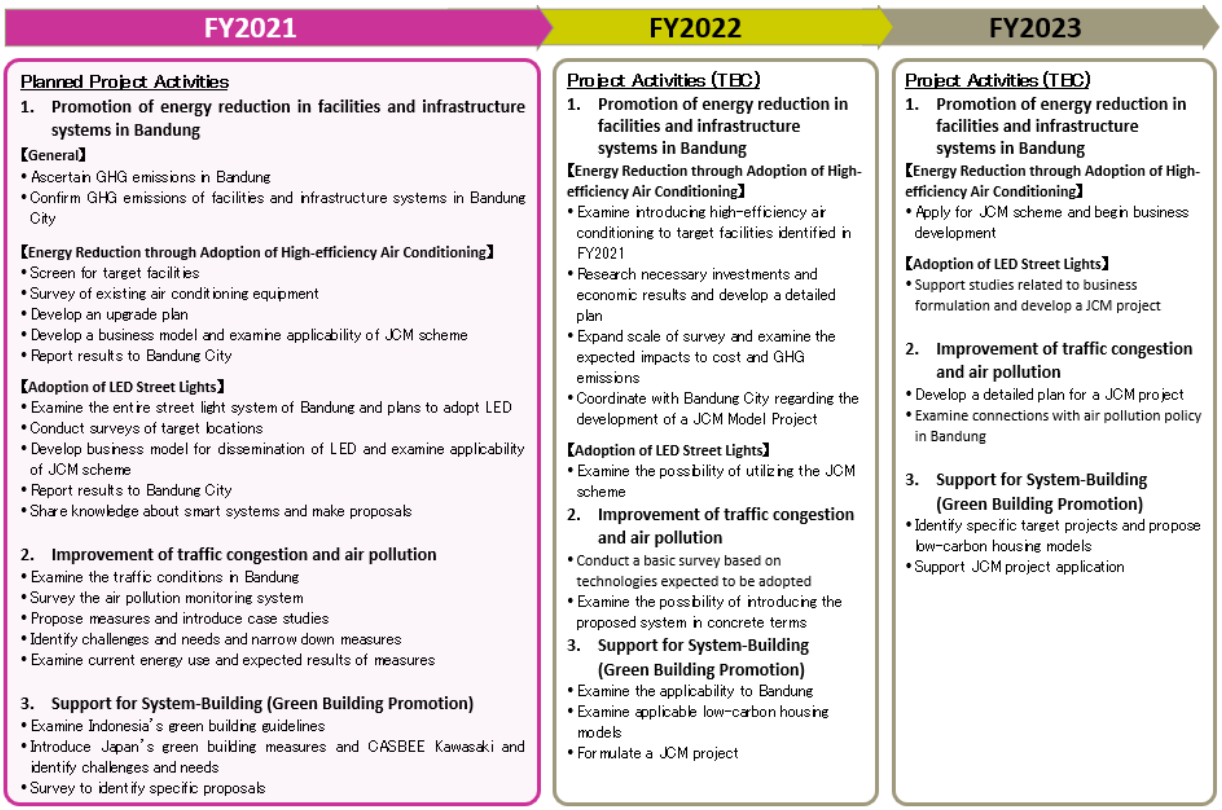


Figure 1-2 Project Implementation Policy

Table 1-1 Schedule of This Fiscal Year

Project Items	FY2021				FY2022		
	9	10	11	12	1	2	3
Meetings	Kick-off ▲			Mid term report ▲		Final report ▲	
I. Promotion of Low-Carbon Measures for Facilities and Infrastructure Systems in Bandung							
【Energy saving through high-efficiency air conditioning】 －Screening of target facilities and site survey of existing airconditioning －Examination of renewal plan －Development of business models and examination of applicability of JCM scheme		←	→	←	→	←	→
【Adoption of LED Street Lights】 －Survey of street light system and plans to install LED lighting in Bandung －Development of conversion plan andproposal for smart system －Development of business models and examination of applicability of JCM scheme			←	→	←	→	
II. Improvement of Traffic Congestion and Air Pollution							
－Survey of current traffic conditions －Survey the air pollution monitoring system －Proposal of measures and introduction of case studies －Identification of issues and needs		←	→	←	→	←	→
III. Support for System-building (Promotion of Green Building)							
－Study on greenbuilding guidelines policies and measures －Introduce Japan's green building measures and CASBEE Kawasaki －Identification of issues and needs		←	→	←	→	←	→
Online workshops		1st ▲		2nd ▲	3rd ▲	4th ▲	
Monthly report		▲	▲	▲	▲	▲	▲
Final report				←	→	←	Submission ▲

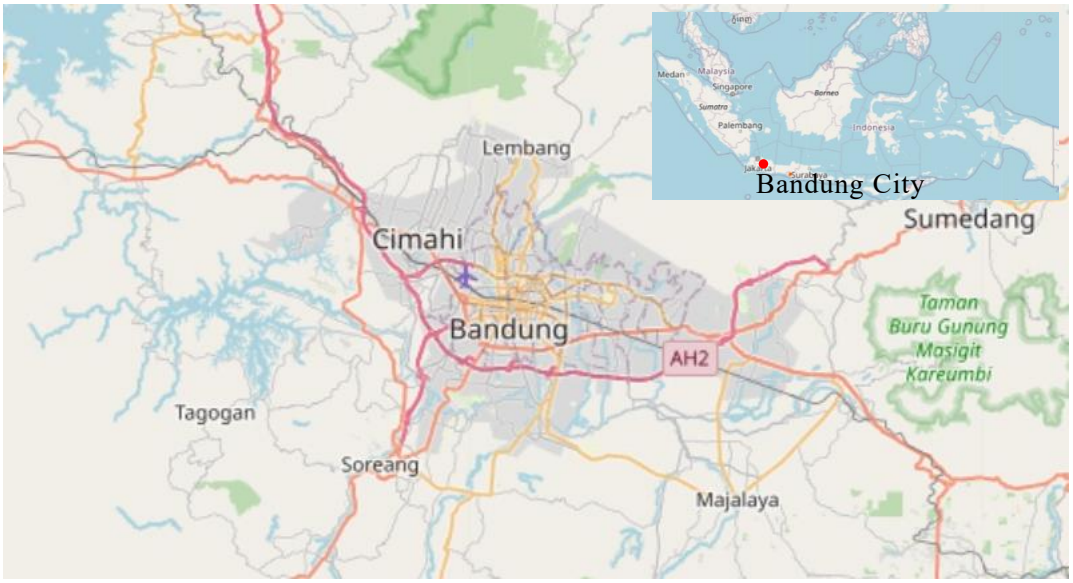
Implementation Period: September 1, 2021 to March 10, 2022

Chapter 2　Overview of Bandung City and Its Climate Change Initiatives

2.1　Overview of Bandung City

Bandung is the capital of West Java Province in western Java Island, located 200km southeast of the national capital of Jakarta. The city has an area of 167.31km2 that consists of 30 districts (kecamatan). Situated at a high altitude of 700-800m above the sea level, it remains cooler throughout the year than other areas of the country. Moreover, Bandung has the third largest population in Indonesia at around 2.44 million, following Jakarta and Surabaya. Population density of Bandung is 14,600 persons/km2, and of Jakarta is 16,700 persons/km2.

With a real GDP growth rate of about 7% (5% higher than the national average) before 2019, Bandung plays an important role in the economic development of Indonesia. The city's main industries include textile (which accounts for about 35% of the municipal total), clothing (15%), and food (12%) industries (Department of Industry and Trade of Bandung, 2020), which have brought many manufacturing plants into the city. The city has a long prosperous history as the political, economic, and cultural center of West Java Province and is also well known as an academic city with more than 20 universities.



Source: OpenStreetMap

Figure 2-1　Map of Bandung City

2.2　Climate Change Initiatives in Indonesia and Bandung

2.2.1　Climate Change Initiatives in Indonesia

Indonesia was responsible for half of the greenhouse gas (GHG) emissions from ASEAN in 2018. This was mainly due to the CO2 emissions from deforestation and peatland degradation. In fact, this ninth largest GHG emitter accounted for 1.6% of global CO2 emissions in 2018. In recent years, the country has seen an increase in GHG emissions from the energy sector. According to the Ministry of Energy and Mineral Resources (MEMR) of Indonesia, power generation increased more than fivefold from 1990 to 2014, making the energy sector responsible for more than 50% of national GHG emissions in 2017. Against this backdrop, the Government of Indonesia adopted Presidential Regulation No. 61/2011 on the National Action Plan for Greenhouse Gas Emissions

Reduction (RAN-GRK), which set GHG emissions reduction targets and defined the scope of action in five priority areas (agriculture, forestry and peatland, energy and transport, industry, and waste management). Then, Regional Action Plans for Greenhouse Gas Emissions Reduction (RAD-GRK) were formulated by all provincial governments before 2013. In April 2021, the Government of Indonesia announced its intention to update Presidential Regulation No. 61/2011 on RAN-GRK. The Government also emphasized the importance of regional initiatives to achieve the 2030 goals and committed to providing financial support for provincial and municipal governments to take the initiative.

In September 2015, the Government of Indonesia submitted its Intended Nationally Determined Contributions (INDC) with ambitious CO_2 emissions reduction targets to the Secretariat of the United Nations Framework Convention on Climate Change (UNFCCC) before the 21st session of the Conference of Parties (COP21) of the UNFCCC. This INDC was complemented by the Nationally Determined Contributions (NDC) submitted in July 2021 to the UNFCCC Secretariat, along with the Long-Term Strategy for Low Carbon and Climate Resilience 2050 (LTS-LCCR 2050), before COP26 in November 2021. This new NDC set a target of reducing GHG emissions by 29% from the BAU levels with its own efforts and by 41% from the BAU levels with international support by 2030. In addition, the Government of Indonesia committed to reducing its net GHG emissions by 2030 and attaining carbon neutrality by 2060, a decade earlier than the original target year of 2070, at the COP26 summit.

Table 2-1 Projected BAU and Emission Reduction from Each Sector Category

Sector	GHG Emission Level 2010 Mt-CO2E	GHG Emission Level 2030			GHG Emission Reduction			
		Mt on CO2E			Mt on CO2E		% of Total BaU	
		BAU	CM1	CM2	CM1	CM2	CM1	CM2
Energy	453.2	1,669	1,355	1,223	314	446	11%	15.5%
Waste	88	296	285	256	11	40	0.38%	1.4%
IPPU	36	70	67	66	3	3.25	0.1%	0.11%
Agriculture	111	120	110	116	9	4	0.32%	0.13%
Forestry and Other Land Uses (FOLU)	647	714	217	22	497	692	17.2%	24.1%
Total	1,334	2,869	2,034	1,683	834	1,185	29%	41%

BAU: If no special measures are taken, CM1: Unconditional mitigation scenario, CM2: Conditional mitigation scenario

Source: Updated Nationally Determined Contribution, Republic if Indonesia, 2021

Community actions against climate change include the Climate Village Program (ProKlim) led by the Ministry of Environment and Forestry (MOEF). ProKlim is intended to promote village- or community-based climate change mitigation and adaptation actions. Villages and communities recognized for their climate change initiatives are provided with grants. Some communities within Bandung have been registered for the program and engaged in actions such as water resources conservation, tree planting, biogas applications, and waste management.

2.2.2 Energy Saving Initiatives in Indonesia

In order to achieve the above-mentioned NDC goals, the Government of Indonesia has focused its climate change efforts on increasing the use of renewable energy sources and promoting energy efficiency and conservation. In the energy sector, particular emphasis has been put on how to increase the share of renewable energy sources in the electricity mix, with an aim to increase it to at least 23% by 2025 and at least 31% by 2050. Today, renewable energy accounts for less than 20% of power generation, while coal accounts for more than 50%. Therefore, it is planned to promote the development of geothermal, hydro, biomass, solar, and wind power.

For energy conservation, the Government of Indonesia formulated a National Master Plan for Energy Conservation (RIKEN) in accordance with Law No. 30/2007 on Energy and Government Regulation No. 70/2009 on Energy Conservation and set sectoral energy consumption reduction targets for 2025 for the commercial (15%), household (15%), industrial (17%), and transport (20%) sectors. Table 2-2 below shows actions to be taken to achieve these sectoral targets.

Table 2-2 Sectoral Energy Saving Targets and Initiatives

Sector/Targets	Policies and Initiatives
Commercial sector energy saving target: 15%	• Energy management structure for large commercial buildings: Government Regulation No. 70/2009 on Energy Conservation. This system requires building managers to designate energy managers, implement energy saving programs, conduct energy audits, and report their energy efficiency plans and measures to the government. • Building energy efficiency standards: Indonesian National Standards (SNIs)
Household sector energy saving target: 15%	• Minimum Energy Performance Standards (MEPS): These standards apply to HVAC equipment, fluorescent bulbs, refrigerators, electric fans, etc. Their scope of applicability will continue to be extended. • Energy performance labeling scheme: The ratings are on a scale of one to four stars, with one being the lowest for MEPS. • Revised electricity rates and energy saving request
Industrial sector energy saving target: 17%	• Energy management system: Government Regulation No. 70/2009 on Energy Conservation
Transport sector energy saving target: 20%	• Program for low-carbon emission vehicles (LCEVs) including hybrid and electric vehicles • Application of biofuels in transport

Source: Compiled by the study team based on the FY2017 Report on Projects Contributing to Energy Conservation and Renewable Energy Promotion in Emerging Countries by Energy Conservation Center, Japan

2.2.3 Climate Change Initiatives in Bandung

The Regional Action Plan for Greenhouse Gas Emissions Reduction (RAD-GRK) of West Java Province, where the city of Bandung is situated, was formulated in 2012, based on the National Action Plan for Greenhouse Gas Emissions Reduction (RAN-GRK), to promote (i) the application of energy saving technologies, (ii) the use of clean fuels, and (iii) the use of renewable energy sources (especially for small- and medium-scale power generation). In addition, the Provincial

Government of West Java has set a target of reducing energy consumption by 20% in response to MEMR Regulation No.13/2012 and started to require energy saving in public buildings. These efforts include installing energy-efficient HVAC systems and replacing existing incandescent lighting with energy efficient lighting, which are subject to analysis in this study.

Meanwhile, the Municipal Government of Bandung takes the lead in combating climate change in Indonesia, highly appreciated inside and outside the country and given a number of awards, including the ASEAN Environmentally Sustainable City Award 2011 and the Adipura Award 2017 (a national honor that recognizes clean cities). The workshops held under this project confirmed that the Municipal Government of Bandung had focused its GHG emissions reduction efforts on four priority areas, (i) energy generation and consumption, (ii) industrial processes and product use, (iii) agriculture, forestry, and other land use changes, and (iv) waste management, in accordance with national environmental policies.

Despite all the above, Bandung only had limited statistics on GHG emissions. For example, the city's emissions from waste management were not included in the estimates because its solid waste disposal sites were located outside the city, and those from the industrial sector were excluded from the estimates because relevant data were not available. In addition, the estimates for the energy sector only covered emissions from some public transport services for which data were available.

Table 2-3 Actions to Reduce GHG Emissions in Priority Areas in Bandung

Priority Area	Actions
Energy generation and consumption	• Energy management in public buildings • Shift from kerosene to LPG in the household and commercial sectors • Implementation of traffic control and safety programs • GHG emissions in FY2020: 1,753.899 Gg-Co2eq.
Industrial processes and product use	• Emissions reduction in the chemical, metal, mining, and electronic industries • GHG emissions in FY2020: Not estimated
Agriculture, forestry, and other land use changes	• Land use optimization program • Productivity improvement program • GHG emissions in FY2020: 67.66 Gg-Co2eq.
Waste management	• Formulation of a solid waste management master plan • 3Rs waste reduction program • GHG emissions in FY2020: 112.564 Gg-Co2eq.

Source: Presentation material of Bandung City at 1st workshop

2.2.4 The Bandung City Department of Environment Strategic Plan 2018-2023

The Department of Environment Strategic Plan 2018-2023, formulated for Bandung, one of the cities selected to develop such plans in the National Medium-Term Development Plan (RPJMN), provides guidelines for translating the RPJMN into action at the municipal level. This municipal development plan first reviews achievements made during the 2014-2018 period (as shown in Table 2-4 below) and then defines the course of action (as shown in Table 2-5 below) based on these results. During the 2014-2018 period, only 85% of the budget was spent due to the stagnation in

infrastructure development caused by delays in procurement, the lack of human resources, and the disorganized process of planning.

As Bandung's GHG emissions are decreasing at a faster rate than planned, the municipal government has set a reduction target of 9% by 2023 (on a year-on-year basis). In the transport sector, identified as the largest emitter, various measures have been taken, such as promoting the use of motorcycles and minibus services and designating no driving areas. In addition, the municipal development plan gives priority to road function maintenance, road traffic management, and mass public transport system development. Moreover, the workshops held under this project confirmed that Bandung had some vehicle emissions testing and air quality monitoring stations. However, the air quality monitoring is unlikely to cover the entire city, given that there are only four monitoring stations. Additional monitoring stations are required, along with a better monitoring system with automated measuring instruments and sensors similar to those used in Kawasaki, to examine the sources of pollution and their changes over time and develop effective measures against air pollution.

Table 2-4 Achievements between 2014 to 2018

No.	Item	Contents
Achieved		
1	Conformity with the air quality standards	Air quality measured at monitoring stations met the standards during the 2014-2018 period.
2	GHG emissions reduction	GHG emissions reduction targets were achieved throughout the 2014-2018 period. 2014 target: 2%→6.38% reduction 2015 target: 2%→5% reduction 2016 target: 6%→7% reduction 2017 target: 8%→9% reduction 2018 target: 10%→10.7% reduction
3	3Rs for waste management	The share of the 3Rs (reduce, reuse, recycle) waste management reached almost 100% between 2014 and 2017 but declined to 73% in 2018.
4	Water sources protection	The target number of water sources were protected throughout the 2014-2018 period.
Unachieved		
5	River water quality improvement	According to Government Regulation No. 82/2001 on water quality standards, 18 out of the 46 rivers running through Bandung were classified as "lightly polluted" and 28 as "moderately polluted."
6	Landfills for waste disposal	The planned waste power plant was not built, and all waste was disposed of in landfills.
7	Waste-to-energy conversion	

Source: Rencana Strategis 2018-2023, DLHK Kota Bandung

Table 2-5 Future Course of Action

No.	Item	Contents
1	Conformity with the air quality standards	Although the targets were achieved, air quality is considered poor according to the Environmental Quality Index (IKLH) and needs to be monitored continuously.
2	GHG emissions reduction	The following targets have been set. It will be essential to monitor GHG emissions and their reductions in the waste management sector. 2019 target: 7% 2023 target: 9%
3	3Rs for waste management	Because there is still room for improvement, the scope of management will be expanded.
4	Water sources protection	A sufficient number of water sources has been protected. It will be essential to manage water sources for waterworks.
5	River water quality improvement	As the water quality of some rivers is extremely poor, efforts will be made, such as water quality monitoring and environmental education for local residents.
6	Landfills for waste disposal	With a strategic goal of expanding the scope of waste management while improving the quality of the living environment, the municipal government will develop waste management infrastructure and conduct a feasibility study of biogas technology.
7	Waste-to-energy conversion	

Source: Rencana Strategis 2018-2023, DLHK Kota Bandung

2.2.5 Energy Saving Activities in Bandung

According to the RAD-GRK of West Java Province, where Bandung is located, 56 of the 151 districts in Bandung will be affected by climate change. In particular, the following four items are raised as issues.

1) Waste left undisposed

2) Increase in slum population

3) Insufficient access to energy, few green spaces

4) There is no organization / institution to deal with climate change issues

In 2013, the annual electricity supply rate in Bandung City was 90%, exceeding the national average. However, the power distribution network remains inadequately developed, overly costly to operate and maintain and supply and demand are mismatched.

Recent years have seen the city gain increasing recognition as an Eco City, alongside Solo and Denpasar, which has earned it selection by the Indonesian government for a pilot project featuring energy-saving LED streetlights and other streetlights equipped with smart meters city-wide. The city is cooperating in collecting and analyzing the data obtained.

Subsidies provided by the Ministry of Energy and Mineral Resources have also been used to conduct audits of city halls, hospitals, government research facilities and shopping malls to determine how best to improve energy use and implement energy-saving measures recommended by consultants. As well as the above efforts, Bandung City has been striving to boost awareness of energy conservation to meet the demand for contribution to the energy conservation goals of West Java Province and these ongoing activities are expected to continue.

Chapter 3 Promoting energy conservation in the facilities and infrastructure systems of Bandung City

3.1 Promoting energy conservation by switching to high-efficiency air-conditioning system

3.1.1 How City Halls, Hospitals and Schools are organized in Bandung City

(1) Organizing trends in air-conditioning equipment in Indonesia

Recent years have seen air-conditioners become indispensable components within infrastructure supporting people's lives around the world. However, according to the International Energy Agency's (IEA) technology report "The Future of Cooling" (May 2018), only a third or so of the world's households have air-conditioners today and air-conditioner penetration remains at only 8% or so, particularly in the tropics; home to nearly 3 billion people. As population soars and economic growth continues, the number of air-conditioners is expected to triple by 2050, when about two-thirds of global households are expected to use them. Conversely, given the sharp rise in energy consumption forecast for developing countries to feed accelerating economic development, there are concerns that the global supply and demand for energy will tighten going forward.

Above all, tropical regions face the problem of excessive electricity consumption to power air-conditioners, which may comprise 45% of all power needs during peak hours, according to the aforementioned IEA report. Installing more high-efficiency inverter air-conditioners which are far more energy-efficient may go a long way to reducing the energy consumption and environmental impact.

Optimizing the operation of inverter air-conditioners by tapping into inverter techno means they have scope to reduce power consumption by approximately 58% compared to non-inverter air-conditioners using inverter technology (manufacturer's survey). In addition, not only room air-conditioners for homes, but also commercial air-conditioners and multi air-conditioners for buildings can achieve energy savings by adopting inverter technology and advanced control technology. With this as the pillar of our approach, a switch to high-efficiency air-conditioners capable of saving more energy would be in line with the energy-efficiency and conservation policies of Bandung City.

According to the "Estimated World Demand for Air-Conditioners" by the Japan Refrigeration and Air-Conditioning Industry Association, the demand for air-conditioners in Indonesia in 2018 amounted to around 2.3 million units, which puts it top of the ASEAN nations. Of this total, 96%, or around 2.25 million units, were room air-conditioners for domestic use. According to the results of interviews with air-conditioner manufacturers, four Japanese manufacturers held more than 50% of the market share and the market size for Bandung City is about 100,000 units per year.

Although economical non-inverter-type air-conditioners remain on sale in Indonesia, the core products sold by Japanese manufacturers are highly energy-efficient inverter air-conditioners and collaboration with Japanese manufacturers leveraging JCM model projects could pave the way to reducing GHG emissions.

Although economical non-inverter-type air-conditioners remain on sale in Indonesia, the core products sold by Japanese manufacturers are highly energy-efficient inverter air-conditioners and collaboration with Japanese manufacturers leveraging JCM model projects could pave the way to

reducing GHG emissions.

In the first year of this study, it is planned to examine the conversion to high-efficiency air-conditioning systems in public hospitals in Bandung among the facilities in Bandung City. In addition, the feasibility of upgrading the air-conditioning systems in municipal buildings, schools, other municipal facilities and private facilities to inverter air-conditioners will be investigated.

(2) Summary of previous years' survey results

In the feasibility study on the formation of large-scale JCM projects for the realization of a low-carbon society in Asia in 2014, we examined the use of LED street lighting and buildings as targets for the introduction of energy-saving technologies. Based on the results, Trans Studio Mall was selected as the target facility for the energy-efficiency and conservation audit, given the expected scope to reduce CO2 emissions by replacing air-cooled chillers for water-cooled units.

Trans Studio Mall is a shopping mall and the electricity consumption of the heat source for air-conditioning in the entire building is considered to be quite high. Since the heat source for air-conditioning has not been upgraded since the building was completed, the equipment has become obsolete and deteriorated. The following Table 3-1 summarizes the results of the study examining the reduction of greenhouse gas emissions when switching air-cooled chillers to water-cooled units.

Table 3-1 Trial calculation showing energy-saving effect of chiller replacement

Type	Unit	Existing	Replacement
Chiller Type	-	Air-cooled chiller	Water-cooled turbo chiller
Cooling capacity	kW	1,165	1,197
Quantity	-	6	6
Power consumption	kW	524	187
Efficiency	kW/Tr	1.58	0.55

Type	Figure
Existing chiller power consumption	8,262MWh/year
Renewal chiller power consumption (including ancillary equipment)	4,423MWh/year
Reduction in electricity consumption (referencing existing chillers)	3,839MWh/year
CO2 emission reduction (based on JCM_ID_AM002 Ver1.0)	475t-CO2/year
Capital expenditure	314 million yen
Cost-effectiveness (estimate based on forecast 15-year service life)	44,070 yen/t-CO2

Source: 2014 Feasibility Study on the Formation of Large-Scale JCM Projects to Realize a Low-Carbon Society in Asia, Institute for Global Environmental Strategies (IGES) / Japan Environmental Sanitation Center (JECC) / Kawasaki City

When the potential to reduce the greenhouse effect in large-scale dissemination was examined, it emerged that energy conservation within buildings could reduce energy-derived CO2 emissions by replacing fluorescent lighting with LED for commercial facilities and upgrading air-conditioning chillers. The following table shows trends of electricity consumption by sector in Bandung City from 2005 to 2012. Based on Table 3-2, if we were to estimate the energy-derived CO2 in the commercial system, it would be possible to expand the greenhouse effect reduction scheme studied in this research throughout Indonesia.

Table 3-2 Trends in Electricity Sales by Customer Type

By sector	2005	2006	2007	2008	2009	2010	2011	2012
Home	41,182	43,754	47,324	50,184	54,945	59,825	65,110	72,132
Business	15,980	18,415	20,608	22,926	24,825	27,157	28,309	30,989
Industry	42,453	43,615	45,802	47,969	46,204	50,985	54,725	60,176
Public	7,417	6,825	7,510	7,940	8,607	9,330	9,848	10,694
Total	107,032	112,069	121,246	129,019	134,581	147,297	157,992	173,991

Source: PLN Annual Report 2009, PLN Annual Report 2012 (PLN, 2009, 2012)

If 2012 is taken as the base, the energy-derived CO2 in commercial systems would amount to 25,225,046 [t-CO2/year], assuming 0.81 [t-CO2/MWh]. Assuming the electricity consumed by large-scale commercial facilities accounts for 20% of this total and that heat sources for lighting and air-conditioning comprise a further 50%, improving the efficiency of these sources by 20% would elicit an expected reduction of 504,500 [t-CO2/year].

(3) Organizing the climatic characteristics of Bandung City

Air-conditioning systems are installed within premises to maintain a constant temperature, regardless of the outside temperature. Accordingly, since the use of air-conditioning systems is dictated by the outside temperature of the target site, the average temperature in Bandung City, a prerequisite when considering the renewal of air-conditioning systems, is shown in Table 3-3.

Bandung City enjoys a tropical climate, with daytime temperatures of 27-28℃, which then fall to 17-18℃ overnight, making it a cool and pleasant environment all year round.

Table 3-3 Annual Temperature Trends in Bandung City
(Hussein Sastranegara Airport, temperatures from 1972 - 94)

Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Year
Average maximum temperature	27.2	26.7	27.2	27.8	27.8	27.8	27.8	28.3	28.9	28.9	27.8	27.2	27.8
Daily average temperature	23.3	23.1	23.3	23.6	23.3	22.8	22.5	22.8	23.3	23.6	23.3	23.3	23.2
Average minimum temperature	19.4	19.4	19.4	19.4	18.9	17.8	17.2	17.2	17.8	18.3	18.9	19.4	18.6

Source: World Bioclimatic Classification System

In Japan, the “Law for Maintenance of Sanitation in Buildings” (hereinafter referred to as “Building Sanitation Law”) states that the temperature of air-conditioning equipment should be set within the standard range (between 17-28°C) (namely 28°C in summer, 20°C in winter). Taking this standard as a benchmark, the amount of time spent on temperature-control of air-conditioning equipment in Bandung is minimal.

With the above in mind, the installation environment and applications requiring the operation of high-efficiency air-conditioning systems should be considered before deciding on which facilities to install.

(4) Organize the objects to be considered in Bandung

Based on the previous section and working with Bandung City, three types of public facilities (including Bandung City Public Hospitals and Computer Labs of State Junior High Schools) were selected as facilities where air-conditioning equipment was expected to be operated for an extended period, as shown in Table 3-4.

Table 3-4 Facilities under consideration in Bandung City

Facility	No. of facilities	Example facilities
Spatial Planning Department and Single Window Service for Investment Department, Bandung City	One	 DPMPTSP Kota Bandung
Bandung City Public Hospital	Nine	 Dr. Hasan Sadikin Central General Hospital
Computer Laboratories of several State Junior High Schools (still coordinated by Bandung City Education Department)	Four	 Bandung Independent School

When considering the GHG reduction effect and ensuring cost-effectiveness, it is important to extract facilities that meet the following conditions.

1) A desire to install fittings and equipment consistent with the approach is confirmed
2) Since thanks to scaling, the reduction effect increases in proportion to the number of units replaced, many large-scale facilities or air-conditioning units are used
3) Since the reduction effect increases in proportion to the overall number of hours and days operated, the operating hours for the air-conditioning equipment are long

(5) Determining facilities with the potential for GHG reduction

Based on the organization described above, hospital facilities were selected as those well-placed to promote energy efficiency and conservation by switching to high-efficiency air-conditioning systems. The public hospitals in Bandung City are shown in Table 3-5.

Table 3-5 List of Bandung City Public Hospitals

No.	Facility Name	Outline	Exterior View
1	Dr. Hasan Sadikin Central General Hospital	The building, with seven stories above ground, was built by the Dutch government in 1920 and completed in 1923.	
2	Rumah Sakit Kebon Jati (Kebon Jati Hospital)	A three-story building (built by the Chinese Community Association in around 1943, facilities added in 1948, then expanded to three stories in 1968.)	
3	Santosa Hospital Bandung Central	Constructed in 2006, with total floor space of 38,728 meters, nine stories above ground and two underground levels.	
4	Rumah Sakit Umun Bangsu (Umun Bangsu Hospital)	Moved from Jl. Guntur in 1949 and went into operation. Area of 3,200 m2, two stories above ground and 50 beds.	
5	Immanuel Hospital Bandung	Constructed in 1910	
6	Monalisa	Three stories high	
7	Muhammadiyah Hospital Bandung	Constructed in 1968, six stories high.	
8	Bandung Advent Hospital	Constructed in 1950, went into operation in 1963 in the current building (age unknown). Three stories and 254 beds.	
9	Bandung City Regional General Hospital	Established in 1993, two stories.	

3.1.2 Current Situation Survey on Air-conditioning Equipment

(1) Selection of target facilities for public hospitals in Bandung

The public hospitals in Bandung City listed in the previous section were coordinated with Bandung City and "Bandung City Regional General Hospital" (RUSD) was selected as the target of the survey and study this year. The facility is outlined in Table 3-6.

Table 3-6 Table summarizing Bandung City Regional General Hospital

Aerial photo of facility

Appearance of facility

Inside of facility

Outpatient Consultations	
1. Department of internal medicine (hospital, etc.)	2. Pediatrics
3. Pediatric surgery	4. Department of obstetrics and gynecology (Ob/Gyn)
5. General surgery	6. Oral surgery
7. Orthopedic surgery	8. Neuroscience
9. Neurosurgery	10. Otorhinolaryngology
11. Eye specialist	12. Dermatology
13. Orthodontics	14. Cardiology
15. Urology	16. Mental health
17. EEG Polyclinic	18. Acupuncture clinic
19. General Clinic	20. Dental and oral clinic
21. VCT & CST Clinic (HIV/AIDS)	22. Nutrition consulting services
23. DOTS Service	24. Counseling services/Pharmaceutical Information (PIO)
Inpatient related* Numbers in parentheses indicate beds: 296	
1. VVIP Room (Junior Suite) (2)	2. VIP Room (2)
3. Classroom I (16)	4. Class II (91)
5. Class III Luan (108)	6. ICU Room (8)
7. PICU/NICU room (5)	8. Room OK (Operational Action) (6)
9. Delivery Room (11)	10. First Aid Room (26)
11. HD Room (11)	12. Medical Rehabilitation Office (10)

(2) Survey of the target facility air-conditioning system

A remote survey was conducted, assisted by local officials, to determine the number of air-conditioning units installed and get specific information on the target facility equipment, since COVID-19 precluded efforts to conduct a field survey.

213 air-conditioning systems were confirmed in Bandung City General Hospital, details of which are shown in Table 3-7.

Table 3-7 List of air-conditioning systems in Bandung City Regional General Hospital

No	Location	Name/Type of Item	Brand	Type	Year of Procurement
1	Pharmacy Store	AC Split 1 PK	LG	SN09LTG	2013
2	Pharmacy Depot	AC Split 1 PK	LG	S09LFG-2	2011
3	Pharmacy Store	AC Split 1 PK	Panasonic		2015
4	Flamboyant Room/ Doctor Room	AC Split 1 PK	LG	S09LFG-2	2011
5	Blood Bank	AC Split 3/4 PK	Daikin	AH-A7PEY	2014
6	Room 321	AC Split 3/4 PK	LG	S07LFG-2	2018
7	Room 219	AC Split 3/4 PK	LG	S07LFG-2	2019
8	Room 223	AC Split 3/4 PK	LG	S07LFG-2	2011
9	Room 224	AC Split 3/4 PK	LG	S07LFG-2	2019
10	Room 220	AC Split 3/4 PK	LG	S07LFG-2	2017
11	Room 222	AC Split 3/4 PK	LG	S07LFG-2	2011
12	Room 227	AC Split 3/4 PK	LG	S07LFG-2	2019
13	Room 226	AC Split 3/4 PK	Daikin	-	2019
14	Room 228	AC Split 3/4 PK	Panasonik	-	2017
15	Room 25	AC Split 3/4 PK	LG	S07LFG-2	2018
16	Room 229	AC Split 3/4 PK	LG	S07LFG-2	2018
17	Room 218	AC Split 3/4 PK	LG	S07LFG-2	2011
18	Room PIO	AC Split 1 PK	LG	S09LFG	2012
19	Pharmaceutical Storehouse	AC Split 1 PK	LG	S09LFG	2012
20	Radiology Instalation/Doctor Room	AC Split 3/4 PK	LG	S07LFG-2	2012
21	Aster Room/Doctor Room	AC Split 3/4 PK	LG	S07LFG-2	2012
22	Medical Rehabilitation	AC Split 3/4 PK	LG	S07LFG-2	2012
23	EEG Polyclinic	AC Split 3/4 PK	Panadonik	-	2012
24	Sakura Room/Neonatal Room	AC Split 3/4 PK	LG	S07LFG-2	2012
25	Super Vision Room	AC Split 3/4 PK	LG	S07LFG-2	2012
26	Radiology Instalation/Xray 1 Room	AC Split 3/4 PK	LG	S07LFG-2	2012
27	Radiology Instalation/Xray 2 Room	AC Split 3/4 PK	LG	S07LFG-2	2012
28	Dental Polyclinic dr Rina	AC Split 3/4 PK	LG	S07LFG-2	2012
29	Dental Polyclinic dr Wili	AC Split 3/4 PK	LG	S07LFG-2	2012
30	Outpatient Registration Floor 2	AC Split 1/2 PK	Daikin	-	2012
31	ICU/Neonatal Room	AC Split 1/2 PK	LG	S05LFG-2	2012
32	Dental Polyclinic dr Edi	AC Split 3/4 PK	LG	SN07LFG-2	2012
33	Dental Polyclinic dr Sule	AC Split 3/4 PK	LG	SN07LFG-2	2012
34	ICU/ICU Unit Head Room	AC Split 3/4 PK	LG	SN07LFG-2	2012
35	ICU/PONEK	AC Split 3/4 PK	LG	SN07LFG-2	2012
36	ICU/Nurse Room	AC Split 3/4 PK	LG	SN07LFG-2	2012
37	CSSD/Sterile Room	AC Split 1 PK	Panadonik	-	2016
38	Clinical Pathology Laboratory Installation/Head of Blood Bank Room	AC Split 1/2 PK	Daikin	Daikin	2013
39	Clinical Pathology Laboratory Installation/Head of Laboratory Room	AC Split 1/2 PK	LG	SN05LFG-2	2013
40	Pharmacy Storeroom	AC Split 3/4 PK	LG	SN07LFG-2	2013
41	Sakura Room/Doctor Room	AC Split 3/4 PK	LG	SN07LFG-2	2013
42	Pharmacy Depot	AC Split 3/4 PK	LG	SN07LFG-2	2013
43	Dental Polyclinic dr Nuni	AC Split 3/4 PK	LG	SN07LFG-2	2013
44	Dental Polyclinic dr Mulyadi	AC Split 3/4 PK	LG	SN07LFG-2	2013
45	Clinical Pathology Laboratory Installation/Microbiology Room	AC Split 1 PK	LG	SN09LFG-2	2013
46	ICU/Doctor Room	AC Split 1 PK	LG	SN09LFG-2	2013
47	Orthopedical Polyclinic	AC Split 3/4 PK	LG	SN07LTG	2013
48	Nerve Polyclinic	AC Split 3/4 PK	Daikin	Daikin	2013
49	Internal Disease Polyclinic	AC Split 3/4 PK	Panasonik	Panasonik	2013
50	neurosurgery Polyclinic	AC Split 3/4 PK	Panasonik	Panasonik	2013
51	Gynecology Polyclinic	AC Split 3/4 PK	Daikin	Daikin	2013

No	Location	Name/Type of Item	Brand	Type	Year of Procurement
52	Skin & genital polyclinic	AC Split 3/4 PK	LG	SN07LTG	2013
53	Skin & genital polyclinic	AC Split 3/4 PK	LG	SN07LTG	2013
54	Nutrition Polyclinic	AC Split 3/4 PK	LG	SN07LTG	2013
55	Surgery Polyclinic	AC Split 3/4 PK	LG	SN07LTG	2013
56	Surgery Polyclinic	AC Split 3/4 PK	LG	SN07LTG	2013
57	Psychiatry Polyclinic	AC Split 1 PK	LG	SN09LTG	2013
58	General Polyclinic	AC Split 1 PK	LG	SN09LTG	2013
59	Children's Polyclinic	AC Split 1 PK	LG	SN09LTG	2013
60	Children's Polyclinic	AC Split 1 PK	LG	SN09LTG	2013
61	Growth and Development Polyclinic	AC Split 1 PK	LG	SN09LTG	2013
62	ENT Polyclinic	AC Split 1 PK	Daikin	Daikin	2019
63	Eye Polyclinic	AC Split 1 PK	Panasonik	Panasonik	2013
64	Children's Polyclinic/Immunization	AC Split 1 PK	LG	SN09LTG	2013
65	Nursing Committee	AC Split 1 PK	LG	SN09LTG	2013
66	Hemodialysis/Treatment Room	AC Split 1 1/2 PK	LG	SN12LFG	2013
67	Hemodialysis/Nurse Room	AC Split 1 1/2 PK	LG	SN12LFG	2013
68	Radiology Installation/CT Scan Treatment Room	AC Split 2 PK	LG	SN18LFG	2013
69	Radiology Installation/CT Scan Treatment Room	AC Split 2 PK	LG	SN18LFG	2013
70	Radiology Installation/CT Scan Treatment Room	AC Split 2 PK	LG	SN18LFG	2013
71	Hemodialysis/Treatment Room	AC Split 2 PK	LG	SN18LFG	2013
72	Obstetrics Polyclinic	AC Split 1/2 PK	LG	SN05LTG	2013
73	Outpatient Room	AC Split 1/2 PK	LG	SN05LTG	2013
74	Polyclinic CST/Lili Clinic Room	AC Split 1/2 PK	Sharp	AH-A5PEY	2014
75	Melati Room/Level 1 Room	AC Split 1/2 PK	Sharp	AH-A5PEY	2014
76	Melati Room/Isolasion Room	AC Split 1/2 PK	Sharp	AH-A5PEY	2014
77	NICU Room/Nurse Room	AC Split 1/2 PK	Sharp	AH-A5PEY	2014
78	OK Room/Depot OK Room	AC Split 1/2 PK	LG	LG	2014
79	Lactation Room	AC Split 1 PK	Sharp	AH-A9PEY	2014
80	Program and Marketing Section	AC Split 1 PK	Sharp	AH-A9PEY	2014
81	Medical and Nursing Division	AC Split 1 PK	Sharp	AH-A9PEY	2014
82	HR Development Subdivision	AC Split 1 PK	Sharp	AH-A9PEY	2014
83	Finance and Budget Subdivision	AC Split 1 PK	Sharp	AH-A9PEY	2014
84	Sakura Room/ Doctor Room	AC Split 1 1/2 PK	Sharp	AH-A12NCY	2014
85	Radiology Installation/ CT Scan Treatment Room	AC Split 2 PK	Sharp	AH-A18NCY	2014
86	Blood Bank	AC Split 3/4 PK	Daikin	Daikin	2014
87	Melati Room/Nurse Station	AC Split 3/4 PK	Sharp	AH-A7PEY	2014
88	Melati Room/Doctor Room	AC Split 3/4 PK	Sharp	AH-A7PEY	2014
89	Medical Support	AC Split 3/4 PK	Sharp	AH-A7PEY	2014
90	Office Elevator	AC Split 3/4 PK	Panasonik	Panasonik	2014
91	Server Room	AC Split 3/4 PK	Sharp	AH-A7PEY	2014
92	Clinic Disease Laboratory Installation/Process Room	AC Casete 3 PK	Panasonic	CS-F28DB4E5	2015
93	Clinic Disease Laboratory Installation/Process Room	AC Casete 3 PK	Panasonic	CS-F28DB4E5	2015
94	Clinic Disease Laboratory Installation/Process Room	AC Casete 3 PK	Panasonic	CS-F28DB4E5	2015
95	Central Surgical Installation/ OK Room 5	AC Casete 3 PK	Daikin	Daikin	2015
96	Eye OK Room	AC Casete 3 PK	Panasonic	CS-F28DB4E5	2015
97	Radiology Installation/ CT Scan Operation Room	AC Casete 3 PK	Panasonic	CS-D28DB4H5	2015
98	Clinical Disease Laboratory Installation/ Reagent Storage Room	AC Split 3/4 PK	Panasonic	CS-YN7RKJ	2015

No	Location	Name/Type of Item	Brand	Type	Year of Procurement
99	Radiology Installation/ CT Scan Operation Room	AC Casete 3 PK	Panasonic	CS-D28DB4H5	2015
100	Clinical Disease Laboratory Installation/ Sampling Room	AC Split 1 1/2 PK	Panasonic	CS-PN12RKJ	2015
101	Clinical Disease Laboratory Installation/ Sampling Room	AC Split 1 1/2 PK	Panasonic	CS-PN12RKJ	2015
102	Installation of clinical disease laboratory/Meeting Room	AC Split 1 1/2 PK	Panasonic	CS-PN12RKJ	2015
103	Pharmacy Depot	AC Split 3/4 PK	Panasonic	CS-YN7RKJ	2015
104	Tulip Room/ Isolation Room	AC Split 3/4 PK	Panasonic	CS-YN7RKJ	2015
105	Clinic Disease Laboratory Installation/Children Sampling Room	AC Split 1 PK	Panasonic	CS-YN9RKJ	2015
106	KPPI RS	AC Split 1 PK	Panasonic	CS-YN9RKJ	2015
107	Pharmacy Warehouse	AC Split 1 PK	Daikin	Daikin	2015
108	Tulip Room/ Birth Room	AC Split 1 PK	Panasonic	CS-YN9RKJ	2015
109	Tulip Room/ Birth Room	AC Split 1 PK	Panasonic	CS-YN9RKJ	2015
110	Tulip Room/ VIP Birth Room	AC Split 1 PK	Panasonic	CS-YN9RKJ	2015
111	Tulip Room/ VIP Birth Room	AC Split 1 PK	Panasonic	CS-YN9RKJ	2015
112	PICU Room	AC Split 1 PK	Panasonic	CS-YN9RKJ	2015
113	Head of Pharmacy Installation	AC Split 1/2 PK	Daikin	Daikin	2015
114	Tulip Room/ Doctor Room	AC Split 1/2 PK	Panasonic	CS-YN5RKJ	2015
115	Tulip Room/ VIP Birth Room	AC Split 1/2 PK	Panasonic	CS-YN5RKJ	2015
116	Head of Program and Marketing	AC Split 1/2 PK	Panasonic	CS-YN5RKJ	2015
117	Flamboyant Room/ Medicine Room	AC Split 1/2 PK	Panasonic	CS-YN5RKJ	2015
118	Jasmine Room/ Baby Room	AC Split 1 1/2 PK	Daikin	Daikin	2015
119	Jasmine Room/ Baby Room	AC Split 1 1/2 PK	Daikin	Daikin	2015
120	Jasmine Room/ Baby Room	AC Split 1 1/2 PK	Panasonic	CS-PN12RKJ	2015
121	NICU room	AC Split 1 1/2 PK	LG	LG	2015
122	NICU room	AC Split 1 1/2 PK	LG	LG	2015
123	Clinic Disease Laboratory Installation/ Routine Clinic Room	AC Split 1 PK	Sharp	AH-A9MEY	2015
124	Radiology Installation/ Dark Room	AC Split 1 PK	Sharp	AH-A9MEY	2015
125	CSSD/ Packing Room	AC Split 1 PK	Sharp	AH-A9MEY	2015
126	Medical Committee/ Meeting Room	AC Split 1 PK	Sharp	AH-A9MEY	2015
127	ICU Room/ Doctor Room	AC Split 1 PK	LG	T09NL	2015
128	OK Room/ Transit Room	AC Split 1 PK	LG	T09NL	2015
129	OK Room/ Transit Room	AC Split 1 PK	LG	T09NL	2015
130	Radiology Installation/ X-ray Room 3	AC Split 2 PK	Panasonic	CS-PN18RKP	2016
131	Radiology Installation/ CT Scan Control Room	AC Split 2 PK	Panasonic	CS-PN18RKP	2016
132	ICU Registration	AC Split 3/4 PK	Panasonic	CS-YN7RKJ	2016
133	ICU/Resuscitation Room	AC Split 3/4 PK	Panasonic	CS-YN7RKJ	2016
134	Nerve Polyclinic	AC Split 1 PK	Panasonic	CS-YN9RKJ	2016
135	Cardiac Polyclinic	AC Split 1 PK	Panasonic	CS-YN9RKJ	2016
136	EEG Polyclinic	AC Split 1 PK	Panasonic	CS-YN9RKJ	2016
137	Accupunture Polyclinic	AC Split 1 PK	Panasonic	CS-YN9RKJ	2016
138	ICU/Nurse Station	AC Split 1 PK	Panasonic	CS-YN9RKJ	2016
139	ICU/Observation Room	AC Split 1 PK	Panasonic	CS-YN9RKJ	2016
140	PA Laboratory/Process Room	AC Split 1 PK	Panasonic	CS-YN9RKJ	2016
141	Room OK 1	AC Split 2 PK	Panasonic	CS-PN18RKP	2016
142	Room OK 3	AC Split 2 PK	LG	LG	2016
143	Room OK 2	AC Split 2 PK	Panasonic	CS-PN18RKP	2016
144	Installation of Corpses Treatment and Spirituality	AC Split 3/4 PK	Daikin	Daikin	2019
145	PA Laboratory/Doctor Room	AC Split 3/4 PK	Daikin	Daikin	2018

No	Location	Name/Type of Item	Brand	Type	Year of Procurement
146	VCT Polyclinic	AC Split 1 PK	Daikin	Daikin	2020
147	Sakura Room/Nurse's Room	AC Split 1/2 PK	Sharp	AH-AP5MSL	2013
148	Gynecology Polyclinic	AC Split 1 PK	Sharp	AH-AP9FMY	2019
149	RM Outpatient	AC Split 1 PK	Sharp	AH-AP9GSY	
150	Sakura Room/Co-assistant Room	AC Split 1 PK	Sharp	AH-AP9KHL	
151	Director's Room	AC Split 1 PK	National	CS-C9GKN	
152	General Meeting Room	AC Split 1 PK	National	CS-C9GKN	
153	Pharmacy Depot	AC Split 1 PK	Daikin	Daikin	2019
154	Aster Room/ Head Room	AC Split 1/2 PK	Panasonic	CS-PC5GKJ	2019
155	Aster Room/Treatment Room	AC Split 1/2 PK	Panasonic	CS-PC5GKJ	2016
156	Aster Room/Treatment Room	AC Split 1/2 PK	Panasonic	CS-PC5GKJ	2016
157	ICU Room/Nurse changing room	AC Split 1/2 PK	Panasonic	CS-PC5GKJ	
158	Aster Room/Isolation Room	AC Split 1/2 PK	Panasonic	CS-PC5GKJ	
159	Tulip Room Midwife	AC Split 3/4 PK	Panasonic	CS-PC7GKJ	
160	Orchid Room B/Class I C . Room	AC Split 3/4 PK	Daikin	Daikin	
161	OK Room/Female Changing Room	AC Split 3/4 PK	Panasonic	CS-PC7GKJ	
162	Eye Polyclinic	AC Split 3/4 PK	Panasonic	CS-PC7GKJ	
163	Ruang OK/ Meeting Room	AC Split 3/4 PK	Daikin	Daikin	
164	Orthopedy Polyclinic	AC Split 3/4 PK	Panasonic	CS-PC7GKJ	
165	Pacemaker Room	AC Split 3/4 PK	Panasonic	CS-PC7GKJ	
166	OK 3 Room	AC Split 3/4 PK	Panasonic	CS-PC7GKJ	
167	OK 4 Room	AC Casete 3 PK	Daikin	Daikin	
168	SIMRS Unit	AC Split 1/2 PK	LG	T05NL	
169	Other Health Personnel Committee	AC Split 1/2 PK	LG	T05NL	
170	Medical Committee Room/ Administration Room	AC Split 1/2 PK	Daikin	Daikin	
171	Medical Rehabilitation	AC Split 3/4 PK	LG	T07NL	
172	Medical Rehabilitation	AC Split 3/4 PK	LG	T07NL	
173	Medical Rehabilitation	AC Split 3/4 PK	LG	T07NL	
174	SIMRS Unit	AC Split 1 PK	LG	T09NL	
175	Room OK/Sterile Room	AC Split 1 PK	LG	T09NL	
176	ICU Room	AC Split 1 PK	LG	T09NL	
177	ICU Room	AC Split 1 PK	LG	T09NL	
178	ICU Room	AC Split 1 PK	LG	T09NL	
179	ICU Room	AC Split 1 PK	LG	T09NL	
180	SIMRS Unit	AC Split 1 PK	LG	T09NL	
181	ICU Room	AC Split 1 PK	LG	T09NL	
182	ICU Room	AC Split 1 PK	LG	T09NL	
183	ICU Room	AC Split 1 PK	LG	T09NL	
184	Medical Committee/Meeting Room	AC Split 1 PK	LG	T09NL	
185	ICU/Non-surgical examination Room	AC Casete 3 PK	Daikin		
186	ICU/Surgical examination Room	AC Casete 3 PK	Daikin		
187	ICU/Pharmacy Depot	AC Split 3/4 PK	Shape		
188	Procurement Service Unit	AC Split 1 PK	Daikin		
189	Central Surgical Installation/ Room OK 4	AC Split 2 PK	Daikin		
190	Central Surgical Installation/ Room OK 5	AC Split 2 PK	Daikin		
191	UPS MRI Room	AC Split 2 PK	Daikin		
192	MRI Control Room	AC Split 1 PK	Daikin		
193	MRI Examination Room	AC Split-duct 3 PK	Daikin		
194	Pharmacy Room Anggrek A	AC Split 3/4 PK	LG		
195	Haemodialisis/Treatment Room	AC Split 1 PK	LG		
196	Security Post	AC Split 3/4 PK	Panasonic		
197	PA. Laboratory Checking Room	AC Split 3/4 PK	LG		
198	Pharmacy Administration Room	AC Split 3/4 PK	LG		2012

No	Location	Name/Type of Item	Brand	Type	Year of Procurement
199	Complaint Room	AC Split 3/4 PK	Panasonic		
200	Pharmacy Warehouse	AC Split 1 PK	Daikin Inverter		
201	Pharmacy Warehouse	AC Split 1 PK	Daikin Inverter		
202	Pharmacy Warehouse	AC Split 1 PK	Daikin Inverter		
203	Pharmacy Warehouse	AC Split 1 PK	Daikin Inverter		
204	Medical Records - Casemix	AC Split 1 PK	Daikin Inverter		
205	Medical Records - Casemix	AC Split 1 PK	Daikin Inverter		
206	PA Laboratory	AC Split 1 PK	Daikin Inverter		
207	Pharmacy Depot	AC Split 1 PK	Daikin Inverter		
208	General Polyclinic	AC Split 1 PK	Daikin Inverter		
209	Psychiatry Polyclinic	AC Split 1 PK	Daikin Inverter		
210	Meeting Room	AC Split 1 PK	Daikin Inverter		
211	Pharmacy warehouse	AC Split 1 PK	Daikin Inverter		
212	2nd floor Pharmacy warehouse	AC Split 1 PK	Daikin Inverter		
213	2nd floor Pharmacy warehouse	AC Split 1 PK	Daikin Inverter		

3.1.3 Review of Renewal Plan

(1) Organizing the air-conditioning system renewal in the JCM Equipment Subsidy Project

The JCM Equipment Subsidy Project to replace air-conditioning systems in Indonesia centers on the “ID_AM004 Installation of Inverter-Type Air-Conditioning Systems for Cooling Grocery Stores”, which, as the name suggests, boosts energy-saving efforts by installing an inverter-type air-conditioning system in grocery stores in Indonesia.

In this study, the above-mentioned methodology was used to develop a renewal plan and to estimate the CO2 reduction effect of installing the equipment. The definitions of the terms used in this study and the outline of the methodology are shown in Table 3-8 and Table 3-9.

Table 3-8 Definition of terms

Term	Definition
Inverter-type air-conditioning system	Inverter-type air-conditioning systems are a type of air-conditioning system that includes an inverter, a device that controls the speed of the compressor motor to maintain the ambient temperature. While the compressor in a non-inverter air-conditioning system only operates at maximum capacity or a complete stop, compressor speed in an inverter air-conditioning system can be seamlessly adjusted, which is expected to save energy.
Energy consumption efficiency (COP)	Energy consumption efficiency (COP or Coefficient of Performance) is the cooling capacity per rated power consumption of an air-conditioning system. The cooling capacity and rated power consumption values are defined under specific temperatures, as described in ISO 5151:2010.
Cooling capacity	Cooling capacity refers to the ability of an air-conditioning system to reduce heat; calculated in terms of the amount of heat reduced per unit time at a specific temperature.

Table 3-9 Outline of methodology

Item	Summary
GHG emission reduction methods	The project applies to grocery stores in Indonesia aiming to save energy by installing inverter-type air-conditioning systems for cooling.
Calculation of reference emissions	Reference emissions are calculated using the power consumption of air-conditioning equipment introduced as part of general equipment renewal and the CO2 emission factor for power consumption; calculated from the operating hours and load factor.
Calculation of project emissions	Project emissions are calculated based on the power consumption of the high-efficiency air-conditioning equipment to be installed and the CO2 emission factor for power consumption; calculated from the operating hours and load factor.
Monitoring parameters	Power consumption of existing air-conditioning systems and those to be installed.

Eligibility requirements and monitoring methods for this approach are shown in Table 3-10 and Table 3-11.

Table 3-10 Eligibility requirements for ID_AM004

<table>
<tr><th></th><th>Eligibility requirements</th></tr>
<tr><td>Standard 1</td><td>Install a new air-conditioning system with an inverter or replace the existing non-inverter air-conditioning system. The sales area shall be less than 400m2.</td></tr>
<tr><td>Standard 2</td><td>The air-conditioning system to be installed should be of the wall-mounted or ceiling-cassette type. The COP of the air-conditioning system to be upgraded should exceed the values in the following table:
<table>
<tr><th>Cooling capacity [kW]</th><th>COP</th></tr>
<tr><td>2.5＜x≦4.1</td><td>4.00</td></tr>
<tr><td>4.1＜x≦5.3</td><td>3.59</td></tr>
<tr><td>5.3＜x≦7.1</td><td>2.96</td></tr>
<tr><td>7.1＜x≦14.2</td><td>2.85</td></tr>
</table></td></tr>
<tr><td>Standard 3</td><td>No instruments using ozone depletion potential (ODP).</td></tr>
<tr><td>Standard 4</td><td>A precautionary plan shall be developed, for both the air-conditioning to be installed within the project scope and existing air-conditioning equipment that has been replaced to ensure no refrigerant is released into the atmosphere when the old air-conditioning is removed. If the existing air-conditioning equipment is to be replaced with newly installed air-conditioning in the project, the implementation status of the prevention plan shall be checked during verification. For example, reuse of refrigerant and confirmation that refrigerant from the existing air-conditioning removed in the project is not released into the atmosphere.</td></tr>
</table>

Table 3-11　Monitoring methods defined in the methodology

Data	Measurement methods and procedures	Measurement frequency
Power consumption of project air-conditioning equipment	Install a measuring instrument to measure the power consumption of air-conditioning equipment using one of the following methods: 【Method 1: Auto-monitoring system】 - Measurement data is automatically transmitted and recorded to a remote server via the Internet. - The data recorded on the remote server is reported and reconfirmed monthly by the staff member in charge to prevent missing data. 【Method 2: Manual monitoring】 - Measurement data from the monitoring device is manually read and recorded by the grocery store staff and rechecked by another member of the staff every month to avoid missing data. - When a calibration certificate issued by an entity accredited to a national/international standard is not provided, the measuring instrument must be calibrated.	Monthly

(2) Organize equipment for renewal

To help us select replacement equipment, we interviewed the manufacturer of the high-efficiency air-conditioning equipment installed in “Santosa Hospital (31,000 m2)”, which is one of the recent large-scale public hospitals in Bandung, to determine the target equipment.

Outdoor units			
RXYQ5MAY1	×1	RX12MAY19	×3
RXYQ10MAY1	×2	RX14MAY19	×1
RX10MAY19	×6	RX16MAY19	×28

Indoor units			
FXA20LVE9	×40	FXF100LVE	×4
FXA25LVE9	×22	FXF125LVE	×1
FXA32LVE9	×41	FXM50LVE	×1
FXA40LVE9	×8	FXM80LVE	×1
FXA50LVE9	×1	FXM100LVE	×4
FXA63LVE9	×11	FXM125LVE	×5
FXF25LVE	×1	FXM200LVE	×9
FXF32LVE	×5	FXM250LVE	×1
FXF40LVE	×1	FXM125MFV1	×1
FXF50LVE	×17	FXM200MFV1	×2
FXF63LVE	×25	FXM250MFV1	×10
FXF80LVE	×2	FBXYP71M	×10

Others			
BRC1A61	×112	DCS601B51	×4
BRC1C62	×24		

Source: Materials provided by Daikin Indonesia

Figure 3-1　List of air-conditioners installed at Santosa Hospital

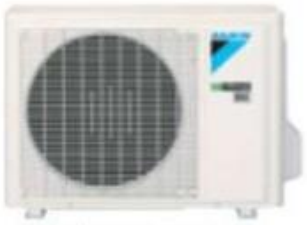
Table 3-12 and Table 3-13 show renewal equipment based on existing equipment.

Table 3-12 Specifications of installed facilities and equipment (reference)

Classification	No.	Model number	Number of units	Cooling capacity (kW)	COP	Example equipment appearance
Outdoor unit	1	RC15NV14	25	1.46	3.75	
	2	RC20NV14	73	2.09	3.30	
	3	RC25NV14	80	2.72	3.41	
	4	RC35NV14	11	3.26	3.49	
	5	RC50NV14	13	5.02	3.24	
	6	RNQ26MY14	11	7.60	3.00	
Indoor unit	7	FCNQ26MV14	10			
	8	FDMNQ26MV14	1			
	9	FTC15NV14	25			
	10	FTC20NV14	73			
	11	FTC25NV14	80			
	12	FTC35NV14	11			
	13	FTC50NV14	13			
Total			213			

Source: Materials provided by Daikin Indonesia

Table 3-13 Specifications of installed facilities and equipment (project)

Classification	No.	Model number	Number of units	Cooling capacity (kW)	COP	Example equipment appearance
Outdoor unit	1	RKC15TVM4	25	1.50	3.83	
	2	RKC20TVM4	73	2.00	3.92	
	3	RKM25SVM4	80	2.50	4.81	
	4	RKM35SVM4	11	3.50	3.89	
	5	RKM50SVM4	13	5.20	4.19	
	6	RZFC71DVM4	11	7.10	2.98	
Indoor unit	7	FBFC71DVM4	10			
	8	FCFC71DVM4	1			
	9	FTKC15TVM4	25			
	10	FTKC20TVM4	73			
	11	FTKM25SVM4	80			
	12	FTKM35SVM4	11			
	13	FTKM50SVM4	13			
Total			213			

Source: Materials provided by Daikin Indonesia

Equipment layout in the target facility shown in Table 3-14. Note that the equipment list includes only the outdoor units, since the trial calculation of the reduction effect is based on the cooling capacity and COP of the outdoor units.

Table 3-14 Specifications of updated equipment

Installation site	Reference			Project		
	Model	Cooling Capacity	COP	Model	Cooling Capacity	COP
Pharmacy Store	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81
Pharmacy Depot	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81
Pharmacy Store	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81
Flamboyant Room/ Doctor Room	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81
Blood Bank	RC20NV14	2.09	3.30	RKC20TVM4	2.00	3.92
Room 321	RC20NV14	2.09	3.30	RKC20TVM4	2.00	3.92
Room 219	RC20NV14	2.09	3.30	RKC20TVM4	2.00	3.92
Room 223	RC20NV14	2.09	3.30	RKC20TVM4	2.00	3.92
Room 224	RC20NV14	2.09	3.30	RKC20TVM4	2.00	3.92
Room 220	RC20NV14	2.09	3.30	RKC20TVM4	2.00	3.92
Room 222	RC20NV14	2.09	3.30	RKC20TVM4	2.00	3.92
Room 227	RC20NV14	2.09	3.30	RKC20TVM4	2.00	3.92
Room 226	RC20NV14	2.09	3.30	RKC20TVM4	2.00	3.92
Room 228	RC20NV14	2.09	3.30	RKC20TVM4	2.00	3.92
Room 25	RC20NV14	2.09	3.30	RKC20TVM4	2.00	3.92
Room 229	RC20NV14	2.09	3.30	RKC20TVM4	2.00	3.92
Room 218	RC20NV14	2.09	3.30	RKC20TVM4	2.00	3.92
Room PIO	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81
Pharmaceutical Storehouse	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81
Radiology Instalation/Doctor Room	RC20NV14	2.09	3.30	RKC20TVM4	2.00	3.92
Aster Room/Doctor Room	RC20NV14	2.09	3.30	RKC20TVM4	2.00	3.92
Medical Rehabilitation	RC20NV14	2.09	3.30	RKC20TVM4	2.00	3.92
EEG Polyclinic	RC20NV14	2.09	3.30	RKC20TVM4	2.00	3.92
Sakura Room/Neonatal Room	RC20NV14	2.09	3.30	RKC20TVM4	2.00	3.92
Super Vision Room	RC20NV14	2.09	3.30	RKC20TVM4	2.00	3.92
Radiology Instalation/Xray 1 Room	RC20NV14	2.09	3.30	RKC20TVM4	2.00	3.92
Radiology Instalation/Xray 2 Room	RC20NV14	2.09	3.30	RKC20TVM4	2.00	3.92
Dental Polyclinic dr Rina	RC20NV14	2.09	3.30	RKC20TVM4	2.00	3.92
Dental Polyclinic dr Wili	RC20NV14	2.09	3.30	RKC20TVM4	2.00	3.92
Outpatient Registration Floor 2	RC15NV14	1.46	3.75	RKC15TVM4	1.50	4.83
ICU/Neonatal Room	RC15NV14	1.46	3.75	RKC15TVM4	1.50	4.83
Dental Polyclinic dr Edi	RC20NV14	2.09	3.30	RKC20TVM4	2.00	3.92
Dental Polyclinic dr Sule	RC20NV14	2.09	3.30	RKC20TVM4	2.00	3.92
ICU/ ICU Unit Head Room	RC20NV14	2.09	3.30	RKC20TVM4	2.00	3.92
ICU/PONEK	RC20NV14	2.09	3.30	RKC20TVM4	2.00	3.92
ICU/Nurse Room	RC20NV14	2.09	3.30	RKC20TVM4	2.00	3.92
CSSD/Sterile Room	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81

Installation site	Reference			Project		
	Model	Cooling Capacity	COP	Model	Cooling Capacity	COP
Clinical Pathology Laboratory Installation/Head of Blood Bank Room	RC15NV14	1.46	3.75	RKC15TVM4	1.50	4.83
Clinical Pathology Laboratory Installation/ Head of Laboratory Room	RC15NV14	1.46	3.75	RKC15TVM4	1.50	4.83
Pharmacy Storeroom	RC20NV14	2.09	3.30	RKC20TVM4	2.00	3.92
Sakura Room/ Doctor Room	RC20NV14	2.09	3.30	RKC20TVM4	2.00	3.92
Pharmacy Depot	RC20NV14	2.09	3.30	RKC20TVM4	2.00	3.92
Dental Polyclinic dr Nuni	RC20NV14	2.09	3.30	RKC20TVM4	2.00	3.92
Dental Polyclinic dr Mulyadi	RC20NV14	2.09	3.30	RKC20TVM4	2.00	3.92
Clinical Pathology Laboratory Installation/ Microbiology Room	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81
ICU/ Doctor Room	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81
OrthopedicalPolyclinic	RC20NV14	2.09	3.30	RKC20TVM4	2.00	3.92
Nerve Polyclinic	RC20NV14	2.09	3.30	RKC20TVM4	2.00	3.92
Internal Disease Polyclinic	RC20NV14	2.09	3.30	RKC20TVM4	2.00	3.92
neurosurgery Polyclinic	RC20NV14	2.09	3.30	RKC20TVM4	2.00	3.92
Gynecology Polyclinic	RC20NV14	2.09	3.30	RKC20TVM4	2.00	3.92
Skin & genital polyclinic	RC20NV14	2.09	3.30	RKC20TVM4	2.00	3.92
Skin & genital polyclinic	RC20NV14	2.09	3.30	RKC20TVM4	2.00	3.92
Nutrition Polyclinic	RC20NV14	2.09	3.30	RKC20TVM4	2.00	3.92
Surgery Polyclinic	RC20NV14	2.09	3.30	RKC20TVM4	2.00	3.92
Surgery Polyclinic	RC20NV14	2.09	3.30	RKC20TVM4	2.00	3.92
Psychiatry Polyclinic	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81
General Polyclinic	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81
Children's Polyclinic	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81
Children's Polyclinic	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81
Growth and Development Polyclinic	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81
ENT Polyclinic	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81
Eye Polyclinic	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81
Children's Polyclinic/ Immunization	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81
Nursing Committee	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81
Hemodialysis/ Treatment Room	RC35NV14	3.26	3.49	RKM35SVM4	3.50	3.89
Hemodialysis/ Nurse Room	RC35NV14	3.26	3.49	RKM35SVM4	3.50	3.89
Radiology Installation/ CT Scan Treatment Room	RC50NV14	5.02	3.24	RKM50SVM4	5.20	4.19
Radiology Installation/ CT Scan Treatment Room	RC50NV14	5.02	3.24	RKM50SVM4	5.20	4.19
Radiology Installation/ CT Scan Treatment Room	RC50NV14	5.02	3.24	RKM50SVM4	5.20	4.19
Hemodialysis/ Treatment Room	RC50NV14	5.02	3.24	RKM50SVM4	5.20	4.19
Obstetrics Polyclinic	RC15NV14	1.46	3.75	RKC15TVM4	1.50	4.83
Outpatient Room	RC15NV14	1.46	3.75	RKC15TVM4	1.50	4.83
Polyclinic CST/ Lili Clinic Room	RC15NV14	1.46	3.75	RKC15TVM4	1.50	4.83
Melati Room/ Level 1 Room	RC15NV14	1.46	3.75	RKC15TVM4	1.50	4.83
Melati Room/ Isolasion Room	RC15NV14	1.46	3.75	RKC15TVM4	1.50	4.83

Installation site	Reference			Project		
	Model	Cooling Capacity	COP	Model	Cooling Capacity	COP
NICU Room/ Nurse Room	RC15NV14	1.46	3.75	RKC15TVM4	1.50	4.83
OK Room/ Depot OK Room	RC15NV14	1.46	3.75	RKC15TVM4	1.50	4.83
Lactation Room	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81
Program and Marketing Section	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81
Medical and Nursing Division	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81
HR Development Subdivision	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81
Finance and Budget Subdivision	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81
Sakura Room/ Doctor Room	RC35NV14	3.26	3.49	RKM35SVM4	3.50	3.89
Radiology Installation/ CT Scan Treatment Room	RC50NV14	5.02	3.24	RKM50SVM4	5.20	4.19
Blood Bank	RC20NV14	2.09	3.30	RKC20TVM4	2.00	3.92
Melati Room/ Nurse Station	RC20NV14	2.09	3.30	RKC20TVM4	2.00	3.92
Melati Room/ Doctor Room	RC20NV14	2.09	3.30	RKC20TVM4	2.00	3.92
Medical Support	RC20NV14	2.09	3.30	RKC20TVM4	2.00	3.92
Office Elevator	RC20NV14	2.09	3.30	RKC20TVM4	2.00	3.92
Server Room	RC20NV14	2.09	3.30	RKC20TVM4	2.00	3.92
Clinic Disease Laboratory Installation/ Process Room	RNQ26MY14	7.60	3.00	RZFC71DVM4	7.10	2.98
Clinic Disease Laboratory Installation/ Process Room	RNQ26MY14	7.60	3.00	RZFC71DVM4	7.10	2.98
Clinic Disease Laboratory Installation/ Process Room	RNQ26MY14	7.60	3.00	RZFC71DVM4	7.10	2.98
Central Surgical Installation/ OK Room 5	RNQ26MY14	7.60	3.00	RZFC71DVM4	7.10	2.98
Eye OK Room	RNQ26MY14	7.60	3.00	RZFC71DVM4	7.10	2.98
Radiology Installation/ CT Scan Operation Room	RNQ26MY14	7.60	3.00	RZFC71DVM4	7.10	2.98
Clinical Disease Laboratory Installation/ Reagent Storage Room	RC20NV14	2.09	3.30	RKC20TVM4	2.00	3.92
Radiology Installation/ CT Scan Operation Room	RNQ26MY14	7.60	3.00	RZFC71DVM4	7.10	2.98
Clinical Disease Laboratory Installation/ Sampling Room	RC35NV14	3.26	3.49	RKM35SVM4	3.50	3.89
Clinical Disease Laboratory Installation/ Sampling Room	RC35NV14	3.26	3.49	RKM35SVM4	3.50	3.89
Installation of clinical disease laboratory/Meeting Room	RC35NV14	3.26	3.49	RKM35SVM4	3.50	3.89
Pharmacy Depot	RC20NV14	2.09	3.30	RKC20TVM4	2.00	3.92
Tulip Room/ Isolation Room	RC20NV14	2.09	3.30	RKC20TVM4	2.00	3.92
Clinic Disease Laboratory Installation/Children Sampling Room	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81
KPPI RS	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81
Pharmacy Warehouse	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81
Tulip Room/ Birth Room	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81
Tulip Room/ Birth Room	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81
Tulip Room/ VIP Birth Room	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81
Tulip Room/ VIP Birth Room	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81
PICU Room	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81
Head of Pharmacy Installation	RC15NV14	1.46	3.75	RKC15TVM4	1.50	4.83

Installation site	Reference			Project		
	Model	Cooling Capacity	COP	Model	Cooling Capacity	COP
Tulip Room/ Doctor Room	RC15NV14	1.46	3.75	RKC15TVM4	1.50	4.83
Tulip Room/ VIP Birth Room	RC15NV14	1.46	3.75	RKC15TVM4	1.50	4.83
Head of Program and Marketing	RC15NV14	1.46	3.75	RKC15TVM4	1.50	4.83
Flamboyant Room/ Medicine Room	RC15NV14	1.46	3.75	RKC15TVM4	1.50	4.83
Jasmine Room/ Baby Room	RC35NV14	3.26	3.49	RKM35SVM4	3.50	3.89
Jasmine Room/ Baby Room	RC35NV14	3.26	3.49	RKM35SVM4	3.50	3.89
Jasmine Room/ Baby Room	RC35NV14	3.26	3.49	RKM35SVM4	3.50	3.89
NICU room	RC35NV14	3.26	3.49	RKM35SVM4	3.50	3.89
NICU room	RC35NV14	3.26	3.49	RKM35SVM4	3.50	3.89
Clinic Disease Laboratory Installation/ Routine Clinic Room	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81
Radiology Installation/ Dark Room	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81
CSSD/ Packing Room	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81
Medical Committee/ Meeting Room	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81
ICU Room/ Doctor Room	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81
OK Room/ Transit Room	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81
OK Room/ Transit Room	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81
Radiology Installation/ X-ray Room 3	RC50NV14	5.02	3.24	RKM50SVM4	5.20	4.19
Radiology Installation/ CT Scan Control Room	RC50NV14	5.02	3.24	RKM50SVM4	5.20	4.19
ICU Registration	RC20NV14	2.09	3.30	RKC20TVM4	2.00	3.92
ICU/Resuscitation Room	RC20NV14	2.09	3.30	RKC20TVM4	2.00	3.92
Nerve Polyclinic	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81
Cardiac Polyclinic	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81
EEG Polyclinic	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81
Accupunture Polyclinic	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81
ICU/ Nurse Station	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81
ICU/ Observation Room	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81
PA Laboratory/ Process Room	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81
Room OK 1	RC50NV14	5.02	3.24	RKM50SVM4	5.20	4.19
Room OK 3	RC50NV14	5.02	3.24	RKM50SVM4	5.20	4.19
Room OK 2	RC50NV14	5.02	3.24	RKM50SVM4	5.20	4.19
Installation of Corpses Treatment and Spirituality	RC20NV14	2.09	3.30	RKC20TVM4	2.00	3.92
PA Laboratory/ Doctor Room	RC20NV14	2.09	3.30	RKC20TVM4	2.00	3.92
VCT Polyclinic	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81
Sakura Room/ Nurse's Room	RC15NV14	1.46	3.75	RKC15TVM4	1.50	4.83
Gynecology Polyclinic	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81
RM Outpatient	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81
Sakura Room/ Co-assistant Room	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81
Director's Room	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81
General Meeting Room	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81
Pharmacy Depot	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81
Aster Room/ Head Room	RC15NV14	1.46	3.75	RKC15TVM4	1.50	4.83
Aster Room/ Treatment Room	RC15NV14	1.46	3.75	RKC15TVM4	1.50	4.83

Installation site	Reference			Project		
	Model	Cooling Capacity	COP	Model	Cooling Capacity	COP
Aster Room/ Treatment Room	RC15NV14	1.46	3.75	RKC15TVM4	1.50	4.83
ICU Room / Nurse changing room	RC15NV14	1.46	3.75	RKC15TVM4	1.50	4.83
Aster Room/ Isolation Room	RC15NV14	1.46	3.75	RKC15TVM4	1.50	4.83
Tulip Room Midwife	RC20NV14	2.09	3.30	RKC20TVM4	2.00	3.92
Orchid Room B/ Class I C . Room	RC20NV14	2.09	3.30	RKC20TVM4	2.00	3.92
OK Room/ Female Changing Room	RC20NV14	2.09	3.30	RKC20TVM4	2.00	3.92
Eye Polyclinic	RC20NV14	2.09	3.30	RKC20TVM4	2.00	3.92
Ruang OK/ Meeting Room	RC20NV14	2.09	3.30	RKC20TVM4	2.00	3.92
Orthopedy Polyclinic	RC20NV14	2.09	3.30	RKC20TVM4	2.00	3.92
Pacemaker Room	RC20NV14	2.09	3.30	RKC20TVM4	2.00	3.92
OK 3 Room	RC20NV14	2.09	3.30	RKC20TVM4	2.00	3.92
OK 4 Room	RNQ26MY14	7.60	3.00	RZFC71DVM4	7.10	2.98
SIMRS Unit	RC15NV14	1.46	3.75	RKC15TVM4	1.50	4.83
Other Health Personnel Committee	RC15NV14	1.46	3.75	RKC15TVM4	1.50	4.83
Medical Committee Room/ Administration Room	RC15NV14	1.46	3.75	RKC15TVM4	1.50	4.83
Medical Rehabilitation	RC20NV14	2.09	3.30	RKC20TVM4	2.00	3.92
Medical Rehabilitation	RC20NV14	2.09	3.30	RKC20TVM4	2.00	3.92
Medical Rehabilitation	RC20NV14	2.09	3.30	RKC20TVM4	2.00	3.92
SIMRS Unit	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81
Room OK/ Sterile Room	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81
ICU Room	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81
ICU Room	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81
ICU Room	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81
ICU Room	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81
SIMRS Unit	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81
ICU Room	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81
ICU Room	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81
ICU Room	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81
Medical Committee/ Meeting Room	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81
ICU/ Non-surgical examination Room	RNQ26MY14	7.60	3.00	RZFC71DVM4	7.10	2.98
ICU/ Surgical examination Room	RNQ26MY14	7.60	3.00	RZFC71DVM4	7.10	2.98
ICU/ Pharmacy Depot	RC20NV14	2.09	3.30	RKC20TVM4	2.00	3.92
Procurement Service Unit	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81
Central Surgical Installation/ Room OK 4	RC50NV14	5.02	3.24	RKM50SVM4	5.20	4.19
Central Surgical Installation/ Room OK 5	RC50NV14	5.02	3.24	RKM50SVM4	5.20	4.19
UPS MRI Room	RC50NV14	5.02	3.24	RKM50SVM4	5.20	4.19
MRI Control Room	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81
MRI Examination Room	RNQ26MY14	7.60	3.00	RZFC71DVM4	7.10	2.98
Pharmacy Room Anggrek A	RC20NV14	2.09	3.30	RKC20TVM4	2.00	3.92
Haemodialisis/ Treatment Room	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81

Installation site	Reference			Project		
	Model	Cooling Capacity	COP	Model	Cooling Capacity	COP
Security Post	RC20NV14	2.09	3.30	RKC20TVM4	2.00	3.92
PA . Laboratory Checking Room	RC20NV14	2.09	3.30	RKC20TVM4	2.00	3.92
Pharmacy Administration Room	RC20NV14	2.09	3.30	RKC20TVM4	2.00	3.92
Complaint Room	RC20NV14	2.09	3.30	RKC20TVM4	2.00	3.92
Pharmacy Warehouse	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81
Pharmacy Warehouse	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81
Pharmacy Warehouse	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81
Pharmacy Warehouse	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81
Medical Records - Casemix	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81
Medical Records - Casemix	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81
PA Laboratory	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81
Pharmacy Depot	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81
General Polyclinic	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81
Psychiatry Polyclinic	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81
Meeting Room	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81
Pharmacy warehouse	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81
2nd floor Pharmacy warehouse	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81
2nd floor Pharmacy warehouse	RC25NV14	2.72	3.41	RKM25SVM4	2.50	4.81

(3) Trial calculation of reduction effects of equipment replacement

We used the method shown in the JCM Equipment Subsidy Project to estimate the reduction effect. The operating hours of the facilities were configured as shown in Table 3-15.

Table 3-15 Key variables for the trial calculation of the reduction effect and the setting approach

Item	Setting approach
Average cooling load per hour (kWh)	Average cooling load per hour = (1)×(2)×(3)×(4)/(5) (1) Heat load: Adapted from "Tokyo Metropolitan Government's Guideline for Organizing the Characteristics of Heat Load Units and Heat Load Patterns by Building Use" in the "District Heating and Cooling Technical Manual (Urban Environmental Energy Association)" (2) 0.8: Assessed to be close to the actual value considering the regional characteristics. Further scrutiny is required in the future detailed planning and implementation stages. (3) Floor area: Calculated by calculating the area of the target facility. (4) Average temperature ratio between Bandung and Tokyo: 1.46 (23.2℃) (Bandung City) /15.8℃ (Tokyo) (5) Annual operating days: assumed as 365 (24/7 basis)
Average daily cooling operating hours (h/day)	24/7 basis (around the clock)
Number of days air-conditioning operated in June (days/months)	Set as annual operating days x hospital bed occupancy rate Annual operating days: 365 days/year Occupancy rate of hospital beds: 80.5% in 2019 (Summary of the Medical Facilities Survey and Hospital Report in 2019)
Electricity emission factor (t-CO2/MWh)	0.88 (Adapted from "FY2021 JCM Subsidy Program Electric Power CO2 Emission Coefficient (tCO2/MWh) List Table" (March 31, 2021 (at the time of public notice)) of the Global Environment Center (GEC) for Java, Indonesia.)

1） Reference emissions

The formula for calculating reference emissions is as follows:

$$RE_p = \sum_i EC_{RE,i,p} \times EF_{elec}$$

$$EC_{RE,i,p} = CC \div COP_{RE,i}$$

RE_p	Reference emissions [tCO2/p].
$EC_{RE,i,p}$	Power consumption of air-conditioning equipment adopted for general equipment replacement [MWh/p].
EF_{elec}	CO_2 emission factor for electricity [tCO2/MWh].
$COP_{RE,i}$	COP of air-conditioning equipment employed in a typical equipment replacement [-].
CC	Cooling capacity [MW].
I	Type of air-conditioning equipment [-].

2） Project emissions

The formula for calculating project emissions is as follows:

$$PE_p = \sum_i EC_{PJ,i,p} \times EF_{elec}$$

$$EC_{PJ,i,p} = CC \div COP_{PJ,i}$$

PE_p	Project emissions [tCO2/p]
$EC_{PJ,i,p}$	Power consumption of air-conditioning equipment to be introduced in the project [MWh/p]
EF_{elec}	CO2 emission factor for electricity [tCO2/MWh]
$COP_{PJ,i}$	COP of the air-conditioning equipment to be installed in the project [-]
CC	Cooling capacity [MW]
I	Type of air-conditioning equipment

3） Formula for calculating reduction

The reduction equates to the difference between reference emissions and project emissions and the following calculation formula is used:

$$ER_p = RE_p - PE_p$$

ER_p	Emission reduction [tCO_2/p]
RE_p	Reference emissions[tCO_2/p]
PE_p	Project emissions[tCO_2/p]

4） Calculation result

Table 3-16 shows the calculation results based on the expected reduction in greenhouse gas emissions and the cost-effectiveness of upgrading the air-conditioning system within the target

facility. Following discussions with the Ministry of the Environment, it was concluded that CFC recovery was not included in the subsidies for JCM equipment, so only the emission reduction due to energy-saving and cost-effectiveness were evaluated in this study.

The estimated emission reduction per unit at the target facility was 3.53 tCO2. The cost-effectiveness was 444,820 IDR (3,559 yen)/tCO2, exceeding the 500,000 IDR (4,000 yen)/tCO2, which is the standard applied for the JCM Model Project with a 50% subsidy rate.

Table 3-16 Estimated Emission Reductions and Cost-Effectiveness

Item	Calculation result
Reference emissions	4,168.2 tCO2
Project emissions	3,312.7 tCO2
Expected emission reductions	752 tCO2
Number of air-conditioning units	213 units
Installation cost*1	4,014,054,000 IDR
Installation cost (in yen)*2	32,112,432 yen
Subsidy rate*3	50%
Subsidy amount	2,007,027,000 IDR
Subsidy amount (yen equivalent)	16,056,216 yen
cost-effectiveness*4	444,820 IDR/t-CO2
Cost-effectiveness (yen equivalent)	3,559 yen/t-CO2

* Figures based on feedback from manufacturers (assuming installation costs equivalent to equipment costs

Indoor unit	Outdoor unit	Equipment cost	
		IDR	Yen
FTKC15TVM4	RKC15TVM4	6,193,000	49,544
FTKC20TVM4	RKC20TVM4	6,248,000	49,984
FTKM25SVM4	RKM25SVM4	9,053,000	72,424
FTKM35SVM4	RKM35SVM4	11,968,000	95,744
FTKM50SVM4	RKM50SVM4	17,842,000	142,736
FCFC71DVM4	RZFC71DVM4	28,325,000	226,600

* 2 0.008 yen/IDR (as of 14 February 2022)
* 3 Subsidy rate set at less than 500,000 IDR (4,000yen)/tCO2, which is the standard for JCM model projects.
* 4 The standard service life of the hospital's air-conditioning equipment is set to 61 years and calculated using the following formula:

【Formula for calculating cost-effectiveness】

Cost-effectiveness (IDR/tCO2) = Subsidy amount (IDR) ÷ [Expected emission reductions due to air-conditioning energy conservation (tCO2) × Service life (years)]

3.1.4 Examining Commercialization Potential Using JCM Model Project

Table 3-17 shows the items to be investigated and the details of coordination with a view to utilizing the JCM Model Project in the next year's survey.

Table 3-17 Items to be implemented and results for the next fiscal year and beyond (tentative)

Item	Implementation details	Results (tentative)
Scrutiny of target equipment	(1) Collection of materials needed for the renewal of the air-conditioning equipment, such as building plans, ceiling plans and wiring system diagrams	(1) Drawings, list of existing equipment.
	(2) On-site survey (location of air-conditioning, installation of ducts and other piping, deterioration of equipment, etc.)	(2) Availability of equipment and condition of existing facilities.
	(3) Verification of scope to consolidate air-conditioning facilities	(3) Equipment that can be integrated with outdoor units.
	(4) Updating the reduction effect based on the results of the equipment review	(4) GHG reduction benefits.
Specifying monitoring methods for installed equipment	(1) Consideration of monitoring methods based on field surveys, manufacturer feedback, etc.	(1) Monitoring methods consistent with methodology.
	(2) Selection of monitoring equipment	(2) Monitoring systems that can be implemented.
	(3) Examination of monitoring implementation system	(3) A system capable of handling data acquisition and analysis, sensor calibration and more.
Coordination of business scheme	(1) Review of project implementation structure	(1) Roles of the project entity, entity responsible for installing and maintaining equipment, entity responsible for monitoring and analysis and the funding method.
	(2) Funding method	(2) Procurement method for each cost related to project implementation.
	(3) Organizing various procedures	(3) Memorandum of understanding among all parties involved in project implementation.

3.1.5 Examine Potential Applicability to Private Facilities such as Hotels and Shopping Malls in Future

(1) Arranging conditions to secure effective CO2 reduction effects by installing equipment

Table 3-18 shows the standard for the renewal of hospital air-conditioning equipment in Bandung City, which is the scale required to adopt the JCM Equipment Subsidy Project (cost-effectiveness of 4,000 yen/tCO2) based on the arrangement described in the previous section.

Table 3-18 Conditions arranged for hospital facilities assuming the use of the JCM Equipment Subsidy Project

Item	Value	Note
(1) Estimated emission reductions per unit for the target facility (hospital) (tCO2)	3.53	Adopted the RSUD calculation results
(2) Equipment service life	6	Adopted the designated service life for air-conditioning equipment
(3) Cost-effectiveness (yen/ tCO2)	4,000	Configured in line with the requirements of the JCM Equipment Subsidy Project
(4) Subsidy rate(%)	50	Configured in line with the requirements of the JCM Equipment Subsidy Project
(5) Estimated cost of equipment installation per unit of the target facility (yen/unit)	169,465	(1)×(2)×(3)/(4)

(2) Consideration of target facilities based on conditions

Table 3-19 shows the Bandung facilities of a certain scale and for which the total number of beds could be determined via a desktop survey. From the next fiscal year onward, there will be a need to select survey partners from among these facilities and proceed with surveys - including on site - to carefully examine the reduction effect and clarify the conditions for selecting target facilities.

When assuming the amount of CO2 reduction to be secured, the need to carefully examine survey targets is reaffirmed; focusing on hospitals equivalent or larger in size than the Bandung City Regional General Hospital (296 beds), which was the subject of this year's study.

Table 3-19 List of hospitals in Bandung

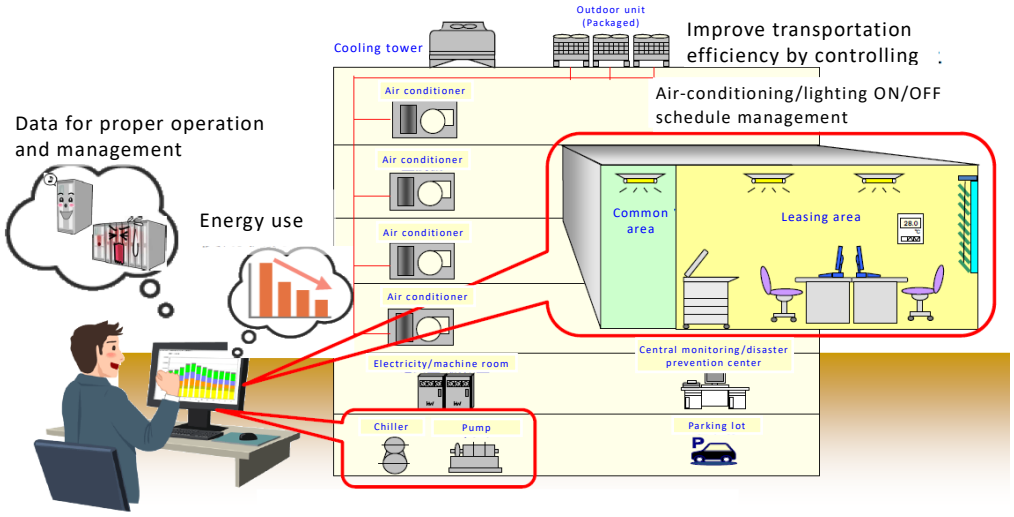
No.	Facility name	Beds
1	RS Hasan Sadikin Bandung	600
2	RS Khusus Ibu dan Anak	550
3	RS Al Islam Bandung	260
4	RS Advent Bandung	254
5	RS Muhammadiyah Bandung	126
6	RS Bungsu Bandung	50
7	RS Khusus Bedah Halmahera	30
8	RS Mata Bandung Eye Center	26
9	RS Khusus Ginjal Ny. R. A. Habibie	12

3.1.6 Explore the potential of introducing a building energy management system (BEMS)

The operation and CO_2 reduction for air-conditioning equipment can be further streamlined by combining it with a BEMS (Building and Energy Management System), which is an integrated system for optimizing indoor environment and energy performance.

BEMS systems use IoT technology to control lighting and air-conditioning in facilities for optimal energy management. As shown in Figure 3-2, BEMS systems can record, monitor, control and operate building conditions, equipment operation status and energy consumption status.

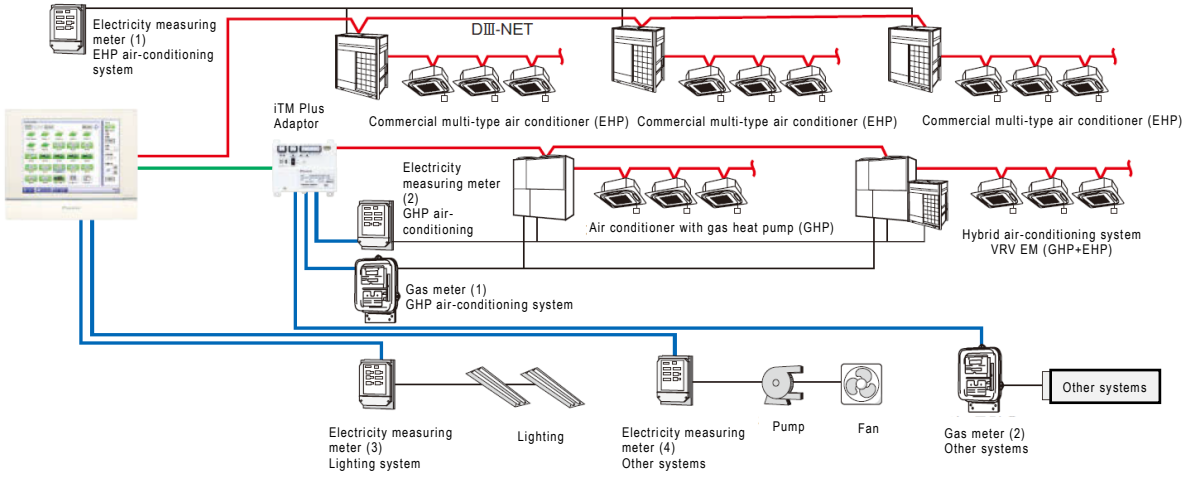
Introducing BEMS will make it possible to visualize energy consumption and enhance awareness of energy conservation. It is also possible to provide measures against COVID-19, such as enhanced ventilation, avoiding contact and confined spaces and cloud building management.



Source: Ministry of Economy, Trade and Industry

Figure 3-2 Conceptual Diagram of BEMS

Since the JCM Equipment Subsidy Project currently under consideration includes scope to monitor the operational status of the installed equipment, there is a need to consider a monitoring system for the air-conditioning equipment as shown in Figure 3-3.



Source: Manufacturer's catalog materials

Figure 3-3 Monitoring methods for equipment installed by air-conditioning equipment manufacturers

3.2 Study on the promotion of LED streetlights

Bandung City has been promoting the introduction of technologies supporting energy conservation and was also selected by the Indonesian government as a pilot project site targeting energy-saving street lighting. LED streetlights with smart meters have been installed in the city and efforts are underway to convert the street lighting to LED.

During the JCM Large-Scale Project Feasibility Study in 2014, with current knowledge of street lighting in Bandung City and the city's street lighting plan as the benchmarks, scope to introduce LED lighting that would help reduce the greenhouse gas effect was studied. In the first year of this project, based on the results of the survey, we clearly grasped the target number of street lighting to be converted to LED in Bandung City and examined the possibility of using JCM model projects for the conversion of the targeted street lighting to LED.

3.2.1 Development Plan for Street Lighting in Bandung City

In Indonesia, the municipal government is responsible for installing and maintaining street lighting, while the installation standards and guidelines are set by the national government.

Among relevant laws and regulations that regulate street lighting systems in Indonesia, the key regulations are those related to the safety and security of road and sidewalk users and those related to energy conservation and GHG (greenhouse gas) emission reduction. Specific related laws and regulations are as follows:

Table 3-20 Laws and regulations regarding the safety of street lighting

No.	Regulation	Contents related to street lighting
1	Law No.22/2009 on Traffic and road transport Traffic and Road Traffic Law (2009)	Article 25, paragraph 1: All roads used for public transport must have road equipment provided in the form of traffic signs, road markings, traffic signal devices and street lighting equipment.
2	Law No. 23/2014 on Local Government Local Autonomy Law (2014)	Article 13: Distribution of power among central government, state governments and local/municipal governments.
3	Government Regulation No. 38/2007 on Division of Government affairs between the Government, provincial government, regency/city regional government (2007)	The supplement to the government regulation explains how government work on energy is demarcated. One of the central government offices – the mineral resources department - needs to prescribe standards and guidelines for public street lighting.

Source: Materials provided by Bandung City

Jurisdiction over street lighting in Indonesia is exercised by the "Ministry of Public Works", "Ministry of Transportation" and "Ministry of Energy and Mineral Resources" as technical regulatory authorities and the individual roles of each ministry are shown in the following table. Conversely, street lighting is installed and maintained under the authority of the Bandung City Government (based on principles of accountability, efficiency, externality and strategic national interests, in accordance with Article 13, paragraphs 1 and 4 of the Law on Local Government). In

addition, the development planning and maintenance of streets in Bandung City has been under the authority of the Ministry of Public Works since 2008 but will be transferred to the Ministry of Transport from 2022.

Table 3-21　Competent Ministry and Role of Street Lighting

Ministry	Role
Ministry of Public Works (now Ministry of Health, Labour and Welfare)	It is tasked with regulating guidelines and standards for planning and technical requirements for public street lighting as roadway support facilities.
Ministry of Transport	It is tasked with regulating the guidelines and standards of human resources regarding roads and the necessary standards regarding the conduct of road traffic.
Ministry of Energy and Mineral Resources	It is tasked with regulating energy conservation and its efficiency.

Source: Materials provided by Bandung City

3.2.2 Status of Street Lighting and LED Street Lighting Penetration in Bandung City

Although the development plan in Bandung City indicates the target number of streetlights to be installed city-wide, it omits any clear target for converting conventional street lighting bulbs to LED equivalents. When we checked with Bandung City, we found that its “Breakdown of conventional and LED bulbs installed by district” survey conducted in 2021, LED street lighting comprised 64% of the total. Furthermore, Bandung City shoulders all responsibility and costs for installation and maintenance, given the limitations imposed on private businesses by presidential regulations.

（1） Current status of Bandung City

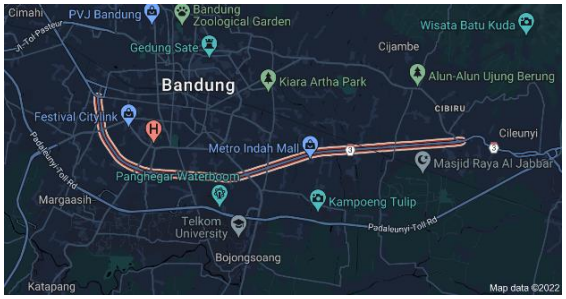
The status of road conditions and street lighting in Bandung City is described below.

Table 3-22　Status of road conditions in Bandung

Item	Status
Area	16,729m2 (including 6 developing areas and 30 areas)
No. of roads	38,000
Road length	125,487km
Average width	5,6m
No. of streetlights	45,507

Source: ESTIMATED MEASUREMENT OF REDUCING STREET LIGHTS CO2 EMISSION IN BANDUNG (The 1st Workshop, Bandung City Materials)

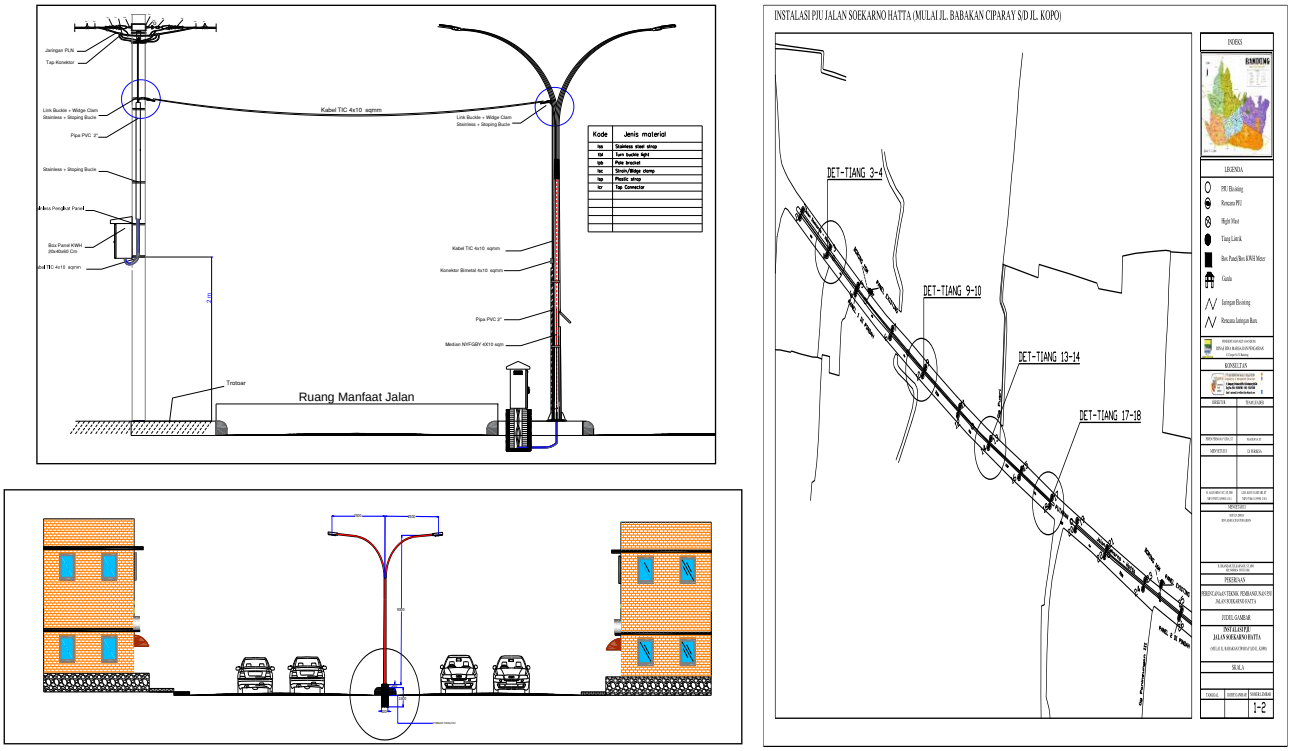
To get a proper understanding of the actual streetlights installed in Bandung City, we took photographs of those installed on the main roads and highways in Bandung City, including Soekarno-Hatta Bandung Road, as well as the alleys (local roads) off Soekarno-Hatta Road and compared them with the drawings provided by Bandung City. We confirmed the differences between the two types.



Source: Courtesy of Bandung City

Figure 3-4 Location of Soekarno-Hatta Bandung Road

Figure 3-5 On-site inspection (photo)



Source: Courtesy of Bandung City

Figure 3-6 Example streetlight diagram

（2） Street Lighting Development Plan in Bandung City

The development plan for street lighting in Bandung City is described in the Regional Medium Term Development Plan (RPJMD)/2019-2023.

The development plan sets a city-wide target of 67,000 streetlights, which, to be feasible, will involve installing 2,500 streetlights per year throughout Bandung. To achieve this goal, 2,500 streetlights per year will be installed in all areas of Bandung City. In addition, the number of streetlights is expected to increase from 44,000 in 2019 to 56,500 by the end of 2030, or about 84% of the total target number of streetlights by 2023.

The installation of street lighting was previously funded by the Province of West Java and the Ministry of Energy and Mineral Resources for the pilot project in 2014 but is now all covered by Bandung City. The annual installment target and budget plan for street lighting in Bandung City is shown in the following table. Within the goals and plan, there are goals and budgets for street lighting in each area but is no goal to replace traditional bulbs with LEDs.

Table 3-23 Annual Installment Targets and Budget Plan for Street Lighting in the City

Item	2019	2020	2021	2022	2023
Target number of additional units installed (units)	-	2,500	2,500	2,500	2,500
Budget (IDR 1 billion)	-	39,680	39,389	40,400	41,411
2019 Number of units installed (units)					44,000
2023 Number of units installed (units)					56,500

Source: RPJMD2019-2023

The city's street lighting maintenance budget does not cover only LEDs but extends to all street lighting. In particular, operation and maintenance (OM) is managed by the street lighting department based on a contract with a vendor for heavy maintenance - such as breakdowns - while routine maintenance is managed by the local operation and technical service unit (UPT-OP) to maintain road facilities. The 2021 budget allocation for OM by region in the Bandung City budget for FY 2011 is shown below.

Table 3-24 Regional budget allocation for OM in the FY2021 city budget

Work unit	Budget (IDR 1 billion)	Target number of units
Public Street lighting Division (Comprising three sections: Planning, Development, Control)	1,804	38
UPT Bojonagara	1,423	1,815
UPT Tegallega	1,560	1,814
UPT Karees	1,601	1,334
UPT Ujungberung	1,529	1,515
UPT Gedebage	1,017	1,942
UPT Cibeunying	1,824	771
Total	10,760	9,229

Source: Ministry of Public Works, Bandung City

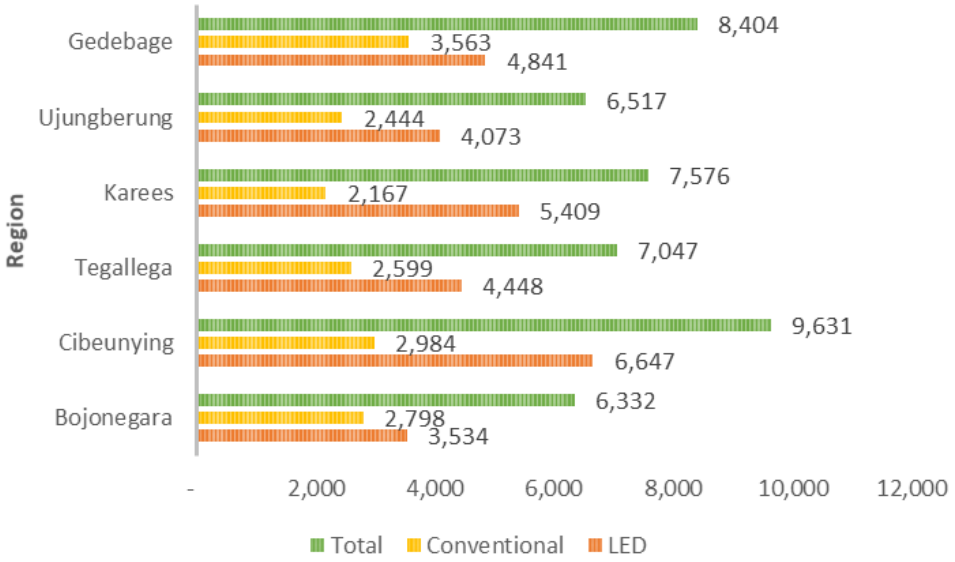
（3） Role of the private sector

No specific public-private partnerships exist for procuring public goods and services, as it is regulated under Article 12, Presidential Regulation No.12/2021 on Public Goods/Service Procurement. The private sector is only involved as a third party for procuring streetlights, including consulting services.

（4） Number of LED street lighting installations by district (2021)

In 2021, the Public Works Department of Bandung City surveyed the distribution of conventional and LED light bulbs by district, the results of which are shown below.

After checking with Bandung City, it emerged that the number of newly installed LED bulbs or conventional bulbs converted to LED during the relevant period was 28,952 units, comprising about 64% of the total. Conversely, the remaining 36% - 16,555 units – were still conventional non-LED bulbs. The breakdown of LED and non-LED streetlights by city area is shown in the following table.



Source: ESTIMATED MEASUREMENT OF REDUCING STREET LIGHTS CO_2 EMISSION IN BANDUNG (The 1st Workshop, Bandung City Materials)

Figure 3-7　Number and type of street lighting by city area

3.2.3 Consideration of Street Lighting Renewal Plan

（1） Organizing specifications for street lighting in Bandung City

As mentioned above, the installation of street lighting in Bandung City is being handled based on the Indonesian installation guidelines. Using the guidelines identified in the past Bandung-Kawasaki Intercity Collaboration Project, we studied scope to install LED lighting as a replacement for 16,555 streetlights with conventional bulbs that are currently subject to renewal.

1） Guidelines for installing street lighting

The relevant standards and specifications for lighting and installation regulations were organized In line with guidelines for installing streetlights.

① Street lighting standards and specifications

The standards and specifications for street lighting are shown in the following table.

Table 3-25 Types of street lighting indicated in the guidelines

Type	Average efficiency (lm/W)	Design life (h)	Power consumption (W)	Remarks
Low-pressure fluorescent lamp	60-70	8,000-10,000	18-20, 36-40	Auxiliary trunk roads, local roads Very high efficiency, but short lifetime Used by some.
High-pressure mercury lamp	50-55	16,000-24,000	125-250 400-700	Auxiliary arterial roads, local roads and intersections. Low efficiency, but long life. Used by some.
Low-pressure sodium lamp	100-120	8,000-10,000	90-180	Auxiliary highways, JCTs, railroad crossings, tunnels, rest areas. Extremely high efficiency and long life. Lamp size is large, light control is difficult and color is poor. Use recommended due to high efficiency.
High-pressure sodium lamp	110	12,000-20,000	150-250, 400	Expressways, trunk roads, auxiliary trunk roads, JCT, IC. High efficiency and extremely long life. Use recommended due to high efficiency.

Source: FY2014 Feasibility Study on the Formation of Large-Scale JCM Projects to Realize a Low-Carbon Society in Asia: Support for the Formation of a Low-Carbon City through City-to-City Collaboration between Bandung City and Kawasaki City -

② Regulations on installing streetlights

As shown in Table 3-26 and Table 3-27, lighting fixtures are classified into two types: Type A is a type of low-pressure sodium lamp and Type B is a type of mercury lamp or a high-pressure sodium lamp.

Table 3-26 Street lighting installation provisions as indicated in the Guidelines: Luminaire Type A

Type	H (m)	L (m)								Illuminance level (LUX)
		4	5	6	7	8	9	10	11	
35WSOX*	4	32	32	32	-	-	-	-	-	3.5
	5	35	35	35	35	35	34	32	-	
	6	42	40	38	36	33	31	30	29	
55WSOX	6	42	40	38	36	33	32	30	28	6.0
90WSOX	8	60	60	58	53	52	50	48	46	
90WSOX	8	36	35	35	33	31	30	29	28	10.0
135WSOX	10	46	45	45	44	43	41	40	39	
135WSOX	10	-	-	25	24	23	22	21	20	20.0
180WSOX	10	-	-	37	36	35	33	32	31	
180WSOX	10	-	-	-	-	22	21	20	20	30.0

* Low-pressure sodium lamp

Source: FY2014 Feasibility Study on the Formation of Large-Scale JCM Projects to Realize a Low-Carbon Society in Asia: Support for the Formation of a Low-Carbon City through City-to-City Collaboration between Bandung City and Kawasaki City -

Table 3-27　Street lighting installation provisions as indicated in the Guidelines:

Luminaire Type B

Type	H (m)	L (m)								Illuminance level (LUX)
		4	5	6	7	8	9	10	11	
50WSON* 1 80WMBF/U* 2	4	31	30	29	28	26	-	-	-	3.5
	5	33	32	32	31	30	29	28	27	
70WSON 125WMBF/U	6	48	47	46	44	43	41	39	37	
70WSON 125WMBF/U	6	34	33	32	31	30	28	26	24	6.0
100WSON	6	48	47	45	42	40	38	36	34	
150WSON 250WMBF/U	8			48	47	45	43	41	39	10.0
100WSON	6	-	-	28	26	23	-	-	-	10.0
250WSON 400WMBF/U	10	-	-	-	-	55	53	50	47	20.0
250WSON 400WMBF/U	10	-	-	36	35	33	32	30	28	
400WSON	12	-	-	-	-	39	38	37	36	30.0

* 1 High-pressure sodium lamp, * 2 Mercury lamp

Source: FY2014 Feasibility Study on the Formation of Large-Scale JCM Projects to Realize a Low-Carbon Society in Asia: Support for the Formation of a Low-Carbon City through City-to-City Collaboration between Bandung City and Kawasaki City -

（2） Current status of street lighting in the city

As shown in 3.1.2 (4), there are a total of 16,555 conventional bulb streetlights in Bandung City. The operation hours are determined by the illuminance sensor and the operation status is about 11 hours/day.

（3） Indicators for LED lighting installation (renewal)

1） Calculation of electricity consumption reduction scope by type of LED replacement

In Bandung City, an index for replacement equipment was set for the purpose of replacing existing streetlights with LEDs according to the capacity of the existing equipment, as shown in the following table. The power consumption required for LED replacement can be categorized into 60-70W, 80-100W and 100-120W. Accordingly, we conducted a study on the replacement of LED streetlights that would comply with the required specifications and guidelines.

Table 3-28 LED Indicators for lighting equipment installation (renewal)

Lighting type	Power consumption (W)	Power consumption after LED update (W)
Fluorescent lamp (LHE)	45	60-70
Fluorescent lamp (LHE)	85	60-70
Mercury lamp (HPL)	70	60-70
Mercury lamp (HPL)	125	80-100
Mercury lamp (HPL)	250	80-100
Sodium lamp (SON)	70	100-120
Sodium lamp (SON)	150	60-70
Sodium lamp (SON)	250	80-100

Source: FY2014 Feasibility Study on the Formation of Large-Scale JCM Projects to Realize a Low-Carbon Society in Asia: Support for the Formation of a Low-Carbon City through City-to-City Collaboration between Bandung City and Kawasaki City -

The renewal study shows that the LED renewal is expected to reduce the amount of electricity used except for existing 70W equipment. In particular, the existing 250W equipment, which consumes considerable power, is expected to achieve a 52% reduction in power consumption. Despite the lack of reduction in power consumption for 70W sodium and mercury lamps, replacing them with LED products is expected to reduce the cost of supplies and maintenance due to the longer service life of the products.

Table 3-29 Calculation of electricity consumption reduction by LED retrofitting by type

Lamp Type	A	b	c	A (a×b×c)	d	B (a×b×d)	A-B
	Power consumption (W)	Operating hours (h/day)	Number of operating days (day/year)	Power consumption (kWh/year)	LED power consumption (W)*	LED power consumption (kWh/year)	Reduction in electricity consumption (kWh/year)
sodium-vapor lamp	70	11	365	281	70	281	-Mr.
	150	11	365	602	70	281	321
	250	11	365	1004	120	482	522
mercury lamp	70	11	365	281	70	281	-Mr.
	125	11	365	502	70	281	221
	250	11	365	1004	120	482	522

Source: ESTIMATED MEASUREMENT OF REDUCING STREET LIGHTS CO_2 EMISSION IN BANDUNG (The 1st Workshop, Bandung City Materials)

2） Calculation of electricity consumption reduction by LED retrofitting for the equipment to be updated

Using the number of streetlights with conventional light bulbs and the associated power consumption set out by Bandung City in the first workshop, the total electricity consumption and scope for CO_2 emission reduction via LED retrofitting was calculated.

Consequently, the expected electricity reduction is 1,679,515 (KWh/year), while the CO2 emission reduction was calculated at 1,253 (t-CO2/year).

Table 3-30 Calculation of electricity consumption reduction by type of LED replacement

Lighting type	Consumed power		Q'ty ※1	Operating hours	Operating days	Power consumption
	(W)	(KW)		(h/day)	(day/year)	(KWh/year)
Conventional bulb	10	0.01	441	11	365	17,706
	70	0.07	2,109	11	365	592,734
	90	0.09	389	11	365	140,565
	150	0.15	13,401	11	365	8,070,752
	250	0.25	215	11	365	215,806
		All	16,555		All	9,037,564
		90-250	**14,005**			**8,427,124**

Lighting type	Consumed power		Q'ty ※1	Operating hours	Operating days	Power consumption	
	(W)	(KW)		(h/day)	(day/year)	(KWh/year)	
LED	10	0.01	441	11	365	17,706	
	70	0.07	2,109	11	365	592,734	
	120	0.12	14,005	11	365	6,747,609	
		All	16,555		All	7,358,050	
		120	**14,005**		**120**	**6,747,609**	
				Power reduction	**120**	**1,679,515**	(KWh/year)
				CO_2 emission reduction *2	**120**	**1,253**	(t-CO2/year)

* 1: Quantity and LED power consumption: ESTIMATED MEASUREMENT OF REDUCING STREET LIGHTS CO_2 EMISSION IN BANDUNG (The 1st Workshop, Bandung City Materials)
* 2: CO_2 emissions (annual) = electricity consumption (KWh) / day x 365 days x CO_2 emission coefficient (based on "FY2014 JCM Large-Scale Project Formation Feasibility Study for Realizing a Low-Carbon Society in Asia - Support for the Formation of a Low-Carbon City through Intercity Collaboration between Bandung City and Kawasaki City")

(4) How LED Street Lighting Replacement was Organized in the JCM Equipment Subsidy Project

For the methodology of LED street lighting, we used the calculation method of ID_AM018 "Installation of LED Street Lighting with Lighting Control System" in the "Introduction of Smart LED Street Lighting System to Industrial Parks in FY2015" to estimate the CO2 reduction effect of introducing LED street lighting.

1) Eligible standard

Eligible standards are shown in the following table.

Table 3-31 LED Streetlight Eligibility Standard

Requirement 1	Install new LED streetlights with lighting control systems or to replace existing streetlights.

Table 3-32 Monitoring methods identified in the methodology

Measurement methods and procedures	Measurement frequency
[Method 1] Sum up the data recorded by the measuring instruments installed in each LED streetlight to obtain the collective electricity consumption of all project streetlights in Group i. [Method 2] The electricity consumption of all the project streetlights in group i will be measured by a measuring instrument installed in the central power distribution system connected to each LED streetlight.	Consecutive

2） Calculation method for emission reductions

Emission reductions are calculated using the following equation:

$$\mathbf{ER_p = RE_p - PE_p}$$

ER_p: Emission reduction p in period p [$_tCO2$]

RE_p: Reference emissions p in period p [$_tCO2/p$](①)

PE_p: Project emissions p in period p [$_tCO2_2/p$](②)

① Calculation of reference emissions

$$\mathbf{RE_p = \Sigma_i\, EC_{pj,\,i\,,p} \times \frac{\eta PJ,i}{\eta RE,i} \times EF_{elec}}$$

REp : Standard emission amount during the period p [tCO2/p]

ECpj,i,p : Electricity consumption of Group i's project street lighting in period p [MWh/p]

ηPJ,i : Luminous efficacy of project street lighting in Group i [lm/W]

ηRE,i : Luminous efficiency of standard street lighting in Group i [lm/W]

EFelec : CO_2 emissions factor trend for electricity consumption [tCO2/MWh]

② Calculation of project emissions

$$\mathbf{PE_p = EC_{PJ,p} \times EF_{elec}}$$

RE_p : Project emissions in period p [tCO2/p]

$EC_{PJ,\,p}$: Total energy consumption of project lighting in period p [MWh/p]

EF_{elec} : CO2 emission factor for electricity consumption [tCO_2/MWh]

3） Organize LED equipment

Standard street lighting (reference equipment) and equipment for project street lighting are organized as follows:

Table 3-33 Configuring the luminous efficacy of LED street lighting equipment

Standard street lighting (Reference Equipment)	As per the concept of equipment setting in ID_AM018, it should be set as 115lm/W or 100lm/W LED street lighting with lighting control system. To set the RPC of the project equipment as "120lm/W", it shall be set as "100lm/W".
Project Equipment	As the target manufacturers in the private sector have not been determined at this time, the luminous efficacy of LED lighting in Bandung City will be set at "120lm/W".

（5） Trial calculation of reduction effect of equipment replacement

Using the above calculation method, we estimated the reduction effect of introducing LED street lighting.

Table 3-34 Trial calculation of CO2 reduction effect by introducing LED street lighting (1/2)

Item	contents	Value	Setting approach
(1) Calculation of reference emissions			
REp	Reference emission amount during the period p[tCO2/p]	7,700.05	Calculated by formula.
ECpj,i,p	Electricity consumption of the project street lighting in Group i in period p [MWh/p]	7,358	Energy consumption of LED lighting (10W-120W).
ηPJ,i	Luminous efficacy of project street lighting in Group i [lm/W]	120	LED lighting luminous efficacy "120lm/W" set.
ηRE,i	Luminous efficacy of standard street lighting in Group i [lm/W]	100	To set the RPC of the project device as "120lm/W", set it as "100lm/W".
EFelec	CO2 emission factor for electricity consumption [tCO2/MWh]	0.88	(Adopted the Java region of Indonesia from the Global Environment Center (GEC)'s "List of CO_2 Emission Factors (tCO_2/MWh) for JCM Subsidy Projects in 3FY2040" (as of the 3331date of the public notice).
I	Power consumption of LED street lighting installed in the project, based on rated power	120	Luminous efficiency of LED lighting.
(2) Calculation of project emissions			
$RE._p$	Project emissions in period p [tCO2/p].	6475.04	Calculated by formula.
$EC_{PJ,\ p}$	Total electricity consumption of project lighting in period p [MWh/p].	7,358	Energy consumption of LED lighting (10W-120W).
EF_{elec}	CO_2 emission factor for electricity consumption [tCO2/MWh].	0.88	(Adopted the Java region of Indonesia from the Global Environment Center (GEC)'s "List of CO2 Emission Factors (tCO2/MWh) for JCM Subsidy Projects in 3FY2040" (as of the 3331date of the public notice).

Table 3-35 Trial calculation of CO2 reduction effect by introducing LED street lighting (2/2)

(3) Calculation of emission reductions			
ER_p	Emission reductions in period p p[$_t$CO2].	1,295.01	Calculated by formula.
$RE._p$	Reference emissions in period p p [$_t$CO2/p].	7,700.05	Calculated by (1)
PE_p	Project emissions in period p p [$_t$CO2/p].	6,475.04	Calculated in (2)

（6） Issues and policies for commercialization using JCM model projects

Based on the survey conducted in the first year of this fiscal year, the issues to be addressed for introducing JCM model projects and the policy for approaches in the second year and beyond are shown below.

1） Examination of the number of units and installation costs for renewal of LED street lighting

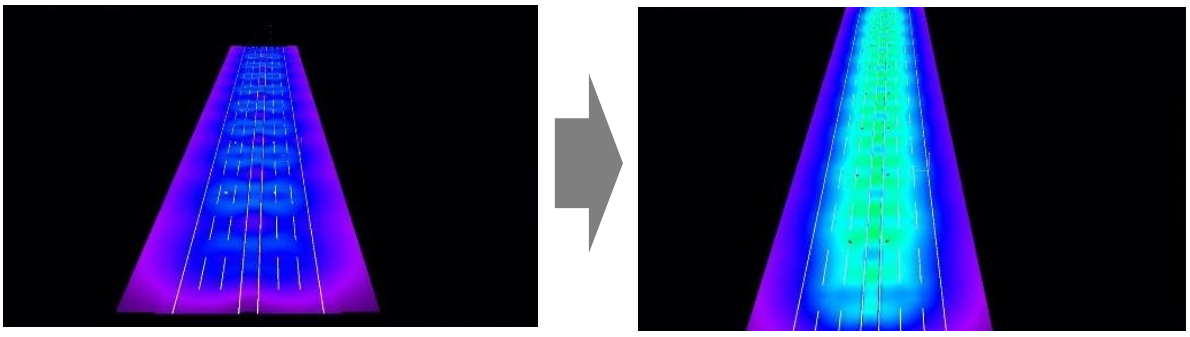
Since the study this year confirmed that LED street lighting in Bandung has a certain level of CO2 reduction effect, it is necessary to narrow down the target routes and select private companies willing to participate in the project through the detailed study described in the previous section, and to carefully examine the number of units and installation costs.

2） Narrowing down target roads and detailed study of the estimation of reduction effects

During the first year of the project, we consulted with Bandung City to accurately determine the current status of street lighting, confirmed the number of non-LED streetlights and estimated the reduction effect replacing all of them with LED lighting. Consequently, since CO2 emission reduction appeared worthwhile and viable, the second year will focus on identifying priority routes for LED conversion based on the policies and policies of Bandung City.

In the second project year, we will select priority routes where streetlights are needed as soon as possible, focusing on routes with uneven lighting installation points and spacing according to the type and extension of the routes and the law of the Department of Transportation (No.27/2018) among the current sections maintained without LED lights. The policy is to increase the certainty of installation plans and cost-effectiveness, including financial aspects, when using JCM model projects. Over and above the economic effects associated with reducing electricity consumption through energy conservation, consideration of added value, such as safety measures, by boosting illumination and management through smart technology may promote specific studies.

Bandung City has previously estimated the reduction in electricity consumption and CO2 emissions from the use of LED streetlights on Soekarno-Hatta Bandung Street in the city and also simulated the effect of illumination when LEDs are installed, so the proposal will be materialized while utilizing such precedent cases.



Source: Courtesy of Bandung City

Figure 3-8 Simulation of LED conversion

3） Identifying businesses to participate in JCM model projects

Re-iterating what was mentioned in section 1) above, to calculate the effect of introducing LED street lighting using the currently established method, it is necessary to find companies that are interested in developing a project in Bandung for LED street lighting to be used in this project. Accordingly, the Kawasaki Green Innovation Cluster (GIC), a platform for companies with

environmental technologies in Kawasaki City, must be leveraged to find companies that will participate in the JCM Model Project from the following year. Recent years have seen many products related to LED street lighting in Japan that have helped effectively promote people's migration through the spread of ICT and IoT technologies and in use during disasters.

4） Consideration of various conditions for using JCM model projects, including financial plans and procurement schemes

During the first year of this project, interviews with Bandung City revealed current budgetary arrangements for street lighting and the role played by private operators in city maintenance. In the second year, we will try to understand the regulations governing public procurement and the bidding conditions and systems in Bandung City and the feasibility of considering JCM, to make equipment subsidies more feasible. In addition, since Bandung City is a public institution, the conditions for participation in international consortia must also be confirmed, since this is a condition for applying for a JCM model project for LED street lighting.

During the second year, we are planning to identify issues and organize measures to maintain and manage LED street lighting, as well as study potential to utilize smart LEDs with IoT for appropriate monitoring when implementing the JCM.

Chapter 4 Reduction of Traffic Congestion and Air Pollution

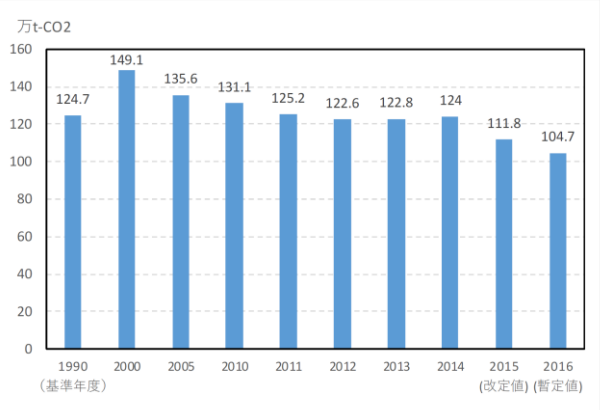
4.1 Background

(1) Efforts by Kawasaki and Bandung Cities

Bandung and Kawasaki cities have worked in collaboration, exchanging information on advanced environmental technologies and national and international environmental measures since they participated in the third Eco-Business Forum in 2007. In Bandung City, in FY2014 and FY2015, a JCM project formation for realizing a low-carbon society in Asia of the Ministry of Environment of Japan was implemented. Against the backdrop, the two cities concluded a memorandum of understanding (MOU) concerning city-to-city collaboration toward sustainable low-carbon city development and they decided to cooperate in solid waste, water and air quality management in February 2016. They concluded another MOU to further promote the collaboration for sustainable city development in February 2020. Since the MOU conclusion, JICA grassroot technical cooperation projects and programs of the Ministry of Environment and the Ministry of Land, Infrastructure, Transport and Tourism of Japan have been utilized to implement multiple projects mainly to improve the solid waste management capacity and river water quality. With the aim to promote efforts to improve air quality management, which is the remaining issue, in this Project, efforts to reduce traffic congestion which is a main cause of air pollution and conduct air pollution monitoring are studied.

(2) Traffic Pollution Management Measures in Kawasaki City

Kawasaki City has been tackling environmental problems taking low-carbon measures, pollution reduction measures, energy and air quality improvement measures while supporting Japanese industries as a core city of the Keihin Industrial Zone. It has formulated the Kawasaki traffic pollution management plan to tackle automobile pollution. The Kawasaki plan sets basic and action goals to implement measures to promote the introduction of low-emission vehicles and control the traffic volume and flow in collaboration with business operators, citizens and relevant organization and government agencies. The efforts have contributed to certain improvements--nitrogen dioxide emissions met environmental standards at all monitoring stations in FY2013, for example. The CO2 emissions by the transport sector have continued to decrease gradually since FY2005 to achieve 16-percent reduction in FY2016 (tentative value) from the base year (FY1990).



Source: Kawasaki Traffic Pollution Management Plan

Figure 4-1 Trend of CO2 Emissions by Transport Sector (Kawasaki City)

4.2 Congestion Reduction Measures by Improving Traffic Flow

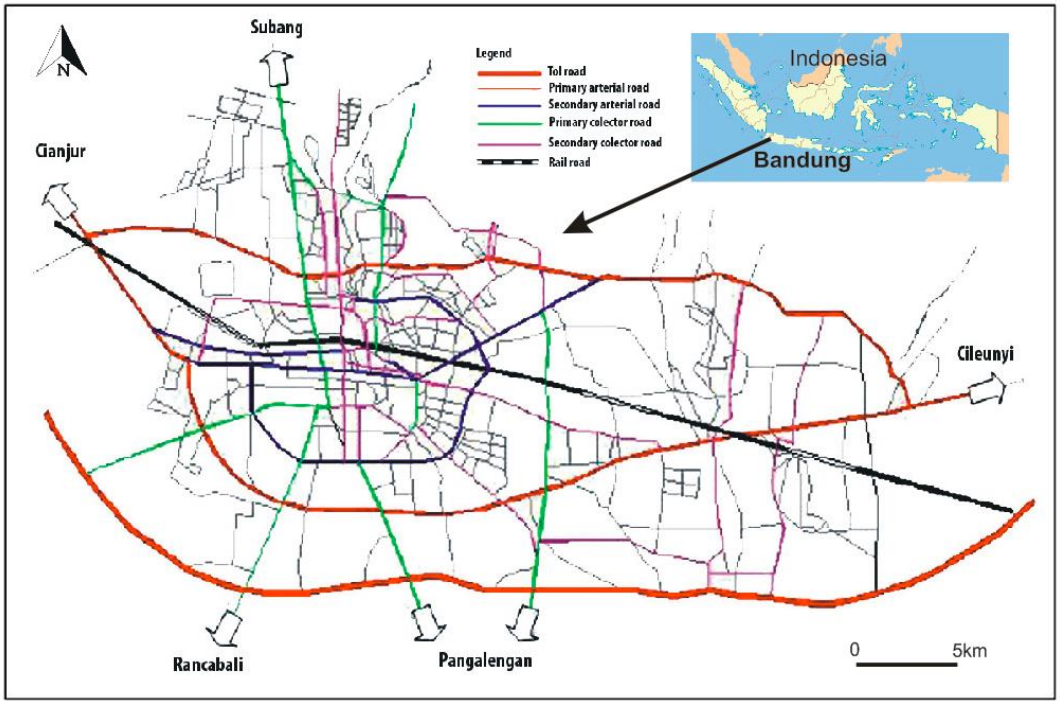
4.2.1 Current Status and Challenges Concerning Road Traffic in Bandung City

The current status and challenges concerning road traffic in Bandung City are summarized below.

（1） Road and Traffic Conditions

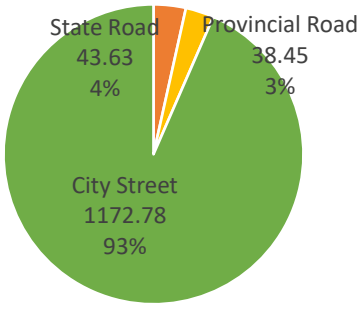
1） Road Conditions

In Bandung City, there is a loop road (partially unconnected) around the city center and roads to access the expressway in the eastern and western areas in the city run radially from the center. The total road length in the city is approx. 1,254 kilometers (excluding the expressway) and city streets account for approx. 90 percent. No new road was built between 2018 and 2020 with no change in the total length.



Source: Incorporating Air Quality Improvement at a Local Level into Climate Policy in the Transport Sector: A Case Study in Bandung City, Indonesia

Figure 4-2 Bandung City Road Network



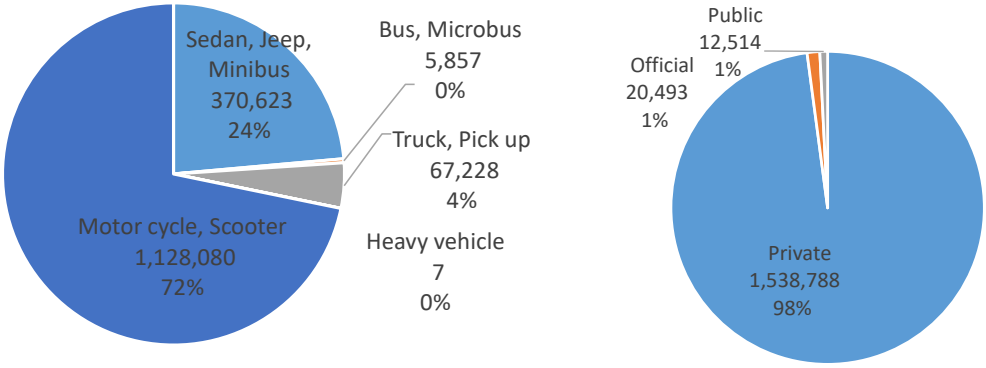
Type of Road	2018	2019	2020
State Road	43.63	43.63	43.63
Provincial Road	38.45	38.45	38.45
City Street	1172.78	1172.78	1172.78
Village/Local Road	-	-	-
Toll road	-	-	-
Total	1254.86	1254.86	1254.86

Source: Kota Bandung Dalam Angka Bandung Municipality in Figures 2021

Figure 4-3 Road Length in Bandung City

2） Number of Registered Vehicles

Approx. 1.57 million vehicles are registered with Bandung City: approx. 1.13 million motorcycles followed by 370,000 sedan and other passenger cars. Approx. 98 percent of passenger cars are for private use. The number of vehicles per 1,000 residents in Bandung is approx. 40 percent bigger than that of the national average of Indonesia and it is forecast to increase further as city dwellers increase.



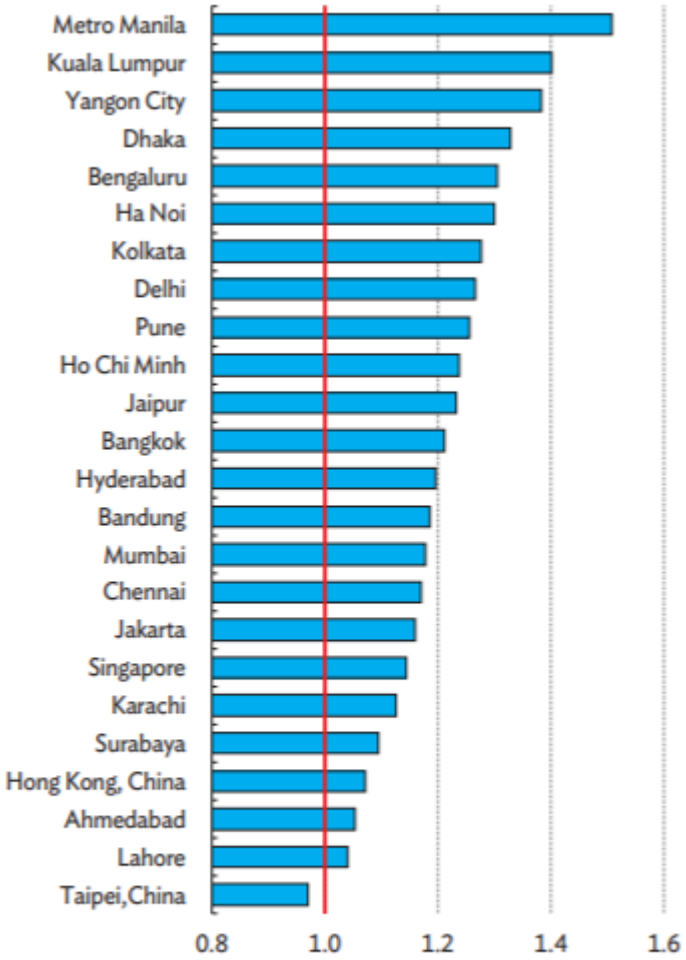
Source: Kota Bandung Dalam Angka Bandung Municipality in Figures 2021

Figure 4-4 Number of Registered Vehicles

3） Traffic Congestion

The Asian Development Bank (ADB) surveyed traffic congestion in cities with a population of five million or more in Asia and the data is available (refer to Figure 4-6). It is a comparison of the congestion level in the cities with the average sample value. When the value is higher than 1.0, it shows that the relative congestion level in the city is higher than the sample value. That of Bandung City is approx. 1.2, ranked 14th as a congested city. Jakarta, the capital city of Indonesia, is ranked 17th, which indicates how serious traffic congestion is in Bandung.

Figure 4-5 Traffic Congestion in Bandung City (Africa Street)



Source: ADB estimates using nighttime lights images from the National Ocean and Atmospheric Administration (Accessed 1 April 2017 and 10 August 2018), grid population data from Land Scan Datasets of the Oak Ridge National Laboratory (accessed 31 August 2017 and 31 Aufast2018) and trip routes from Google Maps (Accessed 19 March 2019)

Figure 4-6 Traffic Congestion in Asian Cities with a Population of Five Million and More

As for the congestion level of roads managed by Bandung City, eight roads are categorized as high traffic with the value over one and the average speed being 15km/h or below and 20 roads are medium traffic with the value between 0.8 and one and the average speed being 15km/h to 25km/h.

Table 4-1 Congestion in the City

	Congestion (VCR)	Average Speed(km/h)	Number of Roads
High traffic	> 1	0 - 15	8
Medium traffic	0.8 - 1	15 - 25	20
Smooth	< 0.8	> 25	87
Total			115

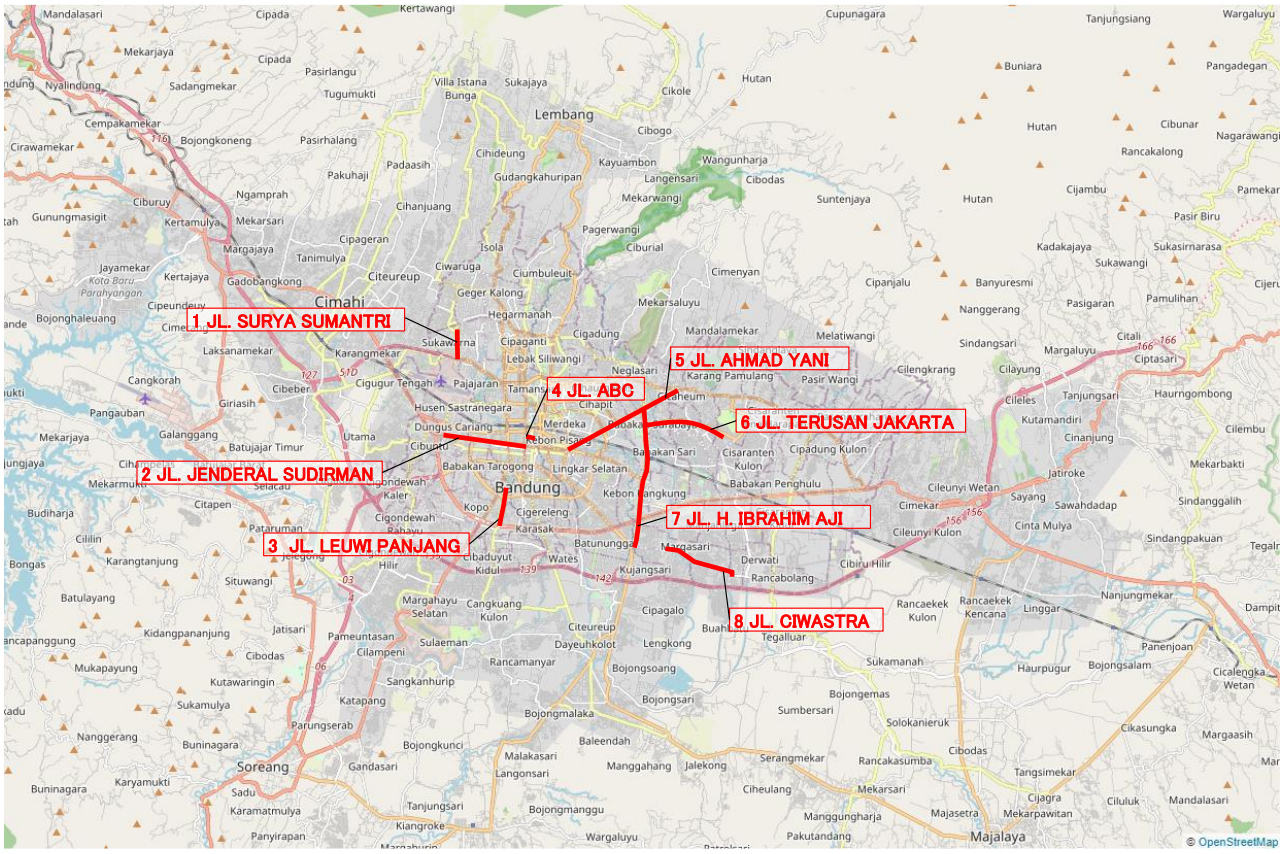
Source: Department of Transportation, Bandung City

Table 4-2 shows roads where the congestion value is over one and the average speed is 15km/h or below and Figure 4-7 is a map with the heavily congested roads. Most of the congested roads are access roads from toll roads to the city center. Congestion is likely to be caused in at points with a small capacity where toll roads and other main arterial roads merge with secondary arterial roads managed by the city. Another possible cause is an increase in traffic as vehicles flow into the roads to avoid congestion on arterial roads. JL. AHMAD YANI (No. 5) is congested at the crossing with a railway and JL. JENDERAL SUDIRMAN (No.2) and JL. ABC (No.4) and other roads in the city center are congested probably because many vehicles parked along stores on streets block the traffic.

Table 4-2 VCR and Speed of Congested Roads

No	Road Name	Road Status by Function	Length (km)	Road Network Performance	
				Vehicular Cloud for Road Side Scenarios (VCR)	Speed (Km/hour)
1	JL. SURYA SUMANTRI	-	-	0.94	13,89
2	JL. JENDERAL SUDIRMAN	Secondary arterial	4.350	0.96	14,32
3	JL. LEUWI PANJANG	Secondary collector	1.527	0.91	14.44
4	JL. ABC	Secondary collector	0.605	0.98	12.69
5	JL. AHMAD YANI	Secondary arterial	4.765	0.99	12,82
6	JL. TERUSAN JAKARTA	Secondary collector	1.219	0.90	14.00
7	JL. H. IBRAHIM AJI	Secondary arterial	4.675	0.97	11,19
8	JL. CIWASTRA	Secondary collector	5.400	0.91	14.26

Source: Department of Transportation, Bandung City



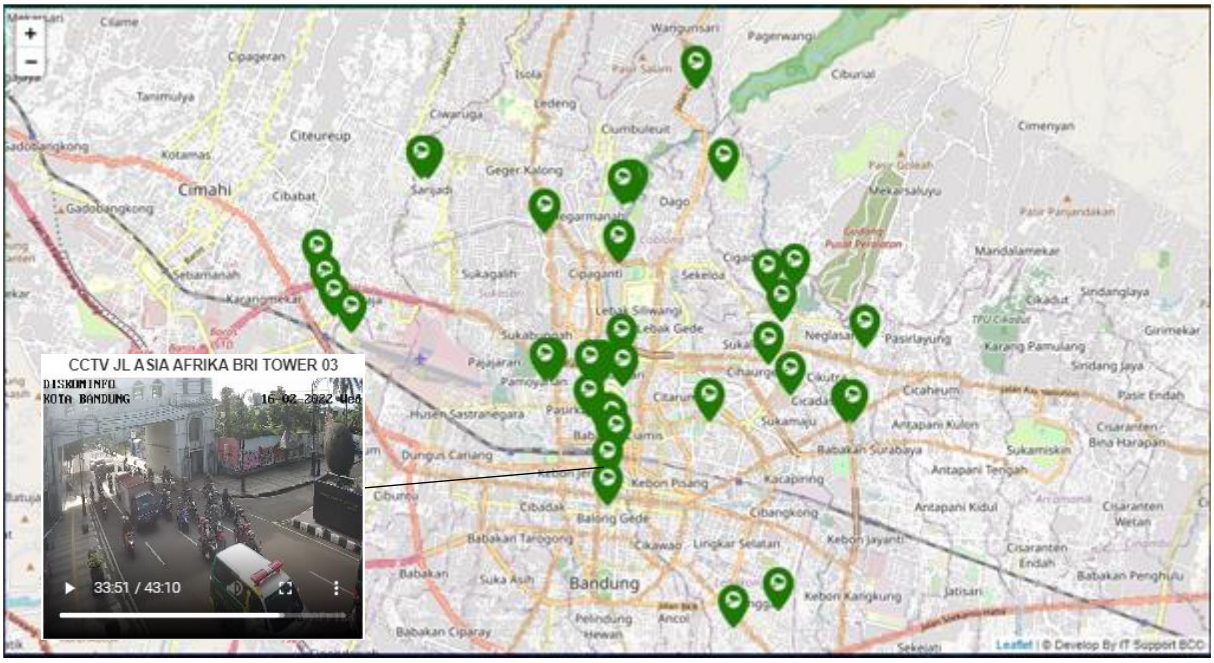
Source: Department of Transportation, Bandung City

Figure 4-7 Location of Congested Roads

4） Traffic Management

The Bandung traffic is managed by the Department of Transportation and closed circuit television (CCTV) cameras are installed for monitoring at 45 locations mainly along major routes. With the cameras, their locations and images can be observed.

In the city, area traffic control systems (ATCS) that control traffic lights are installed at 59 locations. The ATCS controls traffic lights by selecting and computing optimal traffic light control parameters depending on the traffic demand.



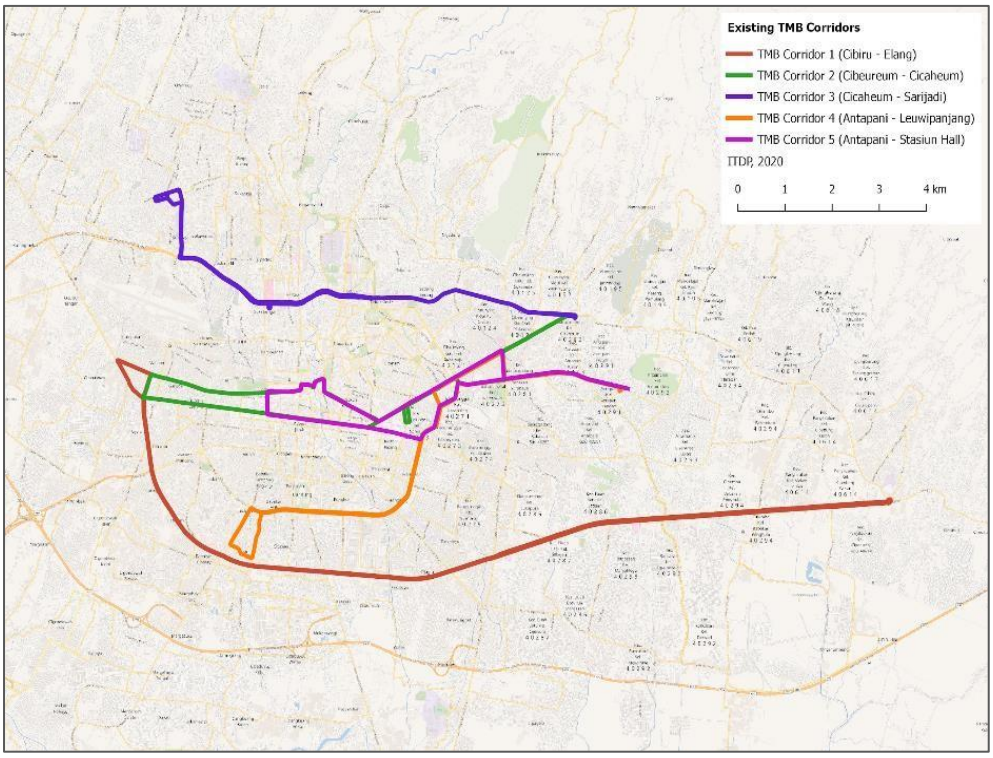
Source: https://pelindung.bandung.go.id/maps

Figure 4-8 CCTV Points and An Example CCTV Image

（2） Public Transportation

1） Types of Public Transportation

Currently, the public transportation network consists mainly of buses in Bandung City. Five routes of Trans Metro Bandung (TMB) of bus rapid transit (BRT) are currently operated with the longest route being 25 kilometers and the shortest, eight kilometers. (Refer to Figure 4-9.) Such public transportation as damri (large bus) that connects the city center and surrounding areas and angkot (minibus with capacity of around nine passengers), local transportation that connects communities and terminal stops as well as tour buses called bandros and school buses are operated. There are 12 damri routes and the average length of all routes is approx. 36 kilometers and three to 14 buses are operated daily on each route. (Refer to Table 4-3.) The Angkot for short-distance traveling is available on 40 routes and the average length is approx. 14 kilometers. (Refer to Table 4-4.)



Source: ROGRAM PEMERINTAH KOTA BANDUNG PENGURAPNGAN EMISI KARBON MELALUI PEMBANGUNAN SISTEM ANGKUTAN UMUM MASAL (Presentation material of Bandung City at 1st workshop)

Figure 4-9 BRT Route Map

Table 4-3 Summary of Damri (Large Bus) Operation

Route No.	Route	Unit number	Route distance (km)	Trip/day	Operational Time
	Bus				
I	Cicaheum - Cibeureum	30	26	5.8	05.30-20.00
II	Ledeng - Leuwipanjang	15	28	5.8	05.30-19.00
III	N/A				
IV	Kiaracondong - Ciroyom	1	32	0	06.00-12.00
V	Dipatiukur - Leuwipanjang	13	19	5.4	05.30-19.00
VI	Elang - Jatinangor	13	54	7.4	05.30-19.00
VII	Dipatiukur - Jatinangor	14	46	2.8	05.30-19.00
VIII	Kebon Kelapa - Tanjung Sari	15	54	4.6	04.00-19.00
IX	Cicaheum - Leuwipanjang	32	23.5	8.4	05.30-21.00
XI	Cibiru - Kebon Kelapa	13	36	13.6	05.30-20.00
XIV	Kiaracondong - Sarijadi	3	30	7.2	05.30-18.00
XV	Alun - Ciburuy	18	48	3.8	05.30-19.00
	Midibus				
	Antapani - KPAD	12	0	4	
	Total	179	396.5	68.8	

Source: Public Company DAMRI Bandung City

Table 4-4 Angkot (Minibus) Routes

Code	Route	Distance (km)	Vehicle
1.A	Abdul Muis –Cicaheum Via Binong	16.3	355
1.B	Abdul Muis-Cicaheum Via Aceh	11.55	100
2	Abdul Muis-Dago	9.3	271
3	Abdul Muis-Ledeng	16.6	245
4	Abdul Muis-Elang	9.75	101
5	Cicaheum-Ledeng	14.25	214
6	Cicaheum-Ciroyom	17	206
7	Cicaheum-Ciwastra-Derwati	17	200
8	Cicaheum-Cibaduyut	16.1	150
9	Stasiun Hall-Dago	10	52
10	Stasiun Hall-Sadang Serang	11	150
11.A	Stasiun Hall-Ciumbuleuit-Via Eykman	9.8	53
11.B	Stasiun Hall-Ciumbuleuit-Via Cihampelas	8.3	30
12	Stasiun Hall-Gede Bage	21	200
13	Stasiun Hall-Sarijadi	10.2	80
14	Stasiun Hall-Gunung Batu	8.5	53
15	Margahayu Raya-Ledeng	19.8	125
16	Dago-Riung Bandung	20.6	201
17	Pasar Induk Caringin-Dago	19.85	140
18	Panghegar Permai-Dipati Ukur-Dago	19.35	155
19.A	Ciroyom-Sarijadi Via Sukajdi	11.75	88
19.B	Ciroyom-Sarijadi Via Setrasari	10.75	31
20	Ciroyom-Bumi Asri	8.35	115
21	Ciroyom-Cikudapateuh	12.9	140
22	Sederhana-Cipagalo	16.05	276
23	Sederhana-Cijerah	8.9	63
24	Sederhana-Cimindi	9	55
25	Ciwastra-Ujung Berung	13.4	32
26	Cisitu-Tegallega	13.95	82
27	Cijerah-Ciwastra -Derwati	22.3	200
28	Elang-Gede Bage-Ujung Berung	22.45	115
29	Abdul Muis-Mengger	10.55	25
30	Cicadas-Elang	18.05	300
31	Antapani-Ciroyom	13.7	160
32	Cicadas-Cibiru-Panyileukan	13.65	200
33	Bumi Panyileukan-Sekemirung	24.35	125
34	Sadang Serang-Caringin	18.1	200
35	Cbaduyut-Karang Setra	16.6	201
36	Cibogo - Elang	7	32

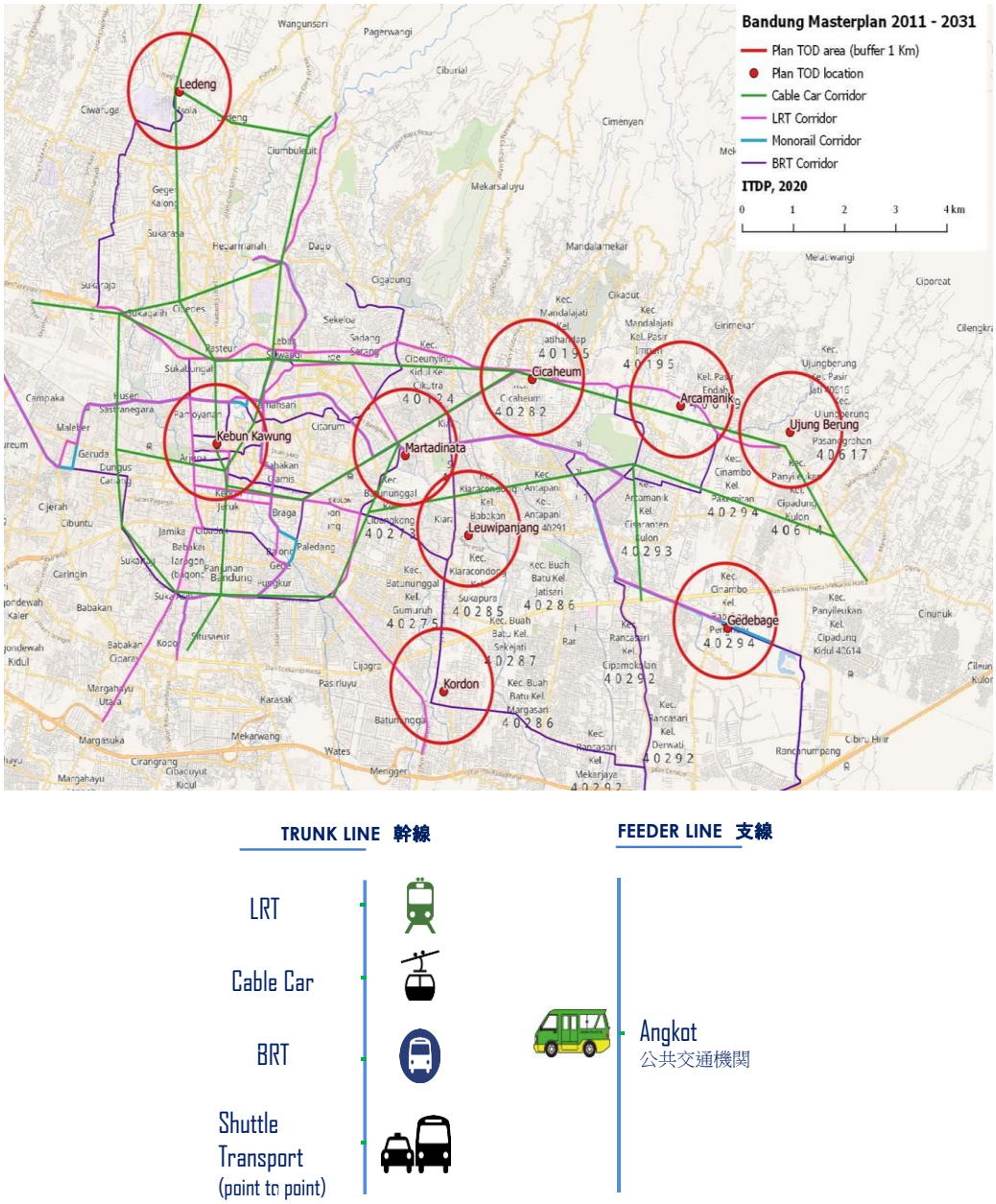
Source: Dinas Perhubungan Kota Bandung

（3） Future Plan

1） Public Transportation

The Bandung Master Plan 2011-2031 includes a plan of establishing nine transit oriented development (TOD) bases and opening nine cable car routes, 11 light rail transit (LRT) routes and

13 BRT routes. The LRT is a rail transportation system characterized by easy getting on and off and excellent punctuality, fastness and comfortability due to use of low-floor cars and improved tracks and stops. The realization of the routes is expected to form a public transportation network that covers not only central Bandung but its surrounding areas. (Refer Figure 4-10.) LRT and BRT are expected to connect the city center and TOD base areas or between TOD base areas to enable wide-area mobility in the city and serve as a network that contributes to the establishment of its backbone. The angkot serves as the main feeder line for local transportation. Like this, transportation routes in Bandung are expected to be classified based on their role and function and form a public transportation network with appropriate services in accordance with the demand characteristics.



Source: ROGRAM PEMERINTAH KOTA BANDUNG PENGURAPNGAN EMISI KARBON MELALUI PEMBANGUNAN SISTEM ANGKUTAN UMUM MASAL (Presentation material of Bandung City at 1st workshop)

Figure 4-10 Future Public Transportation Network Plan (2030)

（4） Summary of Challenges

Bandung City is not fully coping with increasing vehicles and the traffic demand exceeds the service supply. Because the public transportation service is insufficient, dependance on automobiles is high and chronic congestion in roads in the city center and surrounding areas is extremely serious. The loss caused by the increase in travel time due to congestion hinders people's living and business activities and the slower travel speed leads to increased emissions of CO2, nitrogen oxides (NOx) and other air pollutants. The population increase and economic growth are expected to continue in Bandung City and the increase in vehicles will further deteriorate traffic congestion. Thus, it is important to swiftly implement measures to ease the congestion.

To improve the congestion in the city, urgent challenges are proper management of current automobile traffic demand and reduction of automobile dependance by improving the public transportation service that includes its development. In Bandung, new LRT and BRT lines are planned to be built to extend the public transportation network by 2031. The development of public transportation is expected to shift dependence on automobiles to public transportation and measures need to be taken to encourage to use the service.

4.2.2 Traffic Congestion Reduction Measures in Japan

（1） Examples in Japan

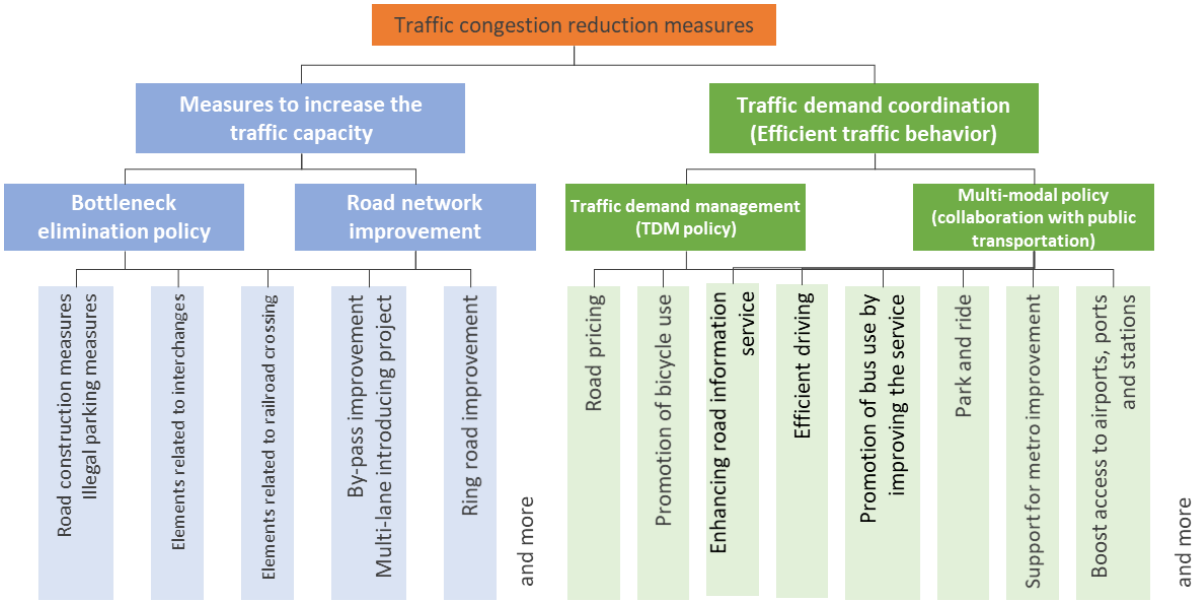
Measures to eliminate traffic congestion are to increase the road capacity and adjust traffic demand (improve efficiency of traffic behaviors).

Measures to increase the traffic capacity include the improvement of intersections that are causes of the congestion, construction of grade crossings and establishment of left- and right-turn lanes to eliminate the bottleneck, proper distribution of traffic concentration by constructing bypasses and loop roads, and development of road network to eliminate passing-through traffic whose destination is not in the area.

Measures to adjust the traffic demand are traffic demand management (TDM) measures to promote road users to change the time and route they drive or means of transportation to ease congestion and multimodal measures that are comprehensive traffic measures to ease vehicle concentration in collaboration with multiple transportation service operators.

Local road network development and improvement is the most effective measure. For drastic elimination of traffic congestion, although it is essential to build roads to improve the network and increase the traffic capacity to eliminate bottlenecks, it requires an enormous amount of budget and time. Thus, it is also necessary to take traffic demand management measures to properly encourage road users for efficiency improvement together with the infrastructure development. Specific measures to adjust the traffic demand include provision of road traffic information and promotion of ecological driving and use of public transportation.

The measures to reduce traffic congestion are summarized in Figure 4-11.



Source: prepared by the Survey Team based on materials of the Road Bureau of the Ministry of Land, Infrastructure Transport and Tourism of Japan

Figure 4-11 Structure of Measures to Reduce Traffic Congestion

1) Promotion of Provision of Road Traffic Information

Road traffic information on congestion and parking lots is provided for drivers to select proper routes and avoid wasteful driving. There are two types of traffic information necessary for road users: static information on the road network for reasonable route selection and road structure that includes road line shape and grade and dynamic information that changes as time passes, including the location and degree of congestion, required travel time, travel restrictions for word work and parking lot availability.

Road traffic information is provided on the board over the road and road rest areas. Vehicle detectors to measure the traffic volume and travel speed are installed along the road and it is monitored constantly with video monitors to provide dynamic information. Recently, AI analysis has been introduced to existing CCTVs to measure the traffic volume and monitor other road conditions more easily.

Table 4-5 Provision of Road Traffic Information (An Example)

	Techniques and Measures	Outline	Image
1	Required travel time and route information on road information board	Required travel time is calculated based on vehicle speed measured by the vehicle detectors installed along the road and the information is provided on the board, car navigation system and website, etc.	
2	Provision of road traffic condition at rest facilities	Road traffic information is provided at service areas on the expressway and michi-no-eki (roadside facility of stores, rest and accommodation facilities and local promotion facilities).	
3	Monitoring of traffic	Traffic volume (automobile and pedestrians) is measured and monitored with AI analysis technique using existing CCTV image for road management.	
4	Constant monitoring of traffic volume using AI cameras and disclosure of measurement data	Traffic condition of major roads is measured with AI camera to provide information on changes of traffic flow on the website.	

Source: No.3: Report on accuracy of CCTV camera (AI analysis), Ministry of Land, Infrastructure, Transport and Tourism of Japan (https://www.mlit.go.jp/road/ir/ir-council/ict/pdf05/02.pdf)
No.4: Website of Mie Prefecture (https://www.pref.mie.lg.jp/TOPICS/m0035100043.htm)

2） Promotion of Ecological Driving

Ecological driving means driving an automobile ecologically with less energy consumption to reduce environmental burdens. Such driving techniques as the use of road traffic information to avoid congestion, parking not to block traffic, reduction of acceleration and deceleration, and release of the accelerator early and use of the engine brake as well as changes in driving behaviors of knowing fuel consumption of one's own car are promoted.

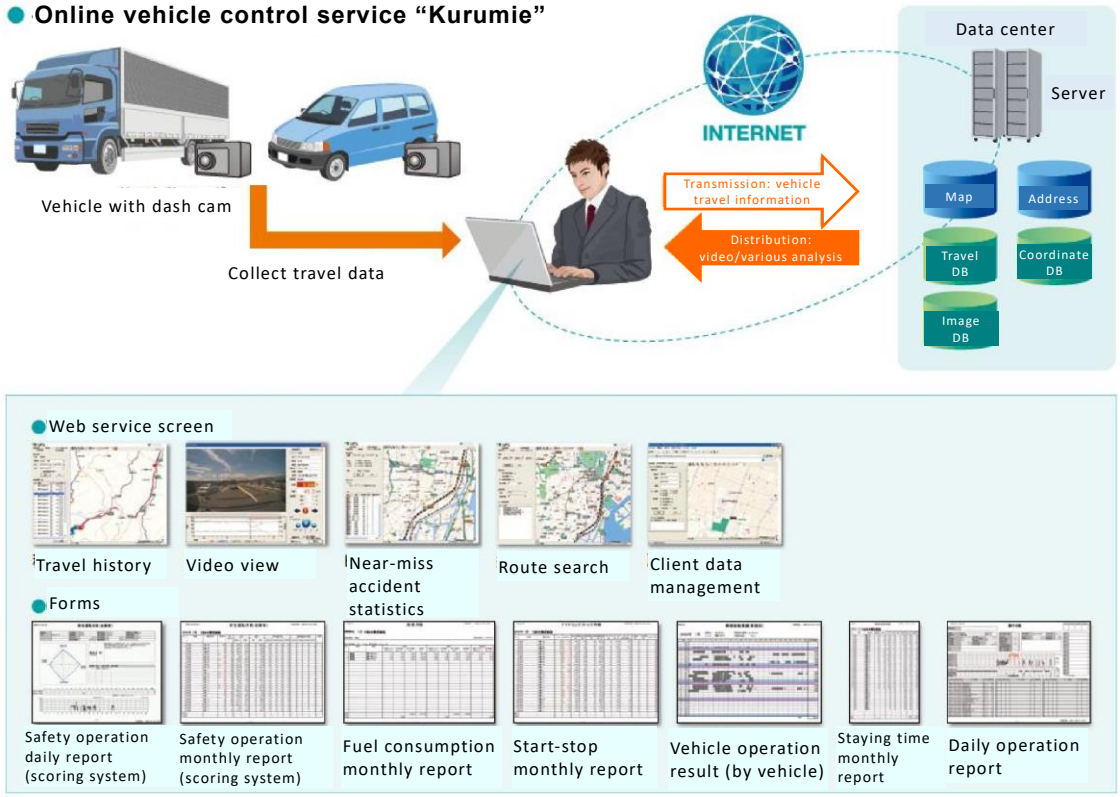
To promote ecological driving in Japan, the National Police Agency, the Ministry of Economy, Trade and Industry, the Ministry of Land, Infrastructure, Transport and Tourism and the Ministry of Environment, as relevant government ministries and agencies, established a promotion liaison group and a study group and compiled the 10 Recommendation of Ecological Driving in FY2003. The plan to achieve the goals of the Kyoto Protocol contains the promotion of green automobile use as a measure and intends to raise people's awareness through publicity activities and develop an environment for ecological driving. In 2006, relevant ministries and agencies and other concerned entities decided measures to be focused as the action plan for ecological driving promotion and continue to work on them at the national level.

Table 4-6 Ecological Driving Promotion Measures (Examples)

No.	Measures	Outline
1	Review of definition of ecological driving and confirmation of effect indicator	Because of no uniform effect indicator to be used to explain ecological driving and establish items, confirm effective and uniform definition, effect indicator, problems and workshop contents.
2	Ecological driving promotion activities	Conduct various promotion and awareness-raising activities including ecological driving promotion month and symposium and other events and driver education as nationwide promotion activities in collaboration with relevant parties.
3	Promotion of introduction of ecological driving assistance device	Promote introduction of ecological driving assistance device that includes start-stop systems and instantaneous fuel consumption meter through subsidy and EMS promotion programs.
4	Establishment of ecological driving evaluation system	As drivers lose willingness to drive ecologically if they cannot see the effect, promote self-assessment ecological driving assistance system and establish a third-party assessment system to lay a foundation to introduce incentives to ecological drivers.
5	Uniformed efforts with local governments and relevant organizations	As local governments are implementing various ecological driving promotion measures, analyze and introduce them and encourage best practice widely, while promoting more effective efforts with collaboration among the national and local governments and relevant organizations.
6	Survey necessary for promotion of ecological driving	Study concerns over the start-stop system and instructor program and other ecological driving measures implemented overseas to reflect the results on future ecological driving measures.

Source: Ecological Driving Promotion Action Plan, Ministry of Land, Infrastructure, Transport and Tourism of Japan (https://www.mlit.go.jp/kisha/kisha06/01/010609_.html)

To promote ecological driving, it is important to evaluate drivers' driving condition and review the features. As an evaluation method, the dashboard camera can be used to see the driving data of sudden starting and acceleration and idling duration. Recently, the service of uploading driving data on the web and making various records including fuel consumption and idling is available. (Refer to Figure 4-12). The introduction of such services to logistics and transportation service operators can help improve drivers' awareness.



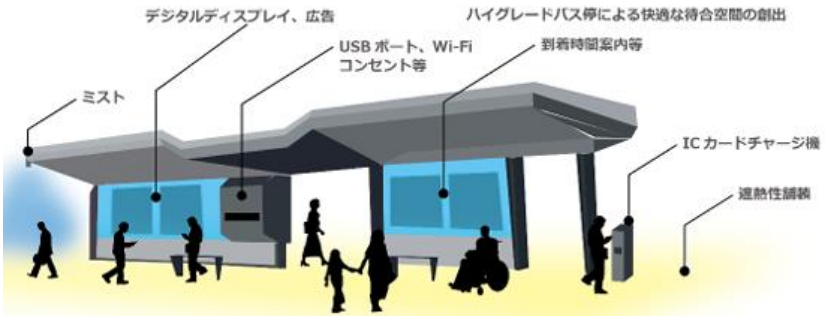
Source: Online vehicle management service pamphlet (NEC)

Figure 4-12 Promotion of Ecological Driving Using Online Vehicle Management

3) Measures to Promote Use of Public Transportation

To promote automobile users to switch to other means of transportation, measures have been taken to improve convenience and service of public transportation by operating it more efficiently and effectively.

Table 4-7 Public Transportation Promotion Measures (Examples)

No.	Measures	Outline
1	Public transportation priority system (PTPS)	A system to give priority to buses and other means of public transportation by setting up exclusive and priority lanes, controlling traffic lights to minimize the stoppage time and warming vehicles illegally running in the exclusive lanes Shorter stoppage time at traffic lights and punctual operation of buses is expected to improve the users' convenience.
2	Information provision system development	Provision of route and operation information in addition to timetable Use wireless communication and GPS to provide information on bus operation (location and expected arrival time) on the Internet and bus stops.
3	Public transportation map to provide information	Collective provision of information on transit, fares and time to the destination Recently, to meet the travel needs by each trip of each individual, MaaS that enables users to search, book and pay for the optimal combination of multiple mobility services including public transportation has been used widely.
4	High-grade bus-stop	Bus stops to create comfortable bus waiting space equipped with large roof and mist sprayers as well as large screens to provide bus approaching and delay information and free Wi-Fi 

Source: Materials for the second review session of Okinawa Advanced Rapid Transit (ART) (Okinawa ART review council) (Okinawa General Bureau, Cabinet Office) (www.dc.ogb.go.jp/road/jisedai/jisedai.htm)

（2） Measures Taken by Kawasaki City

Kawasaki City is taking automobile pollution reduction measures based on the Kawasaki traffic pollution management plan. It has implemented traffic demand management (TDM) measures to control automobile use and improve convenience of public transportation to control the traffic volume and flow.

We reduce the use of automobile by controlling car commuting, encouraging to alternatively use public transportation and promoting bicycle use by improving bicycle parking areas.

Specific project contents	Relevant implementation agency
a) Control car commuting (encouraging to commute on foot, by bicycle or using public transportation)	Business operator
b) Promote commuting by using public transportation alternatively	Administrative organizations concerned
c) Improve bicycle parking areas	Administrative organizations concerned

We strive to control the use of automobile by introducing efficient logistics network and modal shift.

Specific project contents	Relevant implementation agency
d) Promote outsourcing of trucks (transportation method using private trucks is shifted to using efficient commercial trucks)	Business operator Organizations concerned
e) Promote modal shift (e.g., shifting from truck transportation to railway/marine transportation)	Business operator
f) Ensure to increase load factor (promote efficient logistics by increasing load factor, reviewing transportation route, etc.)	Organizations concerned
g) Promote joint transportation (promote joint transportation by adjusting out bound/inbound loads among business operators by utilizing joint transportation center, etc.)	Business operator
h) Utilize the third-party logistics*2	Organizations concerned

We promote convenient public transportation services by improving bus operation based on demand

Specific project contents	Relevant implementation agency
i) Review schedules and routes of bus service	Administrative organizations concerned

We encourage related business operators to promote their voluntary environmental actions based on the traffic environmental consideration action menu.

Specific project contents	Relevant implementation agency
j) Raise awareness via Kawasaki City traffic environmental consideration action menu	Administrative organizations concerned

Source: Kawasaki traffic pollution management plan (revision)

Figure 4-13 Measures to Control Traffic Volume and Flow based on the Kawasaki Traffic Pollution Management Plan

4.3 Air Quality Improvement through Introduction of Air Pollution Monitoring System

To propose air quality monitoring, items to be monitored, monitoring method and monitoring result disclosure method and feasibility were studied.

4.3.1 Air Monitoring System in Japan

（1） Air Pollution Standards

Air pollution standards are stipulated in the Article 16 in the Environmental Basic Act as the standards expected to be maintained to protect human health. Different from emissions standards for plants and businesses, they are pollution improvement target values. Standards of six air

pollutants, sulfur dioxide, nitrogen dioxide, carbon monoxide, suspended particulate matter, photochemical oxidant and particulate matter are provided.

The main purposes of continuous air monitoring are to 1) find out air pollution in the area, 2) find out the source and high concentration areas, 3) find out the effects of pollution prevention measures and 4) find out secular changes of pollution.

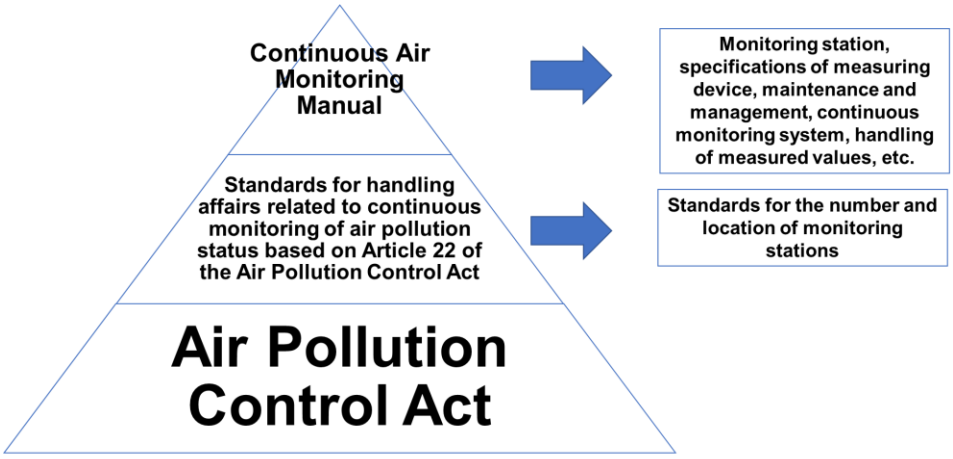
Table 4-8 Air Pollutant Standards

Substance	Environmental Condition (date of establishment, etc.)	Measurement Method
Sulfur dioxide (SO2)	Daily average of hourly values is 0.04ppm or below and hourly value is 0.1ppm or below. (notice on May 16, 1973)	Electroconductivity of solution or ultraviolet fluorescence
Carbon monoxide (CO)	Daily average of hourly values is 10ppm or below and 8-hour average of hourly values is 20ppm or below. (notice on May 8, 1973)	Use of non-dispersive infrared analyzer
Suspended particulate matter (SPM)	Daily average of hourly values is 0.10mg/m^3 below and hourly value is 0.20mg/m3 or below. (notice on May 8, 1973)	Filtration and mass concentration measurement or light scattering, piezoelectric balancing or beta-ray absorption methods with which the amount with a linear relationship with the measured mass concentration can be obtained
Nitrogen dioxide (NO2)	Daily average of hourly values is within the zone between 0.04ppm and 0.06ppm or below. (notice on July 11, 1978)	Absorption photometry that uses Salzman reagent or chemiluminescence assay that uses ozone
Photochemical oxidant (OX)	Hourly value is 0.06ppm or below. (notice on May 8, 1973)	Absorption photometry that uses neutral potassium iodide solution, or coulometry, ultraviolet absorption or chemiluminescence assay that uses ethylene
Particulate matter (PM2.5)	Annual average is 15μg/m3or below and daily average is 35μg/m3 or below. (notice on Sep. 9, 2009)	Filtration and mass concentration measurement or use of automatic measuring device deemed to obtain values equivalent to the mass concentration obtained in the measurement in a place deemed to enable accurate finding of air pollution by particulate matters

Source: Website of MoE of Japan (https://www.env.go.jp/kijun/taiki.html)

（2） Air Monitoring System

In Japan, continuous air monitoring is conducted based on the Article 22 in the Air Pollution Control Act that requires prefectural governors to constantly monitor air pollution. Based on the administrative processing standards concerning the constant air pollution monitoring in accordance with the Article, the number of monitoring stations and their allocation are decided and the continuous air monitoring manual provides measurement device specifications and their maintenance, constant monitoring system and the processing method of measured values.

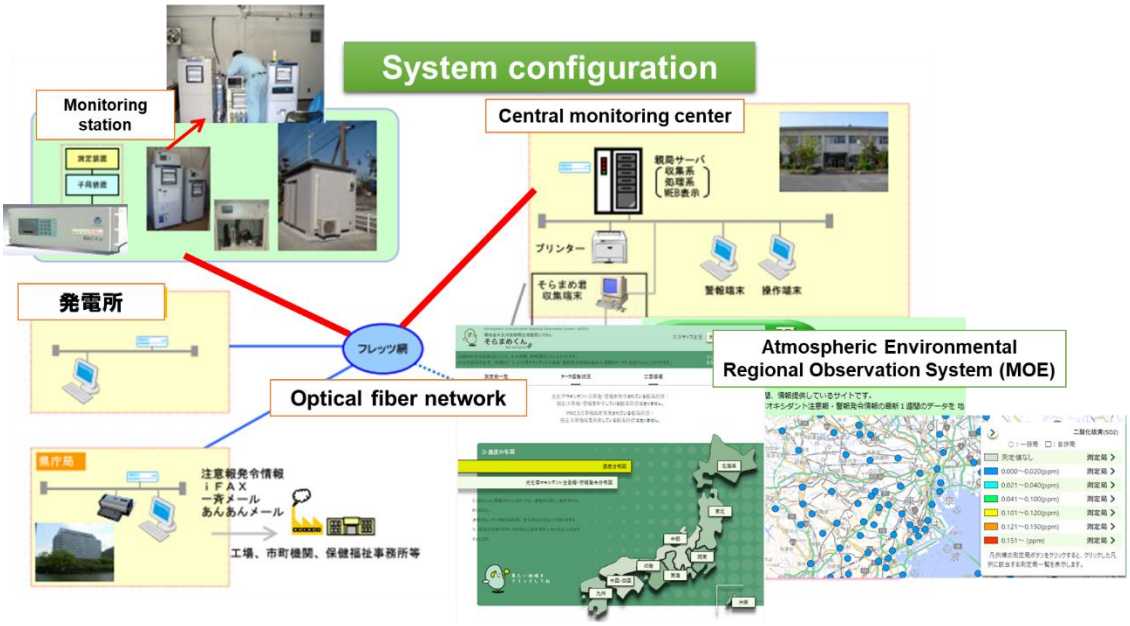


Source: Green Blue Corporation

Figure 4-14 Continuous air monitoring System in Japan

（3） Air Monitoring Method

In Japan, automatic measuring device to measure such air pollutants as NOX, SO_2 and PM2.5 are installed at approx. 1,800 monitoring stations. Data collected by the measuring device is sent to the central environment center of each local government via the optic network to be checked and compiled into records and graphs. The data is also sent to the Ministry of Environment and air pollution information across the country is disclosed all together on the website.



Source: Green Blue Corporation

Figure 4-15 Structure of Continuous Air Monitoring System

4.3.2 Air Quality Monitoring in Kawasaki City

（1） Air Quality Monitoring Method

Kawasaki City monitors air pollution constantly at nine general air monitoring stations and nine vehicular exhaust gas monitoring stations.

・General air monitoring station: installed to constantly monitor air pollution in residential areas

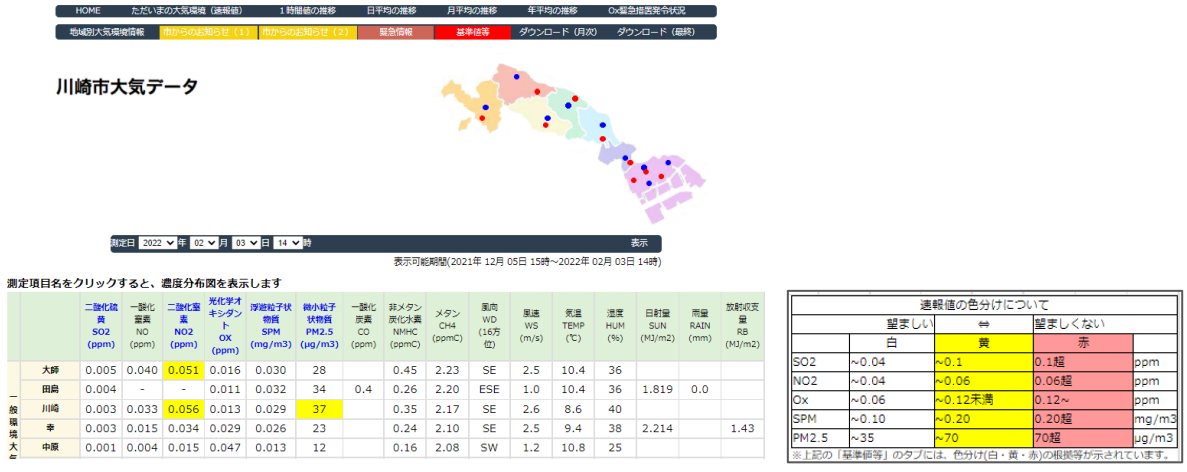
and other ordinary living space by prefectural governors, etc., based on the Air Pollution Control Act. Such substances as sulfur dioxide, nitrogen dioxide, photochemical oxidant, carbon monoxide, suspended particulate matters, and non-methane hydrocarbon are measured.

・Vehicular exhaust gas monitoring station: installed along roads to constantly monitor air pollution by prefectural governors, etc., based on the Air Pollution Control Act. Such substances as sulfur dioxide, nitrogen dioxide, photochemical oxidant, carbon monoxide, suspended particulate matters, and non-methane hydrocarbon are measured.

Source: Website of Kawasaki City (https://www.city.kawasaki.jp/300/page/0000032422.html)

Figure 4-16　A Monitoring Station and Road Next to A Monitoring Station

The measurement result is provided in real time with tables and graphs on the Kawasaki City website. The real-time data is shown in different colors in comparison with standard values for easy understanding of air quality.



Source: Website of Kawasaki City (http://sc.city.kawasaki.jp/taiki/LATEST/HT2022012708.html)

Figure 4-17　An Example of Disclosed Air Quality Data in Kawasaki City

（2） History

Air quality monitoring and other measures by Kawasaki City have been conducted ahead of the national government with the history of its efforts to tackle pollution. The waterfront area of Kawasaki developed with land reclamation projects that were conducted to build an industrial zone and it assisted rapid economic growth of Japan in the 1960s and 1970s. However, smoke emitted

from the plants, etc., caused rapid environmental deterioration, resulting in serious air and water pollution. To tackle the pollution problem, Kawasaki City concluded an air pollution prevention agreement with 39 waterfront plants to enhance measures to control the sources, established a pollution prevention ordinance that regulates total emissions ahead of the national government to require plants to take strict measures, and established a pollution monitoring center and a pollution research center to tackle the problem in collaboration with citizens and businesses.

Table 4-9 History of Major Efforts to Tackle Air Pollution in Kawasaki City

Year	Main Events
1960	Kawasaki City Pollution Prevention Ordinance (former ordinance) announced and enforced
1964	Measurement of sulfur dioxide with automatic measuring device begun
1968	Constant monitoring system of sulfur dioxide, etc., with intensive air pollution monitoring device established
1969	Regulations concerning relief measures for health damage caused by air pollution established and enforced and relief for affected people begun
1970	An air pollution prevention agreement concluded with 39 plants in the city and measures to control the sources enhanced
1972	Kawasaki City Pollution Prevention Ordinance announced, total emissions regulations introduced and pollution monitoring center completed Automatic sulfur dioxide monitoring device at the source completed (42 major plants in the city) Pollution monitoring council established
1976	An ordinance concerning Kawasaki City environmental impact assessment announced and mechanism to prevent environmental deterioration introduced
1978	Automatic nitrogen oxide monitoring device at the source completed (32 major plants in the city)
1979	Environmental standards for sulfur dioxide concentration achieved across the city
1999	An ordinance concerning pollution prevention and living environment protection established and announced
2010	Ecological transportation system launched
2013	Environmental standards for nitrogen dioxide achieved across the city

Source: Website of Kawasaki City (https://eri-kawasaki.jp/publication/torikumi-1/)

4.4 Proposed Efforts in Year Two of the Project

In the first year of the Project, the Survey Team found out the current situation of Bandung City and summarized efforts in Japan and Kawasaki concerning traffic congestion reduction measures and summarized air monitoring methods to improve air quality in Japan. In the second year, we work toward recommending specific measures based on the needs in Bandung.

（1） Congestion Reduction Measures

As traffic congestion can be eased in different ways, we will decide the main target with the Bandung future plan as a reference and conduct in-depth survey of possible technologies to be introduced and basic survey for the introduction.

Specifically, we consider provision of road information, promotion of ecological driving and introduction of measures to promote use of public transportation which we sorted out as example congestion reduction measures in Japan.

Table 4-10 Proposed Efforts in Year Two

Item	Proposed Measures	Description
Provision of road information	Collection of such data as traffic volume, speed and other road traffic conditions using CCTV image analysis with AI technology and creation of information provision base	Confirmation of local road traffic information provision and data collection method Gathering of information on traffic information data collection device
Ecological driving	Having logistics service operators install dashboard cameras to examine the effects of ecological driving	Gathering of information on the device to be installed Selection of logistics service operators that own a large number of vehicles
Promotion of use of public transportation	Provision of locations of angkot, etc., to improve convenience of public transportation to promote shift from motor traffic	Gathering of information on operation of existing means of public transportation of angkot and damri

（2） Air Quality Monitoring

In Bandung City, with rapid industrialization, increases in automobiles and motorcycles in line with petroleum consumption increase and economic growth have led to serious air pollution and there are growing concerns about its impacts on human health. Against the backdrop, it is of great importance to develop a system to monitor air quality and gather and manage the data. To propose a proper air quality monitoring system, it is necessary to correctly understand how it is monitored there.

In the first workshop session, Bandung city employees in charge of GHG emissions reported that air quality monitoring (SO2 and NO2) was conducted using the passive method (Refer to Table 4-11) in 2020 in four zones of an industrial zone, a residential area, a roadside and a commercial district in the city.

However, the measurement method and accuracy are yet to be confirmed and thus, in the second year, we plan to find out the actual status of air quality monitoring. Items to be surveyed include the target of measurement, locations, monitoring method, accuracy management, data processing, reporting structure, whether data is disclosed or not and the results are utilized or not, engineers and budgets.

Based on the results, we will propose a monitoring plan using Japanese examples. In making the monitoring plan, we will study the monitoring method in view of its future introduction and based on training and securing maintenance engineers and securing system maintenance cost. We will also identify where traffic congestion occurs and measure CO_2 emissions in view of improvement of traffic flow to reduce GHG emissions.

Although it depends on COVID-19 infections and Bandung City’s cooperation scheme, if possible, we plan to visit the city to find out pollutant concentration on major roads using sensor-mounted vehicles and examine the optimal monitoring locations. Based on the result, in the third year, as more accurate monitoring, we will be able to study the fixed-position observation and mobile sensing as well as vertical observation with drones.

The plan for the second and third years (FY2022 and FY2023) is summarized in Figure 4-18.

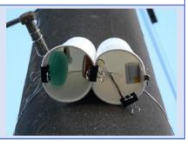
Table 4-11 2020 KPI Data

	Stage I SO2 (µg/m3)	Stage I NO2 (µg/m3)	Stage II SO2 (µg/m3)	Stage II NO2 (µg/m3)	KPI	Note
Residentiala rea	12,00	16,00	8,00	14,00	78,21	Good
Roadside	18,00	10,00	7,00	16,00		
Industrial zone	11,00	14,00	11,00	18,00		
Commercial district	16,00	15,00	14,00	18,00		

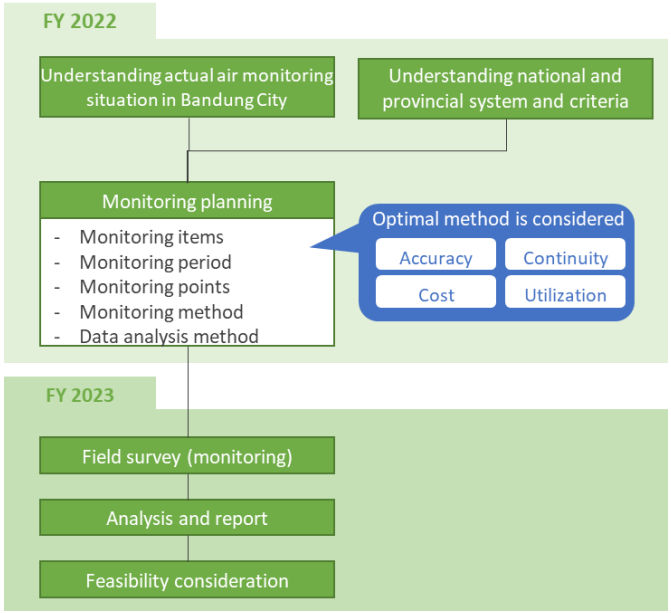
※Residential area: Platista residence, roadside: Dago Terminal, industrial zone: PT Nikatsu, commercial district: DPRD office

Source: INVENTARISASI GAS RUMAH KACA (GRK) KOTA BANDUNG (Presentation material of Bandung City at 1st workshop)

Table 4-12 Main Air monitoring Methods

	Automatic monitoring equipment	Sensor	Active sampler	Passive sampler
Continuous / batch	Continuous	Continuous	Batch collection + analysis	Batch collection + analysis
Point/space	Large Station building	Small	Large Station building	Small
Cost	High	Low	High	Low
Item	Environmental standard items	Environmental standard items	Environmental standard items	Environmental standard items
Image				

Source: Green Blue Corporation



Source: Survey Team

Figure 4-18 Study Flow for Monitoring Survey

Chapter 5　Institutional Development Support (To Promote Green Buildings)

This chapter outlines the green building policies of the Government of Indonesia and the Municipal Government of Bandung to promote low-carbon housing and building initiatives and presents pioneering initiatives and programs implemented by the Kawasaki City Government. It is aimed to contribute to the promotion of environmentally friendly buildings and the effective operation of relevant systems in Bandung with focus on the challenges recognized by the Municipal Government of Bandung and its interest in the initiatives and programs of the Kawasaki City Government as confirmed at the four workshops described below in Chapter 6.

5.1　Green Building Initiatives in Japan and Kawasaki City

5.1.1 Green Building Policies and Initiatives in Japan

In Japan, a significant increase of 66% in CO2 emissions from the commercial sector (e.g. office and commercial buildings) from FY1990 to FY2016, a tight power supply due to the Great East Japan Earthquake, and energy price fluctuations due to changes in international circumstances have raised awareness of the need to achieve energy self-sufficient buildings. Against this backdrop, the Plan for Global Warming Countermeasures (Cabinet Decision in May 2016) set a target of reducing CO_2 emissions from the commercial sector by 40% (from the FY2013 level) by FY2030 and proposed specific measures, including net zero energy building (ZEB) initiatives to achieve net zero energy in new public buildings by 2020 and in all new buildings on average by 2030. In addition, the Long-term Strategy under the Paris Agreement (Cabinet Decision in June 2019), adopted in response to the COP 21 agreement, proposed housing and building policies, including promoting energy conservation, solar power generation, and the use of building energy management systems (BEMS). Then, the latest 6th Basic Energy Plan (Cabinet Decision in October 2021), formulated in response to the Government's commitment in the 2050 Carbon Neutral Declaration (published in October 2020) and its Nationally Determined Contributions (NDC) under the Paris Agreement to reduce greenhouse gas (GHG) emissions by 46% (from the 2013 levels) by 2030, set a revised target of achieving energy efficiency that meets the ZEH/ZEB standards across the housing and building stock on average by 2050 through the energy-efficient retrofit of existing homes and buildings and the installation of energy saving systems. Thus, the Government of Japan recognizes the need to take systematic measures taking into account the lifespan and regular updates of buildings and provides a wide range of support, including supporting technology development, promoting ZEBs and ZEHs, and facilitating green finance.

(1) Act on Improvement of Energy Consumption Performance of Buildings

The Act on Improvement of Energy Consumption Performance of Buildings (hereinafter the "Building Energy Conservation Act"), fully enacted in April 2017, provides for incentives to encourage building developers and other stakeholders to improve energy efficiency on their own initiative as well as housing and building regulations according to their sizes and other attributes in order to improve the energy consumption performance of housing and buildings. The incentives include the energy consumption performance improvement plan certification system with floor-area

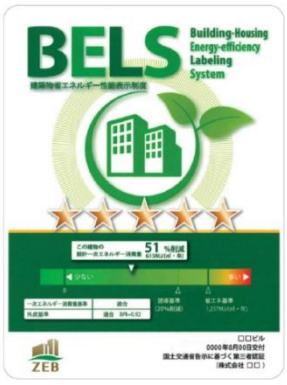
ratio exceptions and the Building-Housing Energy-Efficiency Labeling System (BELS), while the regulations include the requirement for buildings with a total floor area of 2,000m^2 or greater to satisfy the building energy consumption performance standards and the notification of energy saving measures for new homes and buildings with a total floor area of 300m2 or greater as specified in the Act on Rationalizing Energy Use, and the Housing Top Runner Program for new detached houses built by housing developers.

(2) Building-Housing Energy-Efficiency Labeling System (BELS)

The Building-Housing Energy-Efficiency Labeling System (BELS), started in 2014, is used by sellers and lessors of buildings to label their buildings with energy-efficiency ratings as required in Article 7 of the Building Energy Conservation Act mentioned above. In fact, the BELS has been approved as one of the third-party certification systems for the labeling, according to the Guidelines on Building Energy-Efficiency Labeling published by the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) in its official notice (MLIT Notice No. 489 of 2016), which allows sellers and lessors to use either self-assessment or third party ratings for the energy-efficiency labeling. The BELS uses the Building Energy Index (BEI), which represents the ratio of design primary energy consumption to standard primary energy consumption, to assess the design energy efficiency of HVAC, lighting, and hot water supply systems and lifts installed in buildings. The BEI is estimated by dividing design primary energy consumption of an actual new building by its standard primary energy consumption calculated based on its location, purpose, and conditions of use. New homes and buildings with a BEI of 1.0 or lower are certified to conform to the primary energy consumption standards. This means that buildings whose design primary energy consumption is less than their standard primary energy consumption are certified to conform to the energy efficiency requirements. The ratings are represented by stars on a scale of one to five in ascending order. As of July 2020, 1,475 non-housing buildings, 113,613 housing buildings, and 11 complex buildings have been certified under the BELS.

Table 5-1 BELS Rating Standards and Label

Number of stars	Housing Building	Non-housing Building I (Office buildings., schools, factories, etc.)	Non-housing Building II (Hotels, hospitals, department stores, restaurants, assembly halls, etc.)
☆☆☆☆☆	0.8	0.6	0.7
☆☆☆☆	0.85	0.7	0.75
☆☆☆ Standard threshold	0.9	0.8	0.8
☆☆ Energy efficiency threshold	1.0	1.0	1.0
☆ Energy efficiency threshold for existing buildings	1.1	1.1	1.1



Source: Compiled by the Study Team based on the ZEB Portal (Ministry of the Environment)

(3) Comprehensive Assessment System for Built Environment Efficiency (CASBEE)

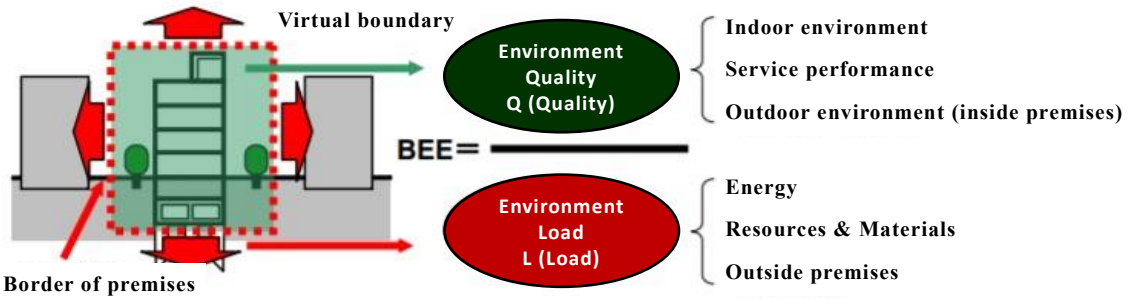
The Comprehensive Assessment System for Built Environment Efficiency (CASBEE) is a rating and ranking system to assess the environment efficiency of buildings. This is a comprehensive assessment of building quality, including not only environmental considerations, such as energy conservation and the use of environmentally friendly materials, but also interior comfort and scenic beauty. In order to ensure an objective assessment of various ecological aspects of buildings, the CASBEE follows the following three principles:

(i) The assessment covers the entire lifecycle of the building;

(ii) Both the Built Environment Quality (Q) and the Built Environment Load (L) are assessed;

(iii) The Built Environment Efficiency (BEE), developed based on the concept of environment efficiency, is used as an assessment indicator.

The BEE is estimated by dividing the building into two parts, inside and outside, by a virtual boundary based on the border of the premises and assessing the environmental measures against environmental indicators related to the Built Environment Quality (Q) inside the premises and the Built Environment Load (L) outside the premises. Buildings of higher Built Environment Quality (Q) with a lower Built Environment Load (L) receive higher BEE ratings. The ratings are on a five-point scale of S, A, B+, B-, and C in descending order. The assessment is conducted using the evaluation software published by Japan Sustainable Building Consortium (JSBC). As of June 2020, 1,071 buildings have been assessed under the CASBEE.



Source: Built Environment Efficiency Plan Development Manual, Kawasaki City Government, 2017

Figure 5-1 Concept of Built Environment Efficiency (BEE)

(4) Subsidy and Support Programs

Japan has various subsidy and support programs to promote green buildings and energy-efficient retrofitting. The Demonstration Project on Innovative Energy-Efficient Buildings toward the Realization of Net Zero Energy Buildings provides support for public buildings owned by local governments and office and commercial buildings owned by small- and medium-scale businesses by promoting the installation of energy-saving equipment and systems that can contribute to the realization of ZEBs. The support is provided to cover costs incurred for the installation of HVAC, lighting, hot water supply, and building energy management systems on the condition that it can reduce energy consumption by 50% or greater. The Project for Promoting Energy Conservation in the Building Stock also supports energy-efficient retrofitting and accessibility modification projects on the condition that it includes the energy-efficient retrofitting of building exteriors and is

expected to reduce energy consumption by more than 20%. This is characterized by providing financial assistance not only for retrofitting but also for energy consumption measurement and energy-efficiency labeling. Meanwhile, the CO2 Reduction Potential Diagnostic Project sends diagnostic engineers to office and commercial buildings to propose specific CO2 emissions reduction measures based on installed facilities and systems and their operating conditions and energy consumption. These subsidy and support programs are used to promote the efforts of local governments and business entities, while the national government is taking the initiative in energy efficiency improvements in public buildings.

5.1.2 Efforts of the Kawasaki City Government to Promote Green Buildings

(1) Environmental Policies of the Kawasaki City Government

The Kawasaki City Government uses the Kawasaki City Basic Environmental Plan (adopted in February 1994 and revised in February 2021) as its basic environmental policy and translates it into specific programs and projects. The Kawasaki City Global Warming Countermeasures Promotion Plan (adopted in October 2010 and revised in March 2018) refers to a long-term national target of reducing CO2 and other emissions by 80% by FY2050 as a long-term target for the city and sets a target of reducing GHG emissions by more than 30% from the FY1990 levels by the end of the plan period in FY2030. The Kawasaki Carbon Zero Challenge 2050 (adopted in 2020) proposes basic policies and pioneering initiatives to achieve net carbon zero by 2050. The proposed initiatives to create a carbon-free society by 2050 include achieving net zero energy in homes and buildings (ZHHs and ZEBs) and promoting the use of renewable energy sources. The pioneering initiatives toward 2030 include developing carbon neutral model zones to focus efforts toward achieving carbon neutrality so that residents can actually see their effects and benefits and embrace an environmentally friendly lifestyle that can promote low-carbon technologies.

In 2006, the Kawasaki City Government issued Kawasaki Green Promotion Bonds, which were the first mini green bonds publicly offered in Japan and effectively stimulated the issuance of other green bonds. The raised funds were used for the Green Building Project to reconstruct the city hall and other buildings. The new city hall building received the highest rating of “S” in the CASBEE Kawasaki mentioned below. These initiatives of the Kawasaki City Government have involved various stakeholders, including residents, and paved the way for other local governments and private companies to invest in environmental, social, and governance (ESG) funds.

Green Building/Energy Efficiency

City Hall Reconstruction Project

- **Installing eco-friendly multi-layered walls (energy efficient exterior walls) and a co-generation system (an energy-efficient system that uses waste heat from power generation to supply heat)**
- **Using as much timber as possible for construction**
- **Likely to be rated S under the CASBEE**

Energy Efficiency

Environmentally Friendly Technology Application Project

- **Replacing lighting with LED lights in municipal buildings**

Visualization of New Kawasaki City Hall Building
(Left: Entire view of the building; Right: Cross-section of the structure)

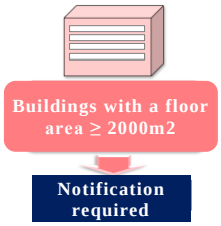
Source: Issuance of Kawasaki Green Bonds, Kawasaki City Government, 2021

Figure 5-2 City Hall Reconstruction Project Funded with Kawasaki Green Bonds

(2) Outline of the CASBEE Kawasaki

In accordance with its basic policy to create an environmentally friendly recycling-based community, the Kawasaki City Government started to apply the CASBEE Kawasaki to buildings within the city in October 2006 to encourage building developers to take environmental measures in their building construction projects and reduce their carbon and other environmental footprints in order to promote sustainable buildings. The CASBEE Kawasaki principally uses the same assessment indicators as for the above-mentioned CASBEE but modifies some of them according to the environmental standards that reflect the city's characteristics and relevant municipal ordinances. The CASBEE Kawasaki requires notification for buildings with a floor area of 2,000 m^2 and greater, which are classified as specified buildings, while the others are classified as non-specified buildings (See Table 5-2 below). Once the notification is submitted, building sellers can provide information on their environment efficiency through advertisements for sale using the Condominium Environment Efficiency Labeling. In addition, the CASBEE Detached Housing was launched in April 2015.

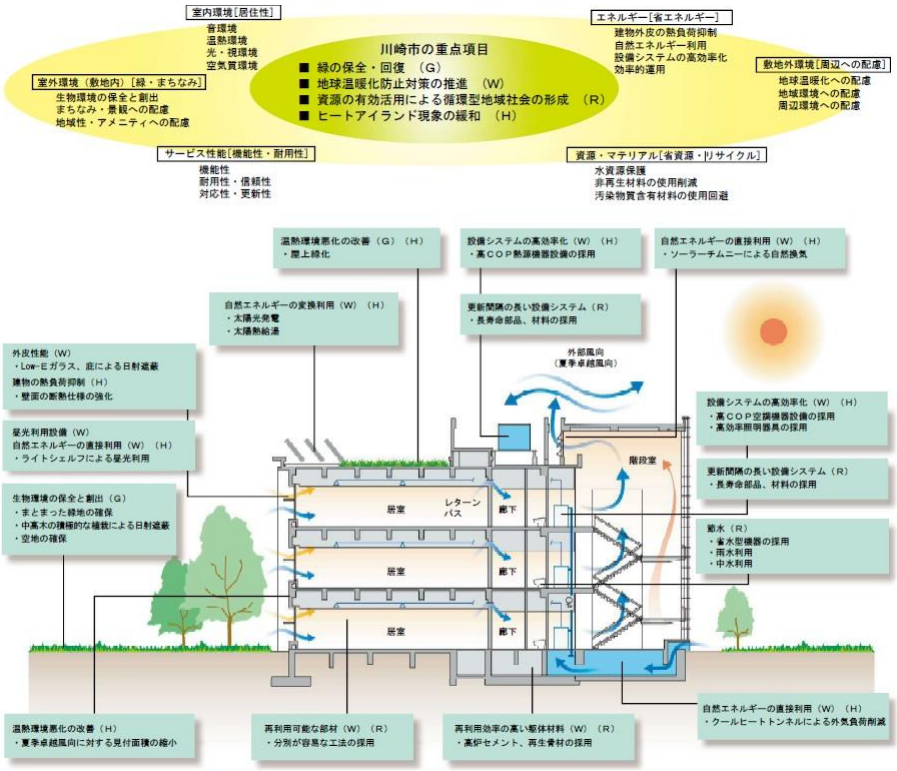
Table 5-2 Buildings Subject to Notification Requirements and Condominium Environment Efficiency Labeling

Specified Bldgs.	Assessment and notification are required under the CASBEE Kawasaki.
	Developers of buildings (except for detached and row houses) with a total floor area of 2,000m2 or greater (an extended/renovated floor area of 2,000m2 or greater for extended and renovated buildings) are required to submit a Built Environment Efficiency Plan for Specified Building to present their environmental measures.
Unspecified Bldgs.	Assessment and notification are not required under the CASBEE Kawasaki (optional).
	Developers of buildings (except for detached and row houses) with a total floor area of less than 2,000m^2 (an extended/renovated floor area of less than 2,000m2 for extended and renovated buildings) can submit a Built Environment Efficiency Plan for Unspecified Building to present their environmental measures (Not required but encouraged to do it).
Condominium Environment Efficiency Labeling:	
	• Sellers of condominiums notified as a specified or unspecified building can provide information on their environment efficiency to potential buyers. • This labeling represents the results of voluntary environmental measures taken by the building developer and does not mean that the condominium is certified by the Kawasaki City Government.
Detached Housing:	Assessment and notification are not required under the CASBEE Detached Housing (optional).
	• The CASBEE Detached Housing allows building developers to submit an assessment report (Built Environment Efficiency Plan) of the detached house to be constructed to the Kawasaki City Government, which validates and publishes the notification. • Buildings are assessed using the CASBEE developed by the Institute for Building Environment and Energy Conservation for detached houses and ranked (starred) on a scale of one to five. The ratings can be labeled using the Detached House Environment Efficiency Labeling.

Source: Presentation material of Kawasaki City at 2nd workshop

(3) Environmental Indicators and Assessments under the CASBEE Kawasaki

The CASBEE Kawasaki sets a number of environmental indicators to comprehensively assess the environment efficiency of buildings. They are grouped into four categories that reflect the priority areas in the building sector selected based on the characteristics of the city (See Figure 5-3 below). For example, the assessment in terms of creating a recycling-based community with effective use of resources typically focuses on the use of recycled materials for framework construction, the exclusion of construction materials containing harmful substances, or the durability of parts and components (which is a key factor for keeping the building in better condition for a longer period of time).



Source: CASBEE Kawasaki Leaflet

Figure 5-3 Environmental Indicators for the CASBEE Kawasaki

The assessment is conducted using the evaluation software published by the Kawasaki City Government. The assessment results including BEE are described in the Assessment Sheet, Priority Area Sheet, and Score Sheet. The CASBEE Kawasaki evaluation software and the Built Environment Efficiency Plan Development Manual are available on the website of the Kawasaki City Government. In addition, the CASBEE Kawasaki's notification information and assessment sheets are also open to the public, raising environmental awareness among residents and companies. The number of notifications made between the launch of the system in 2006 and September in 2021 reached 940.

(4) Subsidies and Preferential Interest Rates Associated with the CASBEE Kawasaki

The CASBEE Kawasaki is intended to encourage building developers to take environmental measures on their own initiative. The labeling and publication of environment efficiency of buildings enable residents and consumers to compare buildings and raise their environmental awareness. From the perspective of developers, the BEE is one of the important indicators because apart from prices, floor plans, and locations, environment efficiency can directly increase the value of real estate when associated with the company’s CSR advertisements or marketing strategies. If it is properly appreciated by customers, environment efficiency can further lead to technology and market development. However, despite its environmental and economic advantages (e.g. utility cost reductions), the CASBEE Kawasaki has not been embraced due to its high capital investment costs. Therefore, various subsidy programs and preferential interest rates have been introduced in a harmonious way with the system.

■ Residents
- Obtain information on buildings within the city
- Compare/purchase housing based on their environment efficiency and eco-friendliness

■ Building developers
- Use the ratings as the basis for environment efficiency target setting and specific environmental measures
- Publicize the ratings as an example of the company's CSR activities
- Use highly rated environment efficiency for strategic marketing

■ Kawasaki City Government
- Promote sustainable buildings
- Set targets for environment efficiency in public buildings
- Credit the ratings as a requirement for permits as specified in the Building Standards Act
- Credit the ratings as a requirement for subsidies for energy creation systems, etc.

■ Financial institutions
- Offer housing loans with preferential interest rates determined according to the environment efficiency ratings
- Credit the ratings as a requirement for environmentally friendly investment funds (for the future)

Source: Presentation material of Kawasaki City at 2nd workshop

Figure 5-4 Use of the CASBEE Kawasaki by Stakeholder Category

Table 5-3 Subsidy Programs and Preferential Interest Rates Associated with the CASBEE Kawasaki

Program	Condition/Example
Smart House Subsidy Program (for detached houses and condominiums' common facilities, etc.): Support program for introduction of household energy creation, saving, and storage systems This program provides subsidies for installation of energy saving systems, etc. These subsidies are used not for a piece of equipment but for a system consisting of multiple devices (For example, when a lithium-ion battery system is installed and connected to a solar power generation system that has been already installed, subsidies will be provided only to cover the cost of installing the battery system).	• Household energy management system (HEMS): 10,000 yen • Solar power generation system: 20,000 yen/kW (up to 100,000 yen in total) • Household fuel cell system (ENE-FARM): 30,000 yen • Stationary lithium-ion battery system: 10,000 yen/kWh (up to 100,000 yen in total) • CASBEE subsidies: 50,000 yen (Providing an additional subsidy for HEMS, solar power generation systems, etc. upon application from residents of houses rated A or higher under the CASBEE Detached Housing)
Housing loans with preferential interest rates	This program was launched in 2006 to offer housing loans with preferential interest rates for houses (condominiums and detached houses) rated four stars or more under the CASBEE Kawasaki (Sumitomo Mitsui Trust Bank, the Bank of Yokohama, and the Yokohama Shinkin Bank).

Source: Website of Kawasaki City

5.2 Green Building Initiatives in Indonesia and Bandung

5.2.1 Green Building Policies and Initiatives in Indonesia

The National Master Plan for *Energy* Conservation (RIKEN) sets a target of a 15% reduction in energy consumption in the commercial sector by 2025 and proposes two specific actions to that end, as described in the table below: an energy management structure for large commercial buildings and building energy efficiency standards. As for the energy management structure for large commercial buildings, it is now suggested that its scope of applicability should be extended to include a wider range of business entities because 98% of commercial buildings in the country have a floor area of less than 30,000 m^2. Meanwhile, the national energy efficiency standards are not compulsory and only recommended as guidance to building developers.

Indonesia's first green building regulation was developed and adopted in Jakarta Special Province in 2012 and enforced in 2013. This regulation was incorporated into the National Green Building Guidelines issued by the Ministry of Public Works and Housing (MPWH) in 2015. These guidelines were intended to serve as a framework for green building standards respectively set out in big cities in Indonesia. As mentioned below, the Municipal Government of Bandung also used these national guidelines as a basis for Bandung Mayor Regulation No. 1023/2016 on green building standards issued in 2016.

Moreover, Indonesia has a certification scheme called "Greenship" Developed by the Green Building Council of Indonesia (GBCI), which was established in 2009 as a member of the World Green Building Council, this scheme has its own criteria and methodology to assess buildings on a four-point scale.

However, despite these policies and initiatives, Indonesia's green building sector faces challenges due to the lack of knowledge of energy saving practices among building developers and the low recognition of green buildings. In addition, Indonesia Clean Energy Outlook 2019, published by the Institute for Essential Service Reform (IESR), states that green buildings have not been widely deployed because their economic values are not properly appreciated due to their high capital investment costs and the underdeveloped financing environment in the country.

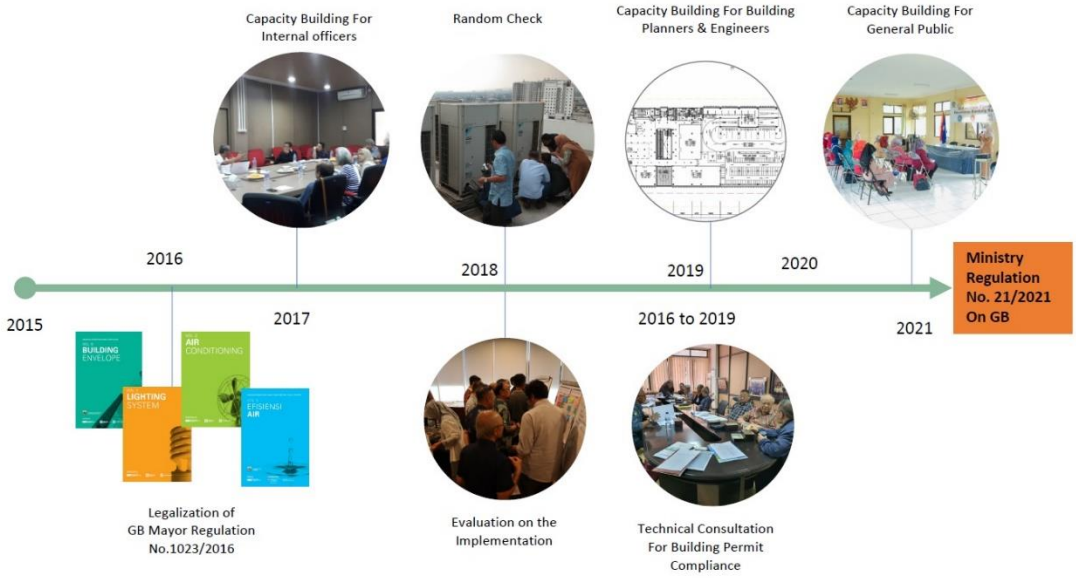
Table 5-4 Green Building Policies in Indonesia

Policies and Initiatives	Targets, etc.
National Energy Policy: Government Regulation No. 79/2014 National Master Plan for Energy Conservation (RIKEN) 100.K/48/M.PE/1995 (revised in 2014)	• Reducing total final energy consumption (TFEC) by 15% in the commercial sector, 15% in the household sector, 17% in the industrial sector, and 20% in the transport sector by 2025. • Energy saving initiatives in the commercial sector (1) Energy management structure for large commercial buildings (2) Building energy efficiency standards
Energy Conservation Regulation: Government Regulation No. 70/2009	• Setting forth the energy management structure for large commercial buildings • Requiring buildings and industrial business entities with an annual energy consumption of more than 6,000 tons of oil equivalent (toe) to designate energy managers, implement energy saving programs, conduct energy audits, and report their energy efficiency plans and measures to the government.
National Green Building Guideline: Ministerial Regulation No.02/PRT/M/2015 on National Green Building Guidelines (Ministry of Public Works and Housing)	• Reducing CO2 emissions in the building sector by 2020 • Getting 50% of all state-owned buildings certified as a green building • Establishing the definition and categories of green buildings and defining standards, procedures, and certifications to follow • Dividing green buildings into three categories by their level of obligation to comply with the specified technical standards (Mandatory, Recommended, and Voluntary) according to their type, purpose of use, and height • Requiring local governments to develop their own green building regulations based on these standards
Indonesia National Standard (SNIs)	• Setting out building energy efficiency standards (e.g. design, exterior performance, HAVC, and lighting) and energy audit process standards
Greenship: Certification of Green Building (since 2012)	• Appling to Net Zero Healthy (net zero buildings): new and existing buildings, housing, and interior and exterior environments • Ratings: Platinum, Gold, Silver, and Bronze • The GBCI implements another international green building certification scheme called “EDGE Certification”
Jakarta Green Building Regulation: Governor Decree No.38/2012 on Green Building	
Bandung Green Building Regulation: Bandung Mayor Regulation No.1023/2016 on Green Building	
Semarang Green Building Regulation: Mayor of Semarang City Regulation No.24/2019 on Green Building	
New Green Building Regulation in Bandung: Ministry Regulation No.21/2021	

Source: Study team

5.2.2 Green Building Initiatives in Bandung

With support from International Finance Corporation (IFC), the Municipal Government of Bandung enacted Bandung Mayor Regulation No.1023/2016 on green buildings in 2016. This mayor regulation is in principle consistent with the above-mentioned national guidelines but has a greater scope and higher technical standards than required by the national guidelines. In fact, Bandung's green building standards rank with the country's most advanced standards set by the Provincial Government of Jakarta. The Municipal Government of Bandung leverages national and international support programs to continue capacity development in the green building sector (see Figure 5-5 below) and take specific energy saving measures. In 2019, Bandung Mayor Regulation No.006/2019 was issued to demonstrate innovative energy saving practices in public buildings, such as the municipality-led Eco Office project aimed to reduce paper, water, and electricity consumption and demonstrate biogas-based power generation in three district offices and the regional offices of the Department of Environment and Hygiene and the National Development Planning Agency.



Source: Presentation material of Bandung City at 3rd workshop

Figure 5-5 Green Building Promotion Initiatives in Bandung

Table 5-5 Breen Building Codes of Bandung City

<table>
<tr><td rowspan="2">Parameter</td><td colspan="2">Building types and sizes</td></tr>
<tr><td>New buildings and expansion of existing buildings (floor area more than 5,000 m2)</td><td>New buildings (floor area less than 5,000 m2)</td></tr>
<tr><td colspan="3">Mandatory requirements</td></tr>
<tr><td>Energy efficiency</td><td colspan="2">・Building envelope overall thermal transfer values (OTTV) < 45 W/m2 (only for buildings other than houses)
・Variable speed drive for the secondary loop chilled water pump
・Minimum air-conditioning efficiency standards</td></tr>
<tr><td rowspan="3">Water efficiency</td><td>Lighting system (natural and artificial) with photoelectric or motion sensor; lighting power density standard for artificial lighting</td><td>Window-to-wall ratio > 15% and lighting system with efficient lighting (light-emitting diode (LED) bulbs, compact fluorescent lamps [CFL], T5 fluorescent, and luminous efficacy > 75 lumen/W]</td></tr>
<tr><td colspan="2">・Infiltration pond and infiltration well
・Water-efficient sanitary equipment with maximum standards except for individual houses (only need to use dual-flush water closet)</td></tr>
<tr><td>・Rainwater harvesting with water treatment plant
・Wastewater(grey water)treatment recycling system
・Wastewater piping and treatment plant</td><td></td></tr>
<tr><td>Indoor air quality management</td><td>・Window opening area of at least 5% of the building area
・Mechanical ventilation system with a CO2 sensor with alarm (< 1,000 parts per million [ppm])
・Carbon monoxide (CO) sensor with alarm (< 35 ppm)
・Room density > 25 people/100 m2</td><td>Mechanical ventilation system, except for housing</td></tr>
<tr><td>Site management</td><td colspan="2">・On-land green open area (lawn); off-land green open area (green roof or vertical garden) covering < 25% of the total building on-land green area
・Pedestrian area
・Bicycle parking: one for every 25 car parking spaces
・Solid waste management system for housing (at least a system that separates organic and inorganic wastes)</td></tr>
<tr><td>Building management system</td><td>For buildings with an area of > 10,000 m2
・Monitoring and control system for energy and water consumption</td><td>N/A</td></tr>
<tr><td colspan="3">Voluntary codes</td></tr>
<tr><td>2-star rating</td><td colspan="2">10% more than minimum requirements, OTTV 35 W/m2, coefficient of performance</td></tr>
<tr><td>3-star rating</td><td colspan="2">30% more than minimum requirements, OTTV 30 W/m2, COP for full load AC system</td></tr>
<tr><td>Others</td><td colspan="2">Existing buildings are required to report their electricity usage, water consumption, and waste disposal</td></tr>
</table>

Source: Using the climate auction model to promote energy-efficient buildings in Indonesia, World Bank

In 2021, Ministry Regulation No.21/2021 was issued to enact a new ministerial regulation on green buildings. This regulation in principle reflects Bandung Mayor Regulation No. 1023/2016 but follows Government Regulation No. 16/2021 on building permits. The differences between

Ministry Regulation No.21/2021 and Bandung Mayor Regulation No. 1023/2016 are summarized in Table 5-6 below. One of the differences is that the new ministerial regulation has been extended in scope to cover not only new buildings but also existing buildings including inherited buildings. Another difference is that the new assessment covers the entire lifecycle of buildings from planning/designing to demolition. In addition, the new regulation has introduced the Information Management System for Building (SIMBG) to deliver online document and data management.

Table 5-6 Comparison of 2016 Mayoral Regulation and 2021 Ministry Regulation on Green Building

	MAYOR REGULATION No.1023/2016	MINISTRY REGULATION No.21/2021
Coverage	・Applicable for new building only ・Mandatory for all type of building	・Applicable for new building, existed building (inc. heritage) ・Mandatory only for building with area >5000 m2
Implementation	Specification Check on building permit drawing	Specification check ・prior to building permit legalization ・during the construction ・prior to the operationalization ・during the demolishing of building
Document Submission	Manual/conservative	Online submission through SIMBG web
Emphasizing	―	・Land Management ・Energy Efficiency ・Water Consumption ・Indoor air quality ・Sustainable building material ・Waste management

Source: Presentation material of Bandung City at 3rd workshop

5.3 Green Building Promotion Challenges and Actions for Coming Years

(1) Extraction and proposal of technologies that contribute to green building

By organizing information on buildings that have obtained green building certification in Bandung, specifications and technologies to be introduced that meet the actual conditions in Bandung will be identified, and technical proposals from Japan will be considered. For example, green building in Indonesia is promoting efforts for the building envelope, and measures to prevent global warming are being taken with green wall surfaces, as shown in Figure 5-6 on the next page. The "Regional Action Plan for Coping with Climate Change Impacts in Bandung (RAD-PI: Rencana Aksi Daerah Penanganan dampak Perubahan Iklim di Kota Bandung)" also includes the "Application of the Eco-building Concept to Office Buildings The "The World's Most Beautiful City" is a good example of the kind of work that is being done.

Specific initiatives could be proposed with reference to the following distinctive efforts at Carutz Kawasaki, a sports and public facility complex that received an S-rank from CASBEE Kawasaki, which was introduced at the 3rd Workshop. It is also possible to utilize technologies possessed by member companies of the Kawasaki GIC, a platform for environmental technologies centered in

Kawasaki City, as described below.

- Adoption of exterior materials with high heat insulation performance
- Water-saving measures such as water-saving toilet bowls and rainwater harvesting
- Rooftop greening
- Contribute to the community by installing galleries and tree-lined avenues
- Solar power generation and solar heat utilization

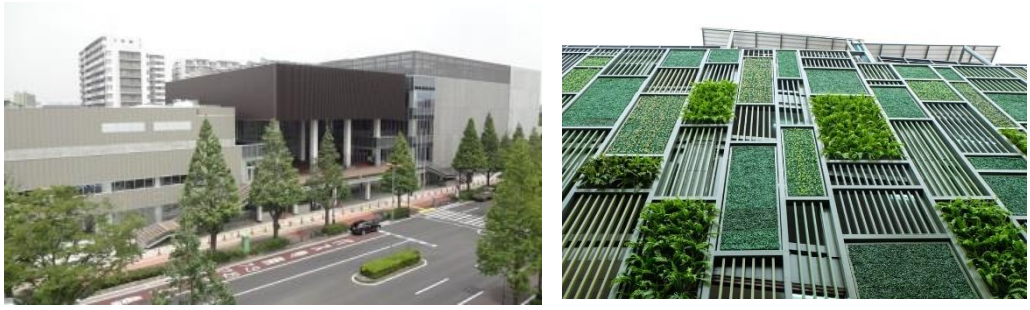


Figure 5-6 Culttz Kawasaki (left) and green building in Indonesia

(2) Proposal to introduce BEMS

By introducing a BEMS (Building Energy Management System), we aim to measure and visualize energy consumption and continuously reduce energy consumption by controlling air conditioning and lighting equipment, etc. Since it is effective to set up a specific model case to understand the effects of the project, we propose the possibility of converting the entire facility into a green building, assuming the replacement of lighting with LED and the introduction of BEMS, in addition to the replacement of air conditioning, for the regional general hospital where the replacement of air conditioning equipment was studied in Chapter 3. The new Administrative Decree No. 21/2021 on Green Building also covers existing buildings, which will also lead to initiatives that are consistent with Bandung City policies. In particular, more than 90% of existing buildings in Indonesia are not suitable for green building standards, renovation and facility renewal targeting existing buildings is expected to be a model project for the future.

On the other hand, for new buildings, the school construction project in Bandung, which was introduced at the workshop, was designed to green building specifications, and although the budget for the project is currently being delayed due to the Corona disaster, it can be considered as a green building initiative for new buildings when the project is resumed.

Promoting BEM as a green building for the entire facility will lead to the incorporation of automatically controlled functions for HVAC, electricity, security, and other equipment, and will promote energy and cost saving intelligence buildings (smart buildings). Especially as the number of new coronavirus cases in Bandung continues to average over 30,000 per day as of February 2022, there will also be high demand for smart building solutions that enable smarter workflows, more efficiently managed facilities, and safer and healthier buildings. Consideration of initiatives linked to the energy-efficient air conditioning upgrades and smart LED proposals discussed in Chapter 3 is also envisioned.

Chapter 6 Online Workshops

As part of this project, a total of four workshops were held online. Relevant organizations from Kawasaki and Bandung shared the policies and initiatives of each city. In addition, with the participation of manufacturers of air conditioning and air quality measurement equipment, technical proposals and installation results in Indonesia were shared. The list of workshops held and the details of each are shown below. The Minutes of the Meeting and the materials used in the presentations are indicated in the Appendix.

Table 6-1 List of Online Workshops

	Date
1st Online Workshop	22 October 2021
2nd Online Workshop	8 December 2021
3rd Online Workshop	20 January 2022
4th Online Workshop	9 February 2022

6.1 1st Online Workshop

(1) Purpose

- To confirm the three-year project implementation policy, plans, and the details of this year's activities and to reach an agreement.
- To understand the latest information on GHG emissions and various measures in Bandung.
- To provide technical information on air quality management.

(2) Outcome

- There was an explanation of the implementation policies for this project, the three-year plan, and the details of this year's activities. It was confirmed that studies will cover the (1) conversion to high-efficiency air conditioning equipment and LED street lights, (2) alleviation of traffic congestion and improvements to air pollution, and (3) promotion of green building.
- The presentation by the city of Bandung provided the latest information on the city's GHG emissions, measures and issues related to green building, the city's promotion of LED street lights, and promotion of public transport use and related future plans.
- The presentation by Green Blue Corp., a member company of the Kawasaki Green Innovation Cluster, introduced an air quality monitoring system using automatic monitors and sensors, and shared knowledge on air quality management with Bandung.

(3) Agenda

Time in Indonesia (Time in Japan)	Contents	Presenter
09:00-09:20 (11:00-11:20)	Opening Remarks by Bandung City Opening Remarks by Kawasaki City	
09:20-10:40 (11:20-12:40)	1.Project implementation policies and plans, and initiatives for the current fiscal year	Oriental Consultants
	2.Announcement of Bandung City 2-1. GHG emissions 2-2. Measures related to green building 2-3. Reducing CO2 emissions through LED street lighting 2-4. Public Transportation Systems for CO2 Reduction	Bandung City
	3.Air Quality Monitoring System	Green Blue Corporation
10:40-10:55 (12:40-12:55)	Question and Answer	
10:55-11:00 (12:55-13:00)	Closing Remarks by Bandung City Closing Remarks by Kawasaki City	

(4) Minutes of the Meeting, presentation materials (Appendix A1-1 to 17)

6.2 2nd Online Workshop

(1) Purpose

- To understand the latest information on measures related to green building in Bandung and air conditioning equipment in facilities under the city's jurisdiction.
- To promote an understanding of the JCM equipment subsidy program.
- To share Kawasaki's policies, initiatives, and expertise for promoting green building.

(2) Outcome

- The latest government ordinances on green building were introduced. The expanded scope of evaluations and the policy to promote online data management going forward were confirmed.
- The benefits of utilizing the JCM equipment subsidy project were recognized for the promotion of energy conservation by switching to high efficiency air conditioning equipment in Bandung.
- The presentation by the city of Kawasaki shared the efforts of CASBEE Kawasaki. The importance of quantitative evaluations and the visualization of the environmental performance of buildings was recognized.

(3) Agenda

Time in Indonesia (Time in Japan)	Contents	Presenter
09:00-09:05 (11:00-11:05)	Opening Remarks by Bandung City	Bandung City
09:05-09:25 (11:05-11:25)	1. Bandung City's Green Building Policy and about the City's Air Conditioning System	Bandung City
09:25-09:45 (11:25-11:45)	2. Introduction of JCM Model Project	Oriental Consultants
09:45-10:10 (11:45-12:10)	Question and Answer	
10:10-10:40 (12:10-12:40)	3. Introduction of CASBEE Kawasaki, an initiative of Kawasaki City to promote green buildings	Kawasaki City
10:40-10:55 (12:40-12:55)	Question and Answer	
10:55-11:00 (12:55-13:00)	Closing Remarks by Kawasaki City	Kawasaki City

(4) Minutes of the Meeting, presentation materials (Appendix A2-1 to 9)

6.3 3rd Online Workshop

(1) Purpose

- To encourage an understanding of high efficiency air conditioning system technology for the promotion of energy conservation by switching to high-efficiency air conditioning equipment in Bandung.
- To review the progress of this year's studies and confirm future implementation policies.

(2) Outcome

- The presentation by Daikin Air Conditioning Indonesia, Ltd. facilitated an understanding of inverter technology and the energy savings it affords, and the potential in Bandung was considered.
- A progress report on studies was made on the (1) conversion to high-efficiency air conditioning equipment, (2) LED street lights, (3) alleviation of traffic congestion and improvements to air pollution, and (4) promotion of green building. A discussion was held on future implementation policies and a request was made to the city of Bandung to provide missing data.

(3) Agenda

Time in Indonesia (Time in Japan)	Contents	Presenter
09:00-09:05 (11:00-11:05)	Opening Remarks by Bandung City	Bandung City
09:05-09:20 (11:05-11:20)	1.Energy-saving air-conditioning systems and examples of their installation	Daikin Air Conditioning Indonesia
09:20-09:35 (11:20-11:35)	Question and Answer	
09:35-09:55 (11:35-11:55)	2.Progress report: High-efficiency air conditioning system Question and Answer	Oriental Consultants
09:55-10:15 (11:55-12:15)	3.Progress report: LED Street Lights Question and Answer	
10:15-10:35 (12:15-12:35)	4. Progress report: Reduce traffic congestion and improve air pollution Question and Answer	
10:35-10:55 (12:35-12:55)	5. Progress report: Green building Question and Answer	
10:55-11:00 (12:55-13:00)	Closing Remarks by Kawasaki City	Kawasaki City

(4) Minutes of the Meeting, presentation materials (Appendix A3-1 to 5)

6.4 4th Online Workshop

(1) Purpose

- To review this year's activities and discuss the policies for next year's initiatives.
- To share case studies, both in Japan and overseas, of air quality monitoring that contributes to the mitigation of air pollution, and to promote an understanding of its necessity and effects.
- To share leasing results and renewal case studies of air conditioning equipment in Indonesia, and to contribute to a study on specific conversion of high efficiency air conditioning equipment in Bandung.

(2) Outcome

- After organizing the activity results of this year, as implementation policies for next year, specific initiatives were confirmed regarding the (1) conversion to high efficiency air conditioning equipment, (2) LED street lights, (3) alleviation of traffic congestion and improvements to air pollution, and (4) specific initiatives to promote green building.
- The presentation by Green Blue Corp. introduced air quality monitoring system using automatic monitors and sensors, and shared its track record in Japan and overseas. The city of Kawasaki shared the expectations and achievements of the government that appropriate monitoring is helpful for air quality management, and the importance of air quality monitoring was recognized in Bandung as well. Additionally, the policies of initiatives related to air quality management in this project next year onward were confirmed.

(3) Agenda

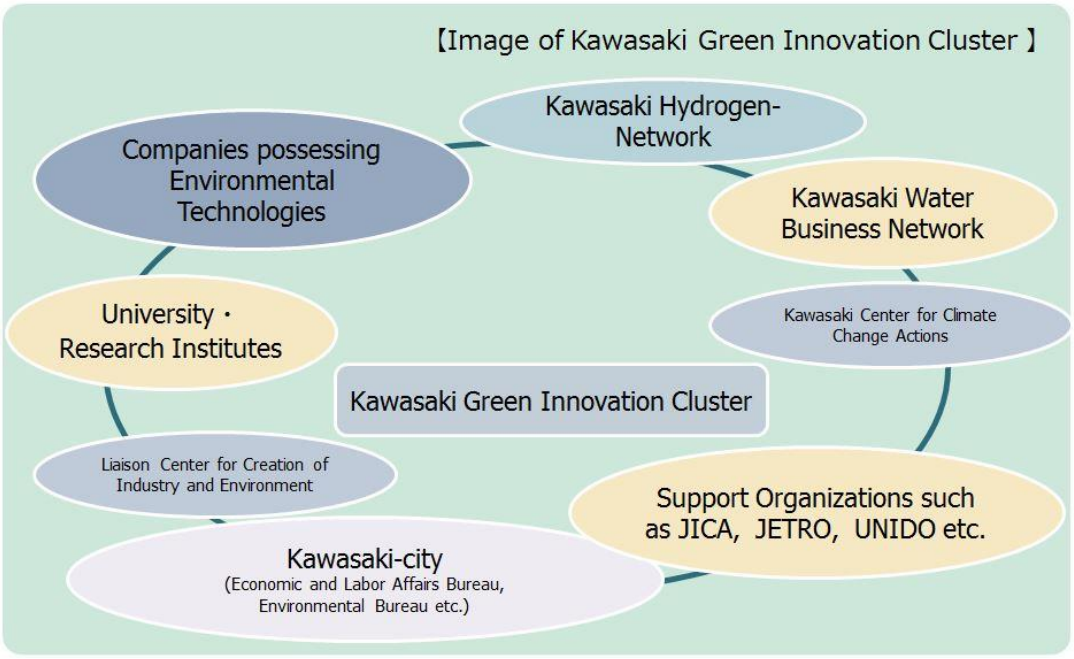
Time in Indonesia (Time in Japan)	Contents	presenter
09:00-09:15 (11:00-11:15)	Opening Remarks by Bandung City	Bandung City
09:15-09:40 (11:15-11:40)	Review of the current year and policy for the next year	Oriental Consultants
09:40-10:00 (11:40-12:00)	Introduction to domestic and international air monitoring using automatic measuring machines and sensors	Green Blue Corporation
10:00-10:15 (12:00-12:15)	Question and Answer	
10:15-10:30 (12:15-12:30)	About achievements of JCM Projects in Indonesia	Tokyo Century Corporation
10:30-10:45 (12:30-12:45)	Case Study of Air Conditioning Equipment Replacement in Indonesia	Daikin Air Conditioning Indonesia
10:45-10:55 (12:45-12:55)	Introduction of the Kawasaki Green Innovation Cluster (GIC) and possibilities for collaboration	Oriental Consultants
10:55-11:00 (12:55-13:00)	Question and Answer	

(4) Minutes of the Meeting, presentation materials (Appendix A4-1 to 11)

6.5 Study of the potential to use Japanese technology

6.5.1 Summary of the Kawasaki Green Innovation Cluster

In accordance with the Kawasaki City Green Innovation Promotion Policy, Kawasaki City has established the Kawasaki Green Innovation Cluster (hereinafter referred to as "Kawasaki GIC"), as shown in Figure 38, as an initiative to improve the environment featuring collaboration among industry, academia, government and the private sector and promoting industrial development and international contributions to create a new society.



Source: The website of Green Innovation Cluster HP

Figure 6-1 Conceptual diagram of the Kawasaki GIC

The member companies and organizations of the Kawasaki GIC are shown in Table 3 35 below.

Table 6-2 Member companies and organizations of the Kawasaki Green Innovation Cluster

	Number of organizations	Main organization
Member [Company]	118	Green Blue Corporation, Century Tokyo Corporation, etc.
Member [Organization]	7	Resource Recycling Network, Japan Association for the Promotion of New Energy Utilization for a Sustainable and Safe Society (JASFA), etc.
Member [University]	2	Keio Leading-edge Laboratory of Science and Technology, Graduate School of Engineering, The University of Tokyo
Cooperating Organizations	12	Japan External Trade Organization (JETRO) Yokohama Trade Information Center, Japan International Cooperation Agency (JICA) Yokohama Center, etc.

Source: prepared by the Survey Team based on the website of the Kawasaki Green Innovation Cluster

During the first year of the project, we introduced details of our project at an exchange meeting for Kawasaki GIC member companies and exchanged information to explore the potential of utilizing Japanese technologies. The project also cooperated with the Kawasaki International Eco-Tech Fair organized by Kawasaki City as a sponsor and participated in interviews on the day of the

exhibition to collect wide-ranging technologies from Japanese companies and study scope for deployment.

6.5.2 Provision of information to Bandung City in this study

During the first year of this project, two member companies of the Kawasaki GIC, namely Green Blue Corporation and Century Tokyo Corporation, provided information on their efforts. Green Blue Corporation is considering specific measures to be taken at the online exchange meeting for GIC member companies mentioned above. Table 3 36 shows the information provided by each company.

Table 6-3 Content of information provided in this year's survey

<table>
<tr><th></th><th>Information provided</th></tr>
<tr><td>Green Blue Co.

[Company Profile]
Business description
Environmental research, measurement analysis, environmental monitoring, system development</td><td>Information was provided on the outline of the system of continuous air monitoring in Japan, the approach taken in Kawasaki City, the survey method used for continuous monitoring (automatic measurement, sensor measurement, etc.) and the approach in Vietnam.
<table>
<tr><th>Initiative</th><th>Business Overview</th></tr>
<tr><td>Air Pollution Data Collection in Vietnam</td><td>Collecting air pollution data (PM2.5, O3, NO2) and video data around a lake in Vietnam with local counterparts through 2020
 
</td></tr>
</table></td></tr>
<tr><td>Century Tokyo Corporation

[Company Profile]
Business description
Domestic leasing business, domestic auto business, specialty business, international business</td><td>Information was provided on the following projects being undertaken as part of the JCM Equipment Subsidy Project in Indonesia.
<table>
<tr><th>Project name</th><th>Business Overview</th></tr>
<tr><td>Installation of absorption chillers in chemical plants</td><td>Timuraya Tunggal, a locally owned chemical company in Karawang, West Java Province, installed an absorption chiller at its plant.
Reduce CO2 emissions from electricity consumption by electric chillers by effectively utilizing waste steam from the process that was previously released into the atmosphere to produce chilled water.
Assumed GHG emission reduction: 712 tCO2/year</td></tr>
<tr><td>Installation of high-efficiency injection molding machines in plastic parts factories</td><td>Installed high-efficiency injection molding machines manufactured by Japan Steel Works, Ltd. at two plants of a major plastic parts manufacturer in Indonesia.
By replacing conventional injection molding machines with high-efficiency injection molding machines, we will reduce power consumption and GHG emissions.
Assumed GHG emission reductions: 4,462 tCO2/year</td></tr>
</table></td></tr>
</table>