MOEJ

Final Report

City to City Collaboration for Zero-carbon Society in FY2022

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

March 2023

Oriental Consultants Co., Ltd.
Kawasaki City

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List of Abbreviations

Abbreviation	Meaning
ADB	Asian Development Bank
AETI	Asia Energy Transition Initiative
APBD	Anggaran Pendapatan dan Belanja Daerah
AQI	Air Quality Index
AQMS	Air Quality Monitoring System
ATCS	Area Traffic Control System
BAS	Building Automation System
BEMS	Building and Energy Management System
CCS	Carbon dioxide Capture and Storage
CCUS	Carbon dioxide Capture, Utilization and Storage
CIF	Climate Investment Funds
ESCO	Energy Service Company
ETM	Energy Transition Mechanism
GHG	Greenhouse Gas
IEA	International Energy Agency
IKLH	Kualitas Lingkungan Hidup
INDC	Intended Nationally Determined Contribution
IoT	Internet of Things
JCM	Joint Crediting Mechanism
JETP	Just Energy Transition Partnership
JFJCM	Japan Fund for the Joint Crediting Mechanism
KLHK	Kementerian Lingkungan Hidup dan Kehutanan
NDC	Nationally Determined Contribution
PLN	PT Perusahaan Listrik Negara
PPP	Public Private Partnership
PSI/ISPU	Pollution Standard Index/Indeks Standar Pencemar Udara
PTPS	Public Transportation Priority System
RPJMD	Rencana Pembangunan Jangka Menengah Daerah
RPJMN	Rencana Pembangunan. Jangka Menengah Nasional

Chapter 1　Project Overview

1.1　Project Objective

With the Glasgow Climate Pact adopted during the 2021 United Nations Climate Change Conference (COP26) held in November 2021, limiting the temperature increase to 1.5 degree above pre-industrial levels was confirmed as a new global goal. To achieve this goal, each country must accelerate their efforts at province, city, district and various other levels. 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 800 (as of January 31, 2023). Each municipality has created advanced measures and proceeded with their initiatives extending nationwide under the Regional Decarbonization Roadmap formulated in June 2021.

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 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 decarbonized societies, will conduct a research project to support the efforts of overseas local governments to form a decarbonized society and the introduction of facilities that contributes to the formation of a decarbonized society.

1.2　Project Overview

Entrusted Project Name:	City to City Collaboration for Zero-carbon Society in FY2022 Zero-carbon Society Development in Bandung City through Energy Saving of Infrastructure System and Mobility Improvement
Implementation Period:	July 8, 2022, to March 10, 2023
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 (MOU) 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 to extend the MOU by February 2025 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. In November 2022, the Mayor of Bandung visited Kawasaki City, with the Director of the Environment Bureau, the Director of the Transportation Bureau, and the Director of the Urban Planning Bureau of Bandung City, and made a courtesy call on the Mayor of Kawasaki City. Inspection tours and discussions on air pollution control, waste management and environmentally friendly public transportation were also held in Kawasaki City.

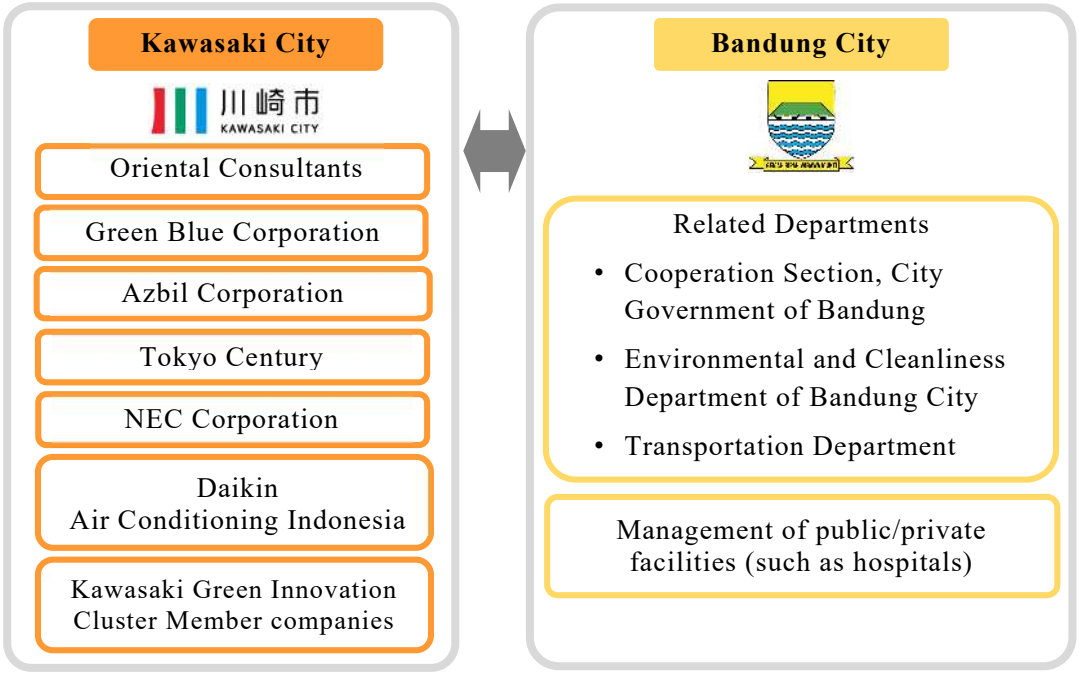


Figure 1-1 Implementation structure

1.4 Project Implementation Plan and Project Implementation Process in FY 2022

As the second year of the three-year plan, deepen the results of the first year and discussions with Bandung City, promote energy conservation in the building sector through the introduction of high-efficiency air conditioning systems and BEMS, and consider proposals for the installation of LED streetlights and smart energy-saving systems in the infrastructure of Bandung City. In addition, the project aims to decarbonize the city of Bandung while taking into consideration the improvement of air quality, which has not yet been addressed in the collaboration between Kawasaki and Bandung in the environmental field based on the MOU. The project will propose measures to promote the use of public transportation and mobility management that utilize the knowledge of Japan and Kawasaki City, and to understand the current status and issues of air quality monitoring in Bandung, in order to reduce greenhouse gas (GHG) emissions and improve air quality management through mobility improvement.

Table 1-1 Schedule of this fiscal year

Project Items	2022						2023		
	7	8	9	10	11	12	1	2	3
Meetings			Kick-off		Progress report		Mid-term report	Final report	
I. Promoting energy conservation in the building sector									
・Study of model projects, screening surveys ・Proposal for introduction of high-efficiency equipment and BEMS ・Examination of the use of ESCOs, etc. for commercialization ・Review of the latest trends in green building	◄	─	─	─	─	─	►		
				◄	─	─	─	►	
	◄	─	─	─	►				
II. Promote energy conservation in social infrastructure systems									
・Sorting out the current status of street lights ・Confirmation of plans and legal systems related to the development of LED street lighting ・Proposal to introduce smart LED street lighting ・Consideration of measures for commercialization	◄	─	─	─	─	─	►		
				◄	─	─	─	►	
III. Mobility Improvement and Air Quality Management									
(1) Proposed Mobility Improvements ・Organization of initiatives by the City of Bandung ・Introduction of measures to promote use of public transportation and promotion of eco-driving and study of feasibility of introducing such measures	◄	─	─	─	►				
			◄	─	─	─	►		
(2) Improved air quality monitoring ・Research on rules and standards related to air quality monitoring ・Current status of air quality monitoring, implementation system, and issues to be addressed ・Suggestions for improving air quality monitoring		◄	─	─	─	─	─	►	
On-site survey (incl. correspondence/discussion of local stakeholders)	◄	─	─	─	─	─	─	►	
Workshops (incl. attending to Kawasaki International Eco-Tech Fair)			▲		▲			▲	
Monthly report		▲	▲	▲	▲	▲	▲	▲	▲
Final report			◄	─	─	─	─	─	► Submission

Implementation Period: July 8, 2022 to March 10, 2023

Chapter 2　Overview of Bandung City and Initiatives to Create a Decarbonized Society

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　Initiatives to Create a Decarbonized Society

2.2.1　Initiatives to Create a Decarbonized Society in Indonesia

（1）　NDC and the Carbon Neutrality Declaration

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 September 2015, the Government of Indonesia submitted its Intended Nationally Determined Contributions (INDC) with ambitious CO2 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

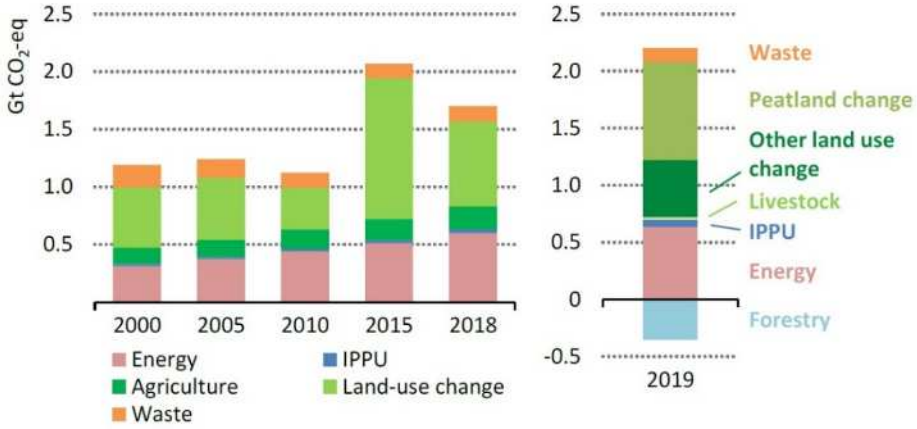
Sector	GHG Emission Level 2010 Mt-CO2E	GHG Emission Level 2030			GHG Emission Reduction			
		Mt on CO2E			Mt on CO2E		% of Total BaU	
		BAU	CM1	CM2	CM1	CM2	CM1	CM2
Energy	453.2	1,669	1,355	1,223	314	446	11%	15.5%
Waste	88	296	285	256	11	40	0.38%	1.4%
IPPU	36	70	67	66	3	3.25	0.1%	0.11%
Agriculture	111	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 of Indonesia, 2021

（2） GHG Emission by Sector

By sector, GHG emissions from forestry and other land use (FOLU) are high, and the revised NDC presents a policy that addresses the restoration of peatland and degraded land, and forest conservation and management. Recently, GHG emissions in the energy sector have increased, so revising the energy mix to transition from dependence on fossil fuels to expanding renewable energy such as solar power, geothermal, and wind power has become a key issue. Carbon dioxide emissions were reduced by 91.5 million tons in 2022.



Source: An Energy Sector Roadmap to Net Zero Emission in Indonesia, IEA, 2022

Figure 2-2　GHG emission by sector

（3） Energy Transition Initiatives

Although COP27 (in November 2022) made no significant revisions to policies or targets, at the G20 Bali summit chaired by Indonesia, world leaders entered into the Just Energy Transition Partnership (JETP) and pledged to achieve net zero GHG emissions in the electric power sector by 2050 as a condition for international aid. In addition, initiatives to reduce GHG emissions in the energy sector have been accelerated. For example, the Energy Transition Mechanism (ETM) facilitated by the Asian Development Bank (ADB) was launched, and Indonesia joined Accelerating Coal Transition, a program that encourages the transition from coal with Climate Investment Funds (CIF), and submitted a bill that aims to make the entire electric power supply based on renewables by 2060.

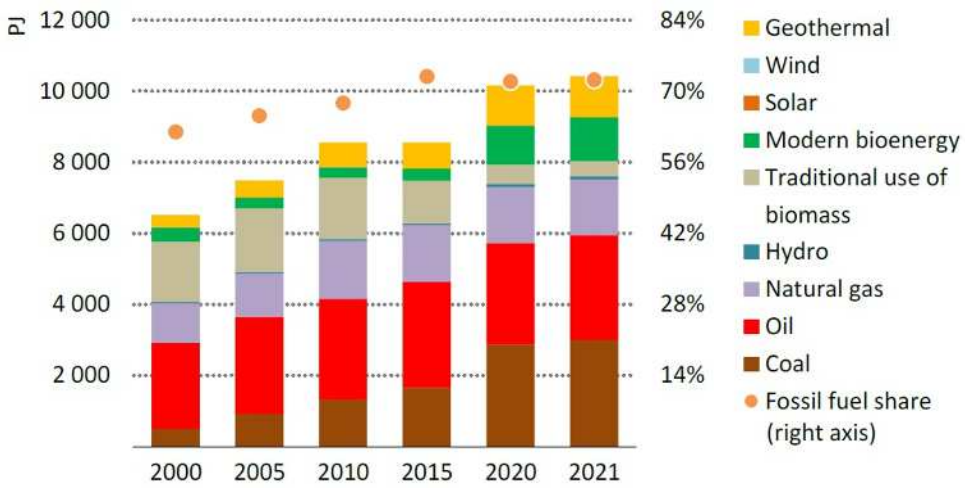
Table 2-2　Energy transition initiatives in Indonesia

CN Declaration November 2021	At the COP26 summit, world leaders announced their goal of lowering net GHG emissions by 2030 and achieving carbon neutrality by 2060.
Presidential Regulation No. 112/2022 September 2022	Presidential Regulation No. 112 of 2022 on the Acceleration of Renewable Energy Development for Power Supply ・Presents standard prices for purchasing electricity generated from solar, hydro, geothermal, wind, biomass, and biogas power ・Prohibits development of new coal-fired power plants as a rule
JETP November 2022	Just Energy Transition Partnership (JETP) International Partners Group (IPG): Indonesia, Japan, US, Canada, Denmark, EU, Germany, France, Norway, Italy, and UK ・Supports retiring coal-fired power plants quickly and accelerating the implementation of renewable energy in Indonesia, and plans to contribute 20 billion USD in the next three to five years ・Indonesia pledges to produce a maximum of 290 million tons of GHG emissions in the electric power sector by 2030, achieve net zero emissions in the sector by 2050, and make at least 34% of all electric power generated be based on renewable energy by 2030 ・Freezes existing pipelines at planned on-grid coal-fired power plants and halts construction of new on-grid coal power generation facilities

ETM November 2021	Energy Transition Mechanism (ETM) ・Aims to stop operation of existing coal-fired power plants ahead of schedule and replace them with clean power generation facilities through ADB-facilitated financing ・Japan contributes a grant of 25 million USD at launch ・Indonesia enters memorandum on mutual cooperation to shorten the period of operations of Cirebon 1 coal-fired power plant in West Java as the first condition for using ETM in November 2022 ・Feasibility studies and pilot projects are conducted in Indonesia, Philippines, and Vietnam
ACT November 2021	Accelerated Transition from Coal (ACT) program ・An CIF program that helps formulate strategies to transition from coal to clean energy, enhance capacity, transform infrastructure, etc. ・Indonesia, India, Philippines, and South Africa have joined
Carbon tax	・Tax of 30 rupiah per 1kg of CO2-equivalent emissions imposed based on 2021 Act No.7 on the Harmonization of Taxation that went into effect in October 2021 ・ It was scheduled to be implemented in April 2022 at coal-fired power plants, but was postponed until 2025 (announced October 2022)

Source: Study team

However, the reality remains that Indonesia's electric power supply is still dependent on coal. According to the International Energy Agency (IEA), the percentage of coal used in electric power generation has increased fivefold from 2000 to 2021, accounting for nearly two-thirds of total electricity generated. The Electricity Supply Business Plan (RUPTL 2021-2030) of the Indonesian government-operated power company PT Perusahaan Listrik Negara (PLN) indicates that the company is gradually reducing coal-fired power plants and expanding renewable energy, but by 2030 coal-fired power will account for around 60% and is expected to continue to be an important source of electric power in Indonesia, where power demand is growing due to economic growth.



Source: An Energy Sector Roadmap to Net Zero Emission in Indonesia, IEA, 2022

Figure 2-3　Changes in Indonesia’s energy mix

In February 2023, Indonesia's Ministry of Energy and Mineral Resources announced that they forecast that electricity generated from new and renewable energy will grow 3% to 12,925 MW in 2023 compared to the previous year, and expect solar power to increase in particular. Specifically, hydroelectric power will increase up to 6,852.2 MW and solar power up to 432.6 MW. While this is a smaller scale than wind and geothermal power, it is a 60% increase from the previous year. The targets for the share of new and renewable energy in the energy mix are 14.1% by 2022, 17.9% by 2023, and 2025 by 23.0%.

Table 2-3 Power supply configuration scenario in RUPTL 2021-2030

Power source	2025	2030
New/Renewable energy	23.0%	24.8%
Gas	15.6%	15.4%
Coal	61.0%	59.4%
Oil	0.4%	0.4%

Source: Regional and Analytical Report, JETRO, July 2022

(4) Initiatives by Government-operated and Private-sector Companies

In accordance with Indonesia's Carbon Neutrality Declaration, the country's major government-operated companies have pledged to achieve carbon neutrality by 2060 and are taking concrete initiatives toward decarbonization. Several of these initiatives are in partnership with Japanese companies (see "2.2.2 Japanese Support" below). Some private-sector companies have incorporated initiatives such as use of renewables, afforestation, and waste reduction into their business activities, and have announced that they will achieve carbon neutrality before the government.

Table 2-4 Initiatives by government-operated and private-sector companies

Company	Description of initiatives
2060 Carbon Neutrality Declaration ・Electric power sector (power): PT Perusahaan Listrik Negara (PLN) ・Oil and gas sector (oil/gas): PT Pertamina ・Transportation sector (railway): PT Kereta Api Indonesia (KAI) ・Industrial sector (fertilizer manufacturing): PT Pupuk Indonesia ・Industrial sector (cement manufacturing): PT Semen Indonesia ・Agriculture and forestry sector (agriculture): PT Perkebunan Nusantara III ・Agriculture and forestry sector (forestry): Perusahaan Umum Kehutanan Negara	
PLN (government-operated power company)	・PLN will gradually reduce coal-fired power plants and expand renewable energy in accordance with its Electricity Supply Business Plan (RUPTL 2021-2030). ・It has partnered with online ride-hailing and logistics service giant to develop battery replacement equipment, with the aim of electrifying automobiles. It is driving initiatives such as offering a nighttime discount of about 24% for charging electric vehicles (EVs) at home. ・It installed a 5 MW rechargeable battery electricity storage system in

	collaboration with Indonesia Battery Corporation (IBC) in 2022, and plans to install the same system in all PLN-owned power plants. ・ It started collaboration with the government-operated oil company Pertamina and government-operated fertilizer manufacturer Pupuk Indonesia to manufacture green hydrogen and ammonia and supply renewable energy.
Pertamina (government-operated oil company)	・ Pertamina will install solar power generation facilities on the premises of oil refineries nationwide operated by oil refinery and petrochemical subsidiary Kilang Pertamina Internasional. It will supply power needed to run the oil refineries with the solar power generation facilities, which it expects to generate a total of 10 MW power at peak.
KAI (public railways)	・ KAI started operating solar panels at Gambir Station in Jakarta and the company's office building. It will gradually install solar panels on other facilities it owns to transition to renewable power generation. ・ The solar panels are on-grid, connected to PLN's power grid. They reduce power consumption at Gambir Station by as much as 6.75%. ・ KAI also uses energy-efficient lighting and engages in afforestation efforts.
Indika Energy	・ Energy giant involved in coal mining, etc. ・ Carbon neutrality target: 2050 ・ Indika Energy uses B30 biodiesel, and has improved energy efficiency of mining equipment, installed solar power generation equipment, launched forest regeneration and restoration project, and developed wood pellets for biomass co-firing. ・ It entered into a memorandum to build an EV industry supply chain with government-operated company Indonesia Battery Corporation and others.
GoTo Group	・ Company that operates online ride-hailing, logistics services, etc. ・ Carbon neutrality target: 2030 ・ GoTo Group plans to implement 5,000 electric two-wheelers and electrify all vehicles it owns by 2030. ・ It conducted a feasibility study and pilot project to accelerate implementation of EVs. ・ It established a joint venture with mining company TBS Energi Utama to develop electric two-wheelers.

Source: Study team

2.2.2 Japanese Support

（1） Support by Government and Public Organizations

Japan announced the Asia Energy Transition Initiative (AETI) in May 2021 with the aim of achieving carbon neutrality in Asia. The initiative provides comprehensive support to countries in Asia for energy transition, while balancing economic growth, the need for stable electricity supply, and decarbonization. Held three times since October 2021, the Asia Green Growth Partnership Ministerial Meeting (AGGPM) emphasized the need to use a wide range of technologies, such as hydrogen and ammonia co-firing and carbon recycling, in addition to promoting renewable energy and energy management advocated by the AETI, to achieve energy transition in Asia. The meeting

also stressed the necessity of further investment and financial support to accomplish that.

In January 2022, Japan's Ministry of Economy, Trade and Industry and Indonesia's Ministry of Energy and Mineral Resources signed the Memorandum of Cooperation on the Realization of Energy Transitions based on the AETI, and announced they would take the following measures in accordance:

1. Help formulate an energy transition roadmap
2. Develop and roll out technologies that contribute to realistic energy transition, such as hydrogen, ammonia fuel, carbon recycling, and CCS/CCUS (carbon capture and storage, and carbon capture, utilization and storage)
3. Support efforts in multilateral forums to accelerate technological cooperation that contributes to realistic energy transition
4. Provide support to formulate policies, develop human resources, and share knowledge related to energy transition and contributing technologies

The following table shows the support and cooperation provided by Japanese government organizations in Indonesia. Japan also provides technological support, including development of renewable energy sources such as hydro and geothermal power, and financial support. In addition, Japanese companies have rolled out businesses in the field of decarbonization in Indonesia.

Table 2-5 Support by government organizations

Organization	Measures/initiatives
JICA	・Data Collection Survey on the Electric Power Sector for Decarbonization (March 2022): Support for formulating a decarbonization roadmap that includes technologies such as ammonia and hydrogen co-firing and CCS ・JICA entered into memorandum on business partnership with PLN in November 2022. They agreed to conduct a study on stabilizing the power grid, which is needed to forecast future power demand and implement renewable energy.
NEXI	・NEXI entered into a memorandum on cooperation with PLN in April 2022. It established a framework to exchange opinions about the Indonesian electricity market and specific future projects, introduces technology of Japanese companies, and provides financial support to PLN.
JBIC	・JBIC entered into a memorandum with PT Sarana Multi Infrastruktur (SMI) in November 2022. It collaborates to bring projects that contribute to energy transition to fruition, such as renewable energy power plant and transmission line projects. ・JBIC entered into a memorandum with government-operated oil company Pertamina in November 2022. This strengthened collaboration in fields such as renewable energy, hydrogen and ammonia value chain, CCS, and green mobility.

Source: Study team

（2） Businesses and Cooperation by Japanese Companies

In addition to efforts by the Japanese government, Japanese companies are also contributing to decarbonization in Indonesia. Contributions span a wide range of fields including construction of geothermal power plants, ammonia co-firing, and development and commercialization of CCUS technology. In 2022, the Jakarta Japan Club established the Carbon Neutral Taskforce. The club estimates that if the businesses being considered by Japanese companies come to fruition, they have the potential to reduce CO2 emissions by 30 million tons in 2022 and 250 million tons in 2060. While some companies are moving forward with partnerships with government-operated companies, further measures such as offering incentives and developing programs for companies tackling decarbonization show promise. Specific measures that have been pointed out include subsidizing implementation of energy-efficient equipment, developing power grids that can accommodate large amounts of renewable energy, and setting appropriate purchase prices.

Table 2-6 Businesses and cooperation by Japanese companies

Field/Company	Measures/Initiatives
Solar power/ Alamport, Shizen Energy	・Shizen Energy is installing a total of 4.2 MW of rooftop photovoltaic systems on 13 plants and stores (began construction in April 2021), and the companies will handle operation and maintenance of equipment after installation for customers. ・Part of the business utilizes a FY2020 JCM grant. It is expected to generate 6,151 MWh of electricity annually and produce 3,772 tons of CO2 emissions per year.
Geothermal power/ Marubeni, Toshiba	・The companies received an order to build Patuha Unit 1 Geothermal Power Plant, located 30 km southwest of the city of Bandung. They were contracted to deliver and build a system that includes a Toshiba-made geothermal steam turbine and electricity generator, for a total output of 55 MW. The system went online in 2014. ・Patuha Unit 2 Geothermal Power Plant is scheduled to be built with ADB’s Japan Fund for the Joint Crediting Mechanism (JFJCM). ・Toshiba delivered geothermal steam turbines and electricity generators to Sarulla Geothermal Power Plant and Dieng Small Scale Geothermal Power Plant in addition to the Patuha geothermal power plants.
Geothermal power/ Fuji Electric	・It delivered steam turbines for Kamojang Geothermal Power Plant 5 (online in July 2015), etc. ・Kamojang Geothermal Power Plant was built in Garut, located 40 km from Bandung, West Java. A planned expansion project that would utilize a Japanese ODA Loan was cancelled due to difficulties with procedures to remove natural protected forest designation, so the Indonesian government is moving forward with the project using its own funds. Because PLN's domestic grid connection has an ultra-high voltage of 500 kV, Fuji Electric can implement a renewable energy geothermal power plant at another site and contribute to decarbonization by reducing the amount of electricity supplied from existing coal-fired power plants.

Ammonia power/ Mitsubishi Heavy Industries (MHI)	・MHI signed a joint research agreement with Institut Teknologi Bandung on generating power with ammonia using gas turbines in September 2022. ・MHI aims to optimize/realize ammonia power generation that uses ITB's chemical reaction engineering by demonstrating the company's H-25 Series gas turbine.
Ammonia, hydrogen, and biomass co-firing/ Mitsubishi Heavy Industries, Indonesia Power	In November 2022, MHI signed an MOU with PLN Group company Indonesia Power to launch three feasibility studies on co-firing low-carbon fuel in the power plants it owns and operates. 1. Suralaya coal-fired power plant: A study was conducted on the feasibility of co-firing and single-fuel firing with biomass from technical and economic perspectives by examining the handling, storage, and transportation of fuel, modifying existing boilers, etc. 2. Suralaya coal-fired power plant: A study was conducted on co-firing ammonia produced at existing ammonia manufacturing plants. The study examined the technology needed to establish a supply chain to produce and transport ammonia and convert it into fuel, and co-fire it in existing boilers. 3. Tanjung Priok power plant: The feasibility of hydrogen co-firing with a natural gas turbine was assessed from technical and economic perspectives.
Biomass fuels/ JGC Holdings, Osaka Gas, INPEX	・The companies entered into a joint research agreement with government-operated oil company Pertamina on using biomethane derived from palm oil liquid waste in April 2022. ・The study examined the feasibility of biomethane derived from palm oil liquid waste produced in Sumatra and Kalimantan, under the assumption it would be supplied to Javanese and other Indonesian consumers.
Biomass power/ Sumitomo Heavy Industries	・The company entered into a memorandum with PN affiliate PT Pembangkitan Jawa-Bali Services on technological cooperation for decarbonization and carbon neutrality in January 2023.
CCS/ JGC Holdings	・The company conducted the Ongoing Survey on the Feasibility of Applying JCM to the CCS Project in the Gundih Gas Field with government-operated oil company Pertamina and Institut Teknologi Bandung in 2021. The purpose was to examine the feasibility to realize a CCS pilot project to transport CO2 separated in the natural gas production process in a pipeline to an injection well in the suburbs, and inject and store it underground.
CCS/ Kansai Electric Power	・In September 2022, the company entered into a memorandum with Medco Power Indonesia, which stipulates they will conduct a joint study on the applicability of decarbonization technology in thermal power plants. ・The study will examine co-firing and single-fuel firing with biomass at existing thermal power plants, the applicability of CCS technology, injecting collected CO2 into oil and gas fields, and building a business model to increase crude oil and gas production.
Solar power equipment leasing/ Hokuriku Electrical Construction	・The company established a joint venture with two other companies in December 2022 to launch a rooftop solar power equipment leasing business. It also entered into a memorandum with Udayana University to conduct joint research on solar power systems.

Source: Study team

2.2.3 Initiatives to Create a Decarbonized Society in Bandung City

（1） GHG Emission in Bandung City

Bandung measures the greenhouse gases of carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O) in accordance with Presidential Regulation No. 71 of 2011 on the Implementation of the National Greenhouse Gas Inventory. Total emissions in 2021 came to 785,555 tons of CO2/year. The energy sector produced the most emissions, accounting for 72.32%. The main sources of emissions were land transportation, households, and wastewater treatment.

Table 2-7 GHG emission in Bandung City (2021)

Category	Emission			
	CO2	CH4	N2O	CO2eq
(1) Energy procurement and use	553,606	0.399	0.015	568,112
Transportation				
Aircraft	2,277	0.000	0.000	2,302
Land transportation	276,733	0.128	0.012	283,606
Railway	4,810	0.000	0.002	5,368
Other				
Households	269,786	0.272	0.001	276,836
(2) Agriculture, forestry, and changes in land use	0.410	0.470	0.170	62,680
Livestock				
Gastrointestinal fermentation in livestock	0.000	0.170	0.000	4,238
Livestock excrement management	0.000	0.049	0.000	1,283
Non-CO2 emissions on land				
Use of urea	0.410	0.000	0.000	410
Direct N2O emissions from soil management	0.000	0.000	0.170	50,500
Indirect N2O emissions from soil management	0.000	0.000	0.000	0
Indirect N2O emissions from livestock excrement management	0.000	0.000	0.000	0
Rice-related emissions	0.000	0.250	0.000	6,240
(3) Waste treatment	0.000	6.140	0.020	158,000
Solid waste treatment	0.000	0.200	0.020	9,510
Wastewater treatment				
Household wastewater treatment	0.000	5.810	0.000	145,260
Total	554,015	6.879	0.200	785,555

Source: Documents provided from Bandung City

（2） 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. 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.

Table 2-8 Achievements and 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	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 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

Chapter 3 Promoting Energy Saving in the Building Sector

3.1 Initiatives for Green Building in Bandung City

3.1.1 Green Building Regulations and Certification

（1） New Administrative Decree on Green Buildings

Bandung City enacted the Comprehensive Mayor's Regulation No.1023/2016 on Green Building in 2016 with support from the International Finance Corporation, in line with the National Green Building Guidelines from 2015. This regulation surpasses the technical specifications provided in the national guidelines, establishing Bandung as a leading province in green building construction standards. In 2021, the Ministry Regulation No.21/2021 on Green Buildings was enacted, which follows the content of Mayoral Decree No.1023/2016 but is in line with the new government regulation (Government Regulation No.16/2021) on building permits. The new regulation expands the scope to include existing and heritage buildings, and it covers the life cycle of a building from planning to demolition. Additionally, it establishes a policy for online document and data management through SIMBG, an information management system for buildings.

Table 3-1 Comparison of mayor regulation and ministry regulation on green building

	Mayor Regulation No.1023/2016	Ministry Regulation No.21/2021 (as derivative rules of Government Regulation No.16/2021)
Coverage	・ Applicable for new building only ・ Mandatory for all type of building (incl. single landed house)	・ Applicable for new building, existed building (inc. heritage) ・ Mandatory only for specific building
Rating	・ Compliance checklist ・ After-construction certification ・ Rating name 1-star rating 2-star rating 3-star rating	・ Scoring-accumulation system ・ Certification on building planning, construction, after-construction ・ Rating name Pratama Madya Utama

Source: Documents provided by Bandung City

The new Regulation No.21/2021 expands the scope of evaluation to cover each phase of the project, including design and demolition, and rates them in three stages based on scores and weightings. The evaluation items for each stage are shown in Table 3-2, while Table 3-3 provides specific scores, weightings, and evaluation details for each item in the planning phase. This is a significant change from the previous Mayor Regulation No.1023/2016, which did not evaluate each phase of the project in such detail.

Table 3-2 Evaluation at various stages of construction

Stage on Building construction	Area of GB Criteria	Certification	Policy-Control Instrument
Planning	・Site management ・Energy efficiency ・Water efficiency ・Indoor-air quality ・Sustainable material ・Waste management ・Waste-water management	Yes	Building Permit
Construction	・Planning conformity ・Green construction ・Green practice ・Green supply-chain	Yes	Building Inspection
Operation /Utilization	・Building utilization management ・SOP for building utilization ・GB guidelines	Yes	Building Certificate of Worthiness
Demolition	・Demolition procedure ・Site restoration	Yes	Building Demolition Permit

Source: Documents provided by Bandung City

Table 3-3 Scores, weightings and ratings for assessment item at the planning phase

Area of GB Criteria	Score (Points)	Weight (%)	Items
Site Management	38	23	Building orientation, landscaping and accessibility, green area, pedestrian availability, basement arrangement, parking, outdoor lighting
Energy Efficiency	46	28	Secondary skin (OTTV), ventilation, air condition, lighting, in-building transportation, electricity, etc.
Water Efficiency	22	12	Water resource, water usage, water fixture
Indoor Air Quality	19	12	CO2 and CO treatment, refrigerant-free cooling system
Sustainable Material	21	13	Eco-labeling material
Waste Management	7	4	3R (reduce, reuse, recycle), waste treatment, waste production monitoring
Waste-Water Management	12	12	Water-waste treatment, grey water recycle

Source: Documents provided by Bandung City

（2） Green Building Certification

Based on the new Ministry Regulation No.21/2021, the results of the three-level evaluation will be certified as ‘Utama, Madya, Pratama (meaning first, second and third class, according to the explanation of Bandung City).

Source: Documents provided by Bandung City

Figure 3-1 Green building certification in Bandung City

These regulations and certifications for green building in Bandung are currently being prepared as a draft ordinance, which, when approved by the City Council, will include incentives for green building initiatives as the city proceeds to draft a new mayoral decree.

3.1.2 Adoption of Passive Design for Public Housing

(1) Public Housing Owned and Managed by Bandung City

Passive design is an architectural design technique that creates a comfortable living environment by controlling the flow of heat and air through the structure and materials of the building. Passive design has been adopted in four public housing projects owned and managed by Bandung City, where the shape and layout of the buildings are designed to allow natural light and ventilation through the use of natural breezes, thereby reducing electricity consumption. The table below provides an overview of public housing buildings that have adopted passive design. Although we could not obtain detailed information on the energy-saving effects of adopting passive design, the Bandung Municipal Public Works Department explained that the energy-saving effect is expected to be about 23%.

Table 3-4 Public housing with passive design

1. Sadang Serang Public Housing (Coblong District): 1 building, 99 units

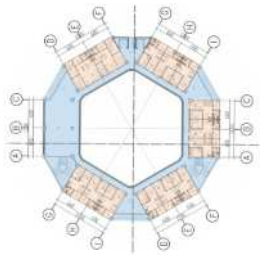


2. Cingised public housing (Arcamanik district): 5 buildings, 483 units



3. Rancacil Public Housing (Rancasari District): 4 buildings (379 units) completed, two under construction

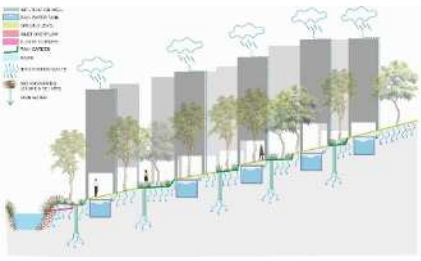




- The shape and layout of the building allows each unit to receive direct natural light and ventilation. This contributes to maintaining a favorable indoor air quality and saving on utility costs.
- Located green open spaces and public facilities.
- Installed compost containers. (Processed and used as fish food)

4. Rumah Deret Tamansari Public Housing (Bandung Wetan): 2 buildings (191 units) under construction with local budget (APBD: Anggaran Pendapatan dan Belanja Daerah)





- Constructing the building on stilts maximizes the catchment area, prevents or reduces the inflow
- of stormwater into storm drains and increases groundwater storage.
- Reduces the use of difficult-to-recycle finishing materials.
- Rain gardens and rooftop gardens boost residents' health, well-being and productivity.

Source: Documents provided by Bandung City

3.2 Consideration of Model Projects

3.2.1 Summary of Survey Results for the First Year of the Project

In the first year of this project, following discussions with Bandung City, the CO2 emission reduction effect was estimated for the Bandung Regional General Hospital (RSUD), a public hospital, assuming an upgrade to the air-conditioning system through the JCM equipment subsidy project (Table 3-5). In many facilities in Bandung City, air-conditioning is performed by individual systems, mainly household air-conditioners and estimates made assuming that the air-conditioning equipment in the Bandung City Regional General Hospital would be replaced confirmed that higher-efficiency equipment would help reduce CO2 emissions.

In this year's study, based on discussion with Bandung City, energy-saving and CO2 emission-reduction effects for the building as a whole will be examined. Specifically, for facilities with central air-conditioning systems, the study will estimate energy savings and CO2 emission reduction effects by pinpointing efforts to make heat source control systems more efficient, since they account for most of the energy consumed by air-conditioning and contribute to building energy management.

Table 3-5 Survey results for the first year of this project

Item	Results
Facility	Bandung City Regional General Hospital (RSUD) Built in 1993, 2 stories
Renewal equipment	Air-conditioning equipment: 213 units ・ Outdoor unit, indoor unit, 213 units each ・ Replace existing equipment with inverter-controlled equipment
Installation cost	4,014,054,000 IDR (32,112,432 yen)
Estimated CO2 emission reductions	752 t-CO2/year
Cost effectiveness	444,820 IDR/t-CO2 (3,559 yen/t-CO2)

Source: Study team

3.2.2 Screening Survey of Candidate Facilities for Model Projects

The operating efficiency and load of air-conditioning systems are greatly affected by outdoor air temperature and humidity. Bandung City has a tropical monsoon climate but is at a high elevation of 700-800m, with an average daytime temperature of 26-29 degree and 17-19 degree at night. The city has a cooler climate throughout the year than other regions in Indonesia and compared to low-altitude regions such as Jakarta, the air-conditioning load needed to control the indoor temperature is low. It is worth considering whether a high-efficiency heat source control system would be effective in saving energy and reducing CO2 emissions, even in such a low air-conditioning load area, to consider scope for applying the solution nationwide.

Conversely, commercial facilities in Indonesia, including those in Bandung, generally lack high-efficiency heat source control systems, with most facilities relying on standard controllers provided by chiller vendors. Facility operation is based on manually set operating points, rather than

advanced systems for efficient heat management. The low adoption rate is attributed to concerns about the potential for reduced air-conditioning functions, the belief that the control system has little impact on energy conservation, and a lack of understanding among local facility management engineers.

Air-conditioning accounts for approximately 40% of a building's energy consumption, with the majority of this energy being used by the chilled water system, which produces cooling capacity. By optimizing the chilled water system through the adoption of a high-efficiency heat source control system, we estimated that significant reductions in electricity consumption and CO2 emissions can be achieved, as demonstrated, as our screening study showed.

（1） Surveyed Facilities

Among the 15 candidate commercial facilities in Bandung that are equipped with central air-conditioning systems and are large, have long air-conditioning operation hours and are expected to have relatively high air-conditioning loads, five facilities that responded positively to the energy conservation study were further selected for the survey (see Table 3-6).

Air-conditioning in commercial and amusement facilities tends to fluctuate greatly depending on the day of the week and the presence or absence of events. Namely, the air-conditioning load is high on holidays when visitor numbers peak and low on weekdays. Accordingly, energy-saving effects can be expected by minimizing and optimizing operation on days with low loads while ensuring that there is no shortage of cooling water capacity on high-load days. Hospitals generally tend to have areas that are air-conditioned 24 hours a day and have high air-conditioning loads throughout the year, so energy savings tend to be high. As well as air-conditioning, many hospitals have steam boiler systems to maintain high temperatures during surgery and for sterilizing linen, which also have high potential for energy saving, but were excluded from the scope of this study.

Table 3-6　Facilities surveyed

1. Bandung Indah Plaza
   Type: commercial facility, chilled water system for air-conditioning: water-cooled, six-story shopping mall completed in 1990, owned by Indonesian conglomerate Lippo Group

2. Rumah Sakit Hasan Sadikin
   Type: hospital, chilled water system for air-conditioning: water-cooled, seven-story hospital opened in 1923

3. Trans Studio Bandung
   Type: amusement facility, chilled water system for air-conditioning: air-cooled, amusement park completed in 2011

4. Trans Studio Mall
   Type: commercial facility. chilled water system for air-conditioning: water-cooled, five-story shopping mall completed in 2001

5. Rumah Sakit Santo Borromeus
   Type: hospital, chilled water system for air-conditioning: air-cooled, hospital opened in 1921



Source: Study team

（2） Survey Method

There are two types of chilled water systems for air-conditioning: water-cooled and air-cooled. The water-cooled system uses evaporative vaporization heat from a cooling tower for cooling, while the air-cooled system uses air heat exchange with outside air heat. In general, the water-cooled type is more energy-efficient. In Bandung, the wet bulb temperature of the outdoor air (a value that correlates with the ease of evaporation and cooling by evaporation) is low, so cooling by cooling towers, or water-cooled type, has a high advantage and three of the five facilities surveyed used the water-cooled type.

The survey was conducted by checking the equipment on site and interviewing the engineers in charge of facility operation and was used as the basis for calculating the energy-saving effects and the estimated costs associated with introducing the equipment. The specific information collected in the survey is shown in below.

Table 3-7 Information collected in the screening survey

No.	Item
1.	Building and equipment layout
2.	Complete set of drawings related to mechanical and electrical (M&E) equipment
3.	M&E equipment specification information
4.	Operation schedules for air-conditioning-related equipment
5.	Inlet and outlet temperature history of the cooling system (for the past year)
6.	Total facility electricity consumption for the last three years and electricity billing information from PLN

Source: Study team

After considering the capacity, operating conditions and piping layout of existing facilities, the most cost-effective energy-saving method for heat source facilities proved to be adopting VWV control (variable water volume control) in all the surveyed facilities. By installing an inverter device in each water flow pump and controlling the pump at the optimal operating point according to the load, VWV control reduces pump transfer power and improves equipment COP (operating efficiency) by improving the onward/return temperature difference. While chilled water systems generally consist of a chilled water chiller, cooling tower, chilled water pump, and chilled water pump, improving the operating efficiency of the chilled water chiller alone will not elicit an overall energy-saving effect. Accordingly, the key point in introducing VWV control is to configure the control settings to achieve a balance that maximizes the operating efficiency of the entire system, including the cooling tower and pumps. Trial calculations of energy-saving effects were mainly conducted by adopting VWV control, which proved to be the most cost-effective method.

The chilled water pumps regulate water flow to match the amount of water passing through the chilled water chiller. Monitoring the air-conditioning load via a flow meter and differential pressure transducer, the inverter output adjusts water flow and water pressure to suit the load. Meanwhile,

the cooling water pump that circulates between the cooling tower and the chilled water chiller monitors the outlet temperature of the chilled water chiller and adjusts the inverter output to maximize the temperature difference from the inlet (usually 5 degrees). Maintaining the outlet temperature on the cooling tower side below a set value (usually 32 degrees) is desirable and can be achieved through automatic control of the cooling tower fan. Lowering the cooling water temperature setpoint to match the outside wet bulb temperature (which correlates with the cooling capacity by the cooling tower) is crucial since lower cooling water temperature improves the heat exchange efficiency of the chilled water chiller and increases equipment COP.

（3） Survey Results

1) Bandung Indah Plaza

Three water-cooled chillers, three 30kw chilled water pumps, cooling towers (two 30kw, one 15kw) and five 11kw cooling water pumps are installed as air-conditioning heat source equipment and are in operation from 10:00 to 21:00 daily. No central monitoring system was installed and the control system comprised general number control and manual adjustment of volume. emission reduction in 133.05 ton-CO2/year. The payback period is approximately 9 years.

Table 3-8 Calculation results (Bandung Indah Plaza)

Item	Calculation results
Investment	1,571 million IDR VWV control: Azbil's BAS ‘savic-net G5’ controls the following: - Primary pump - Condensate pump - Cooling tower
Reduction in power consumption	158.4 MWh/year (174.3 million IDR/year)
CO2 emission reduction effect	133.05 ton-CO2/year
Investment cost recovery period	9.01 years

Source: Study team

2) Rumah Sakit Hasan Sadikin

Four water-cooled chillers, four 1.5kw chilled water primary pumps, four 11kw chilled water secondary pumps, cooling towers (16.5kw: four units) and four 15kw chilled water pumps are installed as air-conditioning heat source equipment, which operates 24/7 around the clock. A central monitoring system manufactured by Azbil Corporation was installed to store and manage basic operation data, but the control system comprised general number control and manual volume adjustment. The ROI is expected to break even after approximately 5.5 years. The payback period is approximately 5.8 years.

Table 3-9 Calculation results (Rumah Sakit Hasan Sadikin)

Item	Calculation results
Investment	1,331 million IDR VWV control: Azbil's BAS 'savic-net FX' controls the following: - Primary pump - Secondary pump - Condensate pump - Cooling tower
Reduction in power consumption	208.7 MWh/year (229.6 million IDR/year)
CO2 emission reduction effect	175.31 ton-CO2/year
Investment cost recovery period	5.80 years

Source: Study team

3) Trans Studio Bandung

The air conditioning and heat source equipment consists of two air-cooled chillers and four 45 kw chilled water pumps, which operate from 9:30 to 21:30 daily. An Azbil central monitoring system has been installed and basic operational data is stored and managed, and control is by inverters installed on the pumps, but the volume was manually adjusted; if the VWV control system is installed (estimated installation cost: IDR 517 million), the electricity consumption would be reduced by 243.9 MWh/year and 204.87 tons-CO2/year of CO2 emission reduction. CO2 emission reduction in 204.87 ton-CO2/year. The payback period is approximately 1.9 years.

Table 3-10 Calculation results (Trans Studio Bandung)

Item	Calculation results
Investment	517 million IDR VWV control: Azbil's BAS ‘savic-net FX’ controls the following: - Primary pump
Reduction in power consumption	243.9 MWh/year (268.3 million IDR)
CO2 emission reduction effect	204.87 ton-CO2/year
Investment cost recovery period	1.93 years

Source: Study team

4) Trans Studio Mall

Three water-cooled chillers, three 37kw chilled water pumps, three cooling towers (15kw: three units) and three 30kw chilled water pumps are installed as air-conditioning heat source equipment, operating from 9:30 to 21:30 daily. No central monitoring system was installed and the control system comprised general volume control and manual adjustment of volume. A 326.0 MWh/year reduction in electricity consumption and 273.84 ton-CO2/year reduction in CO2 emissions are expected if the VWV control system is installed (estimated installation cost: 1,164 million IDR). The payback period is approximately 3.3 years.

Table 3-11 Calculation results (Trans Studio Mall)

Item	Calculation results
Investment cost	1,164 million IDR VWV control: Azbil's BAS ‘savic-net G5’ controls the following: - Primary pump - Secondary pump - Condensate pump - Cooling tower
Reduction in power consumption	326.0 MWh/year (358.5 million IDR/year)
CO2 emission reduction effect	273.84 ton-CO2/year
Investment cost payback period	3.25 years

Source: Study team

5) Rumah Sakit Santo Borromeus

The air conditioning heat source equipment comprises three air-cooled chillers and three 11 kw chilled water primary pumps and is operated 24/7 around the clock. An Azbil central monitoring system has been installed and basic operational data is stored and managed. Control is via inverters on the pumps, but the volume is manually adjusted. If the VWV control system is installed (estimated installation cost: IDR 522 million), a reduction of 30.1 MWh/year of electricity consumption and 25.28 tons-CO2/year of CO2 emission reduction is expected. The payback period is approximately 13.2 years.

Table 3-12 Calculation results (Rumah Sakit Santo Borromeus)

Item	Calculation results
Investment	522 million IDR VWV control: Azbil's BAS 'savic-net FX' controls the following: - Primary pump
Reduction in power consumption	30.1 MWh/year (39.6 million IDR/year)
CO2 emission reduction effect	25.28 ton-CO2/year
Investment cost recovery period	13.20 years

Source: Study team

Of the five facilities studied, two of them, Trans Studio Bandung and Trans Studio Mall, are highly feasible if the payback period for investment costs is set at five years, which is judged to be the target of the investment.

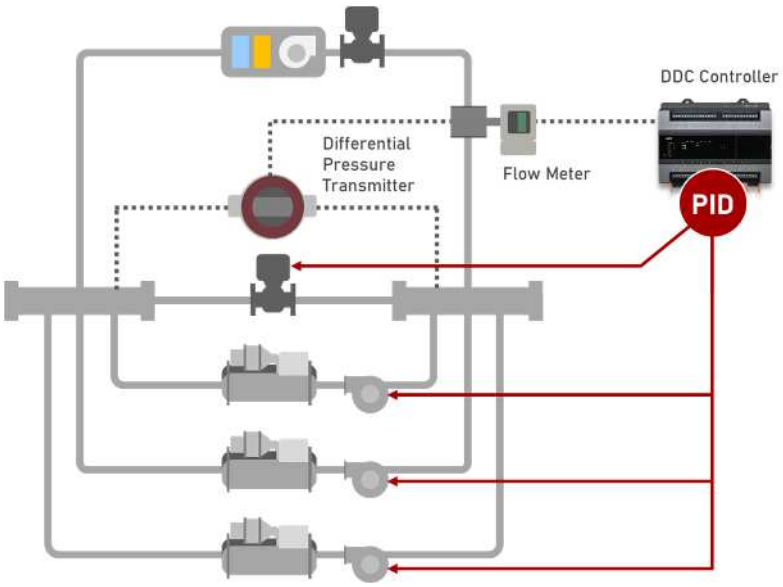
For this survey, 15 commercial facilities with central air-conditioning systems were selected as candidates and permission to conduct the survey was sought from the facilities. This may reflect the current lack of interest in energy conservation and CO2 emission reduction, even among relatively large operators. Furthermore, when facility managers were interviewed about their interest in utilizing the JCM equipment subsidy project, all responded that they were not interested.

This may be due to concerns that they would be required to prepare and submit monitoring reports during the depreciation period (generally 15 years) if they use the JCM equipment subsidy project.

3.2.3 BAS (Building Automation System)

The BAS (Building Automation System), which was considered for introduction in the screening survey, is a system achieving high-efficiency heat source control, including VWV control, which can be roughly divided into control and monitoring portions.

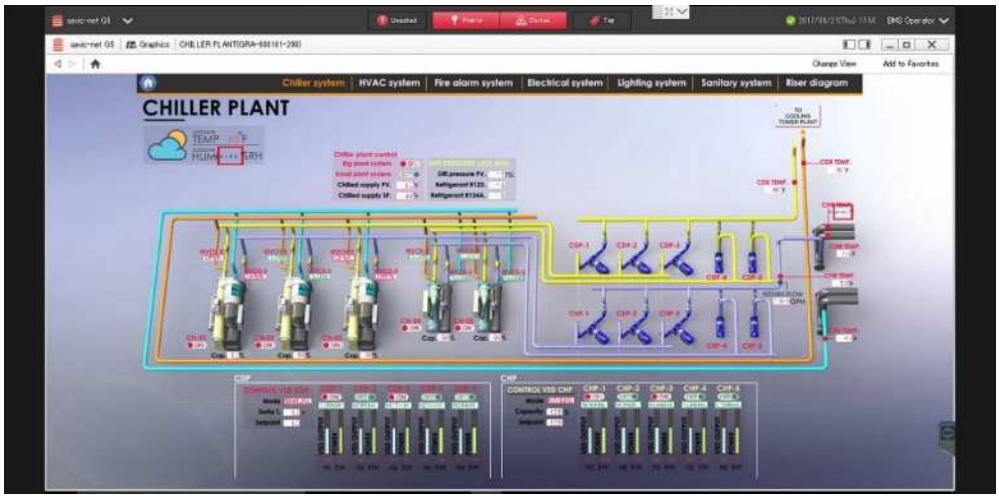
The control part that achieves energy savings comprises sensors, actuators (motion drives) and controllers, which monitor the operation and status of the equipment by connecting information signals to a range of equipment in the heat source facility and arranging sensors to detect temperature, flow rate and so on. For example, the control of the pump output for chiller water operates such that the output varies linearly according to the differential pumping pressure and returning water to the air-conditioner load. To secure the amount of water supplied to the chiller main unit, a limit is set so that it does not fall below the minimum water flow rate and if there is a surplus, even at the minimum water flow rate, an electric valve actuator installed in the chilled water bypass circuit creates a bypass water flow rate to control the differential pressure so that it does not rise. If the pump output changes too fast, it interferes with the capacity control of the chiller's internal circuit (the circuit that adjusts the chilled water volume), causing an emergency shutdown of the chiller itself. The output is gradually reduced and if the chiller is under any strain, the output is quickly increased to a safe level. As well as simple proportional control, many controllers also incorporate control logic that takes safety into consideration to avoid burdening the equipment.



Source: Azbil Corporation

Figure 3-2 Image of equipment connection in the control section

The monitoring part integrates information from wide-ranging control systems, optimizes the entire system and stores and monitors the operational results. This monitoring part is synonymous with BEMS, which will be discussed later.



Source: Azbil Corporation

Figure 3-3 Image of display and operation screen of monitoring section (savic-net G5)

Source: Azbil Corporation

Figure 3-4 Image of data trend confirmation screen (savic-net G5)

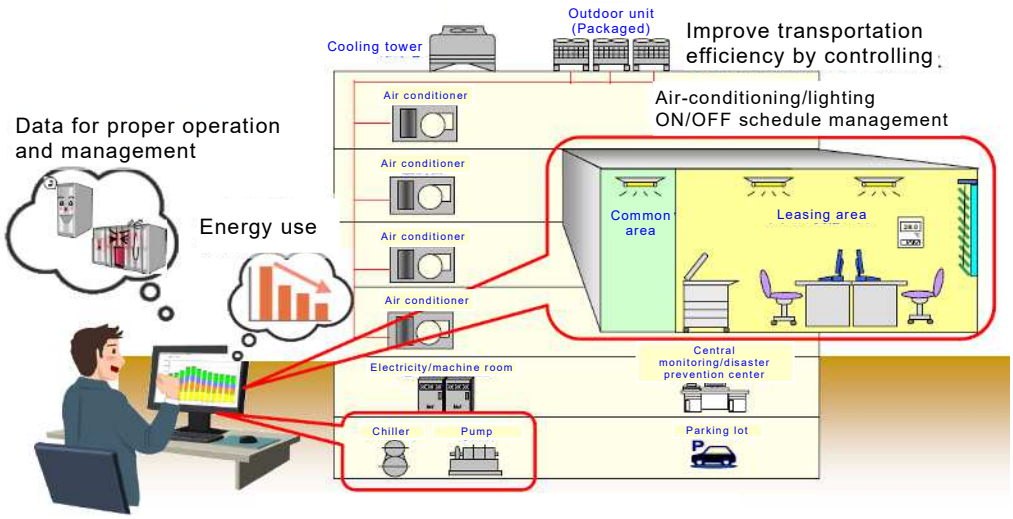
The introduction of BAS requires a detailed on-site survey and system design. Following the screening survey, two facilities, Trans Studio Bandung and Trans Studio Mall, are expected to benefit from the introduction of BAS in terms of the amount of electricity used, CO2 emission reductions and payback period on investment costs. As the next step, it is recommended that detailed operational data be acquired by installing loggers, etc. and designing a specific system to implement energy conservation controls. It should be noted that introducing BAS includes piping modification work for some heat source plants, which may require partial shutdown of the heat source for a certain period.

3.2.4 Proposal to Introduce BEMS

A building energy management system (BEMS: Building Energy Management System) uses IoT technology to control air-conditioning, lighting, etc. in a facility for optimal energy management.

The system records, monitors, controls and operates energy consumption. By constructing an integrated system to optimize the indoor environment and energy performance, BEMS paves the way to operate equipment efficiently and reduce CO2 emissions. As a general rule, it is said that introducing BEMS can reduce energy consumption by 5 to 7%. It will also make it possible to visualize energy consumption, which will boost awareness of energy conservation.

Specifically, sensors and remote devices are placed in various facilities in the building (air-conditioning, lighting, ventilation, sanitation, power distribution, etc.) and connected to the BEMS center equipment via communication lines. Previously, only a limited amount of information could be obtained because communication protocols differed depending on the equipment and manufacturer. In recent years, however, communication protocols have become more standardized and it has become standard for buildings to obtain information via communication called BACnet or Modbus. When measuring energy use and equipment operation status, however, scope to understand and analyze not only the entire building, but also the system, floor, facilities and equipment, makes problem-solving easier. Accumulated data can not only be reflected in optimal operational settings, but also used to determine when equipment is aging and requires maintenance.



Source: Ministry of Economy, Trade and Industry

Figure 3-5 Concept of BEMS

Table 3-13 Energy management flow

Measurement, accumulation and visualization	- Measure power, water and temperature - Assessing equipment operating conditions
Analysis and diagnosis	- Identify problems by comparing accumulated data and differences from target values
Implementation of countermeasures	- Change ON/OFF settings and device output settings - Schedule settings and interlocking settings with facilities in other areas
Verification of effectiveness	- Effectiveness is confirmed by monitoring for a certain period. - Setup of modifications and additions

Source: Study team

One example of BEMS is IBMS SCADA, which Azbil Corporation is developing overseas (Figure 3-6), which can be linked to operations via mobile tools, immediately display surveillance camera video of areas where alarms have been triggered, transmit alarms and response guidance to operators' mobiles and inspect buildings within a 3D virtual space, among other applied system configurations.

During this screening survey, we confirmed scope to reduce electricity consumption and CO2 emissions by making the heat source control system more efficient as a component of the air-conditioning equipment, but introducing BEMS, which manages energy building-wide, is even more effective for further reduction. At the same time, introducing BEMS differs from energy-saving measures that are easy to understand, such as installing solar panels and switching to LED lighting and is not yet widely understood.

Source: Azbil Corporation

Figure 3-6 IBMS SCADA features

3.2.5 Strategies for Commercialization

The table below summarizes similar projects in Indonesia involving consideration of model projects, including cases involving an upgrade to high-efficiency equipment and utilization of ESCO projects. In Indonesia, there are many cases of upgrading to high-efficiency equipment and introducing energy management systems for air-conditioning and cooling facilities in factories and commercial buildings. The first issue to be addressed when implementing a project is financing and the ESCO business scheme described below is highly advantageous in terms of reducing the financial burden on the client side, including the initial investment. Conversely, the smaller the energy reduction, the longer the payback period. This is why the energy-saving methods adopted tend to be biased and those that serve to supplement energy-saving effects, such as introducing insulated glass, for example, tend not to be adopted. Also, items that require considerable time for installation or renewal work, or those that may affect the production line, also tend to be unsuitable. In the following sections, we will discuss the forms of ESCO projects, the current status of ESCO projects in Indonesia and issues that need addressing when utilizing ESCO projects.

Most of the JCM facility subsidy projects in Indonesia are utilized for solar and small-scale hydroelectric power generation projects, or facility upgrades of large-scale plants. As we learned

from operator interviews during the screening survey, it is important to note that the application procedures and long-term monitoring required for the JCM facility subsidy projects are considered an unworthy burden for operators on the scale assumed in the model project.

According to PLN's March 2022 data, the electricity rate is Rp.1,445 per kWh (about 12.8 yen), which is lower than other Southeast Asian countries and allows operators to save energy. However, the low electricity rates mean low savings for businesses on energy conservation projects, leading to a low return on investment and a long payback period. In addition, Indonesia has considerable market potential for renewable energy and national policy includes a priority to develop renewable energy to secure electricity. To introduce high-efficiency equipment and spread energy management, there is also a need to conduct educational activities that spawn increased awareness of energy conservation among citizens and businesses.

Table 3-14 Similar projects in Indonesia

Project	Contents
Installation of high-efficiency equipment and BEMS in shopping malls, etc. through ESCO projects  Implementing company: Azbil Corporation	① Pondok Indah Mall 2 (shopping mall) Reduction in electricity consumption: 1,920 MWh/year ② Puri Indah Mall (shopping mall) Reduction in electricity consumption: 1,260 MWh/year ③ PT. Bekaert Indonesia (plant) - Reduction in electricity consumption: 630 MWh/year - Control of heat source primary pumps, secondary pumps and cooling water pumps by VWV and introduction of a management system (BEMS)
Demonstration of the application of operation optimization technology to power plants Project  Implementing company: Azbil Corporation Implementation period: 2014-2018 fiscal year	Project Site: Pertamina Cilacap Refinery (Central Java) - JCM credits issued: 34,956 t-CO2 - Reduction in power consumption: approx. 4%. - Implemented as a 'private-sector-led low-carbon technology diffusion promotion project' by NEDO - The 'coordinated control' technology, one of the advanced optimization technologies, was introduced to the refinery plant (boiler and turbine facilities) to optimally control the load of each boiler and turbine while ensuring a stable supply of steam and electricity to the manufacturing facilities, thereby minimizing the energy consumption of the entire power plant.
Energy savings in plant air-conditioning and process cooling by introducing high-efficiency compressors Implementing company: Ebara Refrigeration Systems Co. Adoption year: 2013	Project site: PT. Primatexco Indonesia plant (Central Java) - Assumed GHG emission reduction: 117 t-CO2/year - JCM credits issued: 122 t-CO2 - Implemented as a subsidized project for JCM facilities by the Ministry of the Environment - Replace refrigeration equipment with high-efficiency compressors, economizer cycles and refrigerant supercooling cycles to save energy.

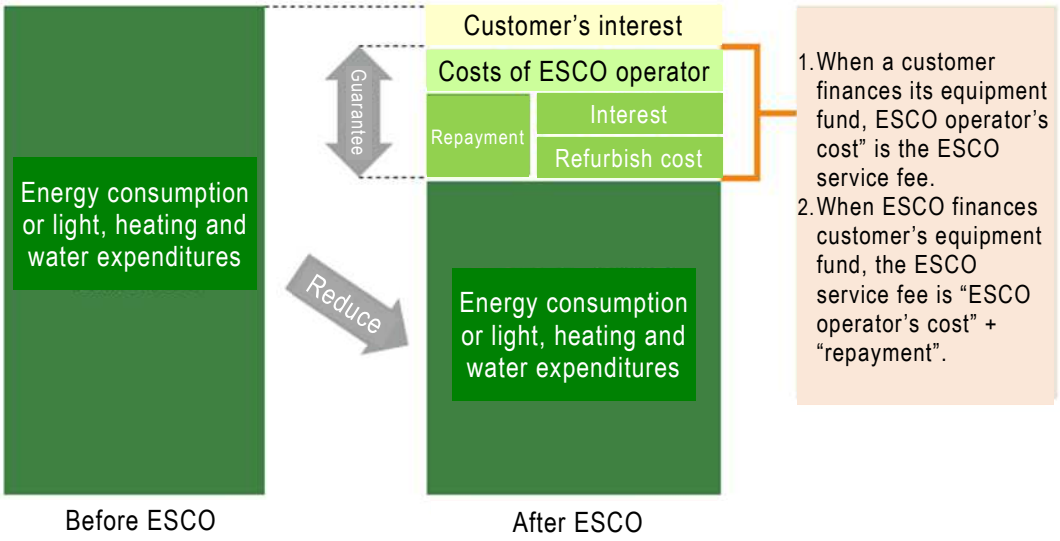
Optimal control of compressors and review of piping system in a paper mill Implementing company: Azbil Corporation Year of implementation: 2014	Business Site: PT. Aspex Kumbong (Suburb of Jakarta, West Java) - Reduction in power consumption: approx. 8.5%. - Seven compressors used to be in constant operation for three paper machines, but after the piping and integrated compressor control were reviewed, four to five compressors now suffice to meet the required volume, which also reduces the burden on monitoring personnel.

Source: Study team

（1） Outline of ESCO

1) Outline of ESCO

An ESCO (Energy Service Company) business is one in which the business reduces utility and water costs for its customers through energy-saving improvements and is compensated based on the results thereby obtained. By concluding a volume contract, called a performance contract, between the ESCO entrepreneur and the client, the ESCO entrepreneur is compensated for the energy savings achieved through the project. If the energy-saving effect is not achieved and the client suffers a loss, the ESCO operator will compensate the client accordingly.



Source: Japan Association for the Promotion of ESCO and Energy Management (JAESCO)

Figure 3-7 Relationship between energy savings effects and guarantees in ESCO

2) Performance Contracts

By concluding a performance contract, the ESCO entrepreneur assumes the risk of guaranteeing energy conservation effects and reduces the guarantee risk by proposing optimal energy conservation technology for the customer. At the same time, the customer is reassured that they will achieve energy conservation effects, establishing a win-win relationship for both parties. The table below summarizes the activities of the ESCO project in each phase from its planning stage to its introduction and operation.

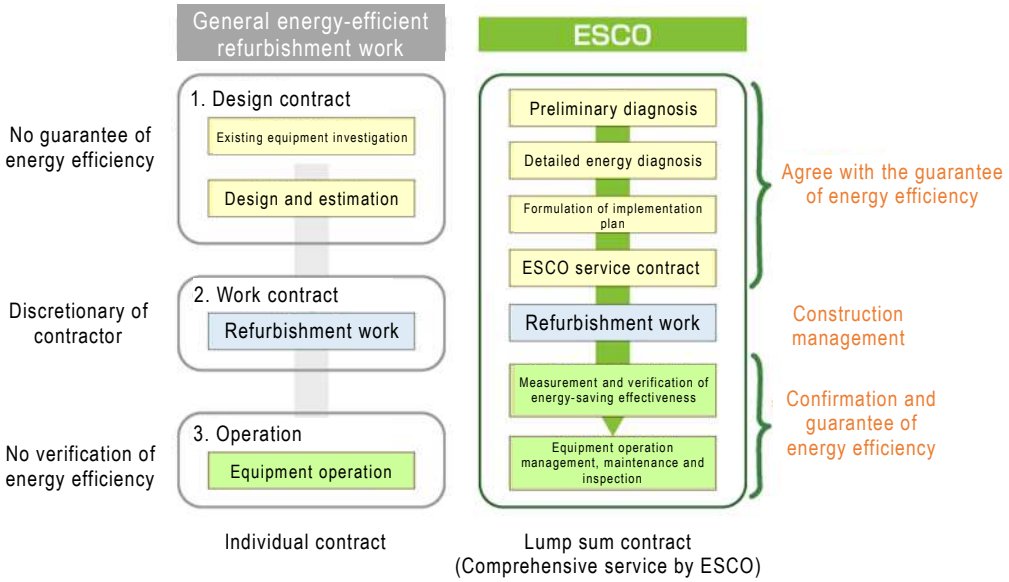
Table 3-15 Implementation details for each project stage

Stages	Contents
Planning	Based on the energy conservation diagnosis, the ESCO entrepreneur selects and proposes ideal energy conservation technology for the customer while considering all energy conservation options.
Design	Once a performance contract has been concluded, the ESCO operator guarantees the energy conservation effects. Responsible operation and management can be expected and at the design stage, the performance of the energy conservation technology to be employed will be estimated appropriately and the designer will reconsider their own proposal strictly to determine the potential energy conservation effects achievable.
Construction	Good or bad construction impacts considerably on the actual energy conservation effect. By concluding a performance contract, the ESCO entrepreneur will strictly manage the construction to ensure the initial design performance and the client can leave the construction to the ESCO entrepreneur with peace of mind.
Operation	Once operation and management begin, the ESCO entrepreneur conducts measurement and verification and reports the energy conservation effects to the customer. The customer then compares the energy conservation effects guaranteed by the ESCO entrepreneur with those reported, confirms the level of achievement, then determines the ESCO service fee. Measurement and verification are important, not only for determining the energy conservation effects, but also for adjusting optimal facility operation and management methods and reconfiguring and are indispensable for continuing efficient operation.

Source: Study team

3) Business Features

The difference between general energy conservation renovation work and the comprehensive services of an ESCO project is shown in the figure below. It is characterized by the fact that throughout each phase, planning and management are realized with awareness of energy conservation effects and smooth operation and management.



Source: JAESCO

Figure 3-8 Comparison of general energy conservation retrofits and ESCO projects

（2） ESCO in Indonesia

1） Background and Laws and Regulations

The history of the ESCO business in Indonesia is said to have begun in the late 1980s when PT. Koneba (now PT. Energy Management Indonesia), a state-owned company established by the Indonesian government, focused on energy conservation and management. Subsequently, despite the lack of significant progress for an extended period, in November 2009, Decree No.70/2009 on energy efficiency and conservation was enacted and Article 12 stipulates that 'businesses that consume more than 6,000 TOE of oil equivalent primary energy per year must appoint an energy manager, conduct energy audits and implement best practice in energy efficiency and conservation in buildings', effectively encouraging ESCOs to enter the market. and implement best practice in energy conservation in buildings. Presidential Decree No.13 of 2011, meanwhile, mandated that government ministries and local government office buildings should implement best practices in energy conservation measures and report on building energy consumption every six months. In 2012, Ministerial Decree No. 14 of 2012 on Energy and Mineral Resources on energy management was enacted, implementing the aforementioned Decree No. 70 of 2009, once again requiring energy consumers above 6,000 TOE to implement energy management and energy consumers below 6,000 TOE to implement energy management voluntarily.

In April 2011, the Indonesian ESCO Association (APKENINDO) was established to bridge the gap between ESCO providers, government and industry in Indonesia. 25 ESCO providers are members of APKENINDO as of 2018. in 2016, the implementation of ESCO projects, Ministerial Decree No.14 on Energy and Mineral Resources stipulated how ESCO business should be defined, the form it should take, the definition of the Energy Savings Performance Contract (ESPC) and the registration for ESCO operators and set out a roadmap for energy savings between users and ESCO operators based on cost-sharing. Below table summarizes ESCO related regulations in Indonesia.

Table 3-16 ESCO laws and regulations in Indonesia

Laws	Main Contents
Decree No.70 of 2009 on Energy Conservation	・(Article 12) End-users consuming more than 6,000 TOE of oil equivalent primary energy per year must appoint an energy manager, conduct energy audits and implement energy conservation best practices. ・Incentives include energy conservation level labeling, tax incentives, reduced state taxes, tariff incentives, lower interest rates from the banking sector and free energy audits under the Public-Private Partnership Program on Energy Conservation.
Presidential Decree No.13 of 2011	・Requires government ministries and local government office buildings to implement best practices for energy conservation measures and report on building energy consumption every six months.
Minister of Energy and Mineral Resources Decree No.14 of 2012 on Energy Management	・A Ministerial Decree to implement the regulations of Decree 70 of 2009, reaffirming the mandatory implementation of energy management for energy consumers above 6,000 TOE and voluntary implementation for energy consumers below 6,000 TOE.

Ministerial Decree No.14 of 2016 of the Minister of Energy and Mineral Resources on ESCO Projects	・An ESCO firm is defined as "an Indonesian legal entity that provides energy efficiency service projects in energy efficiency projects based on energy efficiency performance contracts" (Article 1) and the elements comprising an ESCO project are (1) the energy efficiency concept and planning, (2) energy audits, (3) energy efficiency (2) financing for projects, (3) services related to the installation and development of energy efficiency, (4) operation, monitoring and maintenance of energy facilities and (6) measurement and verification (M&V) of energy efficiency performance (Article 2).

Source: Study team

2） Incentives and disincentives to businesses

The aforementioned Decree No.70 of 2009 establishes incentives and disincentives for businesses for energy management. However, none of the tax incentives have been implemented to date. This is considered attributable to a lack of coordination between the two ministries, as the Ministry of Energy and Mineral Resources has the authority to provide incentives, but the authority to grant tax breaks and investment subsidies is under the Ministry of Finance. The ministry has also not issued the necessary policies, regulations and guidelines for penalties and energy supply shutdowns.

Table 3-17 Incentives and disincentives to businesses

Incentive (Article 20)	・ Tax incentives and local tax credits, reductions and exemptions for energy-efficient equipment ・ Reduction of import duties on energy-saving equipment ・ Low-interest financing for energy-saving investments ・ Free government-paid energy audits
Disincentive (Article 22)	・ Written recommendations ・ Media releases ・ Fine ・ Reduction in energy supply

Source: Study team

3） ESCO Business in Indonesia

An ESCO business is defined in the aforementioned Energy and Mineral Resources Ministerial Decree No.14 of 2016 on ESCO Businesses as "A company that identifies, develops, implements and finances energy conservation projects at energy-consuming facilities on the basis of performance contracts." There are two kinds of performance-based financing mechanisms used by ESCO projects worldwide: shared savings and guaranteed savings, of which the former is more common.

① Shared Saving

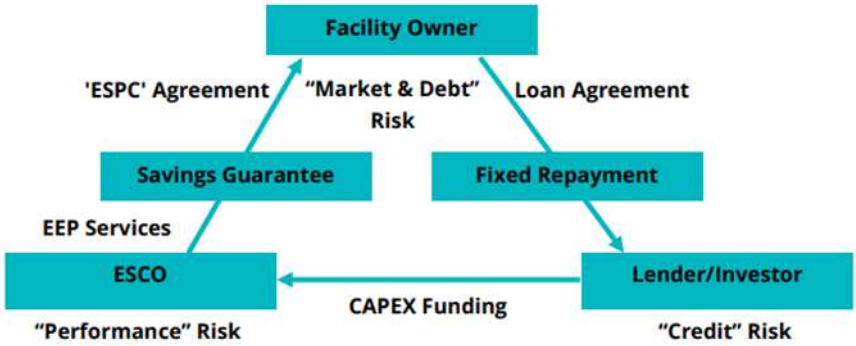
A structure in which the ESCO operator makes the initial capital investment in the project and assumes full responsibility for repaying the lender.

Source: "Diagnostic Review and Analysis of Energy Efficiency Development in Indonesia"
The Energy Transition Partnership, 2022

Figure 3-9 Shared saving

② Guaranteed Saving

A mechanism whereby the facility owner receives financing for the project directly from the lender and guarantees that the ESCO operator will realize sufficient profits for the facility owner.



Source: "Diagnostic Review and Analysis of Energy Efficiency Development in Indonesia"
The Energy Transition Partnership, 2022

Figure 3-10 Guaranteed saving

In Indonesia, a small number of small-scale projects with shared saving scheme have been implemented as ESCO projects.

（3） Challenges of ESCO in Indonesia

1） Financing

Local financial institutions evaluate energy-saving projects based on the perceived high risk, small transaction size, small market potential, high transaction costs, project risks and cash flow benefits and are reluctant to finance then, partly because they lack the necessary internal evaluation capacity.

To finance energy conservation programs, ESCO operators still rely on traditional financing schemes through financial institutions. However, many local financial institutions apply the traditional asset-based approach to energy efficiency and conservation projects, requiring full collateral for the entire loan amount. Since financial institutions do not recognize the value of future cash flows generated through energy-efficiency projects, ESCO operators must either raise funds from existing credit or pledge additional marketable asset collateral or repayment guarantees, making it difficult to obtain financing at favorable (low-cost) terms. ESCO operators in Indonesia are generally small- and medium-sized enterprises (SMEs) with limited credit track record and capital resources to develop energy-efficiency and conservation projects through equity capital. While low-cost financing is often required to implement projects, a significant gap remains between the traditional financing practices of local financial institutions and the project-based financing required by ESCO operators.

2） Technology and know-how

Insufficient skills of ESCO providers and consultants to identify energy efficiency and conservation opportunities through energy audits, including baseline energy consumption of the facility, estimated reductions through applying energy efficiency and conservation technologies and measurement and verification (M&V) plans for energy efficiency and conservation measures. The estimated energy savings are unreliable and there is a lack of experience and technical capacity to conduct investment grade audits (IGAs) based on project plans, which is necessary to structure and finance projects. According to the Ministry of Energy and Mineral Resources of Indonesia, between 2014 and 2018, 28 IGAs prepared by local consultants were examined and it emerged that not a single project had been realized. In addition, the Indonesian ESCO Association (APKENINDO) was established in 2011, and 25 ESCO operators have joined as of 2018. It seems that they were engaged in activities to promote ESCO in Indonesia, but they are currently in a suspended state.

As seen above, although the government is developing a system to promote ESCO projects, the business environment is still in developing, and further awareness-raising and technical capacity-building are needed.

Chapter 4　Promoting Energy Saving of Infrastructure System

During the first-year survey of the project, research was carried out about the current situation and the development plan for street lighting in Bandung City, and reduction of power consumption and CO2 emission through the conversion of non-LED lighting to LED was estimated. In this fiscal year, with understanding of the development status of street lighting and the latest information about the plan, we studied the public procurement system for future project development, based on the assumption that Japanese companies would participate. We also propose the introduction of smart LED, which is an area where Japanese companies have advantage.

4.1　Overview of the Survey in the First Year of the Project

（1） Current State of Roads and Street Lighting in Bandung

The current state of roads and street lighting in Bandung is as shown below.

Table 4-1　Current condition of roads and street lighting in Bandung

Item	Details
Area of the city	16,729 m2
Number of roads	38,000
Total length of roads	1,254.87 km
Width of roads	5.6 m
Number of streetlights	45,50　including 28,952 LED lights and 16,555 non-LED lights

Source: Study team

Source: Study team

Figure 4-1　LED streetlights in Bandung

（2） Reduction of Power Consumption and CO2 Emissions through Conversion to LED Streetlights

During the survey in the first year of the project, we estimated the reduction of power usage and CO2 emissions through the conversion of existing 16,555 non-LED streetlights to LED. Power usage reduction was estimated to be 1,679,515 KWh and CO2 emission reduction was estimated to be 1,253 t-CO2/year.

Table 4-2 Power reduction and CO2 emission reduction through conversion to LED

Lighting type	Consumed power		Quantity *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		Quantity *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)
				CO2 emission reduction*2	**120**	**1,253**	(t-CO2/year)

*1: Quantity and LED power consumption: Based on the materials provided by Bandung City
*2: Annual CO2 emissions = electricity consumption (KWh)/day x 365 (days) x CO2 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")

Source: Study team

4.2 Current State and Development Plan for Street lighting in Bandung City

4.2.1 Current State of Street Lighting

(1) Installation Status of Streetlights in 2022

According to the data collected by the Department of Transportation Bandung at the end of December 2021, 46,629 streetlights (including 30,375 LED lights, 14,688 high pressure sodium lights, and 1,566 other types of lights) had been installed by the end of 2021. Moreover, according to the results of interviews with Bandung City, 51,358 streetlights had been installed by the end of 2022. Since all the (4,729) streetlights installed in and after 2022 were LED, the number of LED streetlights as of the end of 2022 is estimated to be 35,104.

(2) Target Number of Streetlights to be Installed in 2023

While the revised target number of LED streetlights to be installed in the city is 68,984, the target number of LED lights to be installed in 2023 is 58,762. If this target is achieved, the remaining number of LED streetlights to be installed will be 10,222 by the end of 2023. The street lighting improvement rate will be 85,18% and the LED conversion rate will be 71,82%. According to the RPJMD 2019-2023, 2,500 LED streetlights would be installed each year; in reality, the number of streetlights installed has been two or three times higher (5,000-7,500) in recent years. The reasons for such sharp increase are not clear. If streetlights installation continues at this pace and 4,000-5,000 lamps are installed every year, the target number will be achieved in 2026.

Table 4-3　Number of streetlights installed in 2021-2023

Item	2021	2022	2023 (Target)
Target number of streetlights to be installed (a)	67,000	67,000	68,984
Number of streetlights already installed (b)	46,629	51,358	58,762
LED (c)	30,375	35,104	42,207
Non-LED (d)	16,254	16,254	16,254
Street lighting improvement rate (b)/(a)	69.60%	76.65%	85.18%
LED conversion rate (c)/(d)	65.14%	67.76%	71.82%
Increase of streetlights (compared with previous year)	—	4,729	7,404

Source: Documents provided by Bandung City

4.2.2　Street Lighting Improvement Policy and Plan for 2024 and Later

（1） Regional Medium Term Development Plan (RPJMD) 2024-2028

Development projects of Bandung City are carried out according to the Regional Medium Term Development Plan (RPJMD). Improvement of LED streetlights also needs to be consistent with the RPJMD. However, when we checked the status of the next RPJMD during the survey period, it was found out that there was no draft at that time. According to the Department of Transportation Bandung, the policy for LED street lighting improvement is as follows.

- There is no draft of the RPJMD 2024-2028 at this point. A detailed plan or budget plan concerning the improvement of LED streetlights for 204 and later has not been developed. These plans will be considered after the election of next mayor scheduled in 2024.
- There is no detailed plan concerning the installation of new streetlights and no roads or areas seem to require urgent improvement. Therefore, it will be more realistic to replace existing streetlights with LED streetlights, although there is no concrete plan for LED streetlights, either.
- Compared with the unlikely scenario that new roads will be built in Bandung, it is more likely that LED streetlights will be installed/added on existing roads.

（2） Rate of LED Streetlights and Population Density in Each Area

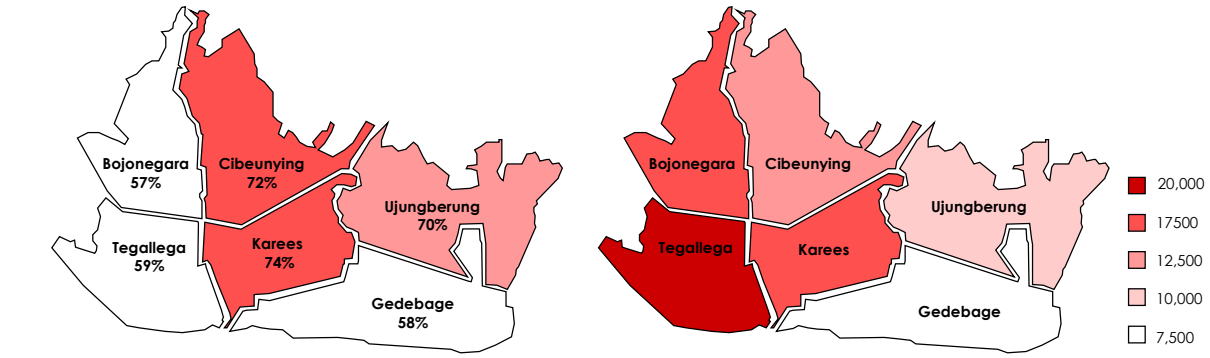
Looking at the percentage of LED streetlights among those already been improved, based on the data collected at the end of December 2021, Karees is most advanced in the use of LED and Bojonegarati is the most behind. Looking at the number of high-pressure sodium lamps, Gedebage has the highest number and Karees has the lowest number.

Table 4-4　Number of streetlights installed and types of lamps

Area	No. of streetlights	LED	No. of high-pressure sodium lamps	No. of other types of lamps	LED rate	Population	Population density
Bojonagara	6,372	3,611	2,026	735	57%	364,143	17,225
Cibeunying	9,717	6,953	2,612	152	72%	398,391	13,280
Tegallega	7,011	4,138	2,857	16	59%	555,501	21,292
Karees	7,692	5,676	2,012	4	74%	387,525	18,151
Ujungberung	6,861	4,788	2,025	48	70%	225,043	10,467
Gedebage	8,976	5,209	3,156	611	58%	125,308	7,410
Total	46,629	30,375	14,688	1,566			

Source: Materials provided by Bandung City, population and population density based on the information on https://en.wikipedia.org/wiki/Bandung

The following figure shows the LED conversion rate and population density. The LED conversion rate in Tegallega, which has the highest population density, is as low as 59%, almost at the same level as Gedebage, which has the lowest population density. The figure is based on the data as of December 31, 2021. As all the streetlights that have been installed since 2022 are LED lamps, the LED conversion rate in all areas have become higher.



Conversion rate from conventional bulbs to LED　　Population density (population/km2)

Source: Study team

Figure 4-2　LED conversion rate and population density

（3） Improvement Policy of the Department of Transportation Bandung

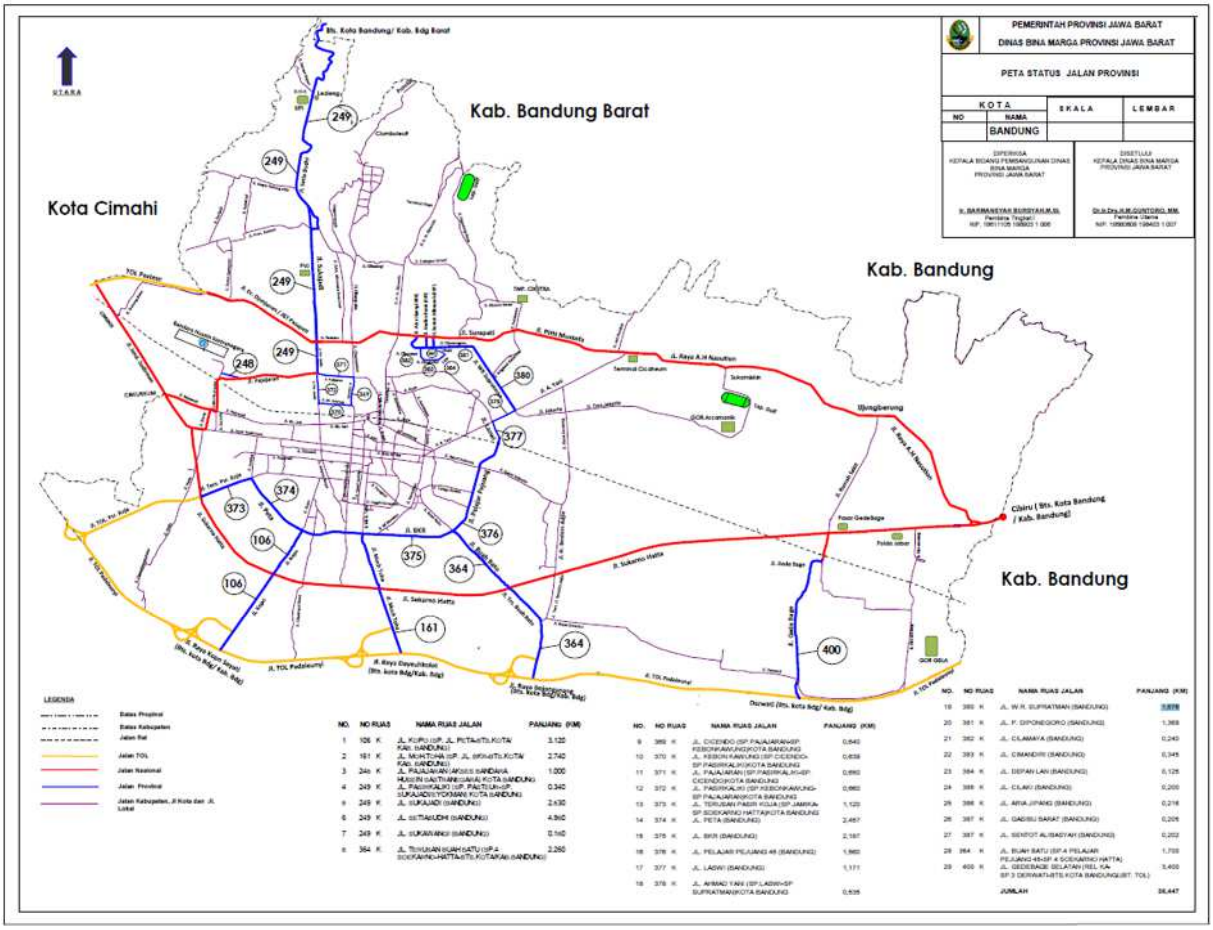
The Department of Transportation Bandung plans to improve streetlights on the 29 roads (mostly provincial roads) shown in the following figure and table. RPJMD 2019-2023 does not include these streetlights as the streetlights to be newly installed by 2023, and the areas and roads improved already do not overlap.

1） Installation of new LED streetlights

All the roads in Bandung have streetlights. However, street lighting installation is not consistent and some sections do not meet the law requirement of 20m intervals. Therefore, out of the 29 roads in the city, the department wants to add new LED streetlights to the sections where the intervals are larger than 20m.

2） Conversion of existing Streetligsts to LED

The priority area for the conversion of existing lamps to LED is Cibeuying, located in the center of Bandung (roads around Haji Juanda Street). Street lighting improvement on Haji Juanda Street has been completed.



Source: Documents provided by Bandung City

Figure 4-3 Locations of candidate roads for new LED street lighting installation

Table 4-5 List of candidate roads for new LED street lighting installation

No.	Road No.	Road	Distance (km)
1	106 K	JL. KOPO (SP. JL. PETA-BTS.KOTA /KAB. BANDUNG)	3.120
2	161 K	JL. MOH.TOHA (SP. JL. BKR-BTS.KOTA/KAB. BANDUNG)	2.740
3	248 K	JL. PAJAJARAN (AKSES BANDARA HUSEIN SASTRANEGARA) KOTA BANDUNG	1.000
4	249 K	JL. PASIRKALIKI (SP. PASTEUR-SP. SUKAJADI/EYCKMAN) KOTA BANDUNG	0.340
5	249 K	JL. SUKAJADI (BANDUNG)	2.530
6	249 K	JL. SETIABUDHI (BANDUNG)	4.980
7	249 K	JL. SUKAWANGI (BANDUNG)	0.180
8	364 K	JL. TERUSAN BUAH BATU (SP.4 SOEKARNO-HATTA-BTS.KOTA/KAB.BANDUNG)	2.260
9	369 K	JL. CICENDO (SP.PAJAJARAN-SP. KEBONKAWUNG)KOTA BANDUNG	0.640
10	370 K	JL. KEBON KAWUNG (SP.CICENDO- SP.PASIRKALIKI)KOTA BANDUNG	0.639
11	371 K	JL. PAJAJARAN (SP.PASIRKALIKI-SP. CICENDO)KOTA BANDUNG	0.650
12	372 K	JL. PASIRKALIKI (SP.KEBONKAWUNG- SP.PAJAJARAN)KOTA BANDUNG	0.660
13	373 K	JL. TERUSAN PASIR KOJA (SP.JAMIKA- SP.SOEKARNO HATTA)KOTA BANDUNG	1.120
14	374 K	JL. PETA (BANDUNG)	2.457
15	375 K	JL. BKR (BANDUNG)	2.187
16	376 K	JL. PELAJAR PEJUANG 45 (BANDUNG)	1.560
17	377 K	JL. LASWI (BANDUNG)	1.171
18	378 K	JL. AHMAD YANI (SP.LASWI-SP SUPRATMAN)KOTA BANDUNG	0.535
19	380 K	JL. W.R. SUPRATMAN (BANDUNG)	1.676
20	381 K	JL. P. DIPONEGORO (BANDUNG)	1.369
21	382 K	JL. CILAMAYA (BANDUNG)	0.240
22	383 K	JL. CIMANDIRI (BANDUNG)	0.345
23	384 K	JL. DEPAN LAN (BANDUNG)	0.125
24	385 K	JL. CILAKI (BANDUNG)	0.200
25	386 K	JL. ARIA JIPANG (BANDUNG)	0.216
26	387 K	JL. GASIBU BARAT (BANDUNG)	0.205
27	387 K	JL. SENTOT ALIBASYAH (BANDUNG)	0.202
28	364 K	JL. BUAH BATU (SP.4 PELAJAR PEJUANG 45-SP.4 SOEKARNO HATTA)	1.700
29	400 K	JL. GEDEBAGE SELATAN (REL KA-SP.3 DERWATI-BTS.KOTA BANDUNG/JBT. TOL)	3.400
		Total:	38.447

Source: Documents provided by Bandung City

4.2.3 Legal System Related to LED Street Lighting Installation

As mentioned earlier, although the street lighting installation plan has not been defined in the next mid-term development plan, PJMD 2024-2028, the installation policy of the Department of Transportation has been clarified. For the future project development, we need to narrow down candidate roads, identify the scale of the project, develop an introduction plan that covers financing, and consider cost effectiveness. On the other hand, to participate in or register products for the public procurement of Bandung City, Japanese companies need to be aware of the city's public procurement system, procurement restrictions, etc. and take necessary procedures and measures in advance. Therefore, we will explain laws, regulations, and policies that might relate to the improvement of streetlights through public procurement in the following sections.

（1） Laws and Regulations Related to the Improvement of Streetlights

Improvement of street lighting equipment is stipulated in the Transport Minister's Regulation PM27of 2018, which includes detailed provisions concerning types of street lighting equipment (self-lighting or cooperative lighting), development of communication standards, types of lamps to be used, how to supply electric power, lighting time and dimming time, pole height restrictions by road type, etc. While there are no restrictions on power consumed by the lamps, illuminance and luminance are specified depending on the road type and level of contact with pedestrians. Definitions of road types and average illuminance based on road type and level of contact with pedestrians are shown below.

Table 4-6 Road types and average illuminance

Road Type	Definition
Highway	Public road without intersections for continuous traffic. Roadways are completely controlled and side strips have fences
Arterial road	Public road for long-distance transportation at a high average speed that serves as a major transportation mode
Connecting road	Public road for middle-distance transportation at a middle average speed that provides divided transportation
Regional road	Public road for short-distance transportation at a low average speed that provides regional transportation
Neighborhood road	Public road for short-distance transportation at a low average speed that provides neighborhood transportation

Road type and level of contact with pedestrians		Illuminance based on type of road surface			Equity ratio
Road type	Level of contact with pedestrians	Type of road coating R1	Type of road coating R2, R3	Type of road coating R4	
		Lux	Lux	Lux	Eavg/Emin
Highway	No contact	6	9	8	3
Arterial road	High	12	17	15	3
	Medium	9	13	11	3
	Low	6	9	8	3
Connecting road	High	8	12	10	4
	Medium	6	9	8	4
	Low	4	6	5	4
Regional road	High	6	9	8	6
	Medium	5	7	6	6
	Low	3	4	4	6
Neighborhood road	High	4	6	5	6
	Medium	3	4	4	6
	Low	2	3	3	6

Source: Abstract from Transport Minister's Regulation 2018 PM27 Annex I

（2） Presidential Decree Concerning Public Procurement

Public procurement has been stipulated in the Presidential Decree No.80 of 2003, the Presidential Decree No.54 and 2005, and the current Presidential Decree No.16 of 2018 with the revision No.12 of 2021. Bandung City used to have its own procurement regulations but have been following the Presidential Decree No.16 of 2018 since it was issued. Below are other related regulations issued by the Procurement Agency.

- National Procurement Agency Regulation No.9 of 2018: Guideline for public procurement using suppliers
- National Procurement Agency Regulation No.11 of 2018: About e-catalogues
- National Procurement Agency Regulation No.122 of 2022: About procurement using e-catalogues

（3） Policies for Foreign Products

1） Policy to give priority to domestic products in public procurement (P3DN)

The government of Indonesia has been implementing a policy to give priority to domestic products (P3DN) since 2018. The policy aggressively promotes the use of Indonesian materials and parts through a program to improve industrial competitiveness. Such measures as provision of TKDN certificates showing the rate of domestic materials/parts contained in a product (TKDN: Tingkat Komponen Dalam Negeri) are taken to improve competitiveness and promote the use of domestic products. As the policy specifies the rate of domestic materials/parts to be satisfied by the items procured by the government, it is said that it has impacts on many products, including products of Japanese companies. There are mainly two cases where the TKDN certificate is required and one is the case of government procured items. Government procurement is defined as procurement activities carried out by government organizations including ministries and agencies and local organizations funded by national or local budgets, and procurement activities by Bandung

City are included. Government procured items have to be domestic products, which are defined as products of 40% or higher TKDN. The second case is about specific products of which domestic product rate is specified by the Ministry of Industry, including mobile phones (Minister of Industry Regulation No.29 of 2017), solar power generation equipment (Minister of Industry Regulation No.4 of 2017), and battery-electric vehicles (Minister of Industry Regulation No.27 of 2020). Domestic product rate calculations are specified for each item. Therefore, attention should be given in case solar power street lighting is proposed.

2） Handling of imported products in government procurement

Despite the policy to give priority to domestic products (P3DN), Article 66 of the Presidential Decree No.16 of 2018 allows procurement of imported products in the following cases.

- In case the item cannot be produced in Indonesia
- In case domestic production cannot meet demand (the item cannot be replaced with a domestic item)

（4） Public Procurement System

Public procurement can be done through E-purchasing, Direct Procurement, Direct Appointment, Quick Tender, or Tender. Procurement is carried out in a method that meets conditions.

Table 4-7 Public procurement methods

Procurement method	Conditions
1) E-purchasing (E-catalogue)	・ In case there are standardized products/services or repetitive demand (Products and services requiring customization of price or specification are not qualified.) ・ For products, constructions and other services included in the E-catalogue ・ For the products and services for which a minister, a head of a government agency, or a head of a local government decides to carry out procurement using the E-catalogue, procurement has to be done with the E-catalogue. For other items, procurement is carried out in one of the methods described in 2) to 5). ・ Whether to use the E-catalogues is decided in consideration of economic equality and opportunities for small and medium-sized businesses and local companies. ・ Procurement of which public offering price is 2.5 billion IDR has to be carried out with small and medium-sized businesses (unless it requires a high level of technological strength that cannot be found in small and medium-sized businesses).

2) Direct Procurement	・ Unstandardized products and services (of which technical specifications and price need negotiation) ・ Up to 200M IDR (about 1.75M yen) Less than 50M IDR: Any item/service can be directly purchased. (Receipts are required.) 50M – 200M IDR: Suppliers have to submit price quotation and specifications. Requires quotes from two or more suppliers.
3) Direct Appointment	Procurement of products, constructions and other services under certain conditions (stipulated in Article 38-5 of Presidential Decree No. 12 of 2021)
4) Quick Tender	・ Specifications and quantity are specified in detail. ・ Participating corporations are registered in SIKap. SIKap (Sistem Informasi Kinerja Penyedi) is a database of suppliers participating in public tender.
5) Tender	This method is taken for the procurement cases that do not meet the conditions described in 1)-4).

Source: Study team

（5） E-catalogue

As a result of the interviews with Bandung City, we learned that they had procured LED streetlights from suppliers listed on the E-catalogue and it would be easier for the city to select products using the E-catalogue. In order to promote the participation of Japanese companies, below is an overview of the E-Catalog and other information such as how to handle imported goods.

1） E-catalog

The e-catalogue is on a website (https://e-katalog.lkpp.go.id/) used by the government and its agencies when they procure goods and services, which includes lists of names, specifications, prices, etc. of goods and services. The government of Indonesia recommends that the central government (central government ministries and agencies and state institutions), state-owned companies, local government bodies, and other entities that use national or local government budget should procure goods and services from among those listed on the E-catalogue. In case the head of a public procurer (e.g., local government) limits the procurement method to the use of the E-catalogue, products that are not listed in the E-catalogue will not have a chance to be selected. The E-catalogue has three categories of “National”, “Local” and “Sectoral”. Different categories are managed by different organizations. Authorities are given to the Procurement Agency (LKPP) for the National category, local government management teams for the Local category, and management teams of ministries and agencies for the Sectoral category. The category manager considers “products for suppliers to register” and places notices and ads in the notice page of the E-catalogue to ask suppliers to register their products. Suppliers register their products that meet the requirements during a fixed application period. “Streetlight” is in the National category and the applications have been accepted since March 2022.

2） E-catalogue registration procedures

Under the Procurement Agency Order No.122/2022, suppliers register their products in the E-catalogue using an e-procurement system (SPSE: Sistem Pengadaan Secara Elektronik). Only Indonesian corporations can register their products because such documents as the business identification number and the articles of corporation are required to apply for a SPSE account. There are no restrictions on foreign-affiliated companies.

Table 4-8 E-catalogue registration procedures and necessary documents

Registration procedures	Documents required for application for SPSE account
1） Apply for SPSE account in the nearest E-procurement Service Office. 2） Obtain SPSE login ID. The ID will be commonly used for E-catalogue and SIKaP. 3） Enter detailed corporate information in SIKaP to get ready to register products in the E-catalogue.	・Taxpayer registration number (NPWP) ・Business identification number (NIB) ・Articles of corporation (Akte) ・Identification number (KTP)

Source: Study team

3） How to register products in the E-catalogue

The Presidential Decree No.16 of 2018 stipulated that products should be selected through bidding or negotiation to be registered in the E-catalogue. However, to encourage more suppliers to register their products, the Presidential Decree No.12 of 2021 abolished bidding and negotiation processes, simplifying the product registration process. The new registration process is as follows:

Table 4-9 E-catalogue product registration

1） The E-catalogue management team posts application guidelines on the E-catalogue website to ask suppliers to register qualified products.
2） Suppliers make online application for qualified products.
3） The management team checks whether the products meet the E-catalogue requirements.
4） After confirmation, products will be included in the E-catalogue.

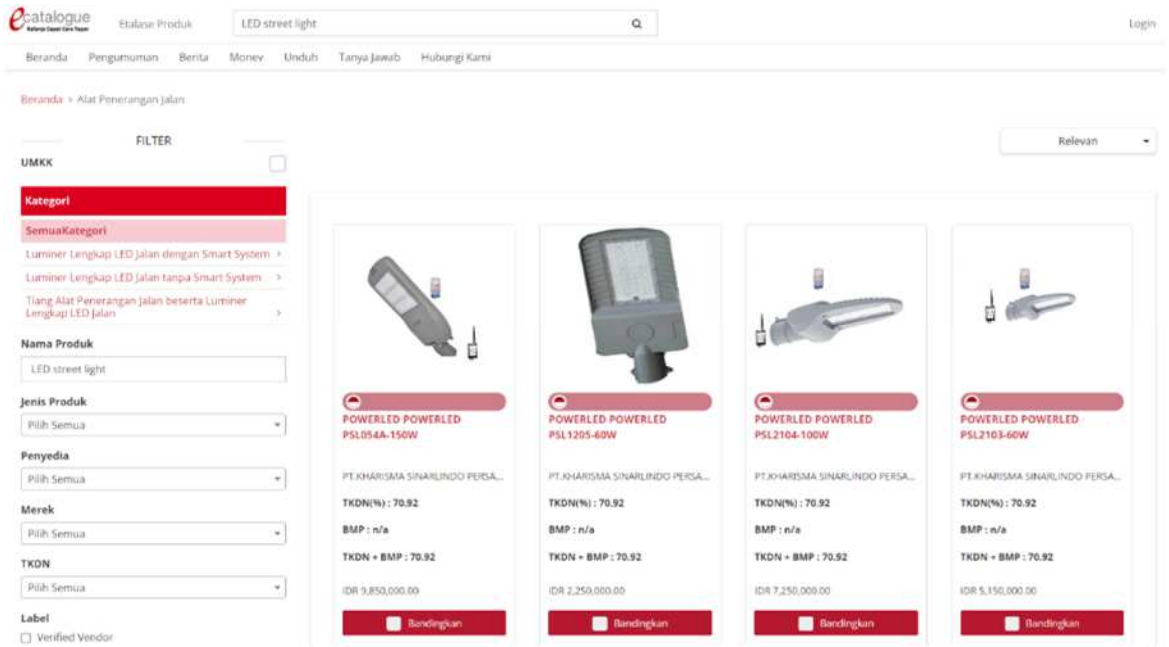
Source: Procurement Agency Regulation No.122 of 2022

4） E-catalogue registration contents and period

The E-catalogue contains such information as lists of products and services, types, technical specifications, TKDN, domestic products, SNI certification, eco-friendly products, country of origin, price, and provider information. The registration period is basically two years. However, the Procurement Agency Regulation No.122 of 2022 allows LKPP or the E-catalogue management team to remove registered products without notifying suppliers. According to a news report of November 2022, 14,161 products including imported products had been removed from the E-catalogue.

5） Registration of LED streetlights

The E-catalogue has 1,432 streetlights (62 imported items and 1,370 domestic items) registered (as of February 2023).



Source: Abstract from https://e-katalog.lkpp.go.id/

Figure 4-4 E-catalogue website (LED street lighting selection page)

6） Case where A public procurer purchases items via the E-catalogue

In case a public procurer (e.g., local government) purchases products via the E-catalogue, they are required to take one of the following actions to get the best prices from suppliers.

A) Price negotiation: Negotiate for lower prices than those listed in the E-catalogue especially for bulk purchases.

B) Mini competition: Ask two or more suppliers that have similar products to improve prices and select the one that shows better prices.

7） Handling of imported goods in the E-catalogue

According to Appendix II ‘K’ of the Procurement Agency Regulation No.122 of 2022, the P3DN policy is also reflected in the use of the E-catalogue. Especially for imported goods, there are provisions: “(2) In case foreign (imported) products can be replaced with domestic products, the products cannot be ordered from the E-catalogue”, and “(3) Foreign (imported) products can be ordered from the E-catalogue if domestic products cannot be used.” Therefore, in case Bandung City procures LED lamps via the E-catalogue, it is unlikely that imported products including Japanese products will be selected. In case the city intends to include imported products for procurement, a local company with import license shall be appointed as a vendor or agent, and products need be registered in the E-catalogue under the name of the company.

4.3 Proposal to Introduce Smart LED Street Lighting

4.3.1 Overview of Smart LED Street Lighting

（1） Overview of Smart LED Street Lighting

Smart LED street lighting uses an IoT network to make it possible to adjust LED lamp light-on and light-off time as well as illuminance to save energy and reduce CO2 emissions. It also contributes efficiency improvement, prevention of failure, and maintenance cost reduction, through consolidation of maintenance. Moreover, using cameras, microphones, sensors, 5G base stations, digital signage, speakers, etc., it can support operation of transportation facilities, measure traffic volume, guide traffic, prevent crimes, prevent disasters, and guide people at the time of disaster, eventually contributing to strengthening of the city. NEC Corporation estimates that, if light-on and light-off time is finely adjusted depending on the season and area and lighting time is reduced by an hour, CO2 emissions can be reduced by about 7%, which equals to annual reduction of about 1.8 tons per 100 streetlights.

（2） Cases of Smart LED Street Lighting Introduction by Local Governments, etc. in Japan

In Japan, some local governments have introduced smart LED streetlights or carried out verification projects. Focus areas can be disaster measures, crime prevention, local traffic or industrial development, depending on the geographical area, and the smart LED street lighting is expected to lead to a solution of such issues.

1） Introduction of smart LED street lighting to monitor rivers and detect road flooding

Suginami City has introduced the IoT street lighting system along the Kanda River, the station plaza in front of JR Asagaya Station, etc. for the purpose of real-time river monitoring and detection of road flooding. With such issues as rivers rapidly swollen by recently increasing localized torrential rain and large typhoons, the city needs to take flood control measures need in urban areas. The light system is expected to contribute to flood control to prevent river and road flooding and make the city safe and secure.

Source: https://jpn.nec.com/streetlight/case.html

Figure 4-5 IoT Street lighting system installed in Suginami City

2） Introduction of the smart LED street lighting system to improve safety and convenience of a shopping district

Roppongi Shopping District Promotion Association has installed 33 smart LED streetlights along

the main street in Roppongi. Sophisticatedly designed, the lamp system has data collection and information transmission functions, and the attached monitor shows shop information and congesting conditions in the shopping district. Using the attached camera and AI video analysis, the system can make real-time estimation of direction of movement, sex, and number of pedestrians. The association has also carried out a project to issue digital coupons on the street lighting monitors for the shops in the less crowded areas for the purpose of expanding visitors' activity area. The purposes of these efforts are analyzing visitors' attributes for product development and acquisition of new customer segments as well as ensuring safety and improving convenience for the visitors.

Source: https://jpn.nec.com/streetlight/case.html

Figure 4-6 Smart LED streetlight installed on a shopping street in Roppongi

3) Verification experiment of shop sales forecast and food loss reduction

Hirakata City of Osaka Prefecture has carried out a verification experiment for shop sales forecast and attraction of visitors to events, using data of people's flows in downtown. The city has introduced smart LED streetlights with a human image analysis system to automatically analyze number, sex, age, etc. of the passersby. In one concrete verification model case, sales forecast was tested for a bakery a few hundred meters away from a streetlight. AI learned relations between data of people's flows, day of the week and weather, and sales volume, to estimate bread sales volume. The result confirmed that the number of unsold bread pieces to be disposed of could be reduced by up to about 90%.

Source: https://jpn.nec.com/streetlight/case.html

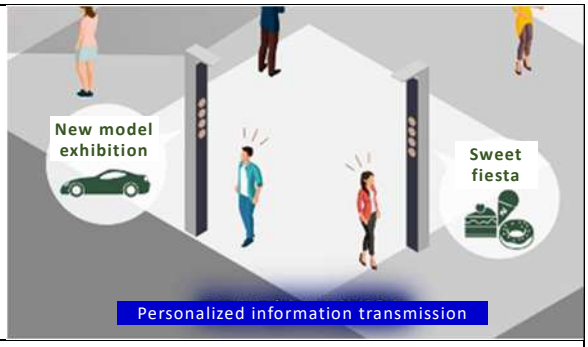
Figure 4-7 Smart LED streetlight introduced by Hirakata City

4.3.2 Candidate Equipment

（1） NEC

NEC's IoT street lighting system is a new network infrastructure device that collects information from the whole community using IoT and network technologies. Combined with AI and other technologies, the system contributes to the development of a community that is safe, comfortable, and energetic. Use of LED lamps and unified network management can improve efficiency of the management of a numerous number of streetlights. For example, fine adjustment of light-on and light-off time and illuminance for each season/area can reduce power consumption, and automatic remote diagnosis and parts replacement can avoid failures, leading to efficiency improvement of maintenance work. Moreover, through real-time monitoring of the whole community, the system fulfills at the time of a typhoon and other weather disasters such functions as monitoring of rivers, sending notifications about public transportation operation status, and evacuation guidance, to ensure safety and security of life.

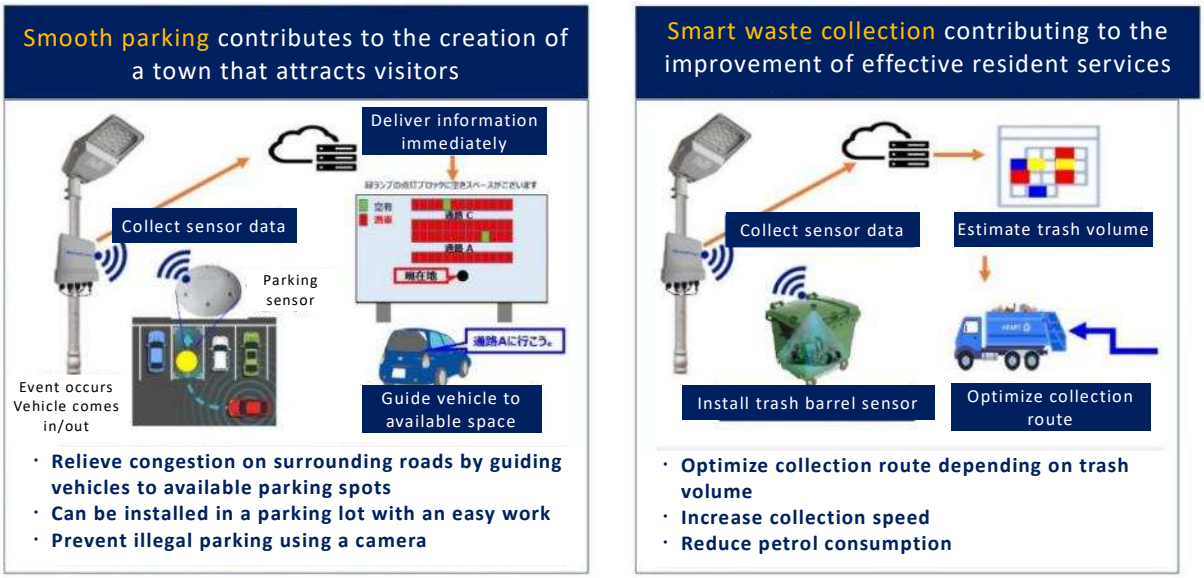
Table 4-10 Major features of the IoT street lighting system

	
① Provide unified management of streetlights with IoT network	② Attract visitors by grasping surrounding situations and providing information
	
③ Ensure safety and security of life through crime prevention, evacuation guidance, etc.	④ Serve as future infrastructure to support the society of 5G and automatic driving

Source: Abstract from NEC's website

（2） MinebeaMitsumi Inc.

There has been an increasing number of MinebeaMitsumi's high-efficiency LED road lamps with wireless functionality installed mainly in overseas countries, with 10,165 units installed in Cambodia in 2020 and a total of 37,300 units in Europe. Quantity of light can be remotely controlled via wireless communication. Electric power consumption is reduced through dimming control by about 90% compared to general mercury streetlights. A new system is under development to monitor lighting time and electric power consumption through unified management of street lighting data in the cloud as well as all the functions related to urban life using a combination of various sensors (including environment sensor and parking sensor), electricity meters, monitoring cameras, etc., contributing to the development of a smart city.



Source: MinebeaMitsumi Inc.

Figure 4-8 Cases of utilization of streetlights for smart city

（3） Smart Street lighting That Serves as a 5G Base Station

5G is a wireless communication standard expected to be a new infrastructure to realize automatic driving, high-resolution 4K/8K image data transmission, smart factory for optimizing the whole manufacturing process, and remote surgeries using robot arms. As 5G base stations do not cover a large area, it is said that antennas have to be installed for cells of about 100 to 300 meters to take advantage of its high-speed and large-capacity features. That means a vast number of base stations and antennas are required for full-scale implementation. Considering the area where streetlights are installed, it will be beneficial to the city if streetlights can also serve as 5G base stations.

（4） Considerations for Introduction of Smart Street Lighting

For the introduction of smart streetlights, consideration should be given to measures against privacy invasion possibly caused by the use of cameras and image analysis. In the aforementioned case of the Roppongi Shopping District Promotion Association, careful consideration was given to

privacy protection using the guidelines for the use of images taken by cameras, developed by the IoT Consortium of the Ministry of Economy, Trade and Industry and the Ministry of Internal Affairs and Communications, and the association also created its own guidelines. They also promote understanding among residents and visitors by educating relevant parties including neighborhood associations and municipalities and posting a notice on its website, “Photo images where individuals can be identified are immediately deleted, and nothing but statistical information about pedestrian traffic is stored.” Considering these existing cases, when smart streetlights are introduced, guidelines should be created concerning private information protection associated with the installation of smart lights and educational activities should be carried out.

4.3.3 Actions to Develop Project

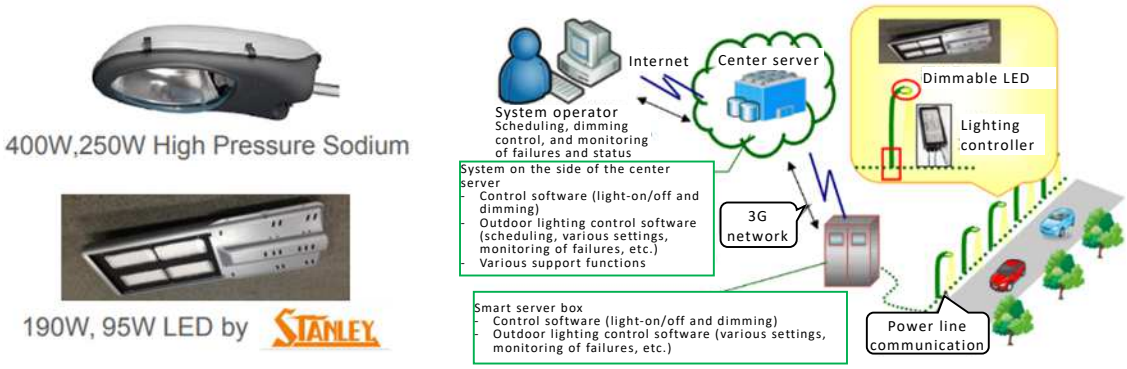
Through the survey conducted in the first year of the project, we estimated power consumption reduction and CO2 emission reduction and clarified the effects in case all existing non-LED streetlights are replaced with LED lamps. However, next RPJMD 2024-2028, which will be the basis for the improvement of streetlights, has not been established. Although the Department of Transportation Bandung has a policy, concrete plans and budget size are unknown, and it is not possible at this point to start proposing or considering a concrete plan for the installation of LED streetlights. On the other hand, LED streetlights have already been introduced in Indonesia through a JCM equipment subsidy project. Information of effects and considerations from a preceding project can be useful for the future study by Bandung City.

（1） Introduction of the Smart LED Street Lighting System in Industrial Parks

Karawang International Industrial City (joint venture by Itochu Corporation and Indonesian corporate group Sinar Mas), an industrial park where many Japanese companies operate, has introduced the smart LED street lighting system. Through conversion of existing streetlights (high-pressure sodium lamps) to LED and introduction of a system for remote control and monitoring of LED lamps, lighting can be adjusted depending on brightness and other factors of the surrounding environment and energy consumption and CO2 emissions have been significantly reduced, compared to conventional lamps. It is said that careful consideration should be given to the process management based on weather and local practices and coordination with a power company for the installation of smart boxes.

Table 4-11　Overview of the project

Project	Introduction of the Smart LED Street lighting System to Industrial Park (JCM Equipment Subsidy Project)
Implementing organization	NTT Facilities
Year of adoption	2015
Estimated GHG emission reduction	543 t-CO2/year (about 40%)
Equipment used	・Dimmable LED lamp: 1,260 units 95w x 660 units (equivalent to HPS 250W) 190w x 600 units (equivalent to HPS 400W) ・Lighting controller: 1,260 units ・Smart server box: 14 units



Source: https://gec.jp/jcm/jp/projects/15pro_ina_02/

Chapter 5　Mobility Improvement and Air Quality Management

5.1　Mobility Improvement Measures

5.1.1　Initiatives in Bandung City for Improving Mobility

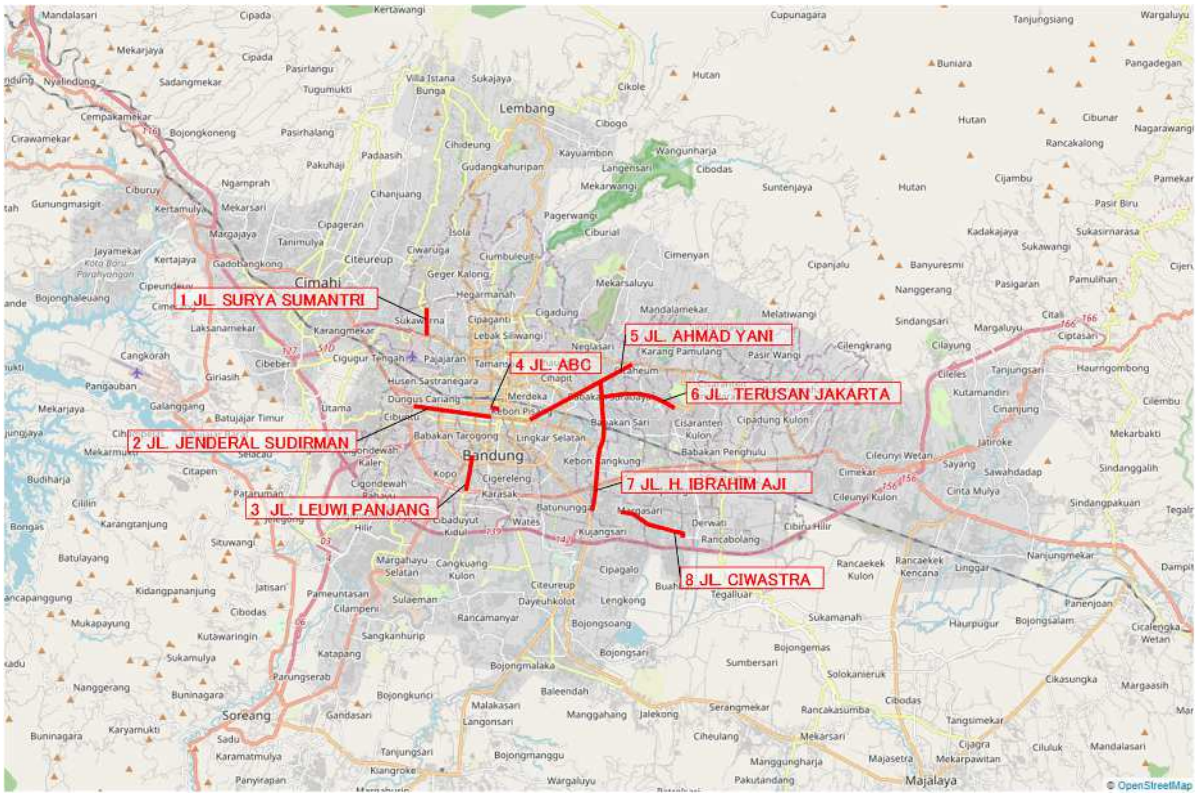
（1） Factors Giving Rise to Road Congestion

One factor contributing to traffic jams in Bandung is the large number of vehicles relative to road expansion within the city. As the figure below indicates, the number of registered vehicles has been trending down since 2017, but exceeded 600 per 1,000 residents in 2020. The number of vehicles per 1,000 residents in Bandung is approximately 1.4 times the national average in Indonesia, and the number of vehicles is projected to continue rising along with urban population growth.　Other factors causing congestion are believed to include insufficient discipline among drivers of public transportation, illegal parking, and driver behavior such as traffic violations at intersections.

Source: Documents provided by Bandung City

Figure 5-1　Bandung City population and number of registered vehicles

Of the routes managed by Bandung City, a large number of congested roads are in the central part of the city (Figure 5-2). Many sections of these routes have 2 lanes in each direction. However, they are lined with buildings such as shopping malls and stores, and numerous sections have one lane blocked by cars and motorcycles that are parked there presumably to shop at these stores. The impact that vehicles parked on the road have on traffic capacity significantly increases as the number of available lanes decreases, and reduced traffic capacity leads to an increase in traffic congestion (Table 5-1). Traffic jams are also caused by behaviors such as unreasonably squeezing into open spaces and cruising around looking for available spaces.



Source: Bandung City Traffic Bureau

Figure 5-2　Location of congested routes

Table 5-1　Reduced traffic capacity at intersections due to on-street parking

Number of lanes per road section	Traffic capacity (vehicles/time)		Decrease (%) in traffic volume due to parking
	No parking	Parking	
1	1,000	600	-40
2	1,700	1,200	-29
3	2,350	1,900	-19

Source: "In Search of a New On-Road Parking System," International Association of Traffic and Safety Sciences (IATSS), 1986

（2） Initiatives in Bandung City

In an effort to relieve congestion in Bandung City, the Bandung Police Traffic Division and Bandung City Traffic Bureau are working together to crack down on traffic control and illegal parking, and raising awareness among residents through actions such as implementing campaign activities in cooperation with regional organizations. They are also tackling tangible improvements that include introducing an Area Traffic Control System (ATCS) to optimally control traffic signals, straightening roads, and installing signs to publicize no-parking areas. The city is also moving forward with developing the bus rapid transit (BRT) and light rail transit (LRT), which are able to provide mass transit services, to promote a shift to public transportation.

Table 5-2 Initiatives in Bandung City for improving mobility

Examples of initiatives	Descriptions	Images
Crackdown on traffic control and illegal parking	・Traffic control (41 of 143 intersections, daily 6:00-10:00, 11:00-13:00, and 15:00-20:00) ・Strategy to deter illegal parking (daily 10:00-16:00, average of 10-15 routes per day)	
Campaign for orderly traffic	・Implementation of educational activities at intersections every Sunday in cooperation with regional organizations	
Optimization of the Area Traffic Control System (ATCS)	・Introduction of a regional traffic management system to control traffic signals (installation of traffic lights (137), CCTV (293), and speakers at intersections (52))	
Road improvements and equipment installation	・Introduction of channelization (guiding the movement of vehicles using lane markers and islands at intersections, etc. to facilitate the flow of traffic; island refers to an island-like mound used to channel traffic) ・Installation of signs (installing signs such as “Parking Prohibited” in locations that may cause congestion) ・Installation of traffic signals and warning lamps at intersections with high traffic volume	
Provision of public transportation services	・Encouraging car owners to switch to utilization of public transportation -BRT commencement (scheduled for 2024) -LRT introduction plan (8 routes) -Educating the public ・Provision of employee buses (the city will provide employee buses and establish no-vehicle days)	BRT routes 

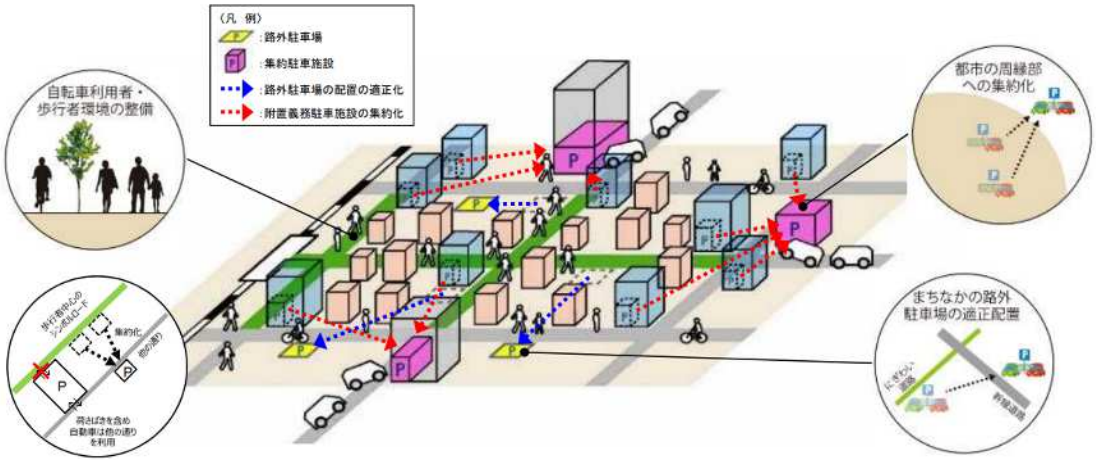
Source: Study team

5.1.2 Proposed Mobility Improvement Measures

Based on the factors causing traffic congestion and Bandung City initiatives, measures were considered that are anticipated to improve traffic congestion if introduced. These include on-street parking measures to increase traffic capacity and measures promoting the use of public transportation to reduce traffic volume.

（1） On-street Parking Countermeasures

One of Bandung City's initiatives tackles illegal parking. On-street parking, including illegal parking, is considered one cause of gridlock on congested routes in the city center, and mobility improvement measures are thought to be highly effective in addressing that issue. In commercial areas where vehicle traffic is extremely congested similar to central Bandung and city centers such as neighboring commercial areas, it is necessary to strive to appropriately balance supply and demand, and address parking lot policies as part of urban development from a quantitative and qualitative perspective.



Source: "Previous Parking Lot Policies and Future Approaches," City Bureau, Ministry of Land, Infrastructure, Transport and Tourism, 2022

Figure 5-3 Parking lot policies in conjunction with urban development

In Japan, provisions in the Parking Lot Act require that when a building is newly constructed parking be established within said building or on the grounds, based on local government ordinances, to meet the new demand for parking that arises by that construction (Article 20 of the Parking Lot Act). In addition, to promote development of parking lots in places such as urban areas, standard parking ordinances provided by the national government and local government ordinances stipulate a unit value that requires a certain amount of parking facilities for a certain area of construction in accordance with factors such as the district a building is in and its uses.

To reduce on-street parking and ensure a safe and comfortable traffic environment, the city is expected to clamp down on illegal parking and establish parking lot policies as part of urban development, as well as introduce a system enabling effective use of parking lots through improvements to parking areas and provision of information and guidance. The following are examples of efforts to improve the convenience of parking lot use.

1） Posting information on full/empty parking lots by vehicle type

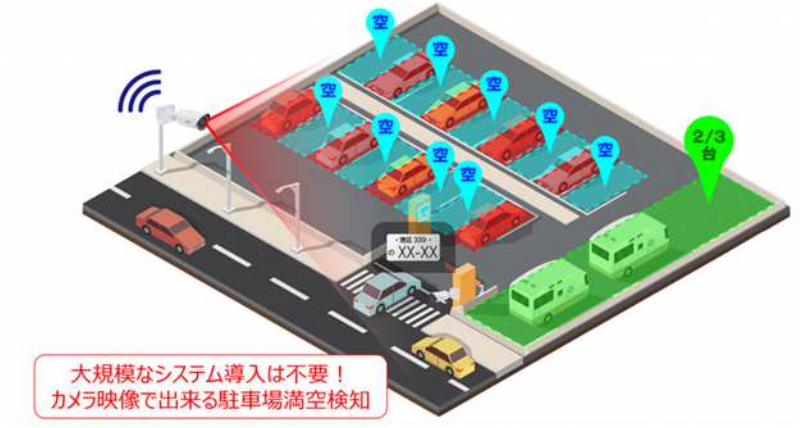
Parking lots are developed to accommodate various vehicle types, including passenger cars, motorcycles, and cargo vehicles. Moreover, information is displayed in front of parking lot entrances on available spaces not only for passenger cars, but also according to vehicle type, such as motorcycles and cargo vehicles. Providing information on available parking spaces is expected to reduce the amount of traffic cruising around looking for parking.

Source: “Approaches to Comprehensive Parking Measures,” Bureau of Urban Development, Tokyo Metropolitan Government, 2021

Figure 5-4 Information on available spaces by vehicle type at parking lot entrances

2） Detecting vacancies using camera images

Information on parking availability can be determined by a system that detects vacancies in real time based on the status of each parking space ascertained from images captured by camera. This does not necessitate the introduction of a large-scale system, and enables monitoring and provision of information on vacancies at a low cost.



Source: Tsuzuki Techno Service Co., Ltd. (https://solution.tsuzuki-techno.com/smart-parking/)

Figure 5-5 Camera image used to determine vacancies

3） A camera-based parking lot management system

The camera-based parking lot management system uses cameras to read vehicle license plates in real time as they enter and exit a parking lot, and digitally manages when, where, and which vehicles

enter and exit the lot. In a pay parking lot, the system only requires installing a camera that reads license plates and a fare machine that can be installed at low cost. Plus, it eliminates the need for gates and thus improves safety. Payment by smartphone is also possible. This allows for smooth entry and exit from the parking lot, and helps eliminate congestion upon entry and exit.

Source: Pitt Design Co., Ltd. (https://www.pitdesign.jp/smartpark/file_20220922.pdf)

Figure 5-6　Camera-based parking lot management system

4）Providing information on parking lots and vacancies online

Looking online in advance for parking lot locations and vacancies enables visitors to efficiently search for parking. “s-park” which is operated and managed by the Tokyo Metropolitan Public Corporation for Road Improvement and Management, provides an online map service for registered parking lots with information on vacancies as well as parking fees and available discounts.

Source: “s-park” Tokyo Metropolitan Public Corporation for Road Improvement and Management

Figure 5-7　Examples of parking information provided

（2） Measures Promoting the Use of Public Transportation

1） Ensuring on-time and speedy BRT performance through traffic signal control

The city of Bandung is moving ahead with plans to introduce bus rapid transit (BRT), a mass transit system. BRT is expected to ensure speedy performance through the establishment of operating spaces such as dedicated lanes. Introduction of the Public Transportation Priority System (PTPS) will enable even faster performance. PTPS is a system that controls signals so that buses have priority in traffic. The traffic control center and buses will be in 2-way communication using sensors installed on roads and buses equipped with on-board devices to control signals and prioritize bus operations, such as extending the duration of green lights and right-turn signals until buses pass through, and shortening the time buses stop at red lights. The system also supports bus operations by warning vehicles improperly traveling on dedicated bus lanes. Given the driving environment impacted by factors such as traffic congestion and the presumed reluctance of many residents to use buses due to unpredictable arrival times, introducing PTPS can promote buses as a means of transportation with a high level of service that ensures fast and on-time operations. However, introducing the system requires coordination with the Area Traffic Control System (ATCS) already in place in Bandung.

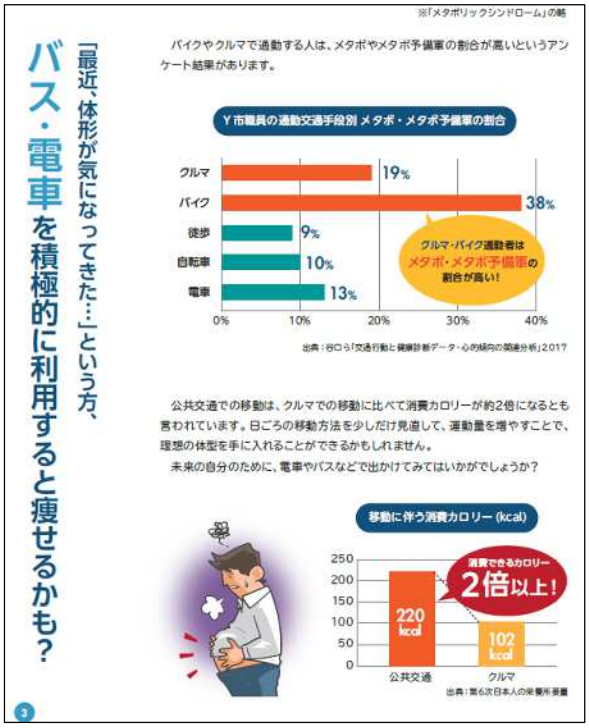
Source: Aichi ITS Council (https://aichi-its.jp/knowledge/glossary/ptps/)

Figure 5-8 Structure of the public transportation priority system (PTPS)

2） Mobility management implementation

Mobility management must also be implemented at the same time so that the utilization of public transportation is not simply a means to arriving at a destination. For example, incentives for riding the bus should be added, such as discounts for shopping at certain commercial facilities when using the bus to create measures that make riding the bus the goal. Conceivably, PR and campaign activities would primarily be used to encourage car owners to switch to public transportation. When doing so, it is also important to replace

the merits of using public transportation with something familiar and communicate that riding public transportation benefits the users themselves.



Source: Pamphlet by Fujisawa City

Figure 5-9 Examples of communicating the merits of using public transportation

（3） Other Projects

In addition to direct measures that contribute to improving mobility, the development and introduction of electric vehicles (EV) and related demonstration projects shown in the table below are also effective from the standpoint of decarbonization. EV buses and EV motorcycles are already operating in Bandung, and the city is facing the challenge of improving the driving environment and expanding recharging facilities. In Indonesia, the Nationally Determined Contribution (NDC) mentions the development of EV as a long-term approach in the energy sector, and it is expected that as EVs become more widespread Japanese companies will also enter the market. The projects of EV and others in Indonesia and Bandung is summarized below.

Table 5-3　EV and other projects

Item	Description
Government-operated Indonesia Battery Corporation (IBC)	・ In March 2021, the government-operated Indonesia Battery Corporation (IBC) was established with the aim of building a supply chain for EV batteries. ・ It mines and refines nickel ore, manufactures LIB, develops charging facilities, recycles batteries, etc.
Electrification of public buses	・ Swedfund International, which is the Development Finance Institution of the Swedish state, supports the electrification of bus operations for TransJakarta, the state-run public bus operating company of Jakarta. ・ Support for improving the capability of bus electrification includes plans to conduct research focusing on developing technology for charging infrastructure and assisting with electrification through transfer of technological knowhow.
Operating EV buses in Bandung	・ 8 electric “E-Inobus” buses manufactured by PT Industri Kereta Api (PT INKA), a government-operated rolling stock manufacturer, began operating in Bandung in December 2022. ・ The introduced E-Inobus buses, which were used at the G20 Summit (November 2022), are 8 meters long and carry 19–25 passengers. The battery has a capacity of 138 kwh, can be recharged in 1–3 hours, and is capable of traveling 160 km when fully charged.  
Bandung Intra Urban Toll Road Project	・ Planned as a Japanese ODA loan project, newly constructing this toll road will expand road transport capacity and help alleviate escalating traffic congestion within the city. ・ The project has not commenced due to a delay in acquiring the planned construction area, but a portion of the section has already been improved using the Indonesian government’s budget.
Building BaaS businesses in Indonesia through a NEDO-subsidized project	“Demonstration Study on Portable Power Storage Sharing as a Decentralized Energy Resource (Indonesia)” ・ The project was implemented from FY2018–2021 as an “International Demonstration Project for Japanese Technology that Contributes to Optimization of Energy Consumption” by the New Energy and Industrial Technology Development Organization (NEDO). ・ It demonstrated a battery sharing service for 2-wheeled EV vehicles in Bandung and Bali with individuals, government, and businesses (delivery companies, tourism companies) as potential users, and supplied electricity to households using small hydroelectric power generation in non-electrified villages as a demonstration of secondary battery use.

Source: Study team

5.2 Improving Air Quality Monitoring

5.2.1 Current Air Quality Monitoring in Bandung City

（1） Regulations and Standards for Air Quality Monitoring

1） Regulations

Air quality monitoring in Bandung is being conducted in accordance with national regulations and standards. The following relevant regulations and standards indicate stipulations and details related to air quality monitoring.

Table 5-4 Regulations for air quality monitoring

Indonesian Law
Indonesian Law No.11/2020 on Job Creation Article 20 ・ Environmental pollution occurrence is measured through environmental quality standards, including ambient and emission quality standards. ・ Everyone is allowed to dispose of waste in environmental media with compliance with environmental quality standards and obtaining approval from the central government or local government.
Government Regulation
Indonesia Government Regulation No.22/2021 on Implementation of Environmental Protection and Management Article 164 and 165 ・ Air inventory ・ Preparation and determination of ambient air quality standards Article 213 ・ The person in charge of the business activities that cause air pollution is obliged to implement air pollution control, including activities. a. providing information to the public about air pollution, b. termination of sources of air pollution, c. other ways align with the development of science and technology.
Indonesian Ministry of Environment Regulation
Indonesian Ministry of Environment and Forestry Regulation No.P.14/MENLHK/SETJEN/ KUM 1/7/2020 on Pollutant Standard Index The regulation discussed the Pollutant Standard Index/PSI, for example ・ Definition of PSI ・ Parameters covered by the PSI consist of particulates (PM10), particulates (PM2.5), carbon, monoxide (CO), nitrogen dioxide (NO2), sulfur dioxide (SO2), ozone (O3) and hydrocarbons (HC) ・ Procedures for calculating PSI; ・ PSI category determination.
Indonesia Ministry of Environment and Forestry Regulation No.27/2021 on environmental quality index (Kualitas Lingkungan Hidup/IKLH) ・ Article 1 mentioned the definition of Air Quality Index/AQI (Indeks Kualitas Udara/IKU) ・ Article 6 discussed the quality of the environment, including ambient air quality. ・ Article 9 discussed the data collection time and frequency of ambient air quality monitoring. ・ Article 10 said about ambient air quality index, which is Sulfur Dioxide (SO2) and Nitrogen Dioxide (NO2). ・ Article 11, which contains the calculation results of environmental quality compiled in the form of an index, including from AQI. ・ Article 12 and so on containing the selection of monitoring locations, e.g. data collection methods, and calculation of environmental quality.

Government Regulation: Implementing regulations on the environmental sector of the job creation law related to air pollution control
Indonesian Government Regulation No.5/2021 on Implementation of Risk-Based Business Permit This regulation aimed to control air pollution, especially for business actors/activities. All of the chapters about the implementation of risk-based business licensing include the following. ・ Risk-based business licensing regulation ・ Norms, standards, procedures, and criteria for risk-based business licensing ・ Risk-based business licensing through electronically integrated business licensing system services (Online Single Submission/OSS) ・ Supervision procedures of risk-based business licensing ・ Evaluation and reform of the risk-based business licensing policy ・ Funding for risk-based business licensing ・ Solving problems and obstacles to risk-based business licensing ・ Penalty
Indonesian Ministry of Environment Regulation: Implementing regulations on the environmental sector of the job creation law related to air pollution control.
Indonesian Ministry of Environment and Forestry Regulation No.4/2021 This regulation was also formulated to control air pollution, especially for business actors/activities. In Indonesia, we have three kinds of environmental permits. ・ Amdal: Analisis Mengenai Dampak Lingkungan Hidup ・ UKL-UPL: Upaya Pengelolaan Lingkungan Hidup and Upaya Pemantauan Lingkungan Hidup ・ SPPL: Surat Pernyataan Kesanggupan Pengelolaan dan Pemantauan Lingkungan Hidup
Indonesian Ministry of Environment and Forestry Regulation No.5/2021 This regulation contains procedures for issuing Technical Approval (SLO: Surat Kelayakan Operasional) for environmental pollution control and fulfilling emission and wastewater quality standards.

Source: Documents provided by Bandung City

2） Air pollution index and assessment

① Pollution Standard Index (PSI)/Indeks Standar Pencemar Udara (ISPU)

When releasing air quality information to the public in Indonesia, the degree of air pollution is published as the air pollution index (Pollution Standard Index (PSI)/Indeks Standar Pencemar Udara (ISPU)) because it is difficult for residents to understand measured values as is. In Bandung City, the air pollution index is calculated based on 24-hour average data measured by the Air Quality Monitoring System (AQMS) installed at the Bandung City municipal health center. The air pollution index measures 6 pollutants: sulfur dioxide (SO2), carbon monoxide (CO), nitrogen dioxide (NO2), ozone (O3), PM10, and PM2.5. As shown in the figure below, the air pollution index has 5 levels.

Table 5-5 Air pollution index levels

Assessment level	Range	Description
Good (Healthy)	0-50	Excellent air quality level No adverse effects on humans, animals, and plants
Normal	51-100	Air quality level permissible for the health of humans, animals, and plants
Unhealthy	101-200	Air quality level harmful to humans, animals, and plants
Very unhealthy	201-300	Air quality level that may increase health risks for some people
Hazardous	≥300	Air quality level that may have serious adverse effects on human health and needs to be addressed immediately

Source: Documents provided by Bandung City

② Air Quality Index (AQI/IKU)

The AQI/IKU is regarded as the foundation for creating air quality management policies and providing information on air quality to the public in an easy-to-understand manner. It is calculated based on the results of NO2 and SO2 monitoring using passive samplers.

③ Standards for each air pollutant, etc.

In addition to measurements using AQMS, Bandung City takes measurements at 27 sites in the city once a year between May and June. According to interviews with Bandung City, the period of May to June was chosen for taking measurements because it is at the height of the dry season when rainfall can be avoided, and traffic congestion is at its worst so air pollution is substantial. The pollutants measured and standards for roadside measurements are listed in the table below.

Table 5-6 Pollutants measured and standards for roadside measurements

SO2 (µg/Nm3)	CO (µg/Nm3)	NO2 (µg/Nm3)	O3 (µg/Nm3)	HC (µg/Nm3)	TSP (µg/Nm3)
75	10,000	65	150	160	230
PM10 (µg/Nm3)	PM 2.5 (µg/Nm3)	Pb (µg/Nm3)	NH3 (ppm)	H2S (ppm)	Noise (dBA)
75	55	2	2	0.02	60

Source: Documents provided by Bandung City

（2） Current Status of Air Quality Monitoring and Implementation System

Air quality monitoring in Bandung is conducted by 1) continuous air quality monitoring using AQMS, 2) regional air quality measurements through passive sampling methods, and 3) roadside air quality measurements. Continuous monitoring and regional measurements are carried out in cooperation with the central government, while roadside measurements are conducted through cooperation between Bandung and accredited laboratories.

1） Continuous air quality monitoring using AQMS

① AQMS

AQMS measuring equipment was donated by the Indonesian Ministry of Environment and Forestry (KLHK) and is installed in the yard of the Bandung City municipal health center (Jl. Supratman No.73). The measuring equipment is made by PT Trusur (see figure below), designed by local experts in consideration of Indonesian conditions and manufactured in Indonesia, and uses sensors to measure air quality.

Source: PT Trusur website

Figure 5-10 PT Trusur AQMS measuring equipment

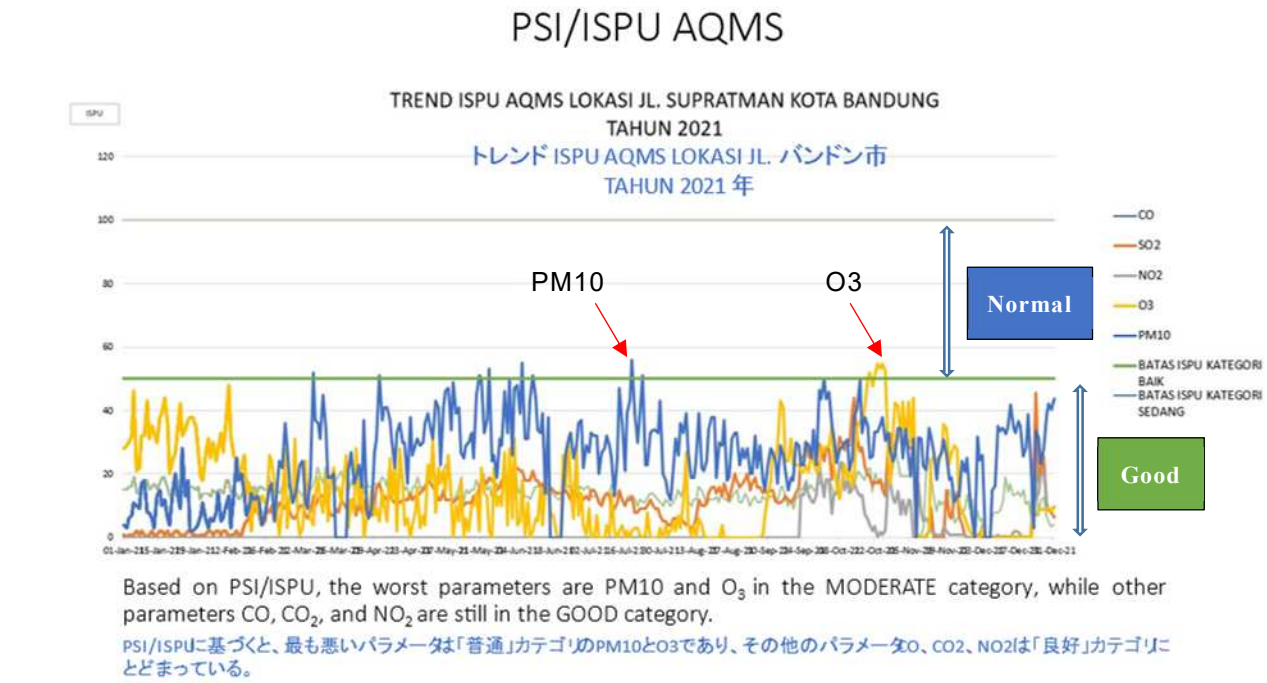
Table 5-7 Specifications of PT Trusur AQMS measuring equipment

Pollutant	Measuring principle	Measuring range	Resolution
PM2.5 PM10	Light-scattering type	PM2.5: 0.0-1999.9 μg/m3 PM10: 0-2999.9 μg/m3	-
Carbon monoxide (CO)	Electrochemical type	0-50 ppm	0.001 ppm/1 ppb
Nitrogen dioxide (NO2)	Electrochemical type	0-2 ppm	0.001 ppm/1 ppb
Sulfur dioxide (SO2)	Electrochemical type	0-1 ppm	0.001 ppm/1 ppb
Ozone (O3)	Electrochemical type	0-1 ppm	0.001 ppm/1 ppb

Source: Prepared by study team based on PT Trusur website

② Monitoring results (PSI/ISPU)

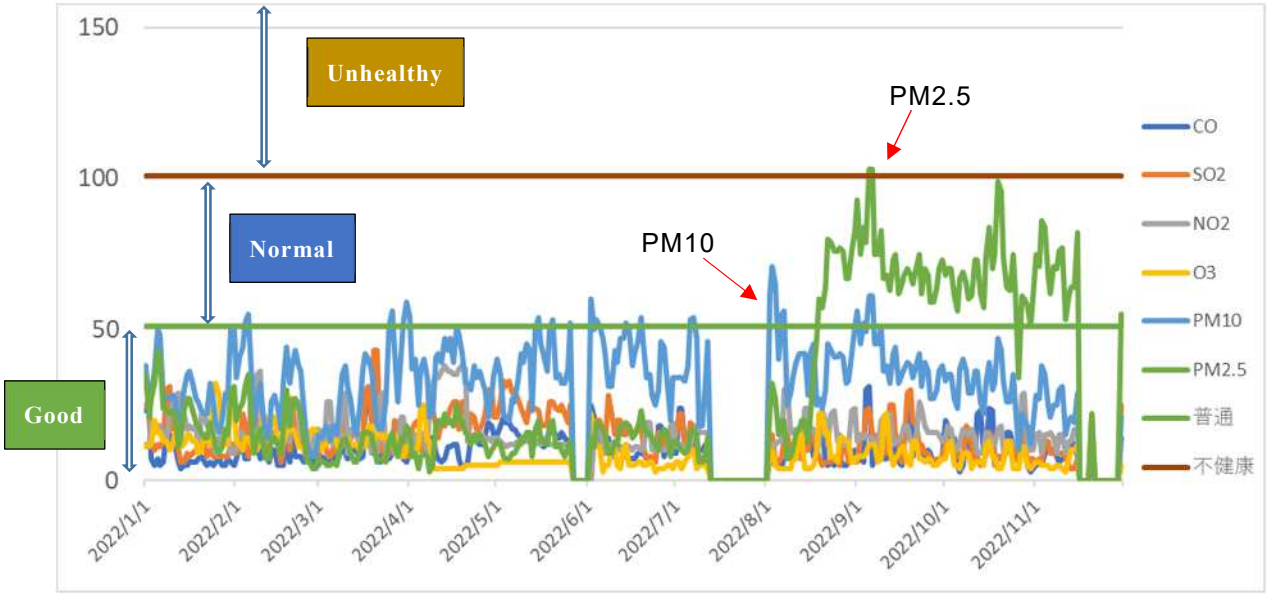
The figure below shows daily variations in the ISPU in 2021. Assessments based on the air pollution index indicated that even the worst parameters (PM10 and O3) were in the “Normal” range, while other parameters (CO, CO2, NO2) were in the “Good” category.



Source: Documents provided by Bandung City

Figure 5-11　Monitoring results for 2021 (continuous air quality monitoring)

In addition, shifts between January and November 2022 are shown in the following figure. PM2.5 tends to have a higher PSI/ISPU from August with an “Unhealthy" level occurring twice in September. Also, PM10 is in the "Normal" category, but has relatively high values.



Source: Documents provided by Bandung City

Figure 5-12　Monitoring results for January to November 2022

2）Regional air quality measurements using passive sampling methods and AQI/IKU

Measurements of nitrogen dioxide (NO2) and sulfur dioxide (SO2) using passive samplers are conducted at monitoring sites in 4 zones that differ by land use (roadside,

industrial area, residential area, and commercial area). The target AQI/IKU score for Bandung is 71. As noted below in the figure, 2021 had a "Good" rating of 78.75.

Water Quality	I_{Eu}
EU Standards are exceeded by one pollutant or more	>1
EU Standards are full on average	1
EU Situation is better than the norms requirements on average	<1

SCORE	CRITERIA
90 – 100	Very good
70 – 89.9	Good
50 – 69.9	Moderate
25 – 49.9	Bad
0 – 24.9	Very bad

The value is IEu 0.48 (<1), which means that the air quality meets the requirements EU standards based on the results of the AQI calculation using the European Union (EU) Directives Standard. The AQI value is 78.75, exceeding the strategic plan target and meeting the GOOD criteria

大気質指標（AQI/IKU）

Location Category	$SO2_{level}$ g/m³	$NO_{2,level}$ g/m³	$I_{Eu\,SO_2}$	$I_{Eu\,NO_2}$	$I_{Eu\,NO_2\&SO_2}$	KPI	$I_{Eu\,Gab}$	IKU Gab
Transport period 1	17,00	9.75	0.85	0.24	0.55	75.17	0.48	78.75
2 period transportation	15.00	4.83	0.75	0.12	0.44	81.37		
1 period settlements	12.00	7.77	0.60	0.19	0.40	83.49		
2 period settlement	17,00	13.50	0.85	0.34	0.59	72.57		
Industry period 1	14.00	10,10	0.70	0.25	0.48	79.10		
Industry period 2	12.00	7.44	0.60	0.19	0.39	83.72		
1 period office	17,00	9.29	0.85	0.23	0.54	75.49		
Office period 2	15.00	8.13	0.75	0.20	0.48	79.08		
Value I_{Eu}			0.74	0.22				

値はIEu 0.48（<1）であり、欧州連合（EU）指令基準を用いたAQI計算結果に基づき、大気の質が要求EU基準を満たすことを意味する。
AQI値は78.75で、戦略的計画の目標を超え、GOOD基準を満たした。

Source: Documents provided by Bandung City

Figure 5-13　Monitoring results for 2021 (regional air quality measurements)

3）Roadside air quality measurements

①　Measurement sites and items measured

Air quality monitoring at 27 roadside sites is conducted in accordance with quality standards presented in "Appendix VII of Government Regulation No.22 for 2021 Ambient Air Quality Standards," "Decree of the State Minister of Environment, Number: KEP-48/MENLH/11/1996 regarding Noise Level Standard," and "Decree of the State Minister of Environment, Number: KEP-50/MENLH/11/1996 regarding Smoke Level Standard." Roadside air quality measurements are conducted once a year between May and June. The measurement sites and pollutants measured are listed below.

Table 5-8　List of pollutants measured

No.	Pollutants measured
1	NO2 (nitrogen dioxide)
2	SO2 (sulfur dioxide)
3	CO (carbon monoxide)
4	HC (hydrocarbon)
5	O3 (ozone)
6	Pb (lead)
7	TSP (total suspended particulate)
8	Noise
9	H2S (hydrogen sulfide)
10	NH3 (ammonia)
11	PM10
12	PM2.5

Source: Documents provided by Bandung City

No.	Measurement Site	No.	Measurement Site
1	Jl. Soekarno Hatta (Depan Aria Graha)	15	Jl. Elang
2	Terminal Ledeng	16	Jl. Padjajaran (Depan Wiyataguna)
3	Jl. Pasteur	17	Terminal Leuwi Panjang
4	KPAD Sarijadi	18	Alun-Alun
5	Jl. Punclut	19	Jl. Tegalega
6	Jl. Siliwangi	20	Jl. BKR (Depan Alifa)
7	Jl. Buah Batu (Depan STISI)	21	Jl. Margahayu Raya
8	Jl. Soekarno Hatta (Depan Astra Bizz)	22	Jl. Ahmad Yani
9	Jl. Arcamanik	23	Jl. Cimuncang
10	Jl. Buah Batu	24	Perumahan Pasir Impun
11	Jl. Dago	25	Terminal Cicaheum
12	Jl. Ciganitri	26	Bunderan Cibiru
13	Balaikota Bandung	27	Jl. Rumah Sakit
14	Jl. Diponegoro		

Source: Documents provided by Bandung City

Figure 5-14 Map and list of measurement sites

② Measurement results

The table below shows the measurement results in 2022. Of the 27 measurement sites, standards were exceeded at 3 sites for SO2, 1 site for NO2, 1 site for O3, and 26 sites for noise. Notably, the site exceeding the ozone standard (No.15 JI. Elang) had a concentration of 789.31 μg/Nm3, which was more than 10 times higher than other sites.

Table 5-9　measurement results in 2022

No	所在地	SO2	CO	NO2	O3	HC	TSP	PM10	PM 2.5	Pb	NH3	H2S	騒音
		µg/Nm3	µg/Nm3	µg/Nm3	µg/Nm3	µg/Nm3	µg/Nm3	µg/Nm3	µg/Nm3	µg/Nm3	ppm	ppm	dBA
1	Jl. Soekarno Hatta (Depan Aria Graha)	52.27	3,435	39.52	69.53	7.64	138.07	60.6	29.4	0.18	0.0723	0.005	63.63
2	Terminal Ledeng	69.98	4,600	59.53	84.23	12.79	145.72	62.3	28.8	0.16	0.0630	0.005	67.31
3	Jl. Pasteur	70.54	6,068	54.70	82.50	13.54	101.37	66.8	38.5	0.21	0.0844	0.006	68.14
4	KPAD Sarijadi	32.89	2,290	21.82	38.10	5.64	88.47	51.3	31.3	0.07	0.0376	0.003	63.56
5	Jl. Punclut	34.67	2,862	22.13	40.70	6.89	72.11	48.3	21.5	0.08	0.0313	0.003	56.06
6	Jl. Siliwangi	40.36	2,290	23.08	46.79	5.79	119.46	58.2	28.3	0.13	0.0313	0.004	65.57
7	Jl. Buah Batu (Depan STISI)	78.81	6,068	62.19	98.15	16.58	168.92	56.4	36.1	0.25	0.0806	0.005	64.62
8	Jl. Soekarno Hatta (Depan Astra Bizz)	52.27	4,008	44.92	57.40	9.60	103.82	68.6	41.3	0.20	0.0551	0.004	65.94
9	Jl. Arcamanik	37.61	2,920	31.12	46.73	6.57	97.22	53.2	38.5	0.07	0.0518	0.004	65.66
10	Jl. Buah Batu	56.68	4,580	42.30	75.39	9.22	132.14	53.2	36.1	0.15	0.0670	0.004	67.03
11	Jl. Dago	56.09	4,924	44.98	68.02	9.54	84.73	48.3	22.8	0.12	0.0622	0.006	66.53
12	Jl. Ciganitri	34.26	2,290	24.05	44.71	5.79	79.27	49.7	21.8	0.06	0.0429	0.003	74.15
13	Balaikota Bandung	48.26	4,580	34.00	56.25	9.21	91.37	55.8	35.1	0.11	0.0509	0.003	63.42
14	Jl. Diponegoro	55.57	4,008	34.92	63.16	7.75	88.50	58.1	36.2	0.14	0.0430	0.004	66.10
15	Jl. Elang	67.62	5,920	48.50	789.31	10.65	110.03	58.9	29.6	0.14	0.0619	0.005	72.93
16	Jl. Padjajaran (Depan Wiyataguna)	54.85	4,385	37.30	61.35	8.21	106.87	57.8	41.1	0.13	0.0538	0.004	68.07
17	Terminal Leuwi Panjang	75.32	5,725	60.90	93.10	14.50	172.24	69.8	52.6	0.22	0.0724	0.006	75.57
18	Alun-Alun	62.67	5,347	54.86	73.64	11.32	97.28	42.1	36.8	0.15	0.0549	0.004	72.61
19	Jl. Tegalega	39.81	3,435	23.79	50.39	6.75	122.37	59.8	46.0	0.10	0.0483	0.004	75.68
20	Jl. BKR (Depan Alifa)	50.16	4,008	37.42	59.09	7.94	98.62	57.4	39.8	0.08	0.0484	0.003	73.57
21	Jl. Margahayu Raya	43.64	2,862	35.12	56.18	8.54	146.60	61.6	42.6	0.17	0.0450	0.004	71.90
22	Jl. Ahmad Yani	63.12	3,435	56.75	73.73	10.78	97.89	52.8	36.7	0.15	0.0619	0.005	71.64
23	Jl. Cimuncang	58.24	4,008	42.83	67.87	9.76	131.82	62.2	48.6	0.15	0.0560	0.004	61.87
24	Perumahan Pasir Impun	32.2	1,718	19.79	39.97	4.62	83.03	42.0	21.2	0.11	0.0441	0.003	63.16
25	Terminal Cicaheum	74.92	4,580	55.38	79.74	10.55	145.17	72.6	52.8	0.13	0.0790	0.005	76.91
26	Bunderan Cibiru	82.98	5,725	71.45	90.30	10.40	198.29	72.8	53.7	0.23	0.0791	0.005	78.22
27	Jl. Rumah Sakit	55.5	3,435	49.53	63.24	8.20	98.12	61.8	38.5	0.16	0.0641	0.004	64.75
基準		75	10,000	65	150	160	230	75	55	2	2	0.02	60

* Highlighted in yellow are measurement results exceeding the standards.
Source: Documents provided by Bandung City

（3） Air Quality Monitoring Issues

The following issues regarding air monitoring are organized in terms of measurement sites and their number, measurement methods and frequency, and data management.

1） Overall

① Continuous air quality monitoring using AQMS

・Currently, continuous monitoring is conducted at a single site. Considering the population, industrial development, and traffic congestion in Bandung City, continuous monitoring at multiple sites is desirable since there are assumed to be a wide variety of sources of air pollution. In Japan, one monitoring station is established per 75,000 residents according to the "Standards for the Administration of Affairs Concerning Continuous Monitoring of Air Pollution Status based on the Provisions in Article 22 of the Air Pollution Control Act."

・AQMS is a sensor-type device, not automatic measuring equipment. While the accuracy control and maintenance/management of automatic measuring equipment is often clearly defined in various countries, sensors do not operate at that level and require actual confirmation of accuracy and maintenance/management. In Japan, the "Manual for Continuous Monitoring of Ambient Air" describes mechanisms and maintenance/ management methods for automatic measuring equipment.

・2022 monitoring results obtained using AQMS confirmed data was missing for approximately half a month on 2 occasions. In the future, it will be necessary to confirm the reasons and causes of missing measurements and to collect information on maintenance and management.

② Regional air quality measurements using passive sampling methods

・As this survey was unable to obtain sufficient information on implementation using passive sampling methods or AQI calculations and assessments, it will be necessary to gather such information going forward.

③ Roadside air quality measurements

・Roadside measurements are taken in a single day only once a year, which is a concern in terms of grasping how illustrative that site is given the lack of measurement frequency and brevity of time invested in taking measurements. For example, the ozone concentration was significantly higher at some sites compared to others, but these measurement values must be confirmed because it is impossible to assess whether there was a unique phenomenon on the day of measurement or whether the ozone concentration is high throughout the year.

・The targeted pollutants at many of the measurement sites were lower than standard values, but some of the pollutants exceeded the standards or were measured at concentrations approaching the standards. There is a significant necessity for ongoing roadside measurements to determine the state of pollution, and a need to carefully confirm whether the current 27 sites are suitable.

・It is important to ascertain matters such as road congestion, hourly traffic volume, and the possible impact of pollution sources other than roads when assessing the measurement values. In addition to batch surveys, implementing continuous measurements at fixed points is advantageous.

・In interviews with Bandung, the city expressed the opinion that, “The current measurement sites are sufficient. We don’t believe it’s necessary to establish additional ones. If there is a shortage of data at a certain time, we’ll take measurements at that location in conjunction with an accredited laboratory. We will continue to optimize the monitoring activities we have been conducting thus far." Bandung City confirmed it recognizes optimization of monitoring as an issue to be addressed in the future.

2） Developing a method for publicizing air quality monitoring results

・Interviews with Bandung confirmed the city is publishing air quality monitoring results online and is planning to develop an app that enables access from mobile devices in 2023. Development of the app was confirmed to be an issue.

3） Maintenance and management

・Interviews with Bandung indicate the city lacks the human resources to fully handle problems that arise such as equipment damage or data errors, and does not have an adequate budget

allocated for air quality monitoring. Furthermore, no specific department has primary responsibility for air quality monitoring. The city is aware that lack of knowledge among city staff regarding the operation and maintenance of measuring equipment is an issue, and has identified the need for training that would involve equipment operators.

5.2.2 Suggestions for Improving Air Quality Monitoring

（1） Support for Optimizing Air Quality Monitoring

When considering optimization of air quality monitoring, it is essential that the method be sustainable and an operational structure be established. For these reasons, further augmentation will take the form of necessary measures premised on fully leveraging current monitoring resources. Interviews with Bandung City recognized that the current measurement sites are sufficient, but taking into account changes in factors such as social conditions, reexamining appropriate, reasonable locations was suggested. Additionally, it is difficult to say the roadside measurements conducted once a year are representative since they are impacted by the concentration levels and weather on the day of measurement. Therefore, it is recommended that, for example, pollutants that can serve as indicators of vehicle emissions be continuously monitored. Continuous monitoring is effective in understanding the impact of roadside vehicle emissions associated with traffic congestion. Moreover, it facilitates proper evaluation of the effectiveness of measures.

The figure below shows the main methods used for air quality monitoring in Japan. In Bandung City, measuring equipment is not limited to automatic instruments. As described below, the placement of multiple automatic measuring equipment is effective for grasping roadside air pollution and the effectiveness of vehicle emission control measures, but its introduction must be contemplated since it is expensive and incurs maintenance/ management costs. Therefore, further utilization of the sensors already used by Bandung City and use of mobile sensors is recommended.

Table 5-10 Main methods of air quality monitoring

	Auto Measuring Equipment	Sensor	Active Sampler	Passive Sampler
Continuous /Batch	Continuous	Continuous	Batch Collection + Analysis	Batch Collection + Analysis
Space	Large building	Small	Large building	Small
Cost	High	Low	High	Low
Pollutant	Environmental standards	Environmental standards	Environmental standards	Environmental standards
Photo				

Source: Study team

Bandung City uses a sensor-type AQMS for continuous monitoring at a single site, but it is difficult to determine the regional air pollution from this one location alone. Continuously monitoring pollutants such as PM2.5 and NO2 at multiple roadside sites is particularly beneficial to understand the impact of roadside vehicle emissions associated with traffic congestion, as well as valuable in grasping the effectiveness of vehicle emission control measures. The placement of automatic measuring equipment is also recommended for taking measurements, but realistically difficult considering the purchase and maintenance costs. Therefore, further utilization of sensors is suggested as a solution to the cost issue. Specifically, the use of mobile sensors facilitates the understanding of high-concentration sites (hot spots) and the selection of monitoring sites. As indicated in the following figure, mobile sensing makes it possible to gather measurement values linearly and regionally by attaching sensors to automobiles, motorcycles, or pedestrians. Mobile sensing can be used to identify hot spots, check surrounding traffic volume and advisability of equipment installation to narrow down target sites, and select sites for continuous monitoring.

Source: https://gbiot.jp/lab_ex.html

Figure 5-15　Examples of measurements using mobile sensing

Source: https://gbiot.jp/p7_fh0.html

Figure 5-16　Examples of air quality monitoring using fixed-point sensors

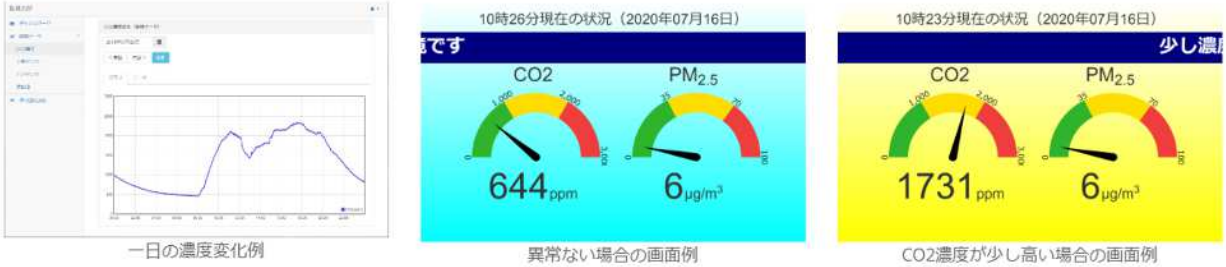
（2） Support for Developing an App to Publish Air Quality Monitoring Results

Indonesia publishes ISPU for each monitoring site of 46 cities in real time on its website. The city of Kawasaki also discloses air quality information on its municipal website such as measurement sites, measurement methods, and measurement data and trends. This includes information on achieving environmental standards.

Source: https://ispu.menlhk.go.id/map.html

Figure 5-17　Website that publishes Indonesia's ISPU

Bandung City plans to develop an app that can be accessed from mobile devices in 2023, but details of this app were not available during this survey period. There are already similar apps in Japan that can be used as reference for future development in Bandung City. The following figure shows that measurement values can be viewed on a mobile device, such as a smartphone, and that the design displays high and low concentrations by color.

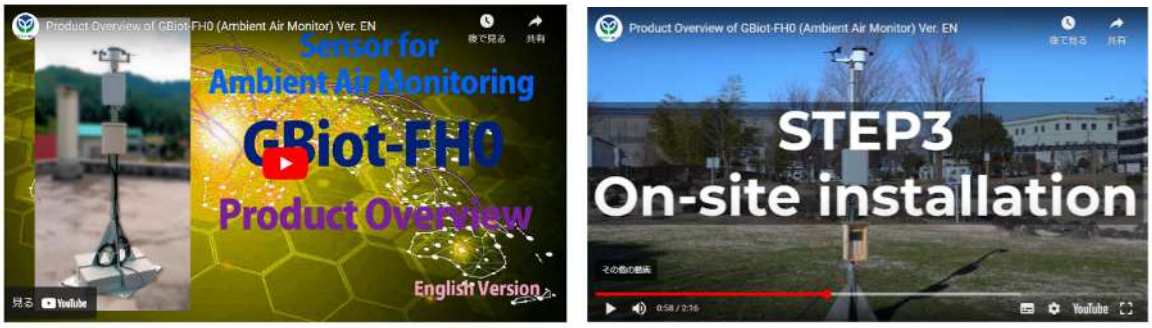


Source: https://gbiot.jp/p2_ic1.html

Figure 5-18　Example of an app screen

（3） Providing Maintenance/Management Support and Manual

Developing a maintenance/management system and a manual contributes to appropriate onsite tasks and ensuring data quality. As the figure below shows, the use of video manuals can be effective, particularly when budgets and human resources are limited, and personnel cannot be allocated for training and handover. In the future, it will be necessary to collect information on the methods, standard operating procedures, and data utilization carried out in Bandung City, and to make concrete proposals for improvements.

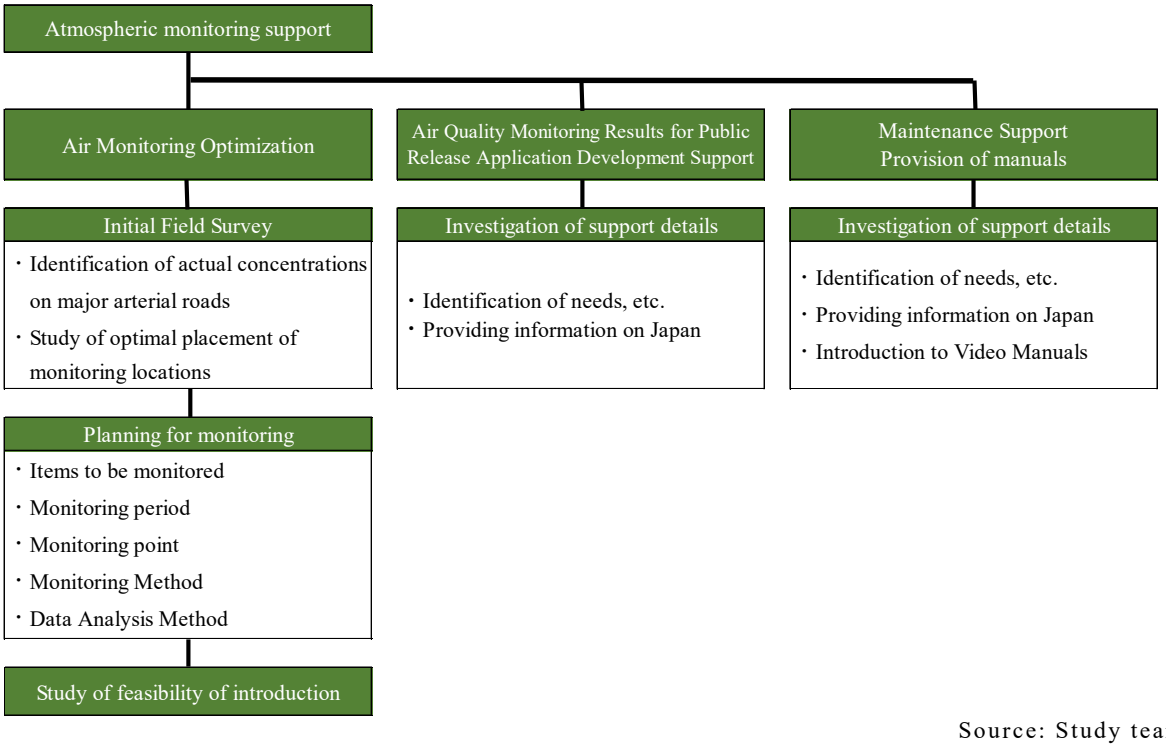


Source: https://gbiot.jp/p7_fh0.html

Figure 5-19 Example of a video manual

5.2.3 Proposed Initiative for Next Fiscal Year

The proposed initiative for next fiscal year will seek to make concrete suggestions for improving the air quality monitoring described in Section 5.2.2. In particular, in the initial field survey the actual measurement conditions in Bandung City will be confirmed, measurements will be taken using mobile sensing by car, motorcycle, or on foot, roadside measurement values will be collected, and proposals for optimal placement of monitoring sites will be considered.



Source: Study team

Figure 5-20 Proposed initiative for next fiscal year

Chapter 6　Workshops, Possibility of Third-country Cooperation

During the project, two workshops were organized with the attendance of concerning organizations from Kawasaki City and Bandung City to share policy and activities of each city. The result and contents of workshops were described as follows. Summary of the Q&A session and presentation materials are shown in Appendix.

Moreover, the project ran a booth at the 15th Kawasaki International Eco-Tech Fair to make the project activity widely known to Japanese companies and associations and collect information of Kawasaki City's initiatives toward decarbonized society and products and technologies of companies in Kawasaki City.

Table 6-1　List of workshops and Kawasaki International Eco-Tech Fair

	Date	Format
1st Workshop	7 September 2022	Hybrid (Venue: Meeting room of Department of Research and Development, Bandung City, online: zoom meeting)
2nd Workshop	3 March 2023	Online (zoom meeting)
The 15th Kawasaki International Eco-Tech Fair	17 and 18 November 2022	Exhibition booth at the venue (Culttz Kawasaki)

6.1　1st Workshop

（1）Purpose

- to confirm and agree with the three-year project implementation policy and plan and activities for FY 2022.
- To determine the latest status of GHG emissions and various policies and activities in Bandung City.
- To provide information on policies and activities to form decarbonized society in Kawasaki.

（2）Outcome

- The project implementation policy and its three-year plan as well as activities in FY 2022 were explained and confirm 1) energy savings in the building sector including a proposal of introducing BEMS, 2) energy savings of social infrastructure systems including a proposal of introducing smart LED in streetlights, and 3) mobility improvement including a proposal of air quality monitoring plan, and investigation on air quality control.
- The following updated information was obtained: GHG emission status in Bandung City, measures for green buildings and activities for public housings, current status of air quality monitoring, progress of introducing LED in streetlights, and traffic congestion countermeasures and promotion of the use of public transportation.
- As part of measures and activities of Kawasaki City to realize a decarbonized society, the City's policy and its progress, vision for the target of zero carbon emissions in 2050, targets by 2030 and five focused efforts were shared.

（3） Agenda

Time in Indonesia (Time in Japan)	Contents	Presenter
14:00-14:15 (16:00-16:15)	Opening Remarks	Bandung City Kawasaki City
14:15-16:20 (16:15-18:20)	1. Project activities in FY2022, expected results and timeline	Oriental Consultants
	2. Presentations by Bandung City ①Environmental policies and air pollution: By Environmental Department ②New Green Building Regulations: By Spatial Planning Department ③Measures for traffic congestion and LED Street Lights: By Public Works Department ④Passive Design for Public Housing: By Transportation Department	Bandung City
	3. Environmental strategies and measures of Kawasaki City	Kawasaki City
16:20-16:40 (18:20-18:40)	Q&A and discussion	
16:40-16:50 (18:40-18:50)	Closing Remarks Photo	Bandung City Kawasaki City

（4） Photo

（5） Minutes of the meeting, presentation materials (Appendix A1-1 to 45)

6.2 2nd Workshop

（1） Purpose

- Share and understand the outcomes of this year and plans for FY2023
- Share the study results about energy saving of building and air quality monitoring
- Share the knowledges and experiences of smart LED streetlight

（2） Outcome

- As for the activities of this fiscal year, 1) promoting energy saving in the building sector, 2) promoting energy saving of infrastructure system, and 3) mobility improvement and air quality management were shared.
- The results of the screening survey of candidate facilities for model projects and efforts to improve air quality monitoring were explained, and proposals for next year's efforts were shared.
- The presentation by MinebeaMitsumi Inc. introduced the technology of smart LED street lighting and its effectiveness, and confirmed its usefulness in realizing a smart city.

（3） Agenda

Time in Indonesia (Time in Japan)	Contents	Presenter
09:30-09:40 (11:30-11:40)	Opening Remarks	Bandung City
09:40-10:50 (11:40-12:50)	1. Outcomes of this year and plans for FY2023	Oriental Consultants
	2. Study results about energy saving of building:	Azbil Corporation
	3. Study results about air quality monitoring	Green Blue Corporation
	4. Smart LED street lights	MinebeaMitsumi Inc.
	Q&A and discussion	
10:50-11:00 (12:50-13:00)	Closing Remarks Photo	Bandung City Kawasaki City

（4） Photo

（5） Minutes of the meeting, presentation materials (Appendix A2-1 to 28)

6.3 The 15th Kawasaki International Eco-Tech Fair

（1）Outline

The 15th Kawasaki International Eco-Tech Fair organized by Kawasaki City is an exhibition to disseminate technologies that help resolve environmental issues domestically and internationally as well as providing a business matching opportunity between exhibiting companies and associations centered on those in Kawasaki City and domestic and overseas companies. The following table outlines the event.

Table 6-2 Outline of The 15th Kawasaki International Eco-Tech Fair

Exhibition name	The 15th Kawasaki International Eco-Tech Fair
Organizer	Kawasaki International Eco-Tech Steering Committee (Kawasaki City, Kawasaki Chamber of Commerce and Industry, Ministry of Economy, Trade and Industry, etc.)
Date and time	10:00 to 17:00, on 17th and 18th November 2022
Venue	Culttz Kawasaki (1-1-4, Fujimi, Kawasaki Ward, Kawasaki City, Kanagawa Prefecture)
Number of visitors	Approx. 4,150 (announcement from admin office on 22 November) 17th Nov.: approx. 2,050 18th Nov.: approx. 2,100
Website	https://www.kawasaki-eco-tech.jp/
Exhibition theme	A bridge to a sustainable future Kawasaki Green Innovation
Purpose	Widely exhibit environmental technologies immediately responding to domestic and overseas environmental issues to advanced environmental technologies that solve global environmental issues to disseminate them from Kawasaki domestically and internationally as well as providing a business matching opportunity between exhibitors and domestic and overseas businesses.
Applicable technologies for exhibition (booth category)	(1) Resource recycling technology (2) Eco-solution (3) Energy-related (4) Contributing to sustainable society (5) Manufacturing, AI and IoT technologies (6) Supporting organizations, industry-government-academia cooperation
Others	・ Gathered 114 exhibitors and 157 booths centered on companies in Kawasaki City. Seminars, business matchings and business negotiations were held in the venue. ・ The onsite event (the 15th Fair) was held for the first time in the last two years (some seminars also accepted online participants) while the 14th (November 2021) and 13th (January 2021) events were organized for about ten days only in an online format. ・ Preregistration required; admission free

Source: Study team

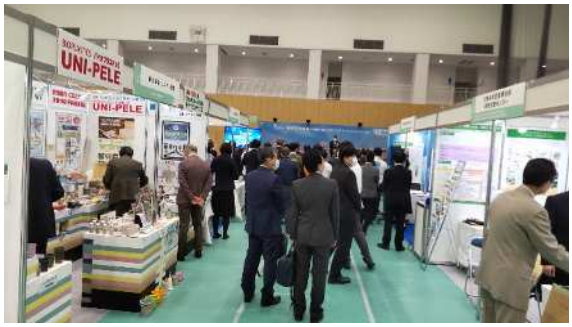
（2） Posters

As well as the project, posters presenting inter-city collaboration projects between Osaka City and Quezon City and Sapporo City and Ulaanbaatar City being implemented by Oriental Consultants Co., Ltd. were prepared and exhibited in the booth showing and debriefing to visitors about overseas exploration of technologies and know-how of Japanese municipalities, collaboration with companies in Kawasaki City and activities to support for decarbonized society in foreign cities. Exhibited posters are shown in Appendix A3-1 to 4.

（3） Photo

<table>
<tr><td> 

Exhibition booth</td><td> 
Explanation to JICA trainees</td></tr>
<tr><td> 

Exhibition site</td><td> 

Visitors</td></tr>
</table>

（4） Project Information from Kawasaki City and Companies

Concurrently with running a booth at the Kawasaki International Eco-Tech Fair, information on initiatives in Kawasaki City was collected via interviews in the venue and by email communication. Kawasaki Eco Town and Kawasaki Zero-Emission Industrial Complex as described in the following table are in areas where recycling facilities, energy-saving and energy-creation facilities are gathered and aim to accommodate environmental load reduction and industrial activity through company-led initiatives and collaboration between companies. As well as their advantage of industrial clusters, they also promote research and development and disseminate information, which will be a good case study for Bandung City.

Table 6-3　Projects in Kawasaki City

Project Outline	Details
[Kawasaki Eco Town]  ・Large-scale photovoltaic power plant ・Urban biomass power plant ・Industrial waste intermediate processing/power generation facility ・Facility to produce ammonia as raw material ・Wastewater treatment plant ・Waste treatment facility ・Plastic bottle recycling facility ・Used paper recycling facility, etc.	Basic Concept of Kawasaki City Environmentally Friendly City Development (Kawasaki Eco Town Concept) in 1998 Kawasaki Carbon Neutral Industrial Complex Concept 2023 Target area: about 2,900 ha in the Kawasaki coastal area Four pillars of the Kawasaki Eco Town Concept: (1) Promotion of company-led initiatives: development of leading recycling system, zero emissions from industrial wastewater and wastes (2) Collaboration between companies: development of Kawasaki Zero-Emission Industrial Complex, joint recycling system (3) Research and development: research on effective energy use, research on resource recycling and such project formulation (4) Information dissemination, educational project, supporting developing countries: the Kawasaki Eco Gurashi Mirai-kan receives domestic and overseas study tours
[Kawasaki Zero Emission Industrial Complex] 	・Developed as a leading model facility in Kawasaki Eco Town (the operation commenced in November 2002) ・13 businesses including paper, metal product manufacturing and construction material renting industries accommodating in the complex reduce wastes and by-products generated by their business activity, reuse and recover resources by company collaboration and promote energy recycling.
[Carbon Zero Action MIZONOKUCHI] ・100% use of renewable energy in public and commercial facilities ・Utilize hydrogen energy and install hydrogen stations ・Power generation utilizing wastes ・Sharing of bicycles, umbrellas, etc.	Zero-carbon actions are intensively carried out in the Mizonokuchi Station area. It is expected for business operators to measure their product and service effectiveness and utilize the actions as an opportunity to understand needs while citizens will realize the effectiveness and convenience of the products and services and raise their awareness of and change their behavior to eco-friendly lifestyle. It is also expected to realize a decarbonization domino effect.

Source: Study team

Information on projects implemented in Indonesia by each company and their latest trend were collected via interview with companies and information gathering activity. Based on their business characteristics, most projects necessarily are related to power generation activity. Although the introduction of renewable energy is not examined in the project in FY 2022, the Indonesian Government promotes energy transition of the country while geothermal power generation projects include those planned to be implemented under the JFJCM scheme by ADB, as mentioned in

Chapter 2. Specifically, a Japanese company introduced steam turbine in the Unit 1 of Patuha Geothermal Power Plant located about 30 km southwest of Bandung City and the Unit 2 construction is planned under the JFJCM scheme. Since renewable energy is supplied to Bandung City from the geothermal power generation plant, it is expected that the project will be ordered to a Japanese company and link to the credit issuance. Each energy saving initiative examined in the project is to help further reduce CO2 emissions by using renewable energy. Accordingly, the project will consider collaborations with each company.

Table 6-4 Project information from companies

Company	Project
Fuji Electric Co., Ltd. (running the Kawasaki Factory) and Voith Fuji Hydro K. K.	・Delivered steam turbine to Kamojang Geothermal Power Generation Plant, which supply electricity to Bandung City, and Wayang-Windu Geothermal Power Generation Plant. ・Voith Hydro is implementing four projects utilizing JCM projects in Sumatera (7MW in Karai, 10MWin Bengkulu, 6MW in West Sumatera and 5MW in Bengkulu)
West Japan Engineering Consultants, Inc. (a group company of Kyushu Electric Power Co., Ltd.)	・Provided technical consultation for Sarulla geothermal development and design support for medium- and long-term promotion system for geothermal development (JICA project) and implement the Tulehu geothermal development project.
Marubeni / MM2100 Industrial Complex	・(Collected information from the perspective of zero-carbon efforts in the industrial complex) ・A private power generation company supply electricity to the industrial complex, which owns fossil fuel gas turbine power generation facility and overhead transmission lines. ・In the premise of industrial complex, rooftop photovoltaic panels are installed and planting activities are carried out.
Sumitomo Electric Industries, Ltd.	・Owns an electric cable factory in Indonesia. ・Implements a verification project of introducing low-power-loss overhead transmission lines (NEDO) in Mongolia (need to investigate the possibility of horizontal expansion in Indonesia)
Toshiba Energy Systems & Solutions Corporation	・Delivers turbines to coal-fired power generation plant including those products for private power generation businesses in Indonesia. ・Also provide Indonesian geothermal power generation plants with IoT services related to trouble predictive diagnosis technology and performance monitoring utilizing IoT and AI technologies

Source: Study team

6.4 Possibility of Third-country Cooperation

In examining the possibility of collaborations with third countries, there are two possible methods. One is a method to expand the framework of international collaborations in the environmental fields and zero-carbon efforts that Kawasaki City has already implemented. The other is a method of incorporating activities in environmental and zero-carbon fields by utilizing sister and friendship city ties.

Kawasaki City holds the aforementioned Kawasaki International Eco-Tech Fair and Kawasaki International Eco-Business Forum every year. Participants and speakers from both developed and developing countries participate. Utilizing these events, which are held for the purpose of exchanging and disseminating information on the outstanding environmental technologies and initiatives inside and outside of Japan by companies in Kawasaki City, it will be possible to expand the contents examined as part of this project and precedents in Bandung City related to waste management to other countries. Kawasaki City is also actively working to accept inspections and training related to environmental technologies from overseas. There is a high level of interest in Kawasaki City's history of overcoming pollution, its measures against water and air pollution, and inspections of monitoring stations. If these efforts can be further expanded to city-to-city collaborations, there is also meaning in terms of strengthening the capacities of city officials.

Table 6-5 Records of overseas visits and trainings of Kawasaki City

Country/Representative	Contents of study tour and training
Viet Nam / Representative of the Bà Rịa–Vũng Tàu Province	・History of overcoming pollution problems in Kawasaki City
China, Mexico, Sudan, Egypt and Mongolia (JICA Knowledge Co-creation Program: Capacity Building towards Air Quality Management)	・Air pollution countermeasures in Kawasaki City ・Introduction and visit to the Kawasaki Environment Research Institute ・Visit to the constant monitoring station
Republic of Maldives / Waste Management Corporation	・Activities for circulating society in Kawasaki City ・Visit to a resource recovery facility ・Visit to a waste treatment plant
Myanmar / Environmental Conservation Bureau, Yangon City and Mandalay City	・Water environmental measures in Kawasaki City ・Introduction and visit to the Kawasaki Environment Research Institute ・Water quality analysis work ・Visit to businesses
China / Shanghai City Environmental Protection Bureau	・Environmental measures in Kawasaki City ・Current state and measures for atmospheric environment ・Current state and measures for water environment

Source: Documents provided by Kawasaki City

Looking at sister and friendship city ties, the possibility of third country cooperation with Shenyang in China is conceivable, for example. The friendship city alliance between Kawasaki City and Shenyang City celebrated its 40th anniversary in 2021. In addition to cultural and economic exchanges, recent years have seen progress in concrete initiatives focused on environmental technologies. Specifically, the Protocol on Environmental Technology Exchange and Collaboration was signed in May 1997, and environmental technology trainees from Shenyang City have been accepted since 1997. A total of 53 trainees were accepted in the 22nd session in 2019, and training has continued online even during the COVID-19 pandemic. This training covers Kawasaki City's environmental policies, aquatic environment conservation, air pollution measures, automobile environmental measures, and so on. It is similar to the content being tackled in this project as well as the issues faced by Bandung City. Kawasaki City also has sister/friendship city ties with Rijeka in Croatia, Baltimore in the US, Wollongong in Australia, and so on. There is the possibility of collaborations that incorporate the perspective of industrial cities and urban redevelopment.

In November 2022, the mayor of Bandung City visited Kawasaki City. In addition to visiting the mayor of Kawasaki City, they carried out inspections and exchanged views on Kawasaki City's air pollution measures, waste management, and environmentally friendly public transportation together with the directors of the Bandung City Department of Environment, Transportation Department, and City Planning Department. Such high-level dialogues directly encourage policy making and implementation, and it is hoped that such talks will also take place as part of third country collaborations.