FY2018 Project for Ministry of the Environment Japan

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

(Feasibility study for assisting ports in Thailand to reduce CO2 Emissions and to become “Smart Ports”)

Report

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Yokohama Port Corporation

City of Yokohama

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Background and Purpose

This feasibility study is being implemented through city-to-city cooperation between Yokohama City and the Port Authority of Thailand (PAT). Its aim is to study the feasibility of applying low-carbon expertise and knowledge that has been accumulated by the Yokohama Port Corporation (YPC) at the Port of Yokohama and introducing Japan's advanced low-carbon technologies and products through the Joint Crediting Mechanism (JCM) to Laem Chabang Port, one of Thailand's leading international ports.

Thailand is continuing along a steady path of economic development based on the two pillars of agriculture and manufacturing. With its 2017 GDP per capita at about US$6,600,*[1] Thailand plays an important role as a middle-income country in the ASEAN region and in the international economy. The Thai government has been actively working on climate change issues as well as economic development since the devastating floods of 2011 that caused significant damage to domestic and international supply chains. In response to the COP 21 Climate Conference in 2015, the government has already submitted its report on "Nationally Determined Contributions" (NDC) for 2020 and later, and set a target of reducing greenhouse gas (GHG) emissions by 20% by 2030. This includes emission reductions in the energy sector, including transportation, as one of the important measures.

Bangkok City adopted a Climate Change Master Plan in December 2015 with the support of the Japan International Cooperation Agency (JICA), based on the Bangkok Climate Change Master Plan 2013 - 2023 project. It includes the reduction of GHG emissions in the transport sector as an important challenge.

Like Bangkok in Thailand, Yokohama in Japan is a crucial port city located in the country's capital region, has experienced rapid urbanization and population growth, and has also encountered and tackled and solved various urban issues. Since 2011, Yokohama has been promoting international technical cooperation through public-private collaboration (the Y-PORT project), utilizing its various resources and technologies, and making full use of its expertise and know-how on urban management and infrastructure development that has been accumulated through these efforts. This Y-PORT project in particular is actively providing support for urban development in emerging countries in Asia and beyond.

During the Bangkok municipal government's process of formulating the aforementioned Master Plan, Yokohama City provided technical advice to JICA and Bangkok. Besides the issue of climate change, Bangkok is also experiencing other urban problems such as waste, sewage and air pollution resulting from rapid urbanization. Recognizing the opportunities, the two cities signed a "Memorandum of Understanding on Technical Cooperation for Sustainable Urban Development" in October 2013.

*[1] JETRO basic economic indicators, https://www.jetro.go.jp/world/asia/th/stat_01.html

Based on that arrangement, further efforts have been made to promote technical cooperation, making use of Yokohama’s expertise in urban development and the advanced technologies of the city’s enterprises, through city-to-city collaboration under the Y-PORT project. Then, the “Bangkok Climate Change Master Plan 2013-2023 Implementation Capacity Building Project” was launched in December 2017 as a new project in collaboration with JICA to support implementation of the Master Plan, and this has included capacity building and a sharing of Yokohama City’s urban planning knowledge and experience with municipal personnel from Bangkok.

In terms of the economy, Thailand achieved average annual real GDP growth of approximately 3.1% from 2011 to 2017, which was relatively low among ASEAN countries, and in recent years, economic growth has slowed. In this context, seeking to avoid the so-called “middle income trap” the Thai government adopted “Thailand 4.0” as its long-term socioeconomic vision for the country, and is implementing the Eastern Economic Corridor (EEC) Development Project as one of its key actions.

The EEC Development Project is an initiative to attract targeted industries through intensive development of transportation infrastructure in the three eastern provinces of Chachoengsao, Chonburi, and Rayong. One of its designated priority projects is an expansion of the Laem Chabang Port as one of the country’s leading international seaports. Laem Chabang Port is managed by PAT, which is a local counterpart for this programme, with annual container throughput of approximately 7.67 million TEUs (2017). At about 2.6 times the scale of the Port of Yokohama (2.93 million TEUs in 2017), it is one of the top trading ports in ASEAN. Japanese automaker plants are also concentrated in this area, and this is an important shipping point for 1.2 million finished motor vehicle exports annually. Based on the EEC Development Project, the Thai government has approved a total of 88 billion baht (about 299 billion yen) for the Laem Chabang Port expansion project, and PAT is currently moving ahead with three priority projects: (1) construction of a coastal shipping terminal, (2) construction of a single rail transfer operator (SRTO) terminal, and (3) the Phase III Expansion Project.

PAT sees the promotion of environmentally-conscious port operations as an important management strategy, and under the “Green Port Project” has been promoting a five-year plan to reduce carbon dioxide (CO2) emissions by the equivalent of 10% from 2013 to 2019 from operations in the five ports managed by PAT.

YPC has had an ongoing and positive cooperative relationship with PAT, and has been actively supporting PAT’s “Green Port Project” by providing knowledge and expertise from environmental measures taken at the Port of Yokohama.

Following discussions with PAT starting in 2015 regarding the potential for introducing low-carbon facilities at the Port of Bangkok using the JCM, in 2016 and 2017, YPC, Green Pacific Co., Ltd. (GP), and the Overseas Environmental Cooperation Centre, Japan (OECC) as three parties together proposed the “Feasibility Study for Assisting Ports in Thailand to Reduce CO2 Emissions and to Become ‘Smart Ports’ ” (hereinafter referred to as the “previous feasibility study”) and it was selected as a project under a government program entitled “Feasibility Studies for the City-to-City Collaboration Programme for Low-Carbon Society.” Under that previous feasibility study, PAT investigated the potential to use the JCM for facilities PAT was planning to introduce for the Port of Bangkok.

Based on the findings, YPC, PAT and GP formed an international consortium, and submitted a project application under the “FY2017 to FY2019 CO2 Emission Reduction Countermeasures Project Fund Subsidy (Equipment Subsidy Program Under the Joint Crediting Mechanism Subsidy Program)” (hereinafter “JCM equipment subsidy project”) for low-carbon facilities PAT would introduce to its export CFS (container freight stations, facilities for container loading and unloading). The funding decision was made in January 2018, after which implementation began (project name: “Introduction of Energy-Efficient Equipment to Bangkok Port, Thailand”).

In providing assistance for PAT’s Green Port Project, YPC has taken a phased approach, starting with a project to introduce low carbon facilities using the JCM at Bangkok Port as Step 1, then expanding the same to other PAT-managed ports including Laem Chabang as Step 2, and then in the medium and long term, seek the development of Thailand’s international ports as low-carbon “smart” logistics centers in the ASEAN region.

This feasibility study is one of a series of initiatives as part of Step 2, a study of project feasibility to introduce advanced Japanese low-carbon technologies and products, etc., to Laem Chabang Port using the JCM. The study will be implemented by making the greatest possible use of knowledge and expertise gained up to this point through the JCM project in Bangkok Port, to examine the potential for applying it at Laem Chabang Port, and will benefit from the partnership between PAT and Yokohama City.

Specifically, this will be a feasibility study for a project to use the JCM to introduce low-carbon cargo handling equipment and utilize renewable energy at Laem Chabang Port container terminal and multi-purpose terminal, as well as coastal terminal and rail terminal (SRTO) expansions being advanced by PAT.

An additional purpose was to study the potential to expand these low-carbon initiatives to other major PAT-managed ports and logistics networks connected with them, including future expansion (Phase III) at Laem Chabang Port. In the medium and long term, these efforts could contribute to the development of Thailand’s international ports as low-carbon smart logistics hubs in the ASEAN region.

Study Content and Study Results

1. Information Gathering Prior to Site Visits

1.1 Previous Work

(1) Relationship between Port Authority of Thailand (PAT) and Yokohama Port Corporation (YPC)

Thailand's major domestic ports are managed by the Port Authority of Thailand (hereinafter “PAT”). PAT is aiming to further utilize Thailand’s port network, including regional ports, as a hub for the ASEAN region. In parallel with that, PAT sees the promotion of environmentally-conscious harbors as an important management strategy. They are promoting ambitious efforts such as setting carbon dioxide (CO_2) emissions reduction targets under a plan called the “Green Port Project” (described below).

Yokohama Port Corporation (hereinafter “YPC”), the main proponent of this feasibility study, continues to have a positive cooperative relationship with PAT. The Port and Harbor Bureau, City of Yokohama has been part of a wide range of cooperative efforts with PAT, including the conclusion in April 2014 of a memorandum of understanding regarding partnership arrangements with PAT, followed by a basic agreement for implementation in January 2015. PAT welcomed being selected for a JCM equipment subsidy based on the achievements of the previous feasibility study, and took the initiative to address multiple institutional issues within the organization and country to move toward implementation of the subsidized project. Building upon these experiences and achievements, for the next JCM project, PAT expressed the strong desire to take a major step toward low-carbon and smart ports while obtaining support from YPC for the design of port facilities with lower environmental impacts.

The Port of Yokohama is an example of the move toward low-carbon and “smart” port facilities, and it declares “a safe, secure and environmentally-friendly port” as one of its three pillars for port planning policy. Under that policy, examples of efforts so far by YPC include the installation of photovoltaic panels on the roofs of Container Freight Stations (CFS: facilities for container freight loading) of the container terminals at the Port of Yokohama, and the installation of LED lighting in the yard. In addition, the Yokohama Port and Harbor Bureau has installed photovoltaic panels on the roofs of the public buildings at Daikoku Pier, and installed a stand-alone hydrogen fuel-cell system at the Yokohama Logistics Center at the Daikoku Pier. As an example of efforts by other Yokohama Port stakeholders, operators have started using hybrid tugboats and LNG fuel powered tugboats.

Based on the results of the previous feasibility study, Bangkok Port modified the CFS Import it was originally planning, and using the Yokohama Cargo Center (Y-CC) as a model, decided to construct high-performance logistics facilities under the name of “DistriCenter,” and discussions are currently under way to make an application as a JCM equipment subsidy project.

YPC has extensive knowledge and experience with many of the latest technologies in the facilities it owns and operates. The use of those resources and the JCM to support PAT's efforts toward low-carbon operations can become an innovative model of efforts as a JCM project in the port sector, to support the decarbonization of ports overseas by referring to the Port of Yokohama, one of Japan's leading ports. By making use of the partnership between the Yokohama Port and Harbour Bureau and Thailand's PAT, as well as the cooperative relationship between the City of Yokohama and Bangkok Metropolitan Administration (BMA) for urban development, and technical cooperation based on the City of Yokohama's knowhow and technical excellence of Yokohama businesses such as YPC, it will be possible to create low-carbon and resilient logistics centers in Bangkok, a leading city in the ASEAN region.

With the need to accelerate CO2 emission reduction initiatives in other ports in Thailand managed by PAT, this feasibility study is intended to expand the efforts to Laem Chabang Port, another leading international port in Thailand. These kinds of activities also could lead to the possibility of future expansion or roll-out in other ports of other countries in the ASEAN region, which gives this initiative added significance.

(2) About the Port Authority of Thailand (PAT)

PAT was established in 1951 as a port administrator under the jurisdiction of Thailand's Ministry of Transport. It manages and operates five ports in Thailand (Bangkok Port, Laem Chabang Port, Chiang Saen Commercial Port, Chiang Khong Port, and Ranong Port) (Figure 1).

Source: Laem Chabang Port's Infrastructure Development & Connectivity, Dec. 2016, Laem Chabang Port, PAT

Figure 1: Location of five ports managed/operated by PAT

The Yokohama Port and Harbor Bureau signed a memorandum of understanding on cooperation in April 2014 (described below), and a basic agreement for its implementation in January 2015. There has been a continuous cooperative relationship with YPC under the memorandum, and since 2015 joint discussions have been underway regarding utilization of the JCM.

PAT is currently working to promote an environmentally-conscious port under a five-year plan (2015-2019) entitled the “Green Port Project.” This plan’s target is to reduce projected CO2 emissions from PAT’s operations in 2019 by 10% of the 2013 emissions (Figure 2). This target is a sign of very high awareness about environmental protection, and strong interest in introducing low-carbon equipment through use of the JCM.

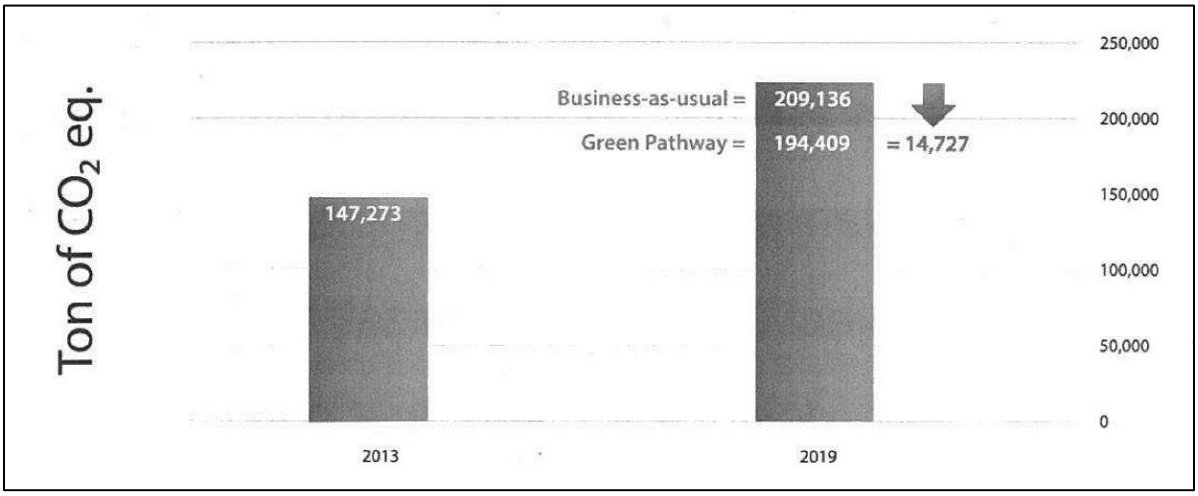


Figure 2: CO2 emissions reduction target under the PAT “Green Port Project”

(Source: PAT documents)

Under this feasibility study, with PAT cooperating as a counterpart in Thailand, PAT has coordinated affairs with Thai government authorities and other parties and cooperated for field surveys, and joint discussions have been conducted with implementing bodies such as YPC on the Japanese side concerning appropriate technologies and project possibility evaluation etc.

Based on the outcomes of discussions under the previous feasibility study, PAT became the local party in the international consortium established for the FY2017 application to become a JCM-funded project.

(3) Current Cooperation among Cities in the Study Area

As mentioned above, since 2011, Yokohama City has been implementing international technical cooperation through public-private partnerships using “Yokohama’s Partnership of Resources and Technologies” (Y-PORT Project), with the aim of supporting solutions to urban issues in emerging countries and supporting business overseas business development of Yokohama-based businesses.

Under the Y-PORT project, in 2013, Thailand's Bangkok Metropolitan Authority signed a "Memorandum of Understanding on Technical Cooperation for Sustainable Urban Development" in 2013, the Bangkok Climate Change Master Plan 2013 - 2023 was prepared, with cooperative support from JICA to formulate it, and it was completed in 2015. To realize the master plan, in FY2014 and FY2015, Y-PORT participated in a Ministry of the Environment JCM commissioned project for formulating a feasibility project to realize a low-carbon society, and developed through city-to-city collaboration the "Scheme Consideration Study for Funding for Development of JCM Projects (Energy Conservation, Waste, Sewerage) and Introduction of Low-Carbon Technologies based on the Kingdom of Thailand / Bangkok Municipal Administration Climate Change Master Plan." As a result of this study, Yokohama-based companies are being considered for the selection of equipment in the JCM-funded project in Bangkok City.

As a recent trend in the Port of Yokohama, in August 2010, through a selection process for target ports for the national government's "International Container Strategy and Port Policy" program for intensive investment and to strengthen competitiveness, the Port of Yokohama was selected as a Keihin region port. The International Container Strategy and Port Policy is a national port policy of the national government to promote Japanese ports as hub ports for container logistics, in response to a decline in relative status of Japanese ports in the context of the development of other Asian major ports in recent years. Based on the International Container Strategy and Port Policy, initially there were plans to merge/integrate the Port of Yokohama, Port of Kawasaki, and Port of Tokyo as a container terminal operation, but the Port of Tokyo later withdrew, YPC was broken up in January 2016, and the Yokohama-Kawasaki International Port Co., Ltd. (YKIP) was established, centering on the Port of Yokohama.

As for the Port of Yokohama, since 2010, based on the basic policies of the International Container Strategy and Port Policy (consolidating freight, generating freight, boosting international competitiveness), the Port and Harbor Bureau, City of Yokohama, which is the port authority, has promoted various efforts for freight consolidation and for development of new container terminals. In particular, to increase the volume of freight handled, which is one of the most important challenges, they have been promoting stronger collaboration with Southeast Asian countries which have been experiencing remarkable growth, and on April 22, 2014, the Port and Harbor Bureau, City of Yokohama signed a memorandum of understanding with PAT which manages and operates five major domestic ports including Bangkok Port and Laem Chabang Port, regarding partnership aiming to develop beneficial relationships for the development of the Port of Yokohama and domestic ports in Thailand.

Unlike the traditional sister port relationship, this partnership aims at concrete measures that are beneficial to both sides and sets up a cooperative system with fixed periods in specific fields, with the benefits being constantly measured. In particular, it stipulates that an emphasis is placed on cooperative installations to increase cargo volume and technical information exchanges, and the implementation of concrete measures are in specific areas. Major cooperation components include (1) information exchange for the development of both sides (port management, shipping trend, international trade, the use of IT, technology and environmental measures), and (2) port sales (helping and promoting cooperation with potential local partners and customers in order to achieve local and regional market expansion).

Furthermore, a basic agreement on the following concrete action items for its implementation was signed on January 19, 2015. The main points of agreement include (1) mutual assistance through information provision and the exchange of personnel (human resources development, technical exchanges, information exchanges), and (2) cooperation on port sales (mutual implementation of seminars and promotions). Based on this agreement, the Port of Yokohama and PAT are undertaking the following efforts on an ongoing basis including trainings to address various issues, receiving study tours, holding port seminars, and regular exchanges of opinion.

Major Initiatives after Signing of Cooperative Partnership Agreement

2014 (Apr):	Eight-person delegation from PAT led by the acting chief director visited the Port of Yokohama
2014 (Aug)	Observation tour received from Laem Chabang Port (Port Authority of Thailand) and Thammasat University
2015 (Jan)	Eight-person delegation including YPC executives led by Port and Harbor Bureau, City of Yokohama, visit PAT, and seminar is held on Thailand-Japan trade and port topics
2015 (Jul)	Yokohama International Affairs Bureau officials visit PAT, conduct interviews on technical cooperation with the Bangkok Metropolitan Administration (Thailand) relating to urban development
2015 (Oct)	City of Yokohama representatives visit PAT to observe overseas government. YPC visits PAT to discuss JCM.
2016 (Jul)	YPC, City of Yokohama (Climate Change Office), and Yokohama International Affairs Bureau visit PAT, conduct on-site observation and discuss JCM
2016 (Sep)	JCM project feasibility study for PAT-managed ports (with cooperation from PAT, and YPC as implementation body) selected by Ministry of the Environment as a “FY2016 Feasibility Study of Joint Crediting Mechanism Project by City to City Collaboration”
2017 (Feb)	YPC, Yokohama City, GP visit PAT to provide final report on results of FY2016 feasibility study project PAT delegation visits Port of Yokohama. Yokohama City Port and Harbour Bureau hosts training program (human resources development, personnel systems, etc.)

	PAT participates in high-level seminar in Chiang Rai, Thailand, makes presentation on PAT's "Green Port Project" environmental plan
2017 (Apr)	JCM project feasibility study for PAT-managed ports (with cooperation from PAT, and YPC as implementation body) selected by Ministry of the Environment for "FY2017 City-to-City Collaboration Programme for Low-Carbon Society," Yokohama City participating as partner
2017 (May)	Regarding equipment for PAT to introduce to Bangkok Port, YPC, PAT and GP create international consortium, and apply for selection as a FY2017 JCM equipment subsided project (project name: "Introduction of Energy Efficient Equipment to Bangkok Port"). Subsidy approved January 2018.
2017 (Aug)	Port and Harbor Bureau, City of Yokohama participates as speaker at workshop organized by PAT in Bangkok
2018 (Feb)	YPC, Yokohama City, GP visit PAT to provide final report on results of FY2017 feasibility study project
2018 (May)	This feasibility study is selected by Japan's Ministry of the Environment for "FY2018 City-to-City Collaboration Programme for Low-Carbon Society," with Yokohama City participating as partner
2018 (Jul)	Seminar held at Port of Yokohama on request of PAT. Delegation of 12 persons includes representatives of PAT Laem Chabang Port.
2018 (Oct)	PAT travels to Japan to attend Ministry of the Environment "Seminar on City-to-City Collaboration for Creating Low-Carbon Society"
2019 (Jan)	YPC, Yokohama City, GP visit PAT to provide final report on results of this feasibility study
	PAT, YPC and GP sign international consortium agreement for implementation of Smart Port Project for Bangkok Port, Thailand, making use of Financing Programme for Joint Crediting Mechanism (JCM) Model Projects

In the area of port environment, based on the policy of being "a safe, secure and environmentally-friendly port" as stated in the Yokohama port plan, the City of Yokohama and YPC are promoting efforts to create a low-carbon and "smart" port that is also resilient to disasters, and as technical cooperation with PAT, they are making use of Yokohama's knowhow and experience to conduct discussions to support environmental initiatives being promoted by PAT. These steady and ongoing efforts resulted in PAT becoming actively engaged in the JCM project, as described below.

For example, in October 2015, YPC visited PAT and discussed technical cooperation to introduce low-carbon facilities by utilizing the JCM. Joint discussions continued thereafter, and in July 2016, YPC visited PAT again to observe facilities at Bangkok Port and Laem Chabang Port with a view to utilization of the JCM, and discussed with PAT concrete topics relating to future project formulation to utilize the JCM. For these activities, the Climate Change Policy Headquarters and the International

Affairs Bureau (both at City of Yokohama) accompanied the missions, and discussed the implementation of support based on the City of Yokohama's efforts.

Subsequently, in August 2016, YPC became the representative applicant for the feasibility study for the introduction of low-carbon facilities to utilize the JCM at PAT-managed ports, applying for the Ministry of the Environment's "FY2016 Feasibility Study of Joint Crediting Mechanism Project by City to City Collaboration," and the application was adopted in September.

In February 2017, as a local workshop for this feasibility study project, a final reporting meeting was provided for the PAT Acting Chief Director, who then expressed a strong interest in submitting an application as a JCM equipment subsidy project for export CFS facilities.

In March 2017, regarding an Import CFS to be newly constructed by PAT, for a feasibility study on the introduction of low-carbon equipment utilizing the JCM, with YPC as the representative applicant and the City of Yokohama and GP as partners, an application was submitted for the Ministry of the Environment's "FY2017 City-to-City Collaboration Programme for Low-Carbon Society," and it was approved in April. Regarding the Import CFS covered by the feasibility study, PAT revised the construction plan in October 2018 and it changed to a comprehensive logistics warehouse (PAT refers to it as a "DistriCenter").

In May 2017, based on the results of FY2016 feasibility study, YPC, PAT and GP formed an international consortium regarding the facilities for PAT to introduce at Bangkok Port, and applied to be a FY2017 JCM equipment subsidy project (project name: "Introduction of Energy Efficient Equipment to Bangkok Port"). The subsidy was approved in January 2018.

In February 2018, a final report was provided in the form of a local workshop on the FY2017 feasibility study described above. Considering the application that had been made for a JCM equipment subsidy for the "DistriCenter" mentioned above, the PAT executives who attended expressed their desire to continue discussions, and also commented that in order to continue to accelerate efforts to reduce CO2 emissions from PAT-managed ports in Thailand, they were highly interested in implementation of a feasibility study (this project) for further deployment to Laem Chabang Port.

Regarding the DistriCenter, information was obtained from PAT that together with the revision of the Bangkok Port Redevelopment Master Plan in May 2018 there were plans to start preparing a master plan.

Documents including the aforementioned memorandum of understanding are provided in the Attachments.

(4) Achievements and Experience of the Yokohama Port Corporation (YPC)

As described above, together with the other partners including the City of Yokohama's Port and Harbour Bureau, YPC has been developing a positive cooperative relationship with PAT over the course of many years. Below is a summary of specific achievements.

1) From 1986 to 1989, YPC dispatched personnel from the Yokohama Port and Harbor Bureau as JICA experts to the Eastern Seaboard Development Committee of Thailand to support development of Laem Chabang Port.

2) In 2013, the City of Yokohama City cooperated in work to formulate the "Bangkok Master Plan on Climate Change 2013-2023" project implemented by the Japan International Cooperation Agency (JICA). The Yokohama City Action Plan for Global Warming Countermeasures was used as a model for the formulation of the Master Plan, and the City of Yokohama created internal support arrangements consisting of multiple departments to provide extensive cooperation. The City of Yokohama's cooperation is mentioned in the FY2015 White Paper on Development Cooperation published by Japan's Ministry of Foreign Affairs.

3) On October 21, 2013, the City of Yokohama and Bangkok Metropolitan Administration signed a Memorandum of Understanding on Technical Cooperation for Environmentally-Conscious Sustainable Urban Development.

4) On April 22, 2014, the City of Yokohama and PAT signed a memorandum of understanding regarding partnership to develop beneficial relationships for the development of the Port of Yokohama and domestic ports in Thailand.

5) On August 4 and 5, 2014, YPC received an observation tour from Laem Chabang Port (Port Authority of Thailand) and Thammasat University. A lecture was conducted relating to the MM21 District and redevelopment plans.

6) Seminar organized by PAT on January 19, 2015. Yokohama City Port and Harbor Bureau Director Itoh joined along with YPC's Director Kanno. A presentation was made on "Efforts of the Port of Yokohama to Become an International Hub Port."

7) On January 20, 2015, the City of Yokohama signed a basic agreement with PAT on concrete actions to fulfill the agreement in the aforementioned memorandum of understanding.

8) In May 2015, YPC received a Port of Yokohama observation tour by professors from Chulalongkorn University in Thailand. Provided information on waterfront development research related to Port Authority of Thailand.

9) In October 2015, YPC visited PAT for discussions about the JCM.

10) From November 10 to 13, 2015, the City of Yokohama received a delegation from PAT and held a training, based on a memorandum of understanding and the basic agreement with PAT.

11) In April 2016, the FY2016 "Feasibility Study for Assisting Ports in Thailand to Reduce CO2 Emissions and to Become 'Smart Ports'" was approved as a Feasibility Study for JCM Project by City-to-City Collaboration, and a feasibility study on CFS Export for Bangkok Port was launched, with the cooperation of PAT.

12) In July 2016, YPC, the City of Yokohama Climate Change Policy Headquarters and Yokohama International Affairs Bureau visited PAT for site research and for discussions about the JCM.

13) In April 2017, the “Study for Assisting Ports in Thailand to Reduce CO_2 Emissions and to Become ‘Smart Ports’” was approved as a JCM Project Feasibility Study based on the FY2017 City-to-City Collaboration Project for Low-Carbon Development, and as a follow-up to the previous year’s work on CFS Export, a study was initiated regarding CFS Import for Bangkok Port, with the cooperation of PAT.

14) In May 2017, with YPC as the representative proponent and PAT as the local proponent, a funding application was submitted entitled “Introduction of Energy Efficient Equipment to Bangkok Port” based on the findings of the feasibility study in 11) above. It was submitted under the “Financing Programme for Joint Crediting Mechanism (JCM) Model Projects in FY2017”. In June 2017, the application was approved.

15) In January 2018, the Global Environment Center Foundation (GEC) approved the application in 14) (project name: “Introduction of Energy Efficient Equipment to Bangkok Port, Thailand”).

16) In May 2017, the “Study for Assisting Ports in Thailand to Reduce CO2 Emissions and to Become ‘Smart Ports’” was selected under the “FY2018 City-to-City Collaboration Programme for Low-Carbon Society,” and discussions began in cooperation with PAT regarding a visioning scheme to introduce low-carbon equipment at terminals of Laem Chabang Port.

1.2 Overview of Laem Chabang Port

(1) History of the Development of Laem Chabang Port

As part of Thailand’s Fifth National Socio-Economic Development Plan (1982-1986) formulated in 1981, plans were made for Laem Chabang Port to be an alternative for the functions of Bangkok Port and as one of the centers of development for the Eastern Coastal Development Plan adopted by the Government of Thailand. In the area inland from this port there were plans for a manufacturing zone for industrial products, with the aim of relocating industrial functions that were concentrated around Bangkok, to expand Thailand’s exports of manufactured goods.

(2) Overview of Laem Chabang Port

Construction began on Laem Chabang Port in 1986, it opened as an international trade port in 1991, and in 1997 it overtook the cargo handling volume of Bangkok Port to become the largest port in Thailand. The port handled an annual 7.67 million TEU of container cargo in 2017, and besides containers, it also has terminals for bulk carriers and vehicle carriers.

The current status of the terminal is shown in Table 1 and Figure 3, and terminal facilities are currently in service in the three sections A to C.

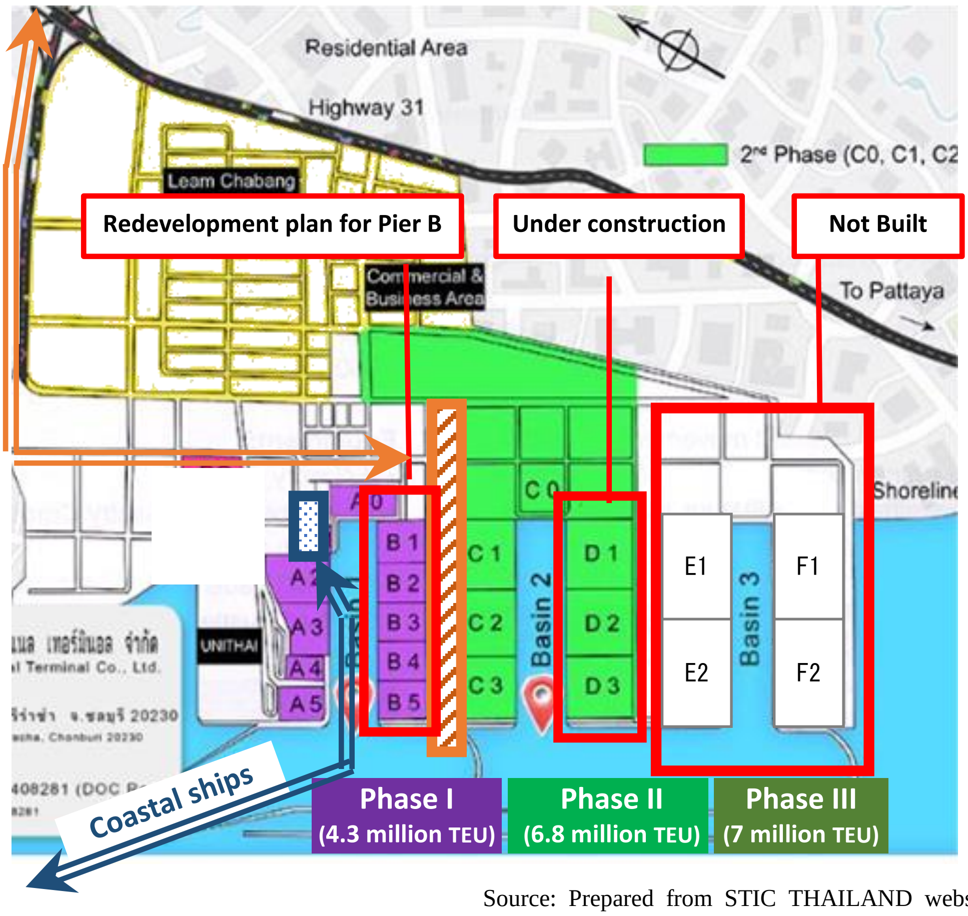
At the three berths in Section D the Hutchison Group is progressing on development with the integrated automation of the terminals, and has started partial service. There are also future plans for terminal development in Sections E and F.

In addition, in order to “promote modal shift,” PAT is moving ahead with preparations to build and provide services at a “rail terminal (SRTO)” and a “coastal terminal.” The rail (SRTO) terminal is under construction between Terminals B and C for rail transport, intended to connect with the Lat Krabang Inland Container Depot in the eastern part of Bangkok, to help mitigate traffic congestion, and promote more efficient transport. The coastal terminal is intended to facilitate traffic from main shipping routes to inland river ports and enable coastal shipping connections with industrial areas of southern Thailand, and is also another measure to mitigate road congestion.

Table 1: Current status and planned expansion at Laem Chabang Port

Phase	Throughput capacity (million TEU/yr)	Terminals	Service status	Remarks
Phase I	4.30	A0 to A5, B1 to B5	Started 1991	Lease contracts with PAT end in 2020 for Terminal B. Thereafter, Pier B will be reconfigured.
Phase II	6.80	C0 to C3, D1 to D3	Started 2007	For Berths D1 to D3, construction is in progress, and partial service has started.
Phase III	7.00	E1, E2, F1, F2	Planned for 2025	Discussions underway for environmental impact assessment
Other	—	Rail terminal (SRTO), coastal terminal	Planned for 2019	Being built as part of modal shift for PAT-operated terminals

Source: PAT Annual Report 2017 and interviews with PAT



Source: Prepared from STIC THAILAND website

Figure 3: Laem Chabang Port terminal layout

(3) Laem Chabang Port Management and Operations Structure

At Bangkok Port, PAT is managing everything from construction and improvements to terminal operations. In contrast, at Laem Chabang Port, PAT owns the land and manages all areas of the port as the port manager, but private sector operators are given terminal operator contracts based on long-term leases, and operations are being done by operators that have obtained contracts on a terminal by terminal basis. Improvements in the structures, as well as operations, are done by operators who have obtained the rights for each terminal (concession contracts). Currently, terminal Sections A to C are being operated by private sector companies based on concession contracts, as listed in Table 2.

Because of the importance of Laem Chabang Port as a logistics center, many Japanese companies are among them, with Nippon Yusen Kaisha at A1, Mitsui & Co. at B2, Marubeni Corporation and Kamigumi Co. at B3, Nippon Yusen Kaisha and Mitsui O.S.K. Lines at B4, and Nippon Yusen Kaisha at C0.

However, for the coastal terminal and the rail terminal (SRTO), PAT is planning to handle its own procurement of equipment and facilities.

Table 2: List of current terminal operators

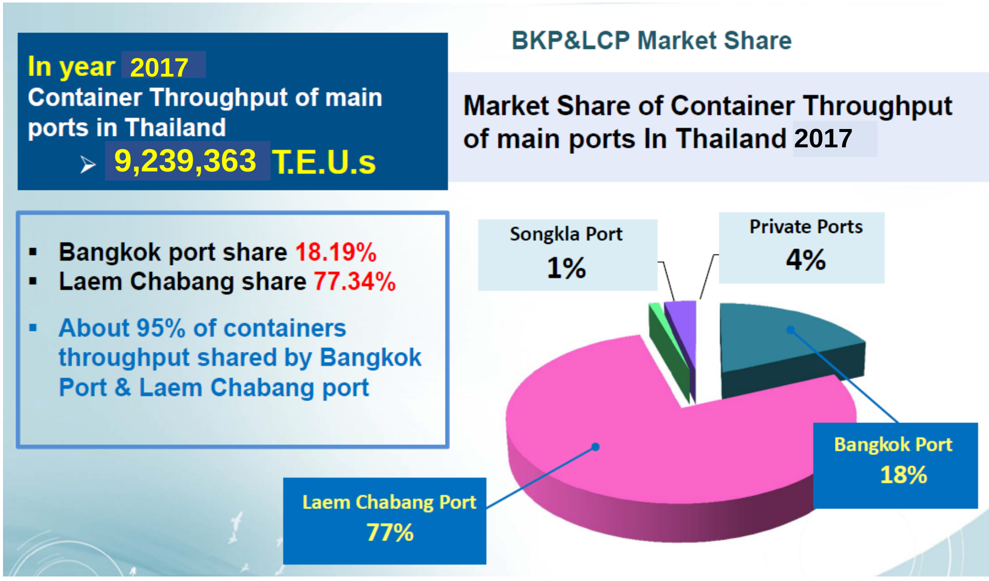
Terminal	Operator	Area (m2)	Use of terminal	Container ground slots (TEU)
A0	LCMT CO., LTD.	170,000	Multi-purpose, coastal cargo	3,551
A1	NYK AUTO LOGISTICS THAILAND CO., LTD.	31,500	Ro-Ro, passenger	—
A2	THAI LAEMCHABANG TERMINAL CO., LTD.	170,000	Multi-purpose	2,970
A3	HUTCHISON LAEMCHABANG TERMINAL CO., LTD.	170,000	Multi-purpose	1,688
A4	AAWTHAI WAREHOUSE CO., LTD.	128,000	Molasses, sugar	—
A5	NAMYONG TERMINAL PUBLIC COMPANY LIMITED	240,000	General cargo, Ro-Ro	—
B1	LCB CONTAINER TERMINAL 1 COMPANY LIMITED	120,000	Container	2,362
B2	EVERGREEN CONTAINER TERMINAL (THAILAND) LTD.	105,000	Container	1,742
B3	EASTERN SEA LAEM CHABANG TERMINAL CO., LTD.	105,000	Container	1,522
B4	TIPS CO., LTD.	105,000	Container	1,908
B5	LAEM CHABANG INTERNATIONAL TERMINAL CO., LTD.	82,089	Container	2,892
C0	LAEM CHABANG INTERNATIONAL RORO TERMINAL CO., LTD.	315,400	General cargo, Ro-Ro, passenger	—
C1-2	HUTCHISON LAEMCHABANG TERMINAL CO., LTD.	540,000	Container	9,540
C3	LAEM CHABANG INTERNATIONAL TERMINAL CO., LTD.	231,668	Container	3,278

Source: Annual Report 2017, Port Authority of Thailand, 2018
ECT case summary

(4) Performance of Laem Chabang Port

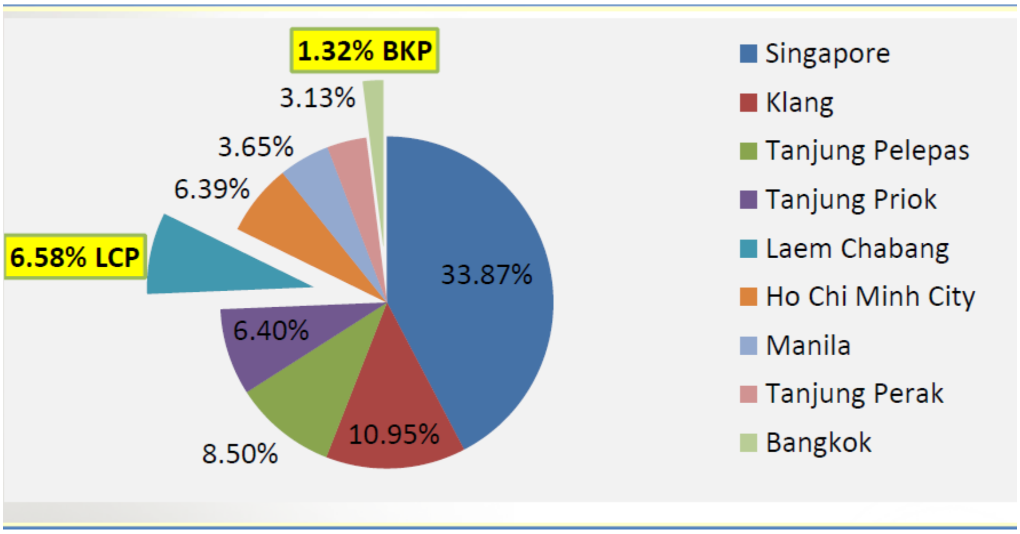
1) Container Throughput Market Share

The container throughput of Laem Chabang Port has been showing an annual 7% growth since 2009, and was at 7.67 million TEU in 2017. The port has about a 77% market share in Thailand (Figure 4) and a 6.6% share in ASEAN (Figure 5).



Source: PAT interview January 2019

Figure 4: Market share of Laem Chabang Port in Thailand



Source: Laem Chabang Port's Infrastructure Development & Connectivity, Dec. 2016, Laem Chabang Port, PAT

Figure 5: Market share of Laem Chabang Port in ASEAN region

2) Port Arrivals

Table 3 shows port arrivals for Laem Chabang Port from 2012 to 2017. The most arrivals for FY2013 to 2016 are by international container ships, but in FY2017 there were more coastal container ships. In FY2017 international container ships had a 35.5% share, while coastal container ships had a 45% share, so the two together accounted for about 80% of container ship arrivals.

Table 3 Trends in port arrivals

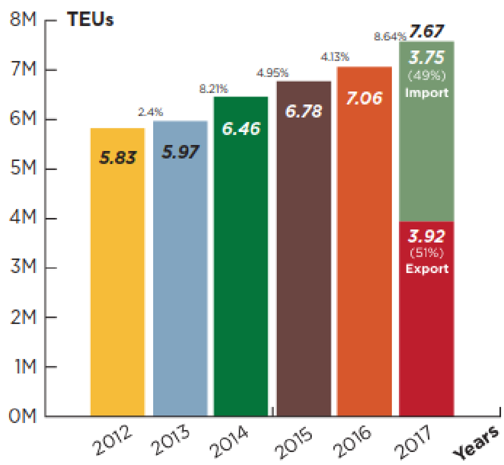
(Units: Ships)

Type of vessel \ Fiscal year	2012	2013	2014	2015	2016	2017
Container ships	7,453	6,443	9,242	9,889	10,075	10,862
International container	—	4,922	4,888	5,153	5,159	4,723
Coastal container	—	1,521	4,354	4,736	4,916	6,139
General cargo	387	390	382	371	344	352
Ro-Ro ships*2	594	670	629	659	665	696
Barge	86	77	68	94	91	60
Passenger ship	37	41	36	42	56	59
Bulk carrier	326	230	320	122	92	86
Other	1,543	749	1,298	1,301	1,284	1,346
Total	10,426	8,600	11,975	12,478	12,607	13,461

Source: "Laem Chabang Port full year results" (สรุปผลการดำเนินงานของท่าเรือแหลมฉบัง ปีงบประมาณ)」
(Laem Chabang Port website, accessed January 2019)

3) Container Throughput

Figure 6 shows the container throughput trends of Laem Chabang Port from 2012 to 2017. The throughput has been increasing year by year, and at 7.67 million TEU in 2017 was 32% greater than in 2012. In FY2017, at 51% of volume handled, export throughput was slightly more than import throughput at 49%.

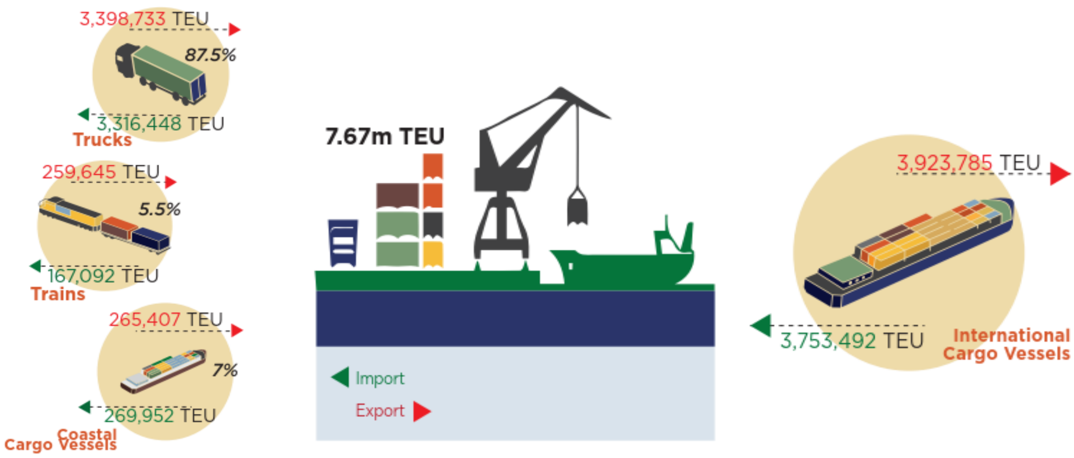


Source: "Statistics of Laem Chabang Port 2017" (Laem Chabang Port website, accessed January 2019)

Figure 6: Laem Chabang Port throughput

*2 RO/RO ships: Vessels that truck and chassis can drive directly on and off (roll-on/roll-off).

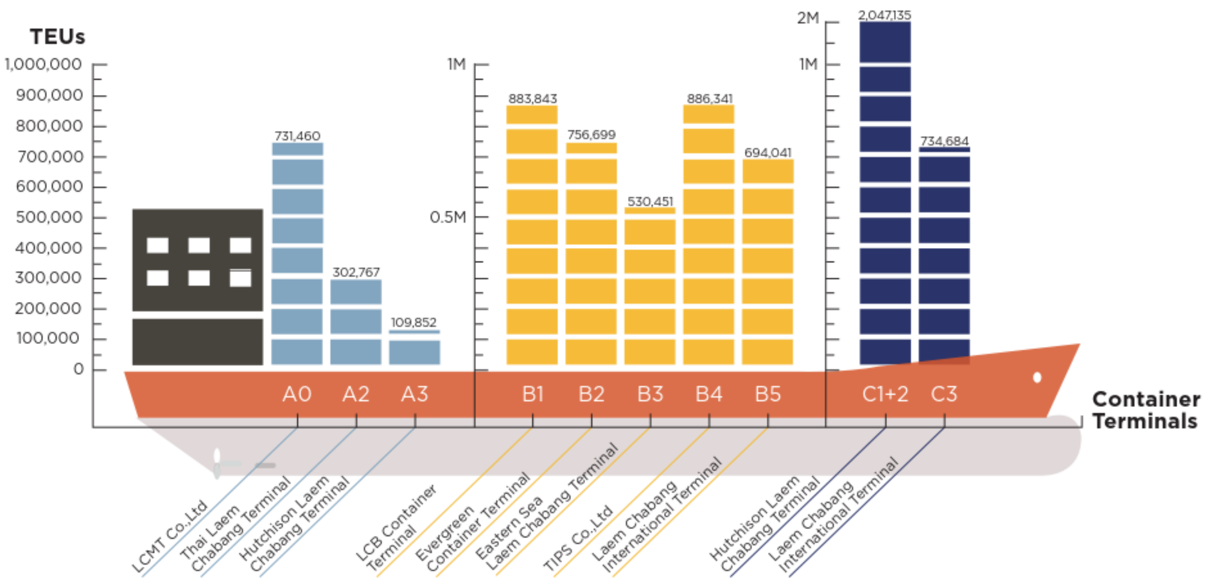
A breakdown of the modal split of container traffic in FY2017 is shown in Figure 7. Trucking accounted for 87.5% of domestic transport, compared to 7% for coastal cargo vessels and 5.5% for rail.



Source: "Statistics of Laem Chabang Port 2017" (Laem Chabang Port website, accessed January 2019)

Figure7: Modal split in container traffic (FY 2017)

The container throughput for each terminal in FY 2017 is shown in Figure 8, with Terminal A, Terminal B, and Terminal C totaling 1.144 million, 3.751 million, and 2.782 million TEU, respectively.



Source: "Statistics of Laem Chabang Port 2017" (Laem Chabang Port website, accessed January 2019)

Figure 8: Containers handled by each terminal (FY 2017)

4) Top Export Partners

The top ten export partners for January to September 2017 are shown in Table 4, with China, the United States, and Japan in the first three spots at 14%, 11.7%, and 9.2%, respectively.

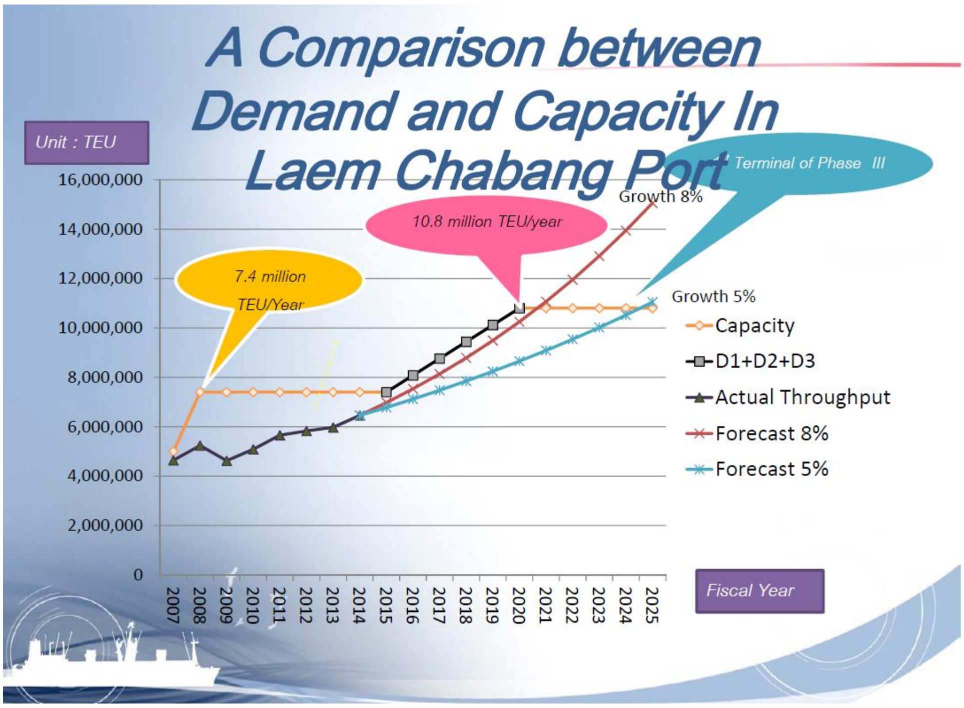
Table 4: Top 10 export partners (Jan to Sep 2017)

	COUNTRY	BOX	TEU	%
NO. 01	China	270,261	398,312	14%
NO. 02	United States	220,528	332,842	11.7%
NO. 03	Japan	175,432	262,015	9.2%
NO. 04	Indonesia	99,698	148,582	5.2%
NO. 05	Vietnam	98,609	147,510	5.2%
NO. 06	India	83,607	125,298	4.4%
NO. 07	Australia	66,697	100,066	3.5%
NO. 08	Philipines	63,618	100,066	3.4%
NO. 09	Malaysia	61,102	92,623	3.2%
NO. 10	Taiwan, Prov. of China	53,733	92,623	2.8%

Source: "Statistics of Laem Chabang Port 2017" (Laem Chabang Port website, accessed January 2019)

1.3 Future Development Plans at Laem Chabang Port

With future increases in cargo throughput being predicted for Laem Chabang Port (Figure 9), three projects are planned: Construction of a coastal terminal, Single Rail Transfer Operator (SRTO), and the Phase III Development Plan. If these projects are implemented, the port capacity is expected to increase as shown in Table 5.



Source: PAT interview, January 2019

Figure 9: Future projections of throughput at Laem Chabang Port

Table 5: Capacity of Laem Chabang Port (million TEUs)

Units: Million TEUs
RO/RO terminal: Million vehicles

Item	Phase I＋II	Phase III
Container terminal	11.1	7.0
RO/RO terminal	1.98	1.0
Rail terminal	2	4.0
Coastal terminal	0.6	1.0

Source: Laem Chabang Port's Infrastructure Development & Connectivity, Dec. 2016, Laem Chabang Port, PAT

(1) Promoting Modal Shift

Responding to strong requests from the Thai central government, PAT is undertaking efforts to reduce truck transportation. Specifically, this includes promoting a modal shift to coastal shipping by building berths and a terminal for coastal ships at both Bangkok Port and Laem Chabang Port, as well as by building a rail terminal at Laem Chabang Port to promote rail transport to a nearby inland container depot and industrial areas.

There are rail connections from Laem Chabang Port north toward the Lat Krabang Inland Container Depot near the Suvarnabhumi Airport, and south toward Rayong. Currently only some sections are double-tracked, but a plan is underway to double-track all lines in the future.

Source: Prepared from Stock Exchange of Thailand materials

Figure 10: Map of Laem Chabang Port and region

1) Coastal Terminal (Figure 11)

Based on policies of the Thai government and directions of the Ministry of Transport, a coastal terminal is being constructed with the aim of reducing logistics costs as well as and reducing environmental impact by promoting a modal shift from trucking to coastal shipping. Additional aims are to bolster the docking capacity for coastal shipping to connect Laem Chabang with regional ports in the northern and southern regions of the country, and to increase transport capacity between Laem Chabang Port and the existing coastal terminal at Bangkok Port.

Construction plans for the coastal terminal are summarized here:

- The plan is to construct and operate a coastal terminal on vacant land (approx. 17.5 acres) between Berths A0 and A1. Plans are for a pier length of 150 m, water depth of 10 m, ship handling capacity of 3,000 DWT, annual throughput capacity of 600,000 TEU, and the launch of operations in May 2019.
- In Phase III as well, there are plans for construction of a coastal terminal with annual capacity of 1 million TEU.

Source: Laem Chabang Port's Infrastructure Development & Connectivity, Dec. 2016, Laem Chabang Port, PAT

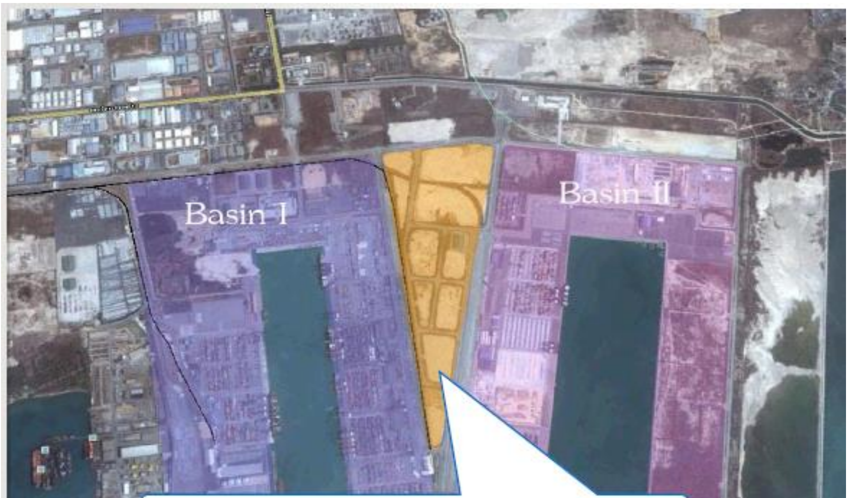
Figure 11: Construction of a coastal terminal

2) Rail Terminal (Single Rail Transfer Operator: SRTO) (Figure 12, Photo 1)

PAT is also working to bolster rail transport at Laem Chabang Port. This is part of a strategy to deal with expected increases in throughput at Laem Chabang Port, and also an effort to reduce environmental impacts through a modal shift, as mentioned above.

Based on these policies, PAT is currently constructing a Single Rail Transfer Operator (SRTO) rail terminal at Laem Chabang Port. Here are some key points regarding the construction plans:

- The rail terminal will be constructed and operated in the triangular area between Wharf B and Wharf C. The plan is to increase the annual rail transport capacity of Laem Chabang Port from the current 500,000 TEU to 2 million TEU, and temporary operations are beginning in the autumn of 2018. Full service is expected to begin about the spring of 2019.
- The SRTO terminal will be directly managed by PAT, but actual cargo handling will be done by operators under bidding and contract.
- For container transport by private sector companies, because there will be a shift from truck to coastal shipping and rail, PAT is considering strategies to reduce transport costs to levels that are competitive with trucking.
- In Phase III as well there are rail transport terminal construction plans with an annual capacity of 4 million EU



Source: Laem Chabang Port's Infrastructure Development & Connectivity, Dec. 2016, Laem Chabang Port, PAT and PAT interview, January 2019

Figure 12: Planned site for Single Rail Transfer Operator (SRTO)

Photo 1: Area around planned site for SRTO

(2) Phase III Development Plan

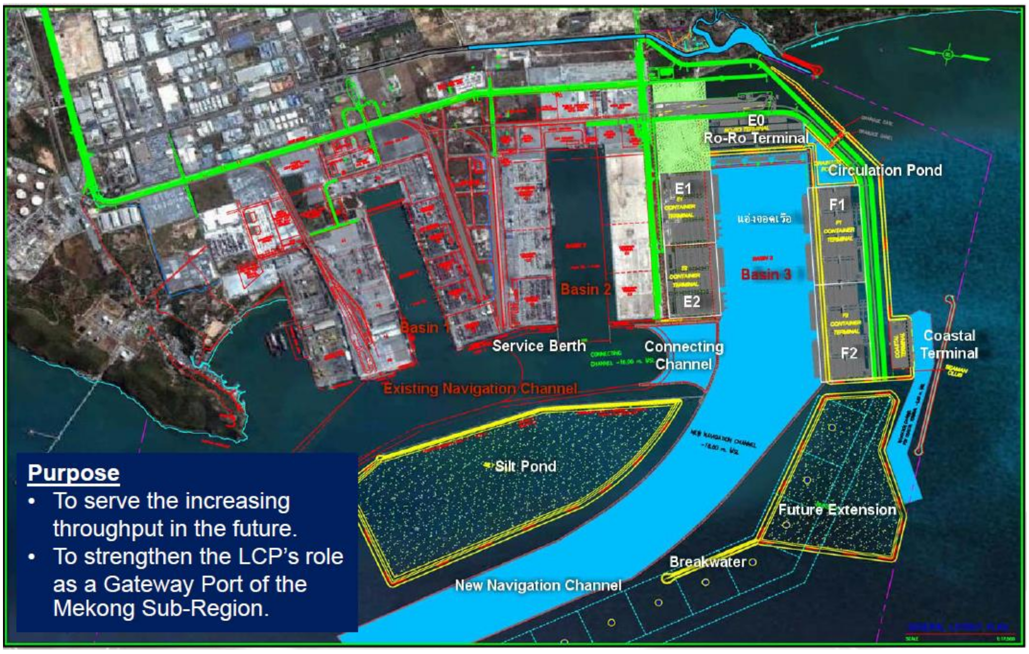
Phase III is to be constructed as shown in Figure 13 with the aim of addressing future increases in container cargo volume in a location adjacent to Phase II. This aim is serve as a gateway port for the Mekong Sub-Region and is prioritized as a means of bolstering the capacity of the Laem Chabang Port.

A feasibility study and detailed design were implemented from 2011 to 2016. Construction work is to run from 2018 to 2021, and there are plans for a bidding process in 2020 for private sector companies to invest in facilities (equipment and structures) and to operate the terminal. Here are some key points regarding Phase III:

- Specifications being considered are 800 m x 2 berths for Wharf E (E0 to E2) and 1,000 m x 2 berths for Wharf F (F1, F2).
- Anticipated water depth is to accommodate the largest vessels: 18.5 m.
- E0 is to be a vehicle terminal, with annual capacity of 100,000 vehicles
- E1, E2 and F1 and F2 are to be container terminals, with potential to handle 7 million TEU/year under the current plan.
- PAT is expected to make the investment for the terminal construction (foundations), while the private sector is expected to make the investments for facilities. This project is being considered as Fast Track to accelerate the speed of PPP procedures, and the government has given instructions to do the work as soon as possible.
- Regulatory arrangements are also needed to speed up the plan. The Thai government is currently preparing tax incentive legislation for investors in the Eastern Economic Corridor (EEC).
- Since the depth is to be 18.5 m, it is envisioned that 18,000 TEU container ships will be accommodated. The capacity for even larger ships will certainly become an issue in the

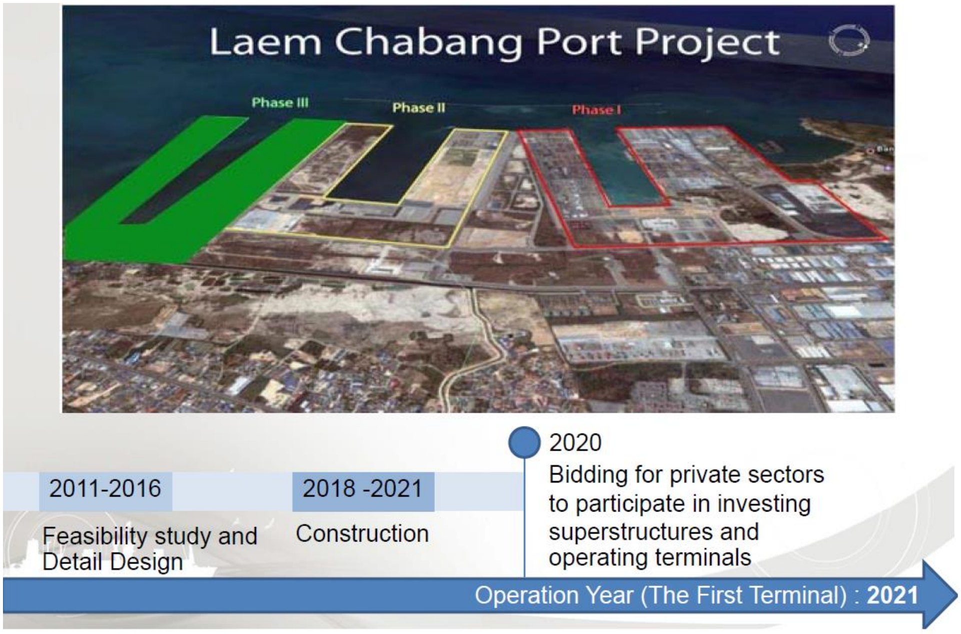
future, but large ships like that might arrive only two or three times a year, and even so, it is unlikely that all of them would be offloading at Laem Chabang Port, so officials are not fully convinced that Laem Chabang Port has to be prepared for the world's largest ships. They carefully considered the size of ships that Laem Chabang Port should be able to accommodate, and this was their conclusion.

- Regarding Wharf E and Wharf F, (1) there is a high likelihood that multiple operators will submit bids for future investments in these wharves, and (2) it is seen as likely that mainly existing terminals will continue to used. As an actual example, Hutchison currently has the contract for Wharf A2 and Wharf A3 from Phase I, and also for Wharf C and Wharf D, and when large ships arrive that cannot dock at Wharf A, they are sent to dock at C or D.
- In Phase III as well, there are plans for construction of a coastal shipping terminal with a capacity of 1 million TEU, and a rail terminal with capacity of 4 million TEU.



Source: Laem Chabang Port's Infrastructure Development & Connectivity, Dec. 2016, Laem Chabang Port, PAT

Figure 13(1): Phase III planned site (1)



Source: Laem Chabang Port's Infrastructure Development & Connectivity, Dec. 2016, Laem Chabang Port, PAT

Figure 13(2): Phase III planned site (2)

(3) Terminal B Reconfiguration Plan

An opportune time is approaching to reconfigure Terminals B2 to B4. Details of contract renewals are not yet clear, but considering factors such as increasing ship sizes and cargo volumes, PAT appears to be in the process of considering the reconfiguration of these terminals to create larger sections than what existed previously.

2. Consideration of Low-Carbon Equipment and Facilities

2.1 Interviews and Discussions with PAT and Terminal Operators

(1) PAT

1) Purpose

To inform PAT Laem Chabang Port divisions about the purpose and content of this study, as well as the JCM program, and seek cooperation going forward. Also, to inquire whether there were any facilities (including those in future plans) for which PAT would like to have cooperation to consider in the context of its environmental initiatives.

2) Interview Date and Participants

The interview date and participants are listed in Table 6.

Table 6: Study dates and participants

Date	May 17, 2018, 10:30 to 12:00	
Location	PAT Laem Chabang Port meeting room (2nd floor)	
Local participants	PAT (Laem Chabang Port divisions)	・Lt.Jg. Yutana Mokekhaow,R.T.N. Deputy Managing Director ・Mr. Grissada Udompoch Assistance Director of Engineering Division ・Lt.Jg. Chaiwat Jaidee,R.T.N. Cargo Operation Officer 12 Coastal Terminal A ・Miss. Natananta Jindapongjaroen ・Mr. Ud Tuntivejakul Port Operation Officer 8 , Office of Operation, Single Rail Transfer Operator
	PAT (Bangkok Port department)	・Mrs. Mayuree Deeroop Scientist 10, Corporate Strategy Department ・Miss. Ruttikarn Chamsub Scientist 8, Corporate Strategy Department
Participants from Japan	Yokohama Port Corporation (YPC)	Hidenori Kishimura, Managing Director Kosuke Shibasaki, Deputy General Manager, Engineering Department Katsuyuki Ozaki, Manager, Engineering Planning Division, Engineering Department Kenta Morikawa, Deputy Chief, Engineering Planning Division, Engineering Department
	Green Pacific Co. (GP)	Mariko Fujimori, Executive Vice President, Director Darmp Phadungsri, Consultant
	City of Yokohama	Shintaro Saito, Director of Logistics Planning Division, Port and Harbour Bureau Katsuyuki Yonemori, Manager for Logistics Planning, Port and Harbour Bureau

3) Discussion Findings

<Items Identified for Feasibility Study>

Discussions centered on low-carbon technologies currently of interest to PAT.

- At Bangkok Port, PAT owns the cargo handling machines and directly manages terminal operations. Meanwhile, at Laem Chabang Port, PAT performs the role of landlord in port management. It develops the land and foundations, which it leases to terminal operators on long-term leases, while structures above the ground are developed by the operators as tenants. For this reason, it was found that PAT's own procurement does not include items such as electrical supply equipment and facilities within each terminal, but rather, is limited to equipment and facilities that are centralized or used in common at the port.
- More specifically, this means increasing the ratio of renewable energy rate in electricity supplied to each terminal, converting to LED lighting on roads at the port, making environmental improvements related to port treatment of waste from ships and port operations, and upgrading to environmentally-friendly tugboats owned by PAT (it owns six).
- As for waste treatment, PAT consolidates waste generated at Laem Chabang Port on the property behind the port and then transports it to the municipal incineration site for disposal. In the future, there is some intention to further reduce the environmental impacts by installing a waste disposal facility on the property inland from the port.
- In addition, it was noted that a new rail terminal and a coastal terminal are under construction at Laem Chabang Port for the purpose of promoting modal shift, and they will be operated directly by PAT. Construction is already under way, but the plan is to build in stages depending on cargo volumes. It was confirmed that there are plans to procure Rubber Tired Gantry cranes (hereinafter "RTG") as cargo handling equipment in around 2020. (Plans are for three cranes for the rail terminal (SRTO) and two cranes for the coastal terminal.)

<Electricity Supply for Port Terminals>

Next, this study confirmed basic information needed for considering environmental efforts at Laem Chabang Port, including electricity procurement and distribution methods, etc.

- For electricity, the port makes its purchases from Thailand's Provincial Electricity Authority (PEA) at 115 kV, steps it down to 22 kV at a PAT substation, and provides it to operators. The total power capacity is about 15 MW.
- PAT has already introduced small wind turbines. The electricity generated is directly consumed onsite through a connection to the grid at Laem Chabang Port. It does not have storage batteries. (Initially about 850 kW of electricity generation was anticipated, but effective generation has not reached 100%.)
- If the port installs solar photovoltaic facilities in the future, the preference is to use space on existing building roofs or open space under the existing small wind turbines (height about 10 to 12 m) (however, for maintenance space, nothing can be installed within a 20 m by 20 m area around each existing small turbine).

<Port Terminal Automation (Remote Operation)>

Discussions also covered plans and the potential for automation of operations and remote operations at Laem Chabang Port.

- Under Phase II, construction is currently underway at Terminal D (managed by Hutchison), with the aim of a fully automated terminal, with the automation of container cranes and RMG cranes. Also, the time for contract renewals is coming soon at Terminal B, and a reconfiguration is being considered to reduce the number of terminals from the current five to two or three. Decisions of whether or not to introduce automation or remote operations are made by the tenants, but there is a possibility to renewal their contracts they may be required to automate their operations. Also, for terminals in Phase III, PAT is considering inviting operators based on the condition that they will have fully automated operations.

(2) Mitsui & Co. (Investor in Terminal B2)

1) Purpose

An interview was conducted with Mitsui & Co., which has invested in Terminal B2, one of the B terminals at Laem Chabang Port, regarding their plans for the terminal, as well as to gather information about adjacent terminals.

2) Interview Date and Participants

The interview date and participants are listed in Table 7.

Table 7: Interview date and Participants <Mitsui & Co.〉

Date	May 2, 2018, 10:00 to 11:00	
Location	Mitsui & Co. headquarters	
Local participants	Mitsui & Co.	Mr. Imazeki, Mr. Suzuki
Participants	Yokohama Port Corporation (YPC)	Kosuke Shibasaki, Deputy General Manager, Engineering Department Katsuyuki Ozaki, Manager, Engineering Planning Division, Engineering Department
	Green Pacific Co. (GP)	Kazuhito Yamada, President Mariko Fujimori, Executive Vice President, Director

3) Interview Findings

- Terminal B is approaching contract expiry dates.
- Detailed information was not obtained about PAT’s future plans for reconfiguration of Terminal B, but various ideas are being considered.
- Thus, the circumstances still make it difficult for capital investments at Terminal B. The situation is believed to be similar at adjacent terminals.

(3) TIPS (Terminal B4 Operator)

1) Purpose

To ascertain if the terminal or operators could be included in a future feasibility study.

2) Interview date and Participants

The interview date and participants are listed in Table 8.

Table 8: Interview date and Participants <TIPS>

Date	May 16, 2018, 10:30 to 12:00	
Location	Laem Chabang Port Terminal B4 (TIPS), Meeting Room, Administration Building	
Local participants	TIPS	Teerapol, General Manager Chayapat, Operations Manager
Participants from Japan	Yokohama Port Corporation (YPC)	Hidenori Kishimura, Managing Director Kosuke Shibasaki, Deputy General Manager, Engineering Department Katsuyuki Ozaki, Manager, Engineering Planning Division, Engineering Department Kenta Morikawa, Deputy Chief, Engineering Planning Division, Engineering Department
	Green Pacific Co.(GP)	Kazuhito Yamada, President Mariko Fujimori, Executive Vice President, Director Darmp Phadungsri, Consultant
	City of Yokohama	Shintaro Saito, Director of Logistics Planning Division, Port and Harbour Bureau Katsuyuki Yonemori, Manager for Logistics Planning, Port and Harbour Bureau

3) Interview Findings

<Operation of Terminal B4>

- Terminal B4 was established by a joint venture by Mitsui O.S.K. Lines, Nippon Yusen, and the Ngo Whock Group (Thailand) (shares of investment are NYK 24.44%, MOL 24.44%, NGOWHOCK 51.12%)
- Service began in 1991. The lease agreement with PAT expires in 2020, and renewal of the agreement is currently undetermined.
- The gantry cranes can reportedly handle approx. 30 containers per hour, a respectable efficiency level.
- Annual container throughput in 2017 was approx. 861,000 TEUs.
- To boost efficiency, terminal companies have introduced their own simulation software (Navis).
- One container yard (CY2) is located about 2 km inland from the port, and an empty container yard (CD1) is at a distance of approx. 6 km, and by operating with nidentical operation systems, they compensate for a lack of yard area at the port. Container transport between terminal and the yards is by truck (diesel).

<Other points>

- Terminal B4 is putting an effort into environmental efforts. For example, to reduce electricity consumption, the target is to reduce per TEU electricity consumption by 5% per year. Also, a conversion of yard lighting to LEDs is being promoted (LEDs being used are made by Chinese manufacturers).
- Extensive environmental measures are in place, including visual observations of trucks entering the yard and refusal of entry for that are found to be emitting black smoke in their exhaust.
- Existing cargo handling equipment is as follows:
  - ・GC: 5 cranes (of which 3 are Mitsubishi 13 rows and 2 are ZPMC Post Panamax 17 rows)
  - ・RTG: 17 cranes (of which 10 are “1 over 4” and 7 are “1 over 6”; all diesel engines)
  - ・Reach stackers: 8 units (all diesel engines)
  - ・Handling lifters: 2 units (all diesel engines)
  - ・Tractor units: 63 units (all diesel engines)
  - ・Forklifts: Approx. 6 units (LP gas fuel)

  Note: A considerable decarbonization effect could be expected by electrifying the cargo handling equipment noted above, but it is difficult to develop concrete plans until the operating conditions are clarified in light of lease contract renewals.

(4) Nippon Yusen (Investor in Terminals A1, B4, C0)

1) Purpose

Nippon Yusen Kabushiki Kaisha (NYK) as a shipping company is putting an effort into environmental initiatives, and at Laem Chabang Port has invested into operations of container terminals and a multi-purpose terminal that handles finished motor vehicles, etc. Interviews were conducted to determine the potential to introduce low-carbon facilities at its terminals at Laem Chabang Port. Regarding Terminal B, information was obtained from two other companies as outlined above, so the emphasis here was on the multi-purpose terminal.

2) Interview Date and Participants

The interview date and participants are listed in Table 9.

Table 9: Interview date and participants <Nippon Yusen>

Date	May 16, 2018, 13:30 to 14:30	
Location	Laem Chabang Port, Terminal C0 (NYK), Meeting Room, Administration Building	
Local participants	NALT	Captain Ito
	LRT	Natakorn Augsornsree, Operation Manager
Participants from Japan	Yokohama Port Corporation (YPC)	Hidenori Kishimura, Managing Director Kosuke Shibasaki, Deputy General Manager, Engineering Department Katsuyuki Ozaki, Manager, Engineering Planning Division, Engineering Department Kenta Morikawa, Deputy Chief, Engineering Planning Division, Engineering Department
	Green Pacific Co.(GP)	Kazuhito Yamada, President Mariko Fujimori, Executive Vice President, Director Darmp Phadungsri, Consultant
	City of Yokohama	Shintaro Saito, Director of Logistics Planning Division, Port and Harbour Bureau Katsuyuki Yonemori, Manager for Logistics Planning, Port and Harbour Bureau

3) Interview Findings

<Usage Status of Multi-Purpose Terminal>

- For finished vehicles, mainly Terminal A1 is being used, and when handling volume is high, Terminal C0 is being used to supplement capacity. Terminal C0 is being used for oversized cargo, such as parts for large vehicles, and rail cars, etc.
- Both Terminal A1 and Terminal C0 were originally being used by a different operator that left and the current operators took over, so the existing administrative building and maintenance facilities were not originally designed for the current form of use, but are being used efficiently.

<Potential for Low-Carbon Equipment and Facilities at Multi-Purpose Terminal>

- The buildings are not particularly large in size and air conditioning is used only for office space, so converting these to high-performance equipment would likely provide limited energy-saving benefits.
- The pre-existing yard facilities are being used, but to increase the handling capacity for finished vehicles, it would be necessary to respond to automakers' requests, including greater quality control and enhanced security.
- Currently yard lighting uses high-pressure sodium lamps, but the operator would like to consider introducing LED lighting, which is more energy efficient and facilitates identification of scratches. However, due with the current locations of light poles it is not possible to have sufficient brightness, so together with converting to LEDs, it may also be important to consider additional light poles, and to install more electrical conduits and wiring

at the same time, so a careful cost-benefit evaluation is needed. The timing of such work is not determined.

2.2 Selection of Terminals for Feasibility Study

(1) Target Terminals for Feasibility Study

Based on interviews with the relevant companies at Laem Chabang Port and results of on-site verification, the target terminals for this feasibility study were selected to be the terminals directly managed by PAT and intended for modal shift (coastal terminal and rail terminal (SRTO)), as well as the inland port property.

Also, the multi-purpose terminal in which Japanese companies are participating in operations was also selected as a target for this study, but since the plans for facilities upgrades are not currently known, this report covers them only to the extent that is possible.

Table 10: Target terminals in feasibility study

Location	Proposed equipment	Operating entity
Rail terminal (SRTO)	・New hybrid RTG	PAT
Coastal terminal	・New hybrid RTG	
	・Refurbish existing diesel RTG as hybrid	
Inland property	・New solar photovoltaic equipment	
Multi-purpose terminal	・Upgrade to LED yard lighting	Private operators

Factors considered in the selection included plans for new or upgraded facilities and equipment, opportunities to introduce low-carbon cargo handling equipment and renewable energy, and the organizational arrangements of the counterpart that would be the implementation body for any JCM project. The envisioned project implementation arrangements are presented in the case of PAT in Figure 14 and private operators in Figure 15.

<Project design concept with PAT >

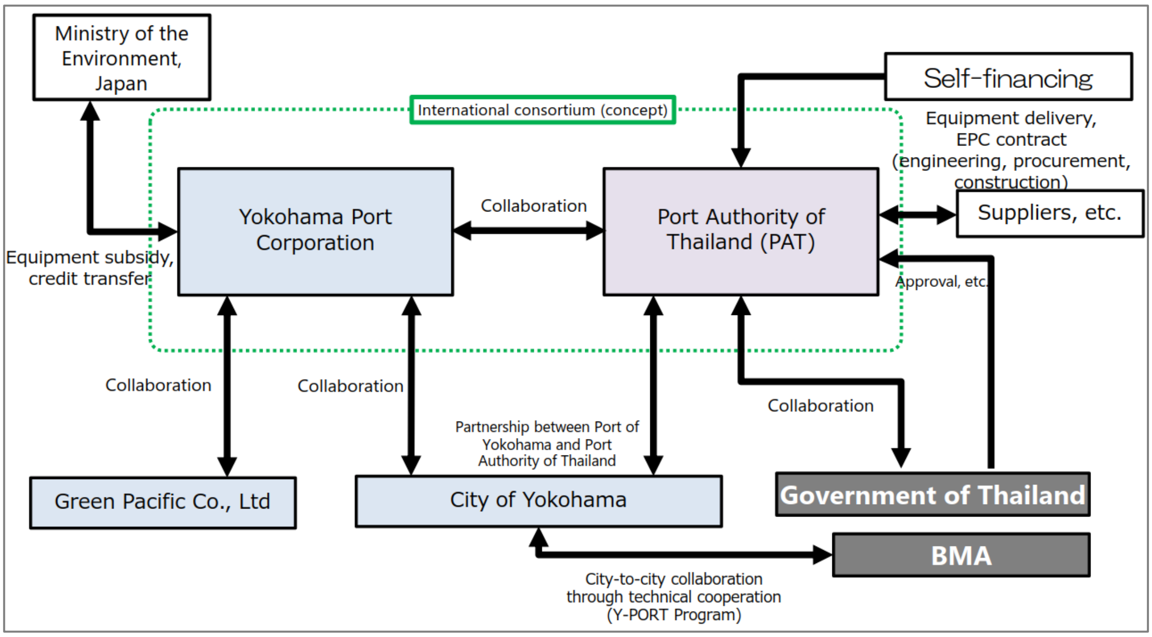


Figure 14: Project design concept with PAT

<Project design concept with private operators >

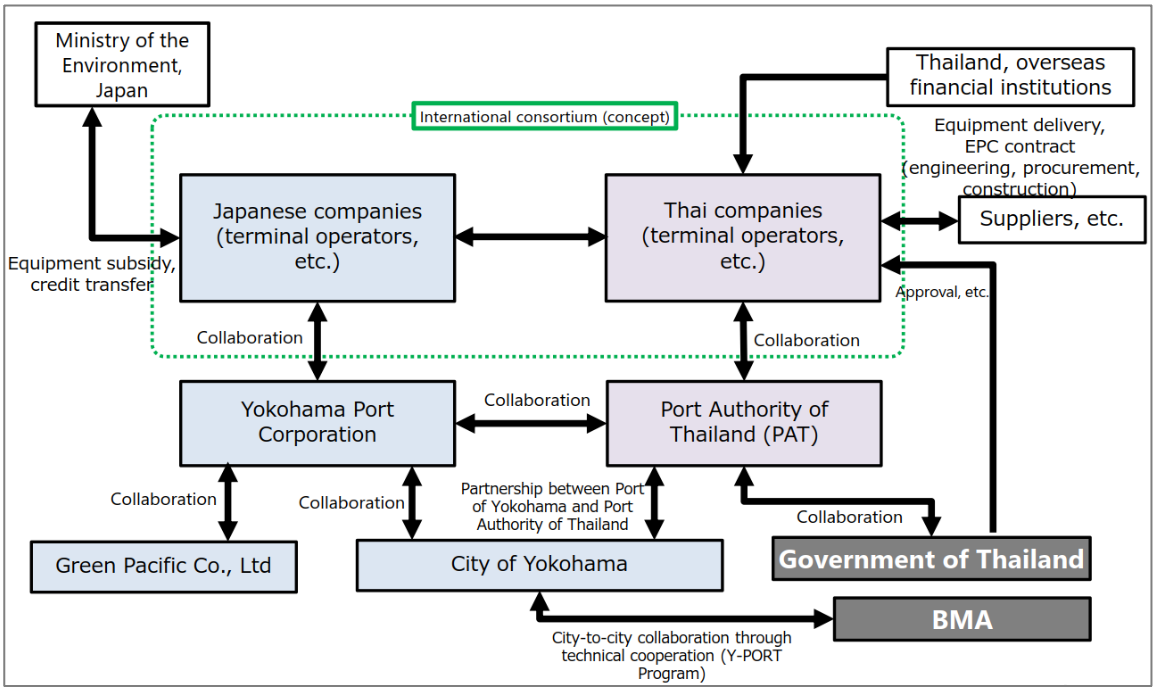


Figure 15: Project design concept with private operators

(2) Terminal B (exclude from study)

Lease contracts between PAT and terminal tenants expire in 2020, and it was confirmed that some actions are being considered for reconfiguration of Pier B. At terminal B2 a significant amount of diesel-powered cargo handling equipment is being used, and due to limited terminal space, a container yard and an empty container yard are also being used further inland, with diesel trucks handling transport between terminals. There are many opportunities to promote low-carbon alternatives, such as converting to electric cargo handling equipment, and introducing electric trucks for hauling between yards. However, since the future form of use and terminal configuration are not yet determined and information about future capital investments is not available, a decision was made not to include Terminal B in this feasibility study.

However, if more detailed development plans come together in the near future, it would certainly be possible to include this terminal in a feasibility study.

(3) Phase III (exclude from study)

Research confirmed that new development is planned and that a coastal terminal and rail terminal are being planned to promote a modal shift, but since detailed plans are not yet determined, a decision was made to exclude Phase III from this feasibility study. When the Phase III development begins, there will likely be a strong push for automation and remote operation, so it will be important to examine low-carbon options at the same time as discussions about the configuration of terminal operations. As with Terminal B, if more detailed development plans come together in the near future, it would certainly be possible to include this terminal in a feasibility study.

2.3 Site Visits and Study Implementation for Target Terminals

Site visits and meetings with key parties were held in order to examine the potential to introduce facilities for the terminals and sites selected for this feasibility study.

(1) Rail Terminal (SRTO), Coastal Terminal, and Inland Property (operated by PAT)

1) First Study Mission

A site visit was conducted for the rail terminal (SRTO) and coastal terminal currently under construction by PAT. At the same time, a site visit was made to inland property that would be a candidate site for installation of solar photovoltaic generation equipment.

a) Meeting Date and Participants

Meeting date and participants are shown in Table 11.

Table 11: Meeting date and participants

<table>
<tr><td>Date</td><td colspan="2">平成 30 年 5 月 17 日　13：30～16：00</td></tr>
<tr><td>Location</td><td colspan="2">PAT Laem Chabang Port, rail terminal, coastal terminal, inland property</td></tr>
<tr><td rowspan="2">Local participants</td><td>PAT (Laem Chabang Port divisions)</td><td>・Lt. Jg. Yutana Mokekhaow,R.T.N.
Deputy Managing Director
・Mr. Grissada Udompoch
Assistance Director of Engineering Division
・Lt. Jg. Chaiwat Jaidee, R.T.N.
Cargo Operation Officer 12 Coastal Terminal A
・Miss. Natananta Jindapongjaroen
・Mr. Ud Tuntivejakul
Port Operation Officer 8 , Office of Operation, Single Rail Transfer Operator</td></tr>
<tr><td>PAT (Bangkok Port divisions)</td><td>・Mrs. Mayuree Deeroop
Scientist 10, Corporate Strategy Department
・Miss. Ruttikarn Chamsub
Scientist 8, Corporate Strategy Department</td></tr>
<tr><td rowspan="3">Participants from Japan</td><td>Yokohama Port Corporation (YPC)</td><td>Hidenori Kishimura, Managing Director
Kosuke Shibasaki, Deputy General Manager, Engineering Department
Katsuyuki Ozaki, Manager, Engineering Planning Division, Engineering Department
Kenta Morikawa, Deputy Chief, Engineering Planning Division, Engineering Department</td></tr>
<tr><td>Green Pacific Co.(GP)</td><td>Mariko Fujimori, Executive Vice President, Director
Darmp Phadungsri, Consultant</td></tr>
<tr><td>City of Yokohama</td><td>Shintaro Saito, Director of Logistics Planning Division, Port and Harbour Bureau
Katsuyuki Yonemori, Manager for Logistics Planning, Port and Harbour Bureau</td></tr>
</table>

b) Points Confirmed by Site Visit

The following points were confirmed by site visit.

<Rail Terminal (SRTO)>

- Construction has been completed for 5 RTG running lanes. Of these, one RTG unit has been installed (electricity-powered cable reel type). (Photo 2(1))
- Construction has been completed for 2 RMG cranes for rail transfer (Photo 2(3)). Two additional units are planned.
- There are plans to install 7 additional RTG cranes. Of these 3 are planned for 2020.
- Reach stackers are being used (Photo 2(2))
- Six tracks are provided for standby trains (Photo 2(4)).

(1) RTG crane

(2) Reach stacker

(3) RMG crane

(4) Standby rail tracks

Photo 2: Scenes at the rail terminal (SRTO)

<Coastal Terminal>

- Construction has been completed for three lanes to run RTG cranes. Equipped with 2 RTG cranes. (Photo 3(2))
- There are plans to install 1 container crane on the quay. There are also plans to procure 1 mobile harbor crane.
- Storage capacity is approx. 1,700 TEU, with 72 electrical outlets for freezers and refrigerators
- There are plans to install 2 additional RTG cranes in the future.

(1) Terminal

(2) RTG crane

Photo 3: Scene at coastal terminal (A)

<Terminal Inland Property>

In anticipation of discussions about installing solar photovoltaic generation equipment, PAT was interviewed regarding potential installation areas. A site visit was also conducted.

- Potential candidate areas include the roof tops of three existing PAT-owned warehouses, plus area around the observation tower.
- The site visit to see the rooftops of existing PAT-owned warehouses found that many years have elapsed since the existing PAT-owned buildings were built, that the surfaces appear to consist of slate rather than corrugated metal roofing material, and that further structural calculations would be required in order to ensure structural safety since the installation of PV modules would result in loads exceeding the original building design. Thus, it was decided be impractical to consider rooftop PV for this feasibility study, and instead to leave it for future consideration. (At a future time when any proposal arises for construction of new roof structures, there will be potential to consider installing rooftop PV systems.)

Photo 4: Inland property behind Laem Chabang Port (May 2018)

Photo 5: Existing warehouse owned by PAT (May 2018)

2) Second Study Mission

This mission was for the purpose of reporting details of low-carbon facilities that had been considered, and meeting to confirm items that would move ahead for more detailed discussions. Site visits were also made to verify items that would move ahead for more detailed discussions.

a) Meeting Date and Participants

The meeting date and participants are shown in Table 12.

Table 12: Meeting date and participants (rail terminal, coastal terminal, inland property)

Date	September 10, 2018, 10 am to 4 pm	
Location	PAT Laem Chabang Port, Meeting Room, rail terminal, coastal terminal, inland property	
Local participants	PAT(Laem Chabang Port divisions)	・Mr. Grissada Udompoch Assistance Director of Engineering Division ・Mr. Ud Tuntivejakul Port Operation Officer 8, Office of Operation, Single Rail Transfer Operator ・Mrs. Patcharapun, Mrs. Pimolmas
	PAT (Bangkok Port divisions)	・Mrs. Mayuree Deeroop Scientist 10, Corporate Strategy Department ・Ms. Ruttikarn Chamsub Scientist 8, Corporate Strategy Department
Participants from Japan	Yokohama Port Corporation (YPC)	Hidenori Kishimura, Managing Director Kosuke Shibasaki, Deputy General Manager, Engineering Department Kenta Morikawa, Deputy Chief, Engineering Planning Division, Engineering Department
	Green Pacific Co.(GP)	Darmp Phadungsri, Consultant

b) Findings

<RTG Cranes>

- Projections for future annual operations are for between 400,000 and 600,000 TEU per year at the rail terminal (SRTO) and 200,000 TEU at the coastal terminal (services are expected to begin early next year), with operation going 19.5 hours per day, 365 days per year.
- Regarding RTG, a proposal was made procure 3 and 2 new hybrid RTG cranes, respectively, for the rail terminal (SRTO) and coastal terminal, and to upgrade 2 existing RTG cranes, and it was confirmed that consideration would proceed. However, there ultimate are plans to procure 4 RTG cranes for the rail terminal, so the number there could potentially be revised from 3 to 4.
- One RTG crane already introduced at the rail terminal (SRTO) is an electricity-powered cable reel type, but the cable is exposed above the ground, resulting in various issues including safety concerns and time being required to reconnect cables during lane changes. Thus, the current discussions confirmed that consideration would proceed on the basis of introducing hybrid cranes. However, because electric cranes have a greater CO2 reduction effect, it was decided to discuss and propose the option of adopting busbar type

electricity-powered models (however, above-ground infrastructure upgrades such as busbar are not part of this discussion, so the focus was only on the RTG cranes themselves).

- Regarding RTG procurement plans, in addition to the current 2 cranes at the coastal terminal the plan is to add 2 more in 2020, bringing the total to 4. At the rail terminal (SRTO), in addition to the current 1 crane, there are two ideas, to either repair 3 used cranes or procure 3 new cranes to bring the total to 4. There is also a plan to procure an additional 4 new cranes in five years, eventually bringing the total to 8. Regarding the 3 used cranes, PAT procured them when service began at Laem Chabang Port and leased them to operators, but after 15 years of use the operator returned them as parts were no longer available and maintenance were relatively high, and they have been left unused for approx. ten years. They were manufactured by NOELL, with “1 over 3” or “1 over 4” specifications and their age since manufacture is 27 years.
- As for RMG, in addition to 2 existing cranes, there are plans to add 2, followed later by 1 more, eventually bringing the total to 5.
- As a future concept, there is interest in RTG automation and remote operation at the rail terminal (SRTO) and coastal terminal, and an interest in future discussions on this.

<Solar Photovoltaic Systems>

- It was found that installation of solar photovoltaic system in open space around the observation tower could have a capacity of approx. 2.7 MW. With this as the starting point, it was confirmed that the ultimate installation scale would be confirmed in greater detail after verifying factors including the control space of for nearby wind turbines.
- Electrical power consumption at Laem Chabang Port is approx. 14 to 15 MW, so it was confirmed that all electricity produced by the PV installation currently being proposed could be consumed on-site. The power substation at the port is aging, so there are plans for renewal nearby (approx. 200 m to the south) (construction is already in progress aiming for completion in 2019).
- With regard to connection to the grid, serious examination will be essential as there are a number of issues, including the current PV installation area being split into several locations, the necessity of crossing a high-traffic road in the case of connecting to the power receiving equipment, and the cost of running new conduits.
- Electricity is received from PEA at 115 kV and distributed within the PAT area at 2.2 kV. Thus, it is highly feasible to connect to the power receiving equipment by stepping up the voltage from the PV system to 2.2 kV. As way to avoid costs would be rather than connecting directly from the PV installation to the power receiving equipment, it is possible to consider connecting to the existing connection point for the wind turbines, although it is necessary to confirm parameters such as the capacity of the existing distribution lines.
- Electricity rates vary from peak times (weekdays 8 am to 8 pm) to off-peak times (weekdays 8 pm to 8 am, plus weekends), but they average approx. 3.5 THB/kWh, which is lower than

at Bangkok Port. For this feasibility study, this rate is used for consideration of project viability.

<Waste Utilization>

- Regarding the volume of waste discharged from Laem Chabang Port, documents obtained from PAT (Table 13, Figure 16) indicate that waste mainly includes items such as pallet scraps and general waste from the terminals, as well as waste oil and other waste materials from ships. However, the volume of both types is low, so at this point there appear to be no ideas to make use of the JCM.

Table 13: Waste emissions from Laem Chabang Port

Fiscal year	Total weight (tons)
2015	805
2014	716
2013	659
2012	496
2011	768

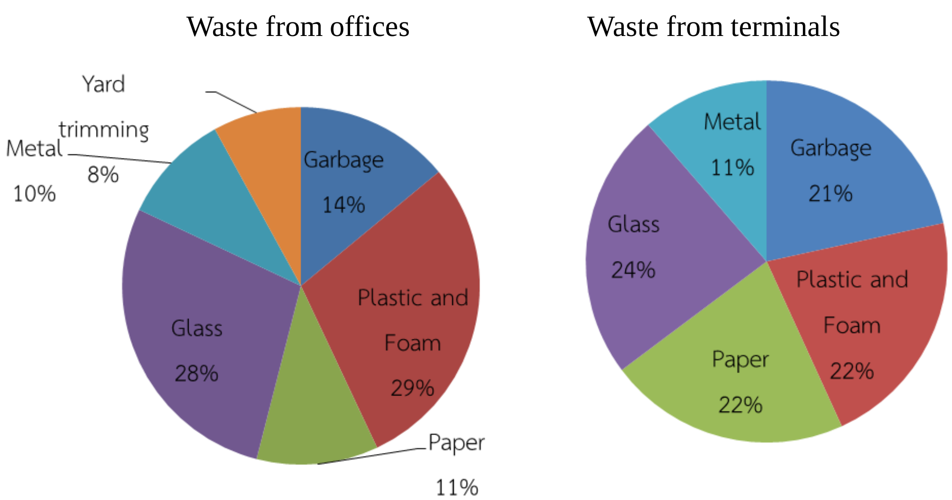


Figure 16: Breakdown of waste from Laem Chabang Port, by category and ratio

<Utilization of JCM >

- The rules of the JCM were explained, and it was then confirmed that subsequent detailed consideration would proceed with the aim of making an application for the introduction of two items – low-carbon RTG (procurement of new units and upgrading of existing units) and solar photovoltaic equipment –as a JCM equipment subsidy project covering three years from 2020 to 2022.

c) Points Confirmed by Site Visits

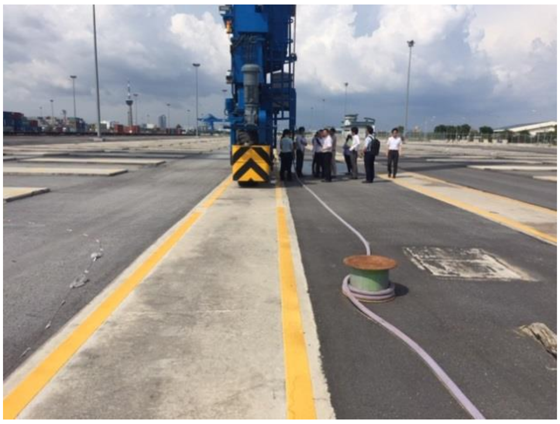
Site visits were made to the rail terminal (SRTO) and coastal terminal as part of this study, and RTG cranes were observed that could be potentially upgraded to low-carbon equipment. A site visit was also made to inland property behind the terminals where there may be potential to install a solar photovoltaic system. Points confirmed by site visits are listed below.

<RTG Cranes>

- Regarding RTG delivery to the rail terminal (SRTO), it was confirmed that after being lifted from barge to the quay, it can move on its own within the yard (this is how the cranes already delivered to the terminal were unloaded).
- The specifications of the existing RTG cranes at the rail terminal (SRTO) and coastal terminal were confirmed. Specific points include the cable of the electric RTG at the rail terminal (SRTO) (Photo 6(1), (2), (3)) and the electrical grid for RTG cranes at the coastal terminal.
- The 3 used-RTG cranes (Photo 6(4)) the port would like to repair and reuse at the rail terminal (SRTO) were also confirmed. Since the operator returned them, they have been left unused for approx. ten years.

(1) RTG cable reel section

(2) Power receiving box for RTG cranes



(3) Electrical cable lying on ground

(4) Used RTG crane

Photo 6: RTG cranes

<Inland Candidate Site for Solar Photovoltaic Installation>

- The open space under wind turbines on inland property that is a candidate site for solar photovoltaic installation was confirmed (Photo 7(1)、(2)).
- The inland property owned by PAT behind Laem Chabang Port is on level land and covers a large area, and is one key component of low-carbon efforts by Laem Chabang Port. The land is already being used for small wind turbines (approx. 80 units, height approx. 10 to 12 m, with an output of approx. 850 kW). This land has good drainage, with no reported cases of flooding even during squalls or storms (PAT interview). It was confirmed that it has good conditions for a solar photovoltaic installation, with favorable prospects of easily connecting to deliver electricity generated by the solar photovoltaic system to the distribution grid being used by the existing wind turbine installation.
- The subject area did not flood during storms in the past, so there is no problem with drainage, although some weeding will be necessary. An adjacent space is being used to park transport trailers, so it would be necessary to install fencing or some similar measure.
- The current substation (Photo 7(3)) is aging, so there are plans to set up a new substation (Photo 7(4)) and move its functions to a nearby location (approx. 200 m to the south) (construction is already in progress aiming for completion in 2019). Electricity generated at the proposed solar photovoltaic installation would be connected to this new substation at one of three candidate locations, but some review will be necessary to consider the road between the tower area and this proposed new substation, as well as distances.
- During the study mission in May, PAT gave instructions to allow a distance of about 20 m from the small wind turbines, but this was later revised to 33 m. Also, where irregularly-shaped sections of the site would result in dead space, they were excluded from site consideration.
- Meanwhile, with a decision to install a solar photovoltaic system on open space around the towers and on catchment pond water areas, PAT requested additional consideration. From a site inspection (Photo 7(5), (6)), it was clear that a solar photovoltaic installation was entirely feasible on the open space, so it was decided to include that in this study. However, there is a distance from this open land to the substation and it would be necessary to cross a road, so it was confirmed that careful consideration is needed regarding the means of connecting to the grid. Also, considering the fact that the catchment pond is a small triangular area, it is not amenable to PV module installation, so it was deemed not practical for this feasibility study and a decision made to leave that idea for future discussions.

(1) Wind turbines and open space (view from tower)

(2) Wind turbines and open space below

(3) Existing substation

(4) New substation under construction

(5) Open space beside tower

(6) Water collection pond beside tower

Photo 7: Views of inland property

3) Third Study Mission

Site visits were made to the rail terminal (SRTO) and coastal terminal to confirm the findings of discussions done to date and to check the latest conditions.

a) Meeting Date and Participants

The meeting date and participants are shown in Table 14.

Table 14: Meeting date and participants (rail terminal, coastal terminal)

Date	January 30, 2019, 10 am to 3:30 pm	
Location	PAT Laem Chabang Port, Meeting Room, rail terminal, coastal terminal	
Local participants	PAT(Laem Chabang Port divisions)	・Mr. Tienchai Makthiengtrong Administrator 13,Laemchabang Port ・Mr. Nuttapon Boonchokchuay Cargo Operation Officer 10 (Coastal Terminal A) ・Mr. Ud Tuntivejakul Port Operation Officer 8, Office of Operation, Single Rail Transfer Operator
	PAT(バンコク港部門)	・Mrs. Mayuree Deeroop Scientist 10, Corporate Strategy Department ・Ms. Ruttikarn Chamsub Scientist 8, Corporate Strategy Department
Participants from Japan	Yokohama Port Corporation (YPC)	Fumio Sakurai, President and CEO Koji Kumamoto, General Manager, Engineering Department Kosuke Shibasaki, Deputy General Manager, Engineering Department Katsuyuki Ozaki, Manager, Engineering Planning Division, Engineering Department Kenta Morikawa, Deputy Chief, Engineering Planning Division, Engineering Department
	Green Pacific Co.(GP)	Kazuhito Yamada, President Darmp Phadungsri, Consultant
	City of Yokohama	Masuyoshi Ariji, Officer, Port Promotion Department, Port Promotion Division, Port and Harbour Bureau

b) Points Confirmed by Site Visits

<Rail Terminal (SRTO)>

- Four rail lines are currently linked to Laem Chabang Port, the main one being from the Lat Krabang Inland Container Depot. Major cargo includes electronic parts and appliances, and agricultural products. Other lines include a northeastern line mainly for agricultural products, a southern line mainly for rubber, and a line connected to Rayong that mostly handles resin (Rayong is just 30 km from Laem Chabang Port). The majority of containers handed by rail are export-bound, so a large proportion of the trains leaving Laem Chabang Port have empty containers. A large portion of agricultural crops are consolidated in Lat Krabang and then transported to Laem Chabang Port.
- PAT is the terminal operator, but there are plans to subcontract actual cargo handling work. Since October 2018 temporarily staff from the PAT direct management division at Bangkok

Port have been implementing this work. A tender decision will be made in May 2019 at the earliest, followed by a training period and then full-scale operation.

- Multiple tracks connect with inland, and they become 6 lines after entering the subject terminal (Photo 2(4)). The standard is a 32-car configuration for cargo trains, 8-car sets can park within the terminal (two of the six lines are longer so two sets can be lined up).
- The yard has a storage area to temporarily place containers, with a maximum storage capacity of 30,000 TEU (calculated as number of ground slots x 6 containers high). There are 5 RTG cranes operating, of which 1 crane is a cable-reel type electric RTG. (Photo 2(1))
- Within the plans for using RMG for transfers with rail 2 cranes have already been installed.
- The handling capacity of the subject terminal is assumed to be one million TEU/year, and service is expected to begin this year. During the first study mission in May, it was stated that "we plan to gradually increase handling capacity after starting service, and the plan is to procure additional handling equipment as we see the usage conditions," but on the third study mission it was learned that PAT had internally approved the refurbishment of 3 used RTG cranes (2019), and the procurement of 2 RMG (2019 to 2020) and 4 RTG cranes (timing not determined). The change was due to plans to expand handling capacity to 1.4 million TEU at the Lat Krabang Depot in 2020, of which the subject terminal plans to handle about half (700,000 TEU).
- Until the completion of additional procurement of handling facilities, reach stackers will also be used.
- All containers handled by rail are dry containers (non-refrigerated), and none are reefer (refrigerated) containers. Reasons for that are that the rail lines are do not have electrical equipment for reefers, and the inland depot as well is not set up with refrigerated warehousing.

<Coastal Terminal>

- As with the rail terminal (SRTO), PAT is the operating entity at this terminal, and there are plans to contract out cargo handling. At the time of the second study mission the plans were to start service in December 2018, but by the time of the third study mission, service had not yet started and had been set back to a planned start in May 2019. It is surmised that this may be due to factors such as the need for more time to complete work on a coastal shipping base on the Bangkok Port side, and to settle conditions for contracting out cargo handling.
- The work contract is expected in February, and with about two months of a training period to follow, the service is expected to begin in about May 2019.
- Main sea traffic to the coastal terminal will be from Bangkok Port. Some cargo will also be handled from Ranong Port to the south. Main products from Ranong Port will be rubber raw materials (sheet form) and furniture made from rubber trees.
- Three RTG lanes are installed and already equipped with 2 RTG diesel cranes. However, because the terminal handling capacity is 600,000 TEU/year, 2 cranes will not be sufficient, so PAT is planning to procure 2 more RTG cranes while observing the usage conditions

going forward.

- On the quay is 1 container crane. Also, one mobile harbor crane has been ordered, and installation on the quay is expected in March 2019. This will be too late for start of service in May, but it is expected to enter into use soon after delivery.
- Storage capacity is approx. 1,700 TEU, with 72 electrical outlets for freezers and refrigerators

(2) Multi-purpose Terminal

A site visit was conducted at the multi-purpose terminal being operated by private operators.

1) Meeting Date and Participants

The meeting date and participants are shown in Table 15.

Table 15: On-site observation dates and participants

Date	May 16, 2018, 13:30 to 14:30	
Location	Laem Chabang Port, multi-purpose terminal	
Local participants	Private operator	Terminal managers
Participants from Japan	Yokohama Port Corporation (YPC)	Hidenori Kishimura, Managing Director Kosuke Shibasaki, Deputy General Manager, Engineering Department Katsuyuki Ozaki, Manager, Engineering Planning Division, Engineering Department Kenta Morikawa, Deputy Chief, Engineering Planning Division, Engineering Department
	Green Pacific Co.(GP)	Kazuhito Yamada, President Mariko Fujimori, Executive Vice President, Director Darmp Phadungsri, Consultant
	City of Yokohama	Shintaro Saito, Director of Logistics Planning Division, Port and Harbour Bureau Katsuyuki Yonemori, Manager for Logistics Planning, Port and Harbour Bureau

2) Points Confirmed by Site Visit

The following points were confirmed by site visit.

- There is a desire to convert to LED for yard lighting, but decision of whether or not to go ahead is to be decided after a comprehensive consideration of initial costs, investment payback period, etc. Also the timing of implementation is currently undetermined due to budgeting factors.
- If consideration is to proceed further, it may also be necessary to install new light poles, as well as the associated electrical conduits and wiring.
- Since it is a private company, a payback period of about three years is expected. If it is much longer, a decision to go ahead would be less likely.

Photo 8: Light poles and lighting equipment at multi-purpose terminal

2.4 Meeting with Supplier Candidates

A meeting was held with suppler candidates in connection with the equipment being considered for introduction using the JCM equipment subsidy program. Also, for RTG cranes, it was decided to inspect an advanced terminal that has introduced remote operations, and to consider low-carbon options with the idea of introducing them as technologies at Laem Chabang Port going forward.

(1) RTG Supplier Candidates

Meetings were held with two RTG supplier candidates to exchange information about this feasibility study regarding RTG cranes at Laem Chabang Port. Particular points confirmed included the potential for converting existing RTG cranes (made by other manufacturers) to hybrids, criteria when procuring new RTG cranes, and considerations for future automation (including remote operation). Also, investigation included an advanced terminal (HIT-9) at the Port of Hong Kong, in order to confirm the potential efficiency improvements of terminal operations from introducing remote operation, as well as indirect potential low-carbon benefits associated with that.

- For new RTG cranes, since they would be fabricated at plants in Japan and transported by barge to Laem Chabang Port in Thailand, it was confirmed that there is a need to confirm with PAT conditions in advance, including how many cranes can be transported at one time for delivery, the feasibility of landing from the nearest quay, and the feasibility of delivering finished units.
- Regarding refurbishment of RTG cranes, PAT expressed an interest in making use of

engines currently installed, but that would mean making excessive use of engines, with a significant reduction of the benefits of low carbonization, so it was confirmed to replace them with smaller engines.

- Also, it was confirmed that before implementing refurbishment it would be necessary to do detailed confirmation of the electrical grid for existing RTG cranes.
- A visit was made to the advanced terminal. Details are provided below.

1) Observation Date and Participants

The date and participants of meeting at the Port of Hong Kong are shown in Table 16.

Table 16: Observation date and participants in Port of Hong Kong visit

Date	May 15, 2018, 9:30 am to 12 noon	
Location	Port of Hong Kong, HIT-9 terminal	
Visited	SHI Machinery Service Hong Kong Limited	Mr. Y. Maeda, Managing Director Mr. Chan Pak Wing, General Manager Mr. Mike Chan, Site Manager
Participants from Japan	Yokohama Port Corporation (YPC)	Hidenori Kishimura, Managing Director Kosuke Shibasaki, Deputy General Manager, Engineering Department Katsuyuki Ozaki, Manager, Engineering Planning Division, Engineering Department Kenta Morikawa, Deputy Chief, Engineering Planning Division, Engineering Department

2) Study Results

- The HIT-9 terminal is managed by Hutchison. A joint project to upgrade the terminal to remote RTG crane operation began in 2012 with Mitsubishi Heavy Industries, Ltd. and was completed in February 2018. (It began with MHI, but the current company name is Sumitomo Heavy Industries Material Handling Systems Co., Ltd., a joint-venture subsidiary in industrial cranes, created by a merger/spin-off from Sumitomo Heavy Industry, Ltd. and MHI.) Currently all RTG cranes at the terminal are operated remotely. One feature of this terminal is that it is boosting operational performance and saving energy by refurbishing existing RTG cranes at the same time as the terminal is still operating, by electrifying existing cranes (using a busbar system for automatic setting/release) and converting to remote operation, as is being investigated by this study.
- With the RTG remote operation system that has been adopted, it is possible to be nearly fully-automated. However, for safety reasons (guidance from the Labour Standards Inspection Office) container transfers to and from chassis coming from both inside and outside the terminal are controlled remotely by operators. The RTG remote control room is located within an existing administrative building, and a container handling volume of 15 to 20 moves per hour has been achieved. Operators work in three shifts, and operations are

performed the office control room via desktop monitor and joystick. No visual confirmation is performed by observation through any window; all operations are done by camera images and animation displayed via desktop monitors. During this inspection tour, 11 operators were controlling 22 of the 28 RTG cranes at the terminal. This works out to two cranes per operator, but in some cases one operator can handle up to three cranes.

- The shift to remote RTG operation requires many sensors and cameras. Many are also installed directly on the RTG cranes, so the movements and work efficiency of the RTG cranes themselves can be monitored. The position and work status of container cranes working in conjunction with the RTG cranes are also monitored simultaneously, as well as the locations of trailers within the terminal. At HIT-9, this information is managed centrally, the productivity of operations is constantly measured, and the terminal is beginning to make use of big data to significantly boost the efficiency of operations.
- In the interest of decarbonization, for the RTG crane electrical power delivery system the terminal has adopted a busbar system (electricity provided by automatic physical setting and release with a low charging rail) for automatic connection/disconnection. Since this eliminates the need for travel to a fueling station, the RTG operational range can be restricted to the storage area, which offers the additional benefit of facilitating remote operation and automation. Meanwhile, leaving the original engine installed on the unit provides a backup option in the event of a power failure or disaster.
- The terminal is also working to make further innovations in the remote operation of the actual RTG cranes. Currently the terminal is using remote control for container transfers for chassis within the terminal, but the aim is to be automated by the end of 2018 by instituting safety measures using sensors. If this can be achieved, the remote operation will only be needed for transfers involving chassis from outside the terminal. Chassis entering from outside the terminal come in various sizes, so the intention is to continue using remote control operators for container transfers involving those chassis.
- To take advantage of remote operations, the company is also considering concentrating remote terminal operations at a few centers around the world. This step could eliminate night shift wage premiums, enabling further labor cost reductions.
- Future potential for Laem Chabang Port

・RTG crane remote operation and automation

RTG remote control and automation is becoming a reality, but it is still a new and developing field. PAT is intending to fully automate the Phase III terminals, and has also shown an interest in retrofitting RTG cranes for remote operation in the rail terminal (SRTO) and coastal terminal, which are designed for modal shift. Remote control and automation can boost the cargo handling performance of the RTG cranes themselves, and if this leads to better performance of the entire terminal, the result will be a contribution to the decarbonization of port cargo handling. Going forward, it was decided to further advance discussions in consideration of PAT's intentions.

・RTG electrification

When converting RTG cranes to remote operation and automation, there are advantages of electrify RTGs at the same time. However, RTG electrification requires a significant amount of electricity, so it is important to also consider power supply infrastructure upgrades in concert with RTG procurement or refurbishment. Thus, together with equipment procurement, it is also important to consider infrastructure upgrade costs. Accordingly, in the case of Laem Chabang Port, it was judged that efficiency and viability could be improved by proposing and expanding RTG electrification in concert with planned infrastructure work in Phase III as well as the reconfiguration of Terminal B, rather than upgrading terminals that are currently in operation.

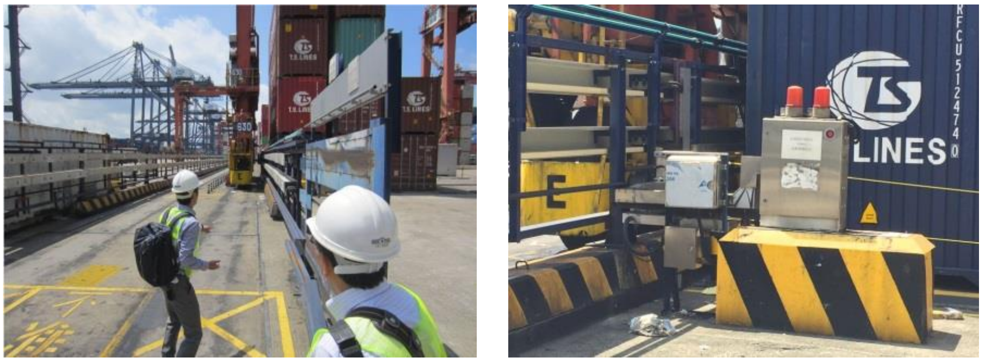


Photo 9: HIT-9 terminal

(2) Candidate Suppliers of Solar Photovoltaic Systems

Meetings were held with three candidate solar photovoltaic system suppliers, and the following information was exchanged and shared regarding the installation of a solar photovoltaic system at the inland property near Laem Chabang Port.

- Recently, the costs of solar photovoltaic systems in Thailand have been falling, with Chinese manufacturers prominent in the market. Japanese manufacturers have mainly focused on Japanese companies with plants in Thailand. They are finding the local market to be relatively challenging.
- When considering JCM in Laem Chabang Port, Japanese manufacturers may not be competitive if price alone is considered.
- For power conditioners and other electrical equipment, mainly overseas manufacturers are popular.
- For solar photovoltaic systems, more time may be required for approvals of ground-mounted compared to rooftop installations.
- The Provincial Electricity Authority (PEA) is the regional authority for the Laem Chabang Port. There have been reports that in many recent projects where PEA is involved, PEA has imposed additional orders after construction has begun. Thus, it is important to consult and

revise plans carefully at the planning stage.

- Information was shared regarding the items requiring consideration when PAT installs a solar photovoltaic system. (Verify boring data to consider foundation design; verify the risk of flooding in target area; verify specifications of windpower equipment; confirm grid connection options (two cases: direct connection to substation, or utilize the windpower system grid), consider location to install reverse power flow prevention equipment; and confirm JCM eligibility).
- Regarding power capacity, it was decided to verify the Laem Chabang Port power consumption and power grid, plus the generation capacity of the proposed solar photovoltaic system, and proceed with discussions based on the assumption that all power generated will be consumed on-site.
- Regarding the installation of power conditioners, information was shared that rather than installing large capacity equipment, there would be cost benefits of installing multiple smaller capacity units (up to about 60 kW), and to proceed with discussions from the perspective that this approach would be preferable in terms of reducing equipment failure risks.

(3) Candidate Suppliers of LED Lighting

Meetings were held with two candidate LED manufacturers and suppliers to share information about converting to LEDs for the multi-purpose terminal and yard lighting.

- If light poles are to be added, the payback period becomes longer because this would involve new electrical conduits and wiring, so it will be important to consider ideas to reduce costs as much as possible.

2.5 Summary of Study Results

Table 17 provides a summary of the study results for the subject terminals, sites and on-site observations, plus meetings with relevant parties. Based on these findings, Table 18 and Figure 17 summarize the details to move discussions forward regarding the installation of low-carbon equipment and facilities at each terminal and site.

Table 17: Summary of feasibility study results

Terminals and site studied	Summary of feasibility study results
Rail terminal (SRTO)	・ Container handling of 1 million TEU/year is assumed, with operations 365 days/year ・ Ultimately 8 RTG cranes are assumed ・ Plans are to procure 4 RTG cranes in about 2020 ⇒ **Potential for equipment subsidy**
Coastal terminal	・ Container handling of 600,000 TEU/year is envisioned, with operations 365 days/year ・ Ultimately 4 RTG cranes are assumed ・ Plans are to procure 2 RTG cranes and refurbish 2 existing RTG cranes in about 2020 ⇒ **Potential for equipment subsidy**
Terminal inland property	＜Solar photovoltaic equipment candidate site> ・Verify property shape/conditions ・ Verify level surface, good drainage, area boring data availability ・ Verify required distance 33 m from small wind turbines ・ Verify general parameters of electrical grid near planned installation ・ Verify tap point of existing wind turbine system (considering connection from future solar photovoltaic system) ・ Planned substation is currently being built in new location, close to existing substation ・ Consider panel nominal power output of approx. 2.4 MW ⇒ **Potential for equipment subsidy** <Waste collection site> ・ Waste volume was determined to be low. ・ Currently waste is transported (by contractor) to municipal incinerator. No measure was identified to reduce environmental impacts by handling separately. ⇒ **No potential for equipment subsidy**
Multi-purpose terminal	・ Existing yard lighting pole lamp assemblies are metal halide lamps. It is preferable to upgrade to LEDs when upgrading/replacing lamp assemblies. However, timing of upgrades is not decided. ⇒ **Potential for equipment subsidy exists, but at present difficult to consider in detail.**

Table 18: Types of low-carbon equipment at terminals and sites for consideration to proceed

	Hybrid RTG	LED	Solar photovoltaic system
Rail terminal (SRTO)	○	―	―
Coastal terminal	○	―	―
Terminal inland property	―	△	○
Private terminals (multi-purpose)	△	△	―

Legend:

○ Proceed with project consideration

△ Future potential exists, but do not proceed with project consideration at present

― Not applicable

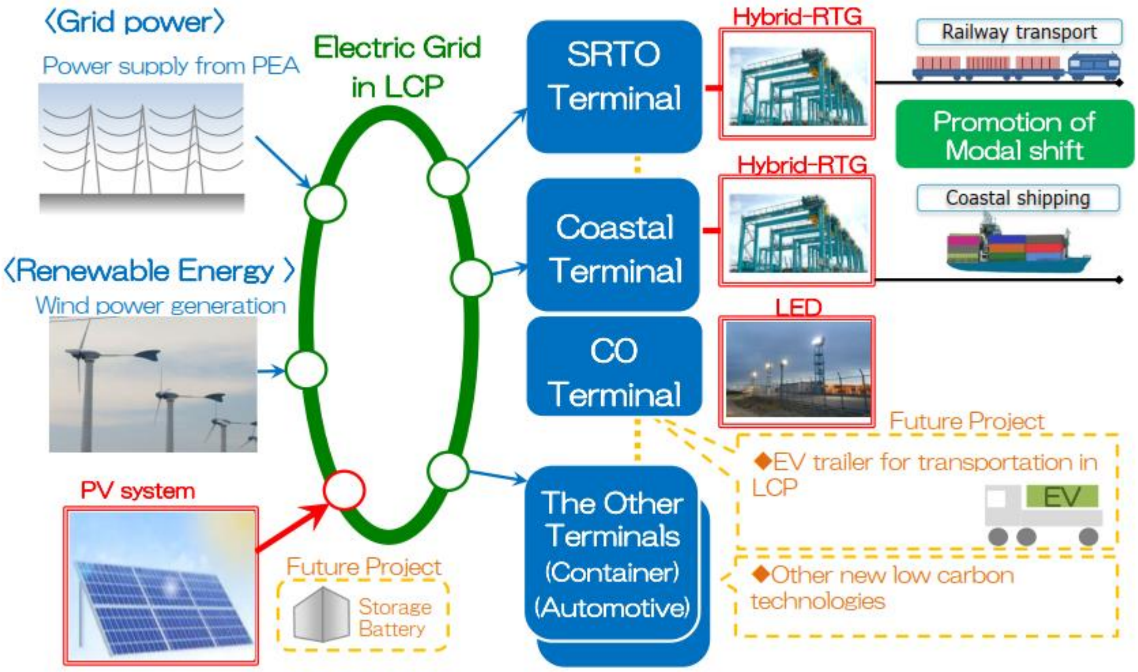


Figure 17: Concept design for projects to introduce low-carbon equipment at terminals and sites

3. Verification of Project Viability

(Project Cost Calculations, GHG Emission Reduction and Energy Saving Calculations, Project Cost-Benefit Estimate)

Based on the study results that were summarized in the previous chapter, project viability was verified for PAT projects (RTGs and solar photovoltaic system), by calculating costs, calculating GHG emission reductions and energy savings, and estimating project costs and benefits (project viability). The numbers used here for initial costs, running costs, JCM subsidies and other amounts are estimated by YPC based on interviews and inquiries with PAT and candidate suppliers, and as well as other information sources.

3.1 RTG Cranes

Regarding RTG cranes used at the PAT-managed rail terminal (SRTO) and coastal terminal, project viability was confirmed considering hybrid cranes using a JCM equipment subsidy.

(1) Evaluation of Project Viability for Hybrid RTGs

For this review, it was assumed that 4 new hybrid RTGs would be introduced at the rail terminal (SRTO) and 2 new hybrid RTGs at the coastal terminal, and that the 2 regular RTGs currently at the coastal terminal would be refurbished as hybrid units.

The project viability results are shown in Table 19.

Table 19: Evaluation of RTG project viability

		New procurement		Refurbish as hybrids	Total
Specs, quantity	Terminal	Rail terminal (SRTO)	Coastal Terminal	Coastal Terminal	-
	Quantity	4 units	2 units	2 units	8 units
	Rated load	40.6 t	40.6 t	40.6 t	-
	Containers	6 + 1, 1 over 6	6+1, 1 over 6	6+1, 1 over 6	-
Viability 性評価	Depreciation period	12 years		12 years	-
	Initial cost (A)	263,478,000 THB (901,094,000 yen)		16,144,000 THB (55,212,000 yen)	279,622,000 THB (956,307,000 yen)
	CO2 reduction (B)	17,310 t-CO2/12yr (1,442.5t-CO2/yr)		5,770t-CO2/12yr (480.8t-CO2/yr)	23,080t-CO2/12yr (1,923.3t-CO2/yr)
	JCM subsidy (C)	20,022,000 THB (68,475,000 yen)		6,457,000 THB (22,082,000 yen)	26,479,000 THB (90,558,000 yen)
	JCM cost/benefit (C)/(B)	1,156 THB (3,953 yen) /t-CO2		1,119THB (3,826 yen) /t-CO2	1,147THB (3,922 yen) /t-CO2
	JCM subsidy ratio	7.6%		40.0%	9.4%
	Running cost savings (reduced fuel cost)	171,791,000THB/12yr (587,525,000 yen)		57,263,000THB/12yr (195,839,000 yen)	229,054,000 THB/12yr (783,364,000 yen)
	Evaluation	○		○	○

Note: Currency rates assumed for this study: 1THB=3.42 yen, 1USD=110.43 yen (calculated from monthly averages for 2018)

For 6 newly procured units, the numbers (approx.) show initial cost at 263 million THB, CO2 reduction at 17,310 t-CO2/12/yr, JCM subsidy at 20 million THB, JCM cost/benefit at 1,200 (4,000 yen)/t-CO2, JCM subsidy ratio at 7.6%, and running cost benefit at 171 million THB/12yr.

For 2 existing units refurbished to RTG hybrids, equipped with lithium ion batteries, small engine replacement, and engine variable speed control unit, the numbers (approx.) show initial costs at 16 million THB, JCM subsidy at 6 million THB, CO2 reduction at 5,770 t-CO2/12yr, JCM cost/benefit at 1,200 (4,000 yen)/t-CO2, JCM subsidy ratio at 40.0%, and running cost savings at 57 million THB/12yr

For a total of 8 units, the numbers (approx.) show initial costs at 279 million THB, JCM subsidy at 26 million THB, cost/benefit at 12,00 THB (approx. 4,000 yen)/t-CO2, and the JCM subsidy ratio at 9.4%, which is a level that qualifies for a JCM project.

If hybrid RTGs are introduced, fuel consumption will be approximately half relative to diesel-only RTGs, and over 12 years this would be expected to reduce running costs by a total of approx. 229 million THB.

(2) Potential for Introducing Electric RTG

Due to the request of PAT, this study settled finally on adoption of hybrid RTGs, but some study examination was also done regarding the potential for introduction of electric RTGs.

If electric RTGs are to be introduced, some additional infrastructure becomes necessary (power transformers, distribution lines, buried conduits, etc.), and if it is not already available, it is important to note that discussions must also include making those improvements. This section below covers the potential for introducing electric RTGs in the rail terminal (SRTO) and coastal terminal, which are subjects of this study.

1) Rail Terminal (SRTO)

This terminal has already procured and is operating 1 electric RTG. It uses a cable reel method, but the cable lies on the ground, limiting the mobility of other cargo handling equipment in the area. Also, considerable effort is required to connect and reconnect the cable during lane changes. Issues such as these can be resolved with the use of a busbar, so if electrification and remote operations of terminal operations are to be done in the near future, electrification is a reasonable option. Until the point when RTGs are actually being procured, revising the policy to choose electrification remains an option.

2) Coastal Terminal

This terminal has already procured 2 diesel RTG cranes and is preparing to put them into service in May 2019. The coastal terminal as well has the potential to electrify and adopt remote operations in terminal operations in the near future, but since the required power supply facilities for RTG electrification are not currently available, the likelihood of introducing electric RTGs is very low.

Based on the above points, this analysis assumes that it is only possible to introduce electric RTG at the rail terminal (SRTO), and therefore compares hybrid RTG and electric RTG (Table 20).

Table 20: Comparison of hybrid RTG and electric RTG

	Hybrid RTG	Electric RTG
Quantity, specs	4 units, 6+1, 1 over 6	4 units, 6+1, 1 over 6
Initial cost	175,652,000 THB (43,913,000THB×4 units) (600,729,000 yen) (150,182,000 yen × 4 units)	187,948,000 THB (46,987,000THB×4 units) (642,782,000 yen) (160,695,000 yen × 4 units)
CO2 emission reduction	11,540 t-CO2/12yr (961.6 t-CO2/yr)	18,058 t-CO2/12yr (1,504.8 t-CO2/yr)
JCM subsidy	13,348,000 THB (45,650,000 yen)	21,049,000 THB (71,987,000 yen)
JCM cost/benefit	1,156 THB (3,953 yen)/t-CO2	1,165 THB (3,984 yen)/t-CO2
JCM subsidy ratio	7.6%	11.2%
Running cost savings(reduced fuel costs)	114,528,000 THB/12yr (391,685,000 yen)	198,000,000 THB/12yr (677,160,000 yen)

(3) Refurbishment of Existing Diesel RTGs

The coastal terminal is expected to start services in May 2019, and 2 diesel RTG cranes brought here in 2017 are still in a new and unused condition.

When refurbishing these to become hybrids, their parts including electrical system and engine should still be in good condition, so no condition-related issues are expected to arise in terms of differences with equipment added for the refurbishment.

Also, inquiries with manufacturers revealed that low-carbon operations can be promoted by significantly reducing fuel consumption through converting to smaller engines from the existing engines, at the time of refurbishing to hybrids units.

A comparison of refurbishment with and without conversion to smaller engines is shown in Table 21.

Table 21: Comparison of proposals to refurbish existing diesel RTGs to make hybrid RTGs

	Convert to small engine	Keep existing engine
Initial cost	16,144,000 THB (250,000USD×2 units) (55,212,000 yen) (27,607,000 yen ×2 units)	14,206,000 THB (220,000USD×2 units) (48,584,000 yen) (24,294,000 yen ×2 units)
CO2 emission reduction	5,770 t-CO2/12yr	2,340t-CO2/12yr
JCM subsidy	6,457,000 THB (22,082,000 yen) (1,119 THB (3,826 yen)/t-CO2)	2,699,000 THB (9,230,000 yen) (1,153 THB (3,943 yen)/t-CO2)
Running cost (fuel)	57,263,000 THB/12yr (195,839,000 yen) (13.3[liters/h])	91,272,000 THB/12yr (312,150,240 yen) (21.2[liters/h])
JCM subsidy ratio	40.0%	19.0%
Payback period	3 years	6 years

PAT commented that its initial preference was to keep the existing engines because otherwise accountability issues would arise if soon after being procured the original RTG engines were removed and replaced with small engines. However, with later consent from PAT, this evaluation included replacement with small engines.

If the existing engines are kept as installed, possible approaches include first refurbishing RTGs to make them hybrid units with the JCM equipment subsidy program, and then at a later time PAT could on its own replace the existing engines with small engines when doing an overhaul.

(4) Indirect Low-Carbon Benefits of Modal Shift

PAT sees the rail terminal (SRTO) and coastal terminal it operates as important facilities in terms of promoting a modal shift from truck to rail and ship transport, seeking to reduce air pollution resulting from traffic congestion and emissions, and to promote low-carbon operations.

The objective of introducing hybrid RTG cranes in this study is to reduce the environmental impacts of the actual cargo handling equipment. Because such a project would be also expected to decarbonize operations by promoting modal shift through increasing the terminals' handling capacity, ideally, the indirect low-carbon benefits should also be evaluated. However, as shown in Figure 18, it is not easy to evaluate the indirect decarbonization benefits due to the diversity of entities involved (shippers, inland depot operators, rail operators, PAT, etc.). Thus, this study does not consider the indirect effects of promoting modal shift and leaves that for a potential future evaluation.

For evaluating the indirect benefits of promoting modal shift it would be worth also considering an expansion of the project including, the potential for railway extensions to the inland depot and Amata Industrial Estate, etc.

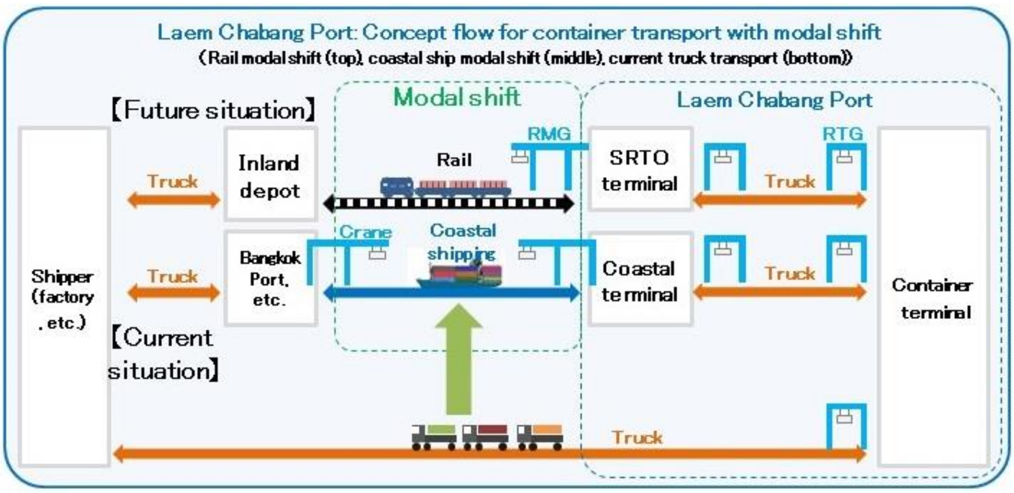


Figure 18: Image of modal shift of container transport at Laem Chabang Port

3.2 Solar Photovoltaic System

This study verified the project viability of installing a solar photovoltaic system directly mounted on open space on the inland property behind the terminals.

(1) Evaluation of Project Viability of Solar Photovoltaic System

This evaluation included consideration of generation capacity, confirmation of geotechnical factors and flood risk, consideration of foundation design, consideration of grid connection method, and the need for security facilities. This was all based on the assumption of installing a solar photovoltaic system on open spaces near the wind turbines and tower on terminal property inland.

The results of project viability evaluation are shown in Table 22.

Table 22: Project viability evaluation results for solar photovoltaic system

	Solar photovoltaic
Depreciation period	17 years
Quantity	1 set (2,730 kW)
Initial cost (A)	115,065,000 THB (393,522,000 yen) Of which, eligible for JCM subsidy 92,052,000 THB (314,817,000 yen) Not eligible for JCM subsidy 23,013,000 THB (78,704,000 yen)
CO_2 emission reduction (B)	35,370 t-CO_2/17yr (2,080 t-CO_2/yr)
JCM subsidy (C)	27,615,000 THB (94,443,000 yen)
JCM cost/benefit(C)/(B)	780 THB/t-CO_2 (2,667 yen/t-CO_2)
JCM subsidy ratio	24% (Ratio for subsidy eligibility is 30%)
Running cost savings (reduced electricity costs)	112,484,000 THB (384,695,000 yen)
Evaluation (result)	○

The generating cost if the JCM is used will be approx. 1.7 THB/kWh, compared to approx. 3.5 THB/kWh electricity rates that would be paid to the local utility (PEA) to purchase from the utility (rate information from PAT inquiry), producing savings of approx. 1.8 THB/kWh. With this difference, the running cost savings over 17 years would be approx. 112 million THB.

The initial cost of approx. 115 million THB for the solar photovoltaic system installation includes approx. 92 million THB (approx. 80% of initial costs) eligible for JCM subsidy (installation and connection costs such as for the PV modules and power conditioners), and approx. 23 million THB (approx. 20% of initial costs) not eligible for JCM subsidy (costs such as panel supporting frame, foundation, and electrical conduits).

The statutory depreciation period is 17 years. The CO2 emission reductions during that period are estimated to be approx. 35,370 t-CO2 and the cost-benefit approx. 780 THB/t-CO2, and these numbers are at levels that are eligible for the JCM subsidy program.

Details of the analysis are provided below.

(2) Consideration of Solar Photovoltaic System

1) Conditions on the Proposed Site

- PAT owns the proposed site, which already has installed small wind turbines (total 86) owned by PAT. For consideration of a solar photovoltaic system, this evaluation excludes an area of 33 sq m around the small turbines to be kept as maintenance space, as required by PAT request, and evaluates an installation on the remaining spaces.
- Also, there is a monument dedicated to Thailand's King Rama IX between AREA-2 and AREA-3 on the proposed site (based on PAT interview), so this section as well was excluded from consideration for installation of the system.
- Thus, three areas were identified for installation on the proposed site at the terminal property inland (AREA-1 with 9,800m^2, AREA-2 with 10,000m^2, AREA-3 with 4,200m^2, totaling 24,000m^2), and the layout of solar photovoltaic modules was considered as shown in Figure 20

2) Configuration of Solar Photovoltaic Modules

- The solar photovoltaic modules have a maximum output of 325 W per module and are installed in sets of four modules. The orientation is south-facing, with a slope of 15 degrees, considering factors such as panel configuration, aisle width, and generating efficiency, etc. (Figure 19). As for the support structure and foundation, this study obtained geotechnical information (boring data, etc.) from PAT from the time when wind turbines were installed, and based on that data has assumed a steel support structure and concrete pile foundation.

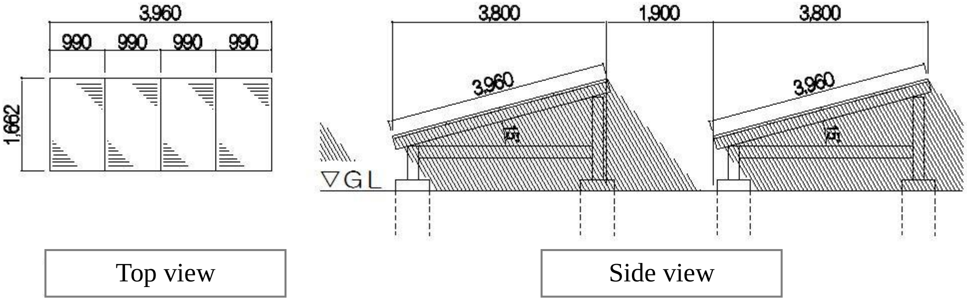
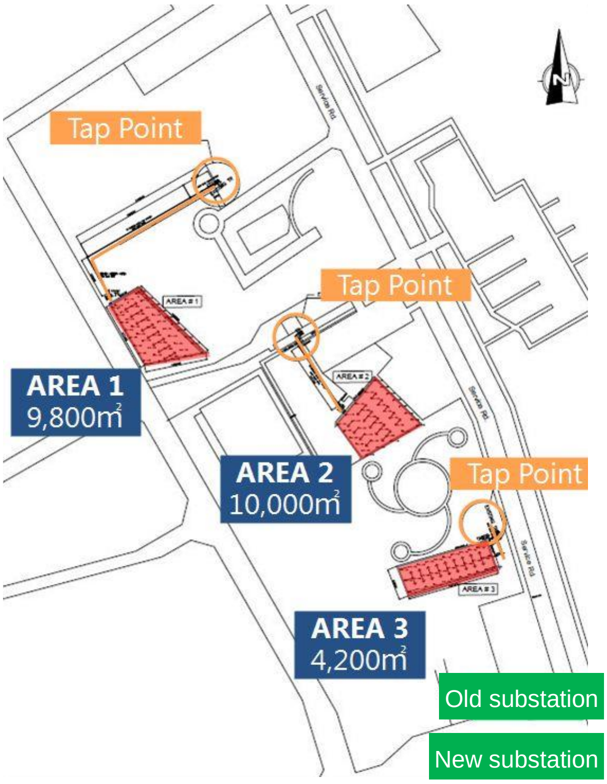


Figure 19: Solar photovoltaic module configuration

- Figure 20 shows the number of modules that can be installed on the three areas on the proposed site, showing a potential installation with the equivalent of approx. 2,730 kW.



	Area of installation	Number of Modules	Output
AREA 1	9,800 m2	3,000	975 kW
AREA 2	10,000 m2	3,000	975 kW
AREA 3	4,200 m2	2,400	780 kW
TOTAL	24,000 m2	8,400	2,730 kW

Figure 20: Proposed site, solar module configuration

3) Electrical Design

- Regarding power conditioners to be used for this facility, considering constraints on initial costs and risk distribution plus the fact that the area is divided into more than one section, it was decided to configure the design with several small units (Figure 21).
- Regarding grid connection, two methods were considered: connecting directly to a receiving substation under construction, and connecting to relay points (tap points) of the existing small wind power generation installation.
- If the connection is to be made to the power receiving substation only from the photovoltaic installation, electrical conduits and lines would have to be very long, and it would be required to cross high-traffic roads, so it was clear that costs would increase.
- For this reason, this study proceeded with a possible proposal to connect to existing connections (tap points) of the small wind turbine installation close to each area.
- Electricity generated by the solar photovoltaic system is collected in each area and connected to existing tap points via power conditioners. The plan is to lay electrical conduits on the ground between the PV equipment and the power conditioners.

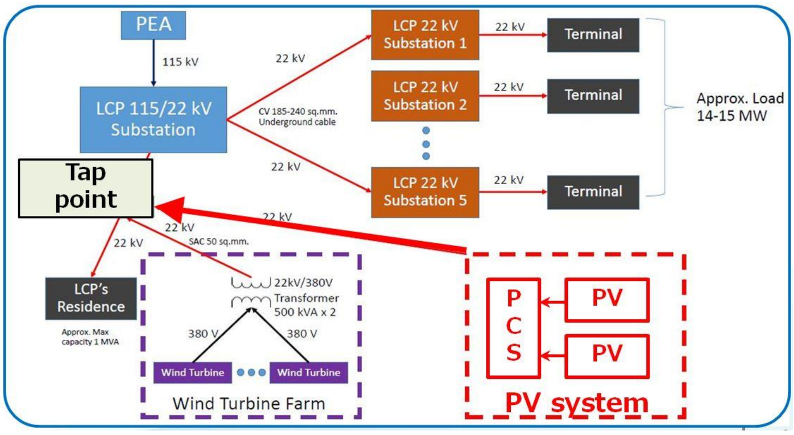


Figure 21: Schematic diagram of power grid at Laem Chabang Port (PAT interview)

4) Security Considerations

- Due to factors such as the presence of roads and standby trailer parking space near the proposed site, this plan includes fencing on the perimeter for the purpose of safety management of the solar photovoltaic modules and related equipment.

5) JCM Subsidy Eligibility

This evaluation classified the JCM eligible and ineligible initial costs for solar photovoltaic system installation, as shown in Figure 22.

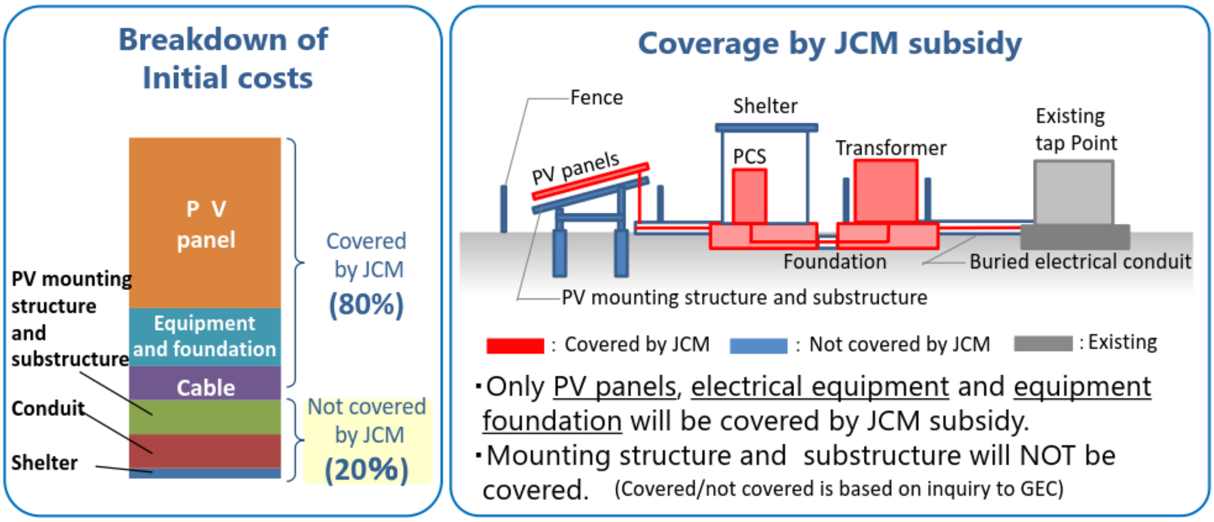


Figure 22: JCM subsidy eligibility

3.3 Summary

A summary of results is shown in Table 23.

Table 23: Results of examination of project viability

	PAT	
Procurement details	**Hybrid RTGs**	**Solar photovoltaic**
Depreciation period	12 years	17 years
Quantity	New purchase 6 units Refurbish 2 units	1 set (2,730 kW)
Initial cost (A)	279,622,000 THB (956,307,000 yen)	115,065,000 THB (393,522,000 yen)
CO2 reduction (B)	23,080 t-CO2/12yr (1,923t-CO2/yr)	35,370 t-CO2/17yr (2,080t-CO2/yr)
JCM subsidy (C)	26,479,000 THB (90,558,000 yen)	27,615,000 THB (94,443,000 yen)
JCM cost/benefit (C)/(B)	1,147 THB (3,922 yen) /t-CO2	780 THB (2,667 yen) /t-CO2
JCM subsidy ratio	Approx. 9.4%	Approx. 24.0%
Running cost savings	229,054,000THB/12yr (783,364,000 yen)	112,484,000THB/17yr (384,695,000 yen)
CO2 reduction	**58,450 t-CO2**	
Total JCM subsidy	**54,094,000** THB (185,001,000 yen)	
JCM subsidy ratio	Approx. **13.7%**	
Running cost savings	**341,538,000**THB (1,168,059,000 yen)	
Integrated evaluation	○	
Procurement period	2020-2022 (planned)	

The subsidy ratio for the entire project is only 13.7%. Reasons for this include the fact that for RTG cranes, the CO2 emission reductions are small relative to initial costs, resulting in a low subsidy ratio; and for the solar photovoltaic system, the subsidy-ineligible share is large relative to the rooftop mount type currently being installed by PAT, resulting in a low subsidy ratio.

However, because the amount of subsidy is approx. 185 million yen, and the post-installation cost reduction benefit is approx. 1.168 billion yen (＝RTG fuel cost reduction of 784 million yen + electricity purchase cost savings with 384 million yen), there are significant merits in favor of introducing the equipment.

Furthermore, the rail terminal (SRTO) and coastal terminal considered in this study are intended to promote modal shift, and increasing these terminals' cargo handling capacity will lead to increased usage levels, likely to result in significant decarbonization benefits, so it would be very worthwhile to fund the procurement of cargo handling equipment using the JCM equipment subsidy.

Looking closely at the timing of procurement, it will be important to start preparations for applying to the JCM equipment subsidy program, it will also be important to proceed with preparations in order to avoid delays with required permit and approval procedures for the RTG cranes as well as solar photovoltaic equipment.

For Reference

This study evaluated the case of upgrading existing yard lighting with LED lighting at the multi-purpose terminal. While this is not a complete summary of all the conditions for consideration, the general results of upgrading to LED lighting are shown in Table 24.

Table 24: Evaluation of project viability for LED yard lighting (Laem Chabang Port multi-purpose terminal)

	LED yard lighting
Depreciation period	10 years
Quantity	242 sets
Initial cost (A)	15,125,000THB (51,727,000 yen)
CO2 reduction (B)	2,600t-CO2/10yr (260t-CO2/yr)
JCM subsidy (C)	3,025,000THB (10,345,000 yen)
JCM cost/benefit(C)/(B)	1,160THB(3,967 yen) /t-CO2
JCM subsidy ratio	20%
Cost of electrical consumption reduced	5,272,000THB (18,030,000 yen)

4. Financing and Procurement Approaches

Based on assumed project costs, this study considered the approaches for procuring funds and equipment required by PAT.

4.1 Confirming the Need for Fund Procurement for Each Terminal's Operator

Until now, PAT has self-funded what it needed for facilities construction. Going forward, this policy is in principle expected to continue. In the previous survey, there was also a comment that PAT will not only do its own self-financing but also consider using a wide range of fund procurement approaches conducting large-scale facilities construction. This relates to large-scale projects such as Phase III projects, and for equipment being considered in this study, it is highly possible that in line with that principle, PAT would self-finance based on the size of the investment.

As for private sector operators, based on inquiries with several companies, in all cases the response was that in principle they would rely on self-financing to cover any funds needed for facilities improvements.

4.2 Procurement Methods

<Government Procurement and Supplies Management Act>

Procurement by PAT for the execution of business is conducted in accordance with legislation.

The Government Procurement and Supplies Management Act 2017 was enacted in August 2017, and the Ministry of Finance promulgated an official notification about procurement methods based on it. It applies to all national public entities and state enterprises.

According to this notification, where any external subsidy is received, the method of procurement must comply with Article 7, Paragraph 5 of the Act.

a) If the subsidy exceeds 50% of the total investment:
  →Where the subsidy granting body has procurement guidelines in place (e.g., stipulating the use of Japanese products or nominated bidding), they are to be followed.

b) If the amount of the subsidy is less than 50% of the total investment and the subsidy granting body has procurement guidelines in place:
  → Procurement can proceed in accordance with those guidelines, but a Thai Ministry of Finance committee makes a separate approval or rejection decision.

c) If neither of the above cases applies:
  → Regular procurement procedures are followed based on the Act.

JCM-subsidized projects are intended to be projects where the amount of subsidy is less than 50% of the total investment, which corresponds to either b) or c) above. If the subsidy-granting body (in this case, the Ministry of the Environment, Japan, or the Global Environmental Centre Foundation, GEC) has procurement guidelines in place, b) applies, and it may be possible for procurement to occur in accordance with those guidelines, but is necessary for a separate approval or rejection decision to be made by a committee of Thailand's Ministry of Finance. If no procurement guidelines exist, c) applies.

Based on the above description, procurement in this case has a high likelihood of being done by general competitive bid.

The Act made it mandatory to hold a public hearing regarding the terms of reference (TOR), prior to implementing the bid, and to broadly accept comments. The content of the special notes provided in the TOR are important in order to introduce high quality equipment, but if the notes are too specialized, there is a higher likelihood of receiving a large number of comments from the public hearing. Where comments have been received, it is necessary to reply to all of them, and then to hold another public hearing, so it is important to allow much time from the TOR formulation to the bid (depending on the scale and details of the project, generally from half to one year).

<Procurement Process>

Under the Act, the process leading up to the bid is as follows:

1) Prepare TOR
2) Implement TOR committee, get approval
3) Implement public hearing
4) Revise TOR based on comments from public hearing
5) Second public hearing based on revised TOR
6) PAT internal decision
7) Bidding notice
8) Bid

<Integrated Assessment Approach>

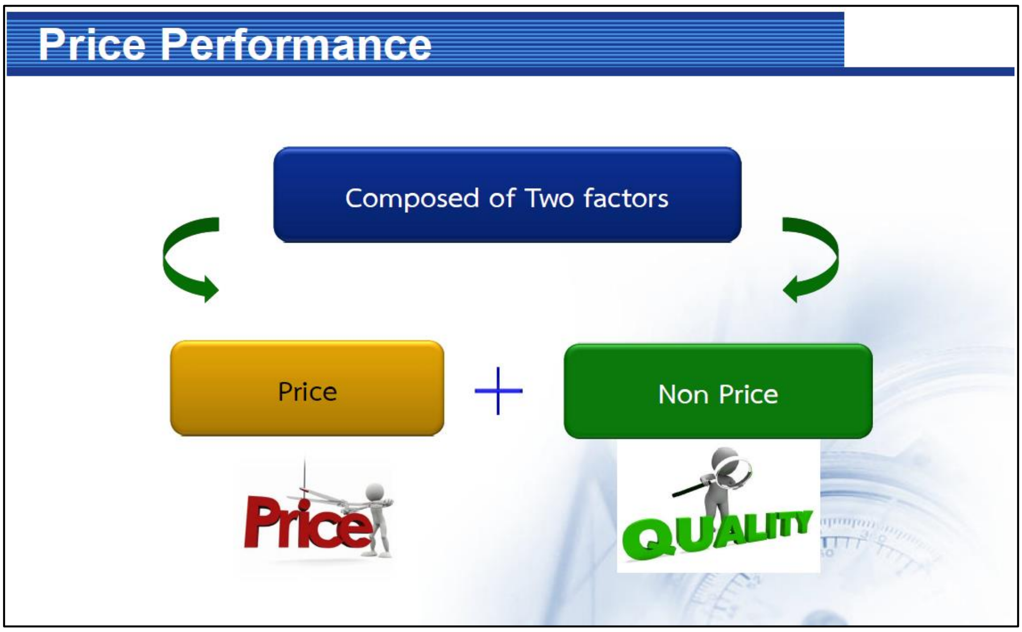
Under the Act, it became possible to utilize an integrated assessment approach to deal with issues that arise with the principle of lowest-cost procurement, which PAT has also adopted.

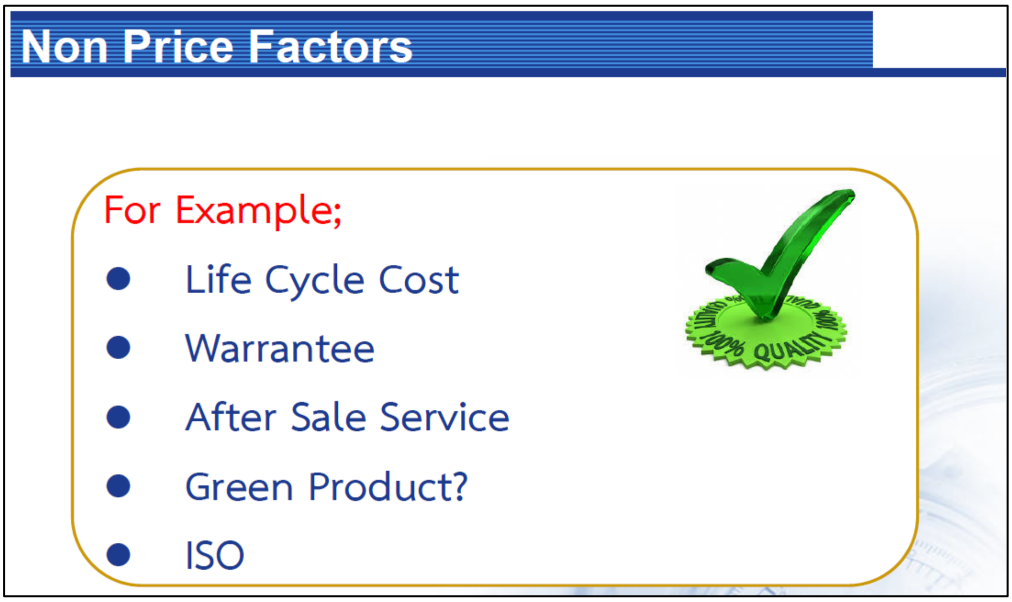
The problems of bid decisions being made based only on lowest price were pointed out some time ago even within the Government of Thailand.*[3] An example provided is where the lowest-cost printer is purchased, the subsequent costs of toner and other supplies as well as maintenance costs could be high, resulting in reduced cost effectiveness. Thus, in addition to the regular evaluation criterion of price, some form of scoring is also encouraged for evaluating equipment and services when making procurement decisions, in order to consider non-price factors such as lifecycle costs, warranties, after sale service, green product features, ISO standards, and so on. This is known as the integrated assessment approach (Figure 23).

*[3] Ms. Nitiyaporn Imjai and Mr. Thanachoke Rungthipanon, "Government Procurement System," Office of Public Procurement Management, Comptroller General's Department, 2016.

Source Comptroller General's Department

Figure 23 (1): Issues with lowest price procurement systems, as explained by Government of Thailand documents





Source: Comptroller General's Department

Figure 23 (2): Issues with lowest price procurement systems, as explained by Government of Thailand documents

Under the Act, the "integrated assessment approach" can be adopted under specific conditions. The Government of Thailand guidelines list six evaluation categories, and businesses/contractors can apply their own weighting systems.

(1) Initial price (for this category only, the minimum permitted weighting is 30%)
(2) Running costs
(3) Product quality and service
(4) After-sale service
(5) Other technical factors
(6) Other

However, when wanting to actually adopt the "integrated assessment approach," it is necessary to have a decision by the Ministry of Finance committee for each case, and until there have been more cases of bidding based on the integrated evaluation method in Thailand, there are concerns that decisions will take a considerable amount of time. When implementing bidding for this project, it would be preferable to have the successful bidder decided not based only on initial cost, but by comprehensive evaluation, such as an evaluation of life cycle cost, assurance of quality and durability, and assurance of after-sales service, etc. For this reason, for the selection of bidding method (whether general competitive bidding or integrated evaluation method), it will be important to ascertain the latest circumstances regarding examples of application of the integrated assessment approach and the time required until bidding occurs, paying attention so as not to affect the schedule of the project.

5. Permit and Approval Process for Solar Photovoltaic Installations

Low-carbon facilities are being considered as proposed projects in this feasibility study. Regarding RTG, the project team has confirmed through interviews with PAT that permits and approval are not required for introduction and upgrades.

Meanwhile, for grid-connected solar photovoltaic (PV) facilities intended for on-site power consumption at Laem Chabang Port, it will be necessary to obtain approval or provide notifications, depending on certain criteria. The project team investigated the relevant laws and regulations pertaining to licenses and approvals required to install photovoltaic power generation facilities, and by interviews with the relevant authorities confirmed various details, including the application content, procedures and necessary documentation.

5.1 Outline of Applications to Relevant Authorities

For a solar PV project, the applicant or project proponent is required to contact and submit the applications to four relevant agencies: (1) Energy Regulatory Commission (ERC), (2) Electricity Authority, (3) Department of Industrial Works (DIW), and (4) local government. This chapter summarizes the relevant agencies and application procedures for the proposed solar PV installation in Laem Chabang Port in Chonburi Province, Thailand.

(1) Energy Regulatory Commission (ERC)

The primary agency to receive general applications is the ERC, which approves licenses for all energy projects in Thailand. Application documents vary depending on the project, for example, depending on the technology or fuel used for electricity generation, the installed capacity, etc. Documentation to be submitted includes a license application form, controlled energy project form, and a Code of Practice (CoP) document, as well as reports relating to environment and safety, including an Environmental & Safety Assessment (ESA) and/or Environmental Impact Assessment (EIA). The ERC also allows online submissions for applicants to follow up on the application status. The license approval process may take about 75 days, depending on the completeness of documents.

(2) Electricity Authority

Another key agency to be contact by the applicant or project proponent is the Electricity Authority. Which one to contact depends on the location of project. For projects located in Bangkok, Nontaburi, Pathumtani, or Samuthprakran, the contact is the Metropolitan Electricity Authority (MEA), but for projects in other parts of the country, the contact is the Provincial Electricity Authority (PEA). Laem Chabang Port is in Chonburi Province, and the port consumes electricity from PEA through the national grid, so it is required to communicate with PEA regarding the details of this project. PEA will verify the details of the electricity generation system to ensure that the project will not interfere with the national grid. (Even if the solar project is only for on-site consumption, the national grid is still the main power source for the port’s consumption). After reviewing the applicant’s submission documents, PEA will conduct on-site inspections. Usually, the process may take from one to 2.5 months, depending on the case.

(3) DIW (Department of Industrial Works)

Regarding any power plant, defined as a factory, the applicant or project proponent must also contact the DIW, which is in charge of factory approvals. Application documents can be obtained at any DIW regional office, located in all provinces in Thailand.

(4) Local Administrative Organization

The applicant or project proponent is also required to contact the "local administrative organization" (municipality) for construction permission, as they are responsible for comprehensive city mapping and zoning (urban planning), and must verify that the proposed solar PV project will be located in an appropriate and permitted area.

5.2 Application Processes

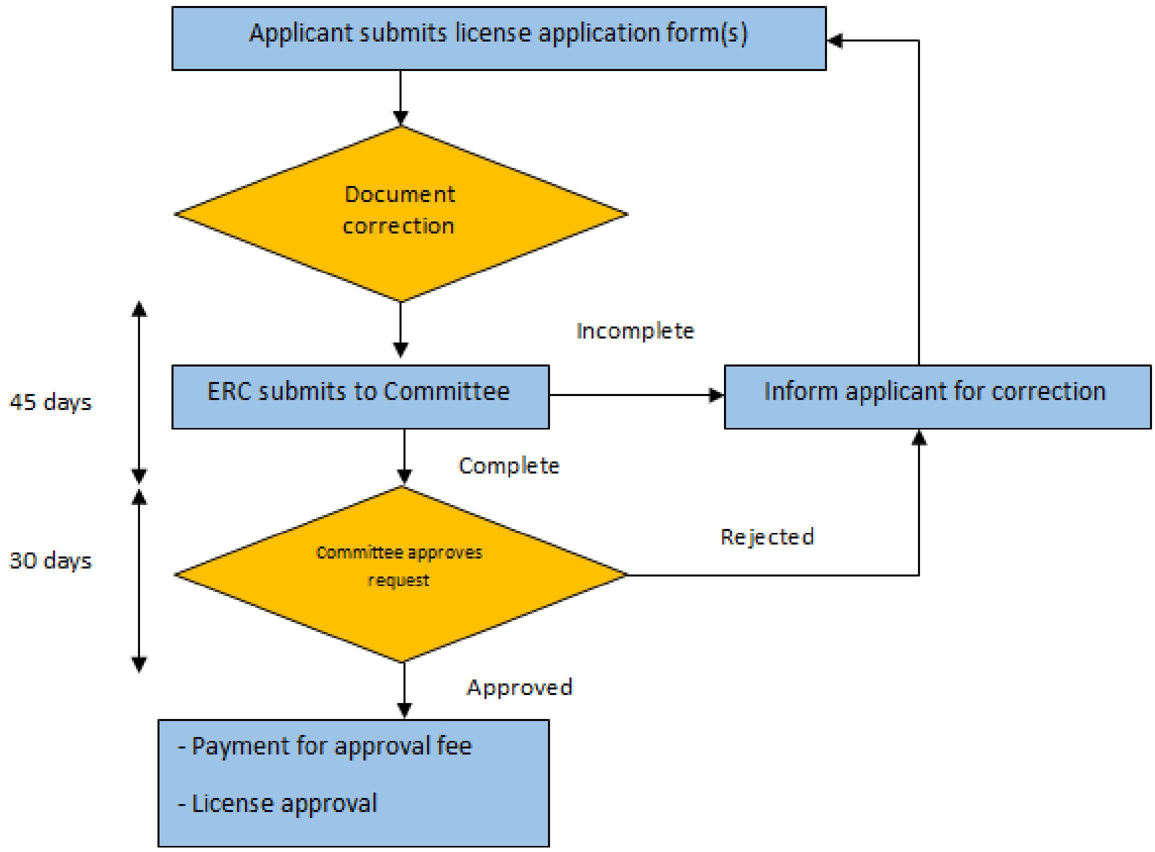
(1) Submission to ERC

1) License Application Process

From the guidelines for license applications (ERC website), there are three stages for submission: (1) pre-licensing, (2) licensing, and (3) permission to construct/operate.*4 The general license application process is shown in Figure 24.

- Applicant submits license application to ERC (content depends on license being requested).
- ERC office takes 45 days to review documents, and will contact applicant if any corrections or additional documentation is required.
- After ERC office has received complete documents, the approval process will take another 30 days. The office will notify the applicant of results, whether or not the application has been approved.

*4 Note that an ERC pamphlet separates these into pre-licensing, pre-construction licensing, and permit to operate.[2]



Source: http://www.erc.or.th/ERCWeb2/Front/StaticPage/StaticPage.aspx?p=15

Figure 24: ERC license application process

2) Required Documentation

Generally, license applications are classified based on the objectives of the project or type of proponent:

1) Independent Power Producer (IPP) [3]
2) Small Power Producer (SPP) [4,5]
3) Very Small Power Producer (VSPP) [6]
4) Industrial Power Supplier (IPS) [4,5,6]
5) In-Plant Utility (IPU) [7]

The proposed solar PV project in this feasibility study is a 2.73 MW installation for on-site consumption. Based on the project team's inquiry with ERC personnel, the fifth classification above applies in this case, and the applicant or project proponent must submit an application and related documentation as follows:

- License application (for power generation) ➔ Download from ERC website
- Controlled factory approval form ➔ Obtain from DIW regional office
- Controlled power generation approval form ➔ Download from ERC website (DEDE/ERC)
- For controlled buildings that require approval from local authorities, ERC personnel indicated

that approval is not required (but it is advisable to reconfirm with local authorities, to ensure the proposal is consistent with the city plan or zoning).

- Code of Practice (COP) of the project ➔ Download from ERC website
- Environment and Safety Assessment (ESA) ➔ Contact ERC for further detail during application submission process

The license application form to be submitted to ERC consists of nine sections, as follows:

1) Applicant information (business register ID, type of license submission, authorized person, address, tax ID, etc.)
2) Information about the project (organization structure, stakeholder list, investment, operation & maintenance cost estimation, financial plan, IRR)
3) Information about energy project activity (address, GPS coordinates, land information, construction plan)
4) Information about the energy generation – for power generation license (objective and energy production plan; power generation system including technology, facilities, equipment; capital cost and installed capacity; system efficiency; connections; etc.)
5) Environmental management (EHIA, EIA, CoP [9] reports; reports on environmental impacts such as exhaust gas and cooling water system, air pollution control, water management, impact management, etc.)
6) Information about the power distribution system – for energy distribution system license application
7) Information about the energy distribution – for energy distribution license application
8) Qualifications and certification of the licensee
9) Supporting documentation and evidence

3) Supplementary Information

License application procedures for on-site consumption are modified for the In-Plant Utility (IPU) process. Below is a general outline:

1. Applicant submits license application to ERC
2. Comments are requested from relevant agencies (local administration, DIW, urban planning)
3. License approval (around 75 days) from ERC
   - Power generation: For installed capacity < 1,000 kVA ➔ license exemption
     For installed capacity > 1,000 kVA ➔ license required
4. After construction is complete and equipment installation is nearly complete ➔ Seek controlled building approval from local authority (takes approx. 30 days) and energy production/management approval from ERC/DEDE (takes approx. 120 days)
5. Comments are requested from relevant agencies (local administration or DEDE)
6. License approval from ERC
7. Start project operation

(2) Submission to PEA

Similar to document preparation for the ERC, the Electricity Authority to be contacted by the applicant or project proponent will depend on the location of the project. Since Laem Chabang Port is located in Chonburi Province, the appropriate contact is the Provincial Electricity Authority (PEA) regional office, which verifies the connection point to ensure system safety. Since the proposed installed capacity for the solar PV is 2.73 MW, it is necessary to submit the following application and related documentation for the proposed project system and grid connections to the PEA office:[10]

Request form for connecting project system with PEA system

1) Applicant information: Company name, address, type of business
2) Technical information: Appropriate voltage (kV), type of power generation, number of generators, total installed capacity (MW), type of equipment (synchronous / induction)
3) Project load: Maximum and minimum kW from MEA/PEA
4) Contact info: Contact person
5) Additional documents:
    - Map of project
    - Schematic diagram/ metering and relaying diagram
    - Detail of power generator (name plate) and specifications
    - Specification of the connection system (transformers, circuit breakers, CT & PT, relays, power quality meters)
    - Detail about control panel unit
    - For a 115 kV system, documentation must be submitted relating to substation grounding test reports, substation layout, and remote supervisory control functions.

Supporting documentation:

1) Request form
2) Map to the project (with coordinate)
3) Schematic diagram
4) Outline of power generation system in the project
5) Specifications: Inverter, test reports, etc.
6) Work flow chart
7) Electricity bill (as the consumer)
8) Authorized person
9) Business registration document
10) Official letter or contract stating that the project will comply with PEA regulations and payments

(3) Submission of Environmental Reports

To address environmental and safety concerns, the applicant or project proponent is required to submit environmental reports. The required documentation depends on the proposed installed capacity, as summarized in Table 25.

Table 25: Environmental reports required depending on PV installed capacity

Installed capacity (MW)	Required procedures
≥ 10 MW	Mini CoP and ESA
1,000 kVA to < 10 MW	Mini CoP and ESA
< 1,000 kVA	Mini CoP

Note: Mini Cop – For environmental and safety concerns, the project proponent of the solar technology must execute a Code of Practice and submit it to ERC (depending on certain conditions the license application is exempted, so this CoP submission substitutes as notification to ERC).

Details of a CoP form are as follows:[9]

1. Project information: Ground mounted or rooftop, solar tracking versus fixed rack, etc.)
2. Equipment standard, installation, connection system, safety
   - EC 61215, 61646, 61730, TISIs, etc.
   - Balance of system components
   - Installation and power distribution system (IEC 60364-7-712, TISIs, etc.)
3. Project design: Plant capacity factor (annual energy yield, etc.)
4. Handling/method for decommissioning panels, equipment, electronic parts: Recycling, landfill, etc.
5. Project proponent guarantee and engineering certification for project

(4) Public Hearing

The applicant or project proponent is required to conduct a public hearing about the project for the local community and residents, as outlined in Table 26.

Table 26: Public hearing procedures and details

Procedure	Details
1. Establish a committee	-
2. Project notification (min. 15 days)	a. Project background and objectives b. Project details c. Name of the licensee d. Location of the facility e. Construction period f. Expected benefits for the community g. Estimated project budget h. Hearing agenda and venue i. Possible impacts/risks, countermeasures
3. Holding public hearing and following up (min. 15 days)	a. Project background and objectives b. Project details c. Name of the licensee d. Location of the facility e. Construction period f. Expected benefits for the community g. Estimated project budget h. Hearing agenda and venue i. Possible impacts/risks, countermeasures
4. Summarize (within 15 days)	a. Facts (date, time, venue of public hearing) b. Participant list c. Public hearing procedures d. Written comments received e. Explanations/response (in case of questions)
5. Publish summary (within 15 days)	a. Impacts or risk that may occur and countermeasures

Source: [2]

(5) Application Fees

Application fees are calculated based on the proposed installed capacity, as shown in Table 27.

Table 27: Application fees

Application fees and installed capacity	
Less than 10 MW	5,000 Baht
10 MW to 150 MW	10,000 Baht
150 MW or greater	50,000 Baht

Persons interviewed

ERC:

Mr. Kan Channoi, official, License Approval Division: 02-2073599#777 (by phone on Friday, December 7, 2018)

Ms. Woranan, ERC Call Center 1204 (by phone on Tuesday, December 11, 2018)

PEA Head Office:

Mr. Shahatphong Pechrak, Engineer, Alternative Energy Encouragement Division, PEA: 02-590-9753 (by phone and email on Friday, December 7, 2018)

PEA's regulation on power network system connection code

https://www.scribd.com/document/366846807/PEA-Interconnection-Code-2016

References

[1] http://www.erc.or.th/ERCWeb2/Upload/Document/Flow-Licences-Concept.pdf

[2] http://www.erc.or.th/ERCWeb2/Upload/Document/คำแนะนำเกี่ยวกับการขออรับใบอนุญาต/รวมInfo_8-10-61_ผอบญ%20-%201%20การขอรับใบอนุญาตผลิตไฟฟ้า.pdf

[3] http://www.erc.or.th/ERCWeb2/Upload/Document/Flow-Licences-IPP.pdf

[4] http://www.erc.or.th/ERCWeb2/Upload/Document/Flow-Licences-SPP-f.pdf

[5] http://www.erc.or.th/ERCWeb2/Upload/Document/Flow-Licences-SPP-nf.pdf

[6] http://www.erc.or.th/ERCWeb2/Upload/Document/Flow-Licences-VSPP.pdf

[7] http://www.erc.or.th/ERCWeb2/Upload/Document/Flow-Licences-IPU.pdf

[8] http://www.erc.or.th/ERCWeb2/Upload/Document/11142013130912722.pdf

[9] http://www.erc.or.th/ERCWeb2/Upload/Document/Code%20of%20Practice_HB.pdf

[10] https://www.pea.co.th/Portals/0/Document/Area-for-submission.pdf

[11] https://www.pea.co.th/Portals/0/Document/connection_code_2016_20170928.pdf

6. MRV Proposal

Based on the above findings, a proposed MRV methodology was developed to implement the projects considered in this feasibility study under the JCM subsidy program.

The following pages show the methodology that was developed.

6.1 Hybrid RTG

JCM Proposed Methodology Form

Cover sheet of the Proposed Methodology Form

Form for submitting the proposed methodology

Host Country	Kingdom of Thailand
Name of the methodology proponents submitting this form	Yokohama Port Corporation
Sectoral scope(s) to which the Proposed Methodology applies	03. Energy Demand
Title of the proposed methodology, and version number	Installation of Hybrid RTG at Port Facility
List of documents to be attached to this form (please check):	☐The attached draft JCM-PDD: ☐Additional information
Date of completion	22nd February 2019

History of the proposed methodology

Version	Date	Contents revised
1.0	22nd Feb 2019	First edition

A. Title of the methodology

Installation of Hybrid RTG at Port Facility

B. Terms and definitions

Terms	Definitions
Rubber tired gantry crane (RTG)	Rubber tired gantry crane (RTG) is a unique crane for ports in a gate shape for handling containers stored in a container yard. Conventional RTG is driven by diesel oil, but there are other types of RTG, such as electric RTG and hybrid RTG.

C. Summary of the methodology

Items	Summary
GHG emission reduction measures	Realizing carbon dioxide (CO2) reduction by hybrid RTGs.
Calculation of reference emissions	Reference emissions are GHG emissions from using reference conventional RTGs commonly used for port facilities in Thailand, calculated based on historical fuel consumption data owned by the project implementers (in Thailand and/or Japan), or ex-ante/ex-post measurement data obtained during the project activity.
Calculation of project emissions	Project emissions are GHG emissions from the project hybrid RTGs, calculated based on their diesel fuel consumptions during a time period *p* after the project implementation.
Monitoring parameters	Operating hours of electric RTG *i* during a time period *p* after the project implementation. [hours/*p*] Diesel fuel consumption of hybrid RTG *i* during a time period of *p* after the project implementation. [litres/*p*]

D. Eligibility criteria

This methodology is applicable to projects that satisfy all of the following criteria.

Criterion 1	The project involves the installation of hybrid RTGs, or the replacement of conventional RTGs with hybrid RTGs.
Criterion 2	The project hybrid RTGs are powered by diesel fuel, and its consumption amount can be measured.
Criterion 3	
Criterion 4	

E. Emission Sources and GHG types

Reference emissions	
Emission sources	GHG types
Fossil fuel consumption of reference equipment	CO2
Project emissions	
Emission sources	GHG types
Fossil fuel consumption of project equipment	CO2

F. Establishment and calculation of reference emissions

F.1. Establishment of reference emissions

The reference emissions are “the amount of CO2 that would otherwise be emitted from the existing facilities and equipment in the absence of the project facilities and equipment.”

The RTGs for cargo handling in the current port facilities in Thailand commonly use fossil fuel (diesel oil). The reference emissions of the RTGs are calculated from diesel consumption intensity of reference RTG [litres/hour] multiplied by their operating hours during the project period p [hours/p] and CO2 emission factor of diesel oil (t-CO2/litre).

F.2. Calculation of reference emissions

Reference emissions of RTGs are to be calculated with the following formula:

$$RE_p = \sum_i [OT_{p,i} \times EC_{RTG} \times EF_{diesel}]$$

RE_p: Reference emissions of the reference RTG_i during the project period p [t-CO2/p]

$OT_{p,i}$: Operating hours of the reference RTG_i during the project period p [hours/p]

EC_{RTG}: Energy consumption intensity of reference RTG [litres/hour]

EF_{diesel}: CO2 emission factor of diesel oil [t-CO2/litre]

G. Calculation of project emissions

Project emissions of RTGs are to be calculated with the following formula:

$$PE_p = \sum_i [FC_{p,i} \times EF_{diesel}]$$

PE_p: Project emissions of the project RTG_i during the project period p [t-CO2/p]

$FC_{p,i}$: Diesel consumption of the project RTG_i during the project period p [litres/p]

EF_{diesel}: CO2 emission factor of diesel oil [t-CO2/litre]

H. Calculation of emissions reductions

$$ER_p = RE_p - PE_p$$

ER_p : Emission reductions during the period p [tCO2/p]

RE_p : Reference emissions during the period p [tCO2/p]

PE_p : Project emissions during the period p [tCO2/p]

I. Data and parameters fixed *ex ante*

The source of each data and parameter fixed *ex ante* is listed as below.

Parameter	Description of data	Source
$OT_{p,i}$	Operating hours of project RTG*i* during the project period *p* [hours/*p*]	If it is difficult to monitor the operating hours of project RTGs during the project period, use fixed values obtained in study before/after the project.
EC_{RTG}	Energy consumption intensity of reference RTG [liters/hour]	Value obtained from the project implementer's historical data, ex-ante measurement, or the catalogue. For a catalogue value, use the value for the latest model.
EF_{diesel}	CO_2 emission factor of diesel oil [t-CO_2/litre]	Use a published value of IPCC, etc.

6.2 Solar PV System

JCM Proposed Methodology Form

Cover sheet of the Proposed Methodology Form

Form for submitting the proposed methodology

Host Country	Kingdom of Thailand
Name of the methodology proponents submitting this form	Yokohama Port Corporation
Sectoral scope(s) to which the Proposed Methodology applies	01. Energy industries (renewable-/non-renewable sources)
Title of the proposed methodology, and version number	Installation of Solar PV System at Port Facility
List of documents to be attached to this form (please check):	☐The attached draft JCM-PDD: ☐Additional information
Date of completion	22nd February 2019

History of the proposed methodology

Version	Date	Contents revised
1.0	22nd Feb 2019	First edition

A. Title of the methodology

Installation of Solar PV System at Port Facility

B. Terms and definitions

Terms	Definitions
Solar photovoltaic (PV) system	An electricity generation system which converts sunlight into electricity by the use of photovoltaic (PV) modules. Solar panels for PV system can either be rooftop-mounted, or on the ground or water surface. The system also includes ancillary equipment such as inverters required to change the electrical current from direct current (DC) to alternating current (AC).

C. Summary of the methodology

Items	Summary
GHG emission reduction measures	Displacement of grid electricity using fossil fuel as power source by installation and operation of the solar PV system(s)
Calculation of reference emissions	Reference emissions are calculated on the basis of the AC output of the solar PV system(s) multiplied by the conservative emission factor of grid electricity.
Calculation of project emissions	Project emissions are the emissions from the solar PV system(s), which are assumed to be zero.
Monitoring parameters	The quantity of the electricity generated by the project solar PV system(s)

D. Eligibility criteria

This methodology is applicable to projects that satisfy all of the following criteria.

Criterion 1	The project installs solar PV system(s) at port facilities.
Criterion 2	The solar PV system is connected to the internal power grid of the project site and/or to the grid for displacing grid electricity at the project site.
Criterion 3	The PV modules have obtained a certification of design qualifications (IEC 61215, IEC 61646 or IEC 62108) and safety qualification (IEC 61730-1 and IEC 61730-2).
Criterion 4	The equipment to monitor output power of the solar PV system and irradiance is installed at the project site.
Criterion 5	Site for additional installation of storage batteries as the emergency power source is available. In case of installing storage batteries, this methodology shall be elaborated as appropriate.

E. Emission Sources and GHG types

Reference emissions	
Emission sources	GHG types
Consumption of grid electricity	CO_2
Project emissions	
Emission sources	GHG types
Generation of electricity from solar PV system(s)	N/A

F. Establishment and calculation of reference emissions

F.1. Establishment of reference emissions

The CO2 emission factor of the Thai grid published by the Thailand Greenhouse Gas Management Organization (TGO) is 0.5661 tCO2/MWh (combined margin, 2014).

When the project PV system is used as the emergency power source, the reference CO2 emission factor is 0.533 tCO2/MWh. This emission factor is for diesel generator with the power generation efficiency of 49%, but it shall be elaborated as appropriate before introducing the emergency power source.

F.2. Calculation of reference emissions

$$RE_p = \sum_i \left[EG_{i,p\_grid} \times EF_{RE\_grid} \right] + \sum_i \left[EG_{i,p\_eps} \times EF_{RE\_eps} \right]$$

RE_p : Reference emissions during the period p [tCO2/p]

EG_{i,p_grid} : Quantity of the electricity generated and supplied to the grid by the project solar PV system i during the period p [MWh/p]

EF_{RE_grid} : Reference CO2 emission factor of grid electricity [tCO2/MWh]

EG_{i,p_eps} : Quantity of the electricity generated by the project solar PV system i to be stored and used as emergency power during the period p [MWh/p]

EF_{RE_eps} : Reference CO2 emission factor of the emergency power source (diesel oil) [tCO2/MWh]

G. Calculation of project emissions

$PE_p = 0$

PE_p : Project emissions during the period p [tCO2/p]

H. Calculation of emissions reductions

$ER_p = RE_p - PE_p$
$= RE_p$

ER_p : Emission reductions during the period p [tCO2/p]
RE_p : Reference emissions during the period p [tCO2/p]
PE_p : Project emissions during the period p [tCO2/p]

I. Data and parameters fixed *ex ante*

The source of each data and parameter fixed *ex ante* is listed as below.

Parameter	Description of data	Source
EF_{RE}	Reference CO2 emission factor of grid electricity is 0.5661 tCO2/MWh. Reference CO2 emission factor for the use of the project PV system as the emergency power source is 0.533 tCO2/MWh. This emission factor is for diesel generator with the power generation efficiency of 49%, but it shall be elaborated as appropriate before introducing the emergency power source.	Additional information 0.5661 tCO2/MWh is the combined margin (2014) published by TGO. The default value should be revised if necessary from survey result which is conducted by the JC or project participants.

7. Attached Documents

Attached Documents

(1) MOU for Cooperation with PAT, etc.

1) Memorandum of Understanding between City of Yokohama and Bangkok Metropolitan Authority

日本国横浜市とタイ王国バンコク都との
持続可能な都市発展に向けた技術協力に関する覚書

バンコクは急速に都市化しており、政策立案及び都市開発に携わる者は多くの都市課題に直面している。その一つが都市化による地域環境及び地球環境への影響、すなわち廃棄物、下水、大気汚染及び気候変動である。しかしながら、関係者が協力し、都市発展が適切に管理されるならば、環境にやさしく持続可能な都市成長が可能となり、都市公害を減少させ都市緑化促進と低炭素社会を希求する機会を創出することができる。

横浜市はこれまでの数十年、急速な都市化や人口増加等、様々な都市課題に直面し、乗り越えてきた過程において、都市マネジメントやインフラ整備に関する専門知識やノウハウを蓄積してきた。現在横浜市は、横浜の資源・技術を活用した公民連携による国際技術協力事業であるＹ－ＰＯＲＴ事業を通じて、横浜ならではの知見を積極的に発信している。また横浜市は、日本国政府より、低炭素都市運営を世界に向け実証するための環境未来都市の一つに選定されている。

国際協力機構（ＪＩＣＡ）は、横浜市と包括連携協定を締結しており（2011年10月25日付）、現在、「バンコク気候変動マスタープラン2013－2023」プロジェクトのもと、気候変動マスタープラン策定においてバンコク都を支援している。このプロジェクト、及び先行プロジェクトであるＪＩＣＡトレーニングプログラムにおいて、横浜市はＪＩＣＡ及びバンコク都に技術的な助言を行ってきた。こうした背景を踏まえ、日本国横浜市とタイ王国バンコク都（以下、「両者」とする）は、バンコク都における環境に配慮した持続可能な都市の発展を通じた、両者の経済活動の活性化を希求して、以下の内容において協力することに合意した。

１．横浜市は、バンコク都の持続可能な都市開発を目指し、エネルギーマネジメント、公共交通、廃棄物管理及び下水管理等の分野における技術的な助言を行う。
２．両者は、上記に掲げた目標を達成するため、低炭素社会の推進に係る知識・経験を持つ民間セクター、学術機関、地域コミュニティの参加を働きかける。
３．両者は、技術協力を実施するに際し適切な支援を得るために、両国の政府及び国際機関に支援を呼びかける。
４．両者は、上記の連携を効率的に行ううえで不可欠となる情報を相互に提供する。

この覚書は、両者の署名の日に効力を発し、2017年３月31日まで有効となり、両者の評価と合意のもとに更新できるものとする。

本覚書は、2013年10月21日、横浜にて日本語、タイ語及び英語で各２部作成され、同等の効力を持つものとする。意見が相違した場合には、両者が英語版に基づいて協議する。

横浜市長	バンコク都知事
林　文子	スクムパン ボリパット

2) Memorandum of Understanding between the Port Authority of Thailand and the City of Yokohama

横浜市と PAT（タイ港湾庁）による覚書

横浜市と PAT（タイ港湾庁）は両者間の、貿易と港湾に関する協力の推進のため、ここに覚書を締結する。

両者はそれぞれの港の発展と振興に関する課題の議論に関与し、友好および双方の協力の下、他方の成長を強化するために最善を尽くすこととし、本覚書における協力は以下の事柄を包含する。

1. 両者発展のための情報交換
   （1） 港湾経営に関すること
   （2） 海運動向に関すること
   （3） 国際貿易に関すること
   （4） IT 化に関すること
   （5） 技術や環境対策に関すること
2. ポートセールス（地元や地域内の市場拡大のため、潜在的な地元のパートナーや顧客との協力を手助けし推進すること）に係る相互支援

本覚書による協力は義務や制限、法的拘束力を持たないこととする。協力活動はその都度決定し総括され、両者の合意により変更や拡大が行われる。上記活動にかかる費用は事前に一件一件合意の下両者で負担することとする。

この覚書はお互いの尊重とお互いの国家間の長期的で友好的な関係に基づくものとする。

両者を代表し、我々署名者は、ここに公式に横浜市と PAT（タイ港湾庁）による覚書の締結に合意する。本覚書は 2014 年 4 月 22 日に日本語および英語で複写にて署名され、2019 年 3 月 31 日まで有効となり、両者の評価と合意のもとに更新できるものとする。

横浜市	PAT（タイ港湾庁）
鈴木伸哉	R. Surapong
副市長	副長官

Memorandum of Understanding
between
The Port Authority of Thailand and
The City of Yokohama

The Port Authority of Thailand and the City of Yokohama hereby establish a Memorandum of Understanding to mutually benefit both parties through promoting trade and port maritime cooperation.

The Port Authority of Thailand and the City of Yokohama will be involved in discussing issues relating to the development and promotion of each port, and make every effort to intensify growth of the other, through friendship and mutual cooperation.

The cooperation, which is called "Memorandum of Understanding between the Port Authority of Thailand and the City of Yokohama", embraces the following issues:

1. Both parties agree to exchange information on issues regarding;
   (1) Port management
   (2) Trend of shipping trade
   (3) International trade
   (4) Introduction of IT
   (5) Technology and environmental issues

2. Both parties agree to assist each other in exploring the local and regional market, by facilitating and promoting cooperation with potential local partners/customers.

It is understood that the above endeavors are in no way imperative or have any limiting or legal binding character. The cooperation activities will be established and reviewed from time and amended or expanded in accordance with the Memorandum of Understanding of both partners. Costs involved in any of the above activities shall be borne by both partners on a case-by-case basis as agreed in advance.

This Memorandum of Understanding will initially be based on mutual respect and friendship inspired by the long - standing and friendly relationship between both countries.

On behalf of the two parties, we, the undersigned, hereby formally agree to the establishment of the Memorandum of Understanding between the Port Authority of Thailand and The City of Yokohama. This Memorandum of Understanding is done in duplicate in English and Japanese on 22nd April 2014, and will be valid until the end of March 2019 with the option to renew the Memorandum of Understanding after evaluation, and consent of the Parties.

For and on behalf of the Port Authority of Thailand	**For and on behalf of the City of Yokohama**
R. Surapong	鈴木伸哉
DEPUTY DIRECTOR GENERAL	**DEPUTY MAYOR**

3) Letter of Intent of the Implementation of the Memorandum of Understanding between the Port Authority of Thailand and the City of Yokohama

2014年4月22日調印の横浜市とタイ港湾庁による覚書の履行のための基本合意書

2014年4月22日調印の横浜市とタイ港湾庁による覚書（以下、「覚書」という。）を受け、横浜市とタイ港湾庁（以下「両者」という。）は覚書の履行のため、以下の項目に合意する。

1　両者は、書類や情報の提供、人材の交流を通じ相互支援する。

（1）人材育成：両者は、短期の研修プログラムを共同で用意する。横浜市におけるプログラムでは、横浜市がタイ港湾庁のスタッフに、研修にかかる移動手段の支援を提供する。タイにおけるプログラムでは、タイ港湾庁が横浜市のスタッフに、研修にかかる移動手段の支援を提供する。支援の内容については、両者が事前に協議する。

（2）技術交流：両者は特定の分野におけるワークショップや技術視察を行う。分野のトピックについては、両者が事前に協議する。

（3）情報交換：両者は書類や情報の提供を通じて、港湾技術、マーケティング調査及び港湾開発において相互に協力する。

2　両者は、潜在的な地元のパートナーや顧客との連携を促進することにより、地域の市場開拓を相互に支援する。

（1）セミナー：両者は、交互に主催者となり地域的なセミナーを開催する。セミナーのテーマは両者で事前に決定する。

（2）プロモーション：両者は、あらゆる会議や展示の機会を捉え、資料等の配布により、相互に継続的なプロモーションを行う。文書や展示資料は適宜更新されるものとする。

上記のプログラムは、覚書の履行にいかなる制限を設けるものではなく、また、法的拘束力も持たない。また、上記の履行に関する費用については、両者で負担する。案件ごとに事前に考慮され、合意される。タイ港湾庁と横浜市の連携は、国家間そして国民間の長期的な友好関係がもたらす相互の友情と敬意に基づく。

両港のために、2015年1月19日、横浜市とタイ港湾庁は以下に署名し、覚書の履行に関して正式に合意する。合意書は、日本語及び英語で作成され、両言語とも等しく正本とする。

横浜市港湾局
伊東 慎介
港湾局長　伊東慎介

タイ港湾庁（PAT）
長官代理　ｱﾃﾞｨｿﾝ ｱﾉﾀｲｼﾝﾀｳｨｰ

LETTER OF INTENT

ON THE IMPLEMENTATION OF

THE MEMORANDUM OF UNDERSTANDING BETWEEN

THE PORT AUTHORITY OF THAILAND AND THE CITY OF YOKOHAMA

DATED APRIL 22, 2014

Following the Memorandum of Understanding between the Port Authority of Thailand and the City of Yokohama dated April 22, 2014, the Port Authority of Thailand and the City of Yokohama (hereinafter collectively referred to as "Both parties") agreed on the following program for the implementation of the Memorandum of Understanding.

1. Both parties shall reciprocally assist each other by providing documentation, information, and personnel exchanges.

   (1) TRAINING: Both parties shall jointly set up short-term training programs. During the program period in Japan, the City of Yokohama shall provide transportation support for staff of the Port Authority of Thailand. During the program period in Thailand, the Port Authority of Thailand shall provide transportation support for staff of the Port of Yokohama. The extent of the support provided shall be discussed by Both parties in advance.

   (2) TECHNICAL EXCHANGES: Both parties shall organize workshops and technical visits on specific issues. The issues of workshops and each technical visit shall be discussed by Both parties in advance.

   (3) INFORMATION EXCHANGES: Both parties shall reciprocally assist each other by providing documentation and information on Port Technology, Marketing Research and Port Development.

2. Both parties shall assist each other to explore the local and regional market, by facilitating and promoting cooperation with potential local partners / customers.

(1) SEMINARS: Both parties shall establish a seminar every year and each party shall take turn to be the host. The subjects of each seminar shall be set by Both parties.

(2) PROMOTION: At all appropriate conferences or exhibitions, Both parties shall continue to mutually promote each other by distributing promotion materials such as brochures, newsletters, leaflets etc., and by exchanging information during those events. In this regard, the documentation and exhibition materials shall be updated.

It is understood that the above endeavors are in no way imperative or have any limiting or legal binding character to the implementation of the Memorandum of Understanding.

The costs involved in the implementation of the above shall be borne by Both parties. This shall be considered and agreed upon in advance on a case by case basis.

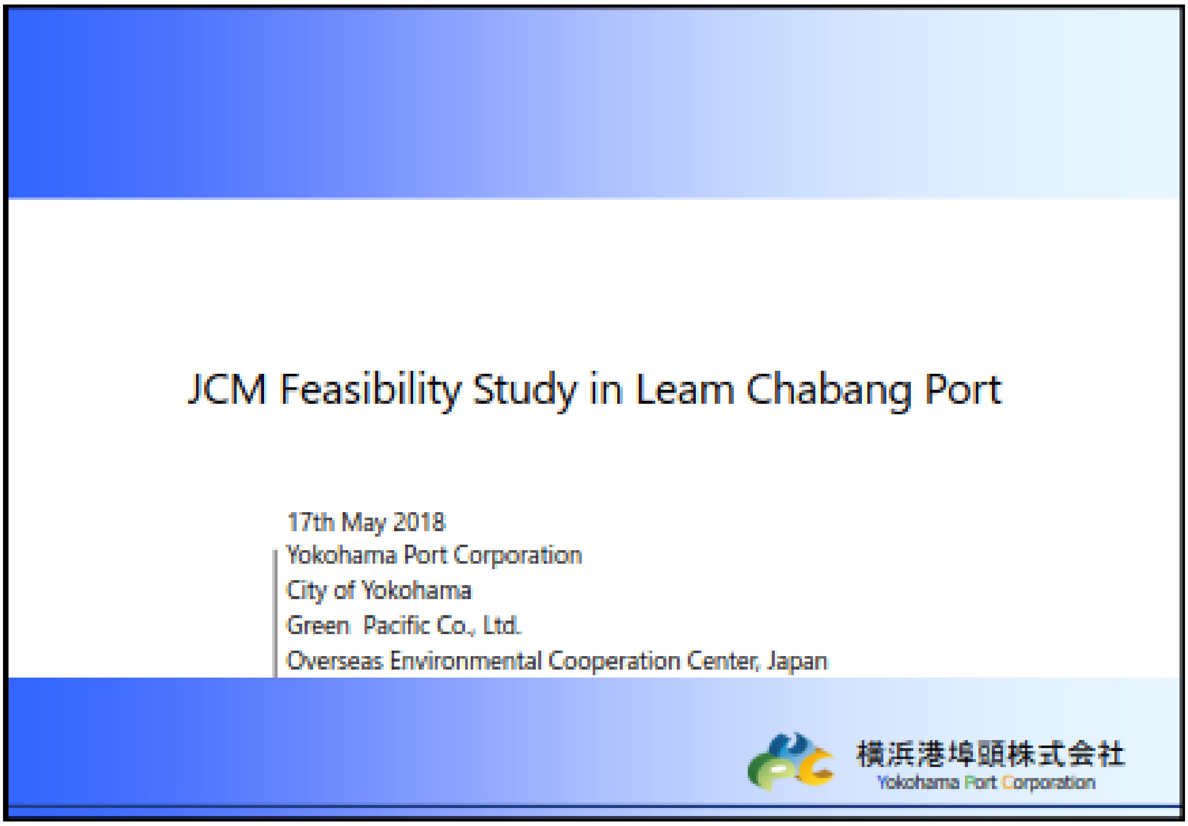
Both parties reiterate that the cooperation between the Port Authority of Thailand and the City of Yokohama is based on a mutual friendship and respect inspired by the long-standing friendly relationship between the countries and their people.

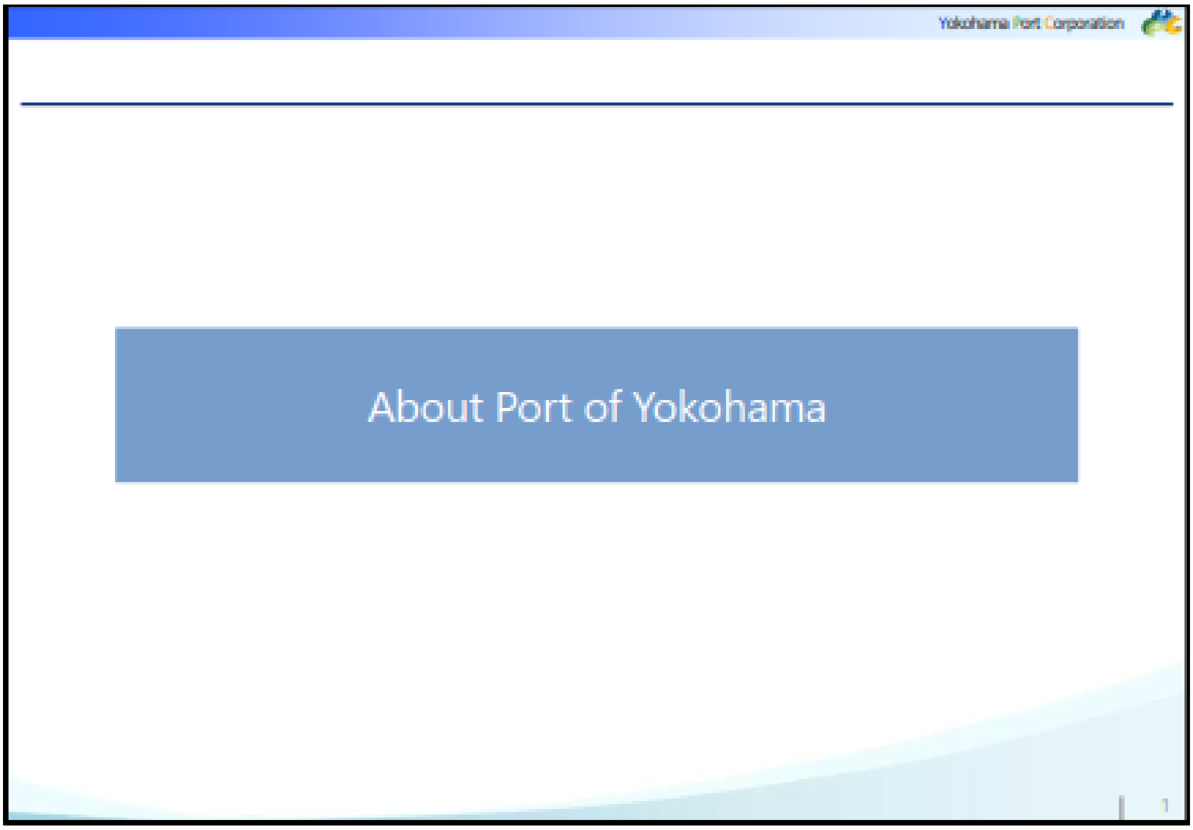
On behalf of the two ports, we, the undersigned, hereby formally agree to the establishment of the Letter of Intent on the Implementation of the Memorandum of Understanding between the Port Authority of Thailand and the City of Yokohama on the nineteenth day of January 2015, in the Japanese and the English languages, both texts being equally authentic.

For the Port Authority of Thailand,	For the Port and Harbor Bureau City of Yokohama,
	伊東 慎介
Adisorn Anothaisintavee Assistant Director General Asset Management and Business Development Port Authority of Thailand	Shinsuke Itoh Director General The Port and Harbor Bureau City of Yokohama

(2) PAT meeting document

1) 17th May 2018





Yokohama Port Corporation

Yokohama Port Corporation

YPC has been engaged in management of logistics-related facilities at the Port of Yokohama for almost 50 years, including container terminals and conventional terminals in cooperation with the City of Yokohama which is port managing body of the Port, and with the Yokohama Kawasaki International Port Corporation (YKIP)* which was founded in 2016 through company split of YPC.

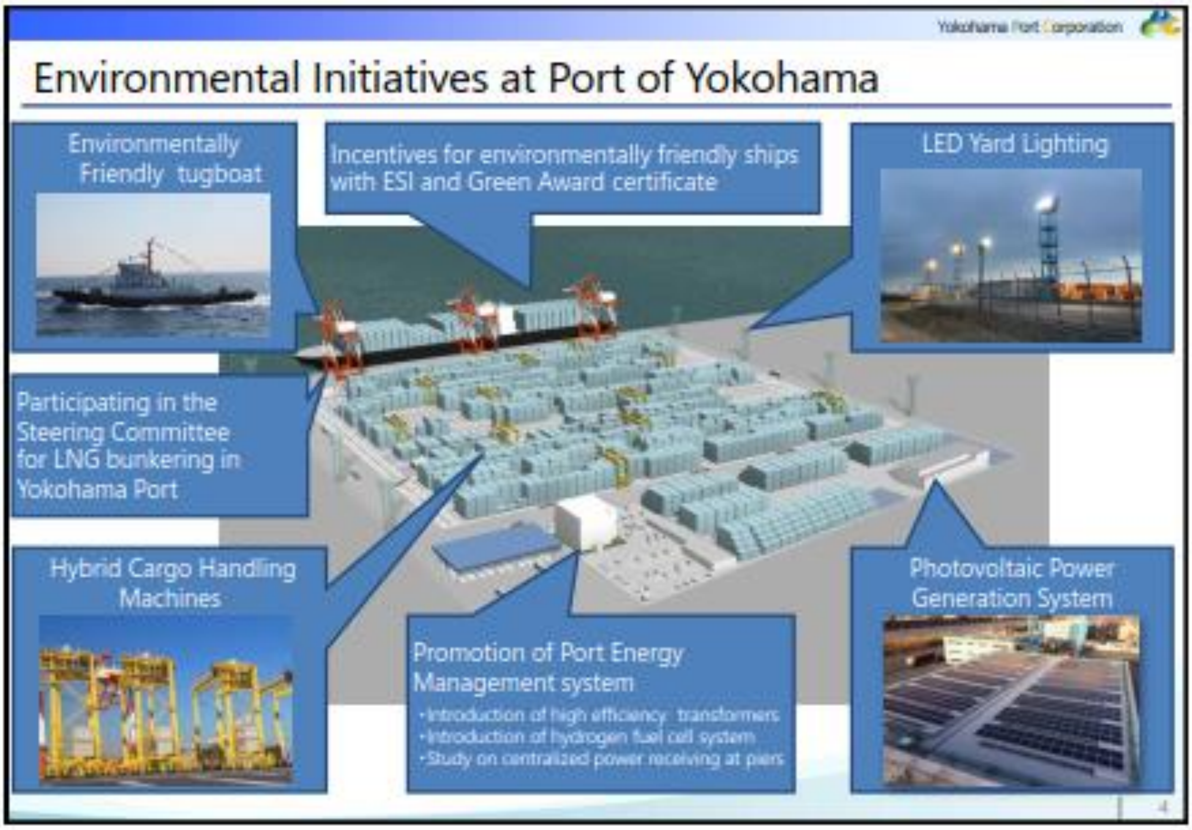
- Construction and Reinforcement of Port Facilities
- Terminal Management
- Maintenance and Management of Port Facilities
- Engineering Services and Marketing

*Yokohama Kawasaki International Port Corporation (YKIP) was founded on January 12, 2016 to integrate container businesses of Port of Yokohama and Port of Kawasaki based on the Strategic Container Port policy of the national government.

2

Yokohama Port Corporation

Port of Yokohama



Photovoltaic Power Generation

Over 1 MW PV system have been installed on terminal buildings in Yokohama Port

Terminal	MC-1/2	MC-3	D-4
Dimensions	4,000m^2	2,700m^2	1.600m^2
Capacity	0.50 MW	0.38 MW	0.23 MW
Estimated power generation	481,000 kWh	395,000 kWh	234,000 kWh
Actual power generation	577,000 kWh	433,000 kWh	253,000 kWh
CO_2 reduction*	317 [t]	238 [t]	139 [t]
start of operation	Mar 2014	Mar 2015	Mar 2015

* Coefficient 0.55t-CO2/MWh

Attachment 10

Hybrid RTG

44 Hybrid RTGs are in operation out of 93 units in Yokohama Port

※As of March 2016

Environmentally Friendly Tug Boat

Japan's first hybrid tugboat began operation in 2013,
and the world's first LNG fueled tugboat in 2015 in Port of Yokohama

Hybrid tugboat "Tsubasa"

Diesel Engine + Motor (with battery)

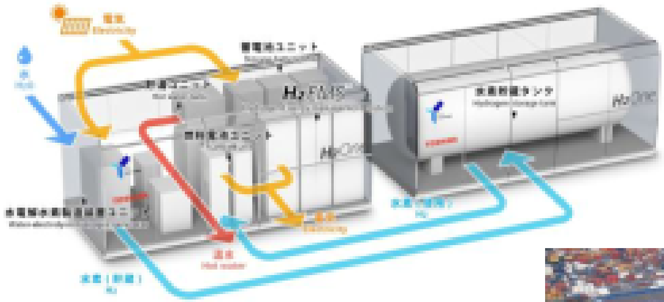
LNG fuelled Tug Boat "Sakigake"

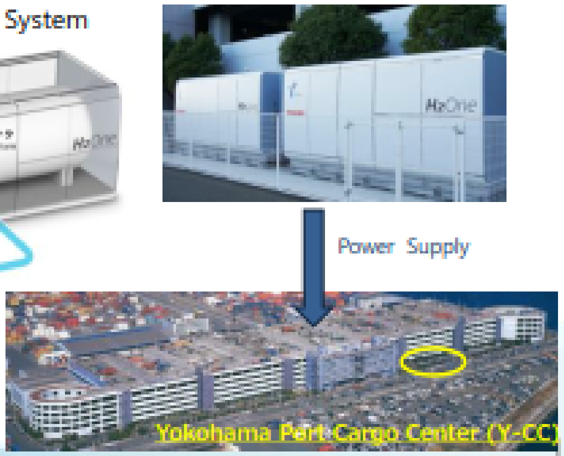
Dual Engine (LNG and Diesel)

Long term projects (1) Utilization of Hydrogen

- City of Yokohama is working together with local universities and companies to realize hydrogen society. Independent Hydrogen Energy Supply System has been set in Yokohama Port Cargo Center (Y-CC) for a demonstration experiment for energy management and emergency power supply.
- Also conducting another experiment to produce Hydrogen by wind-generated electricity and provide it to fuel cell forklifts in port area.

Independent Hydrogen Energy Supply System





Source: City of Yokohama

JCM initiatives with PAT

Outline of the initiative

- Our collaboration has been developed based on the partnership between PAT and the City of Yokohama (CoY) since FY 2014.

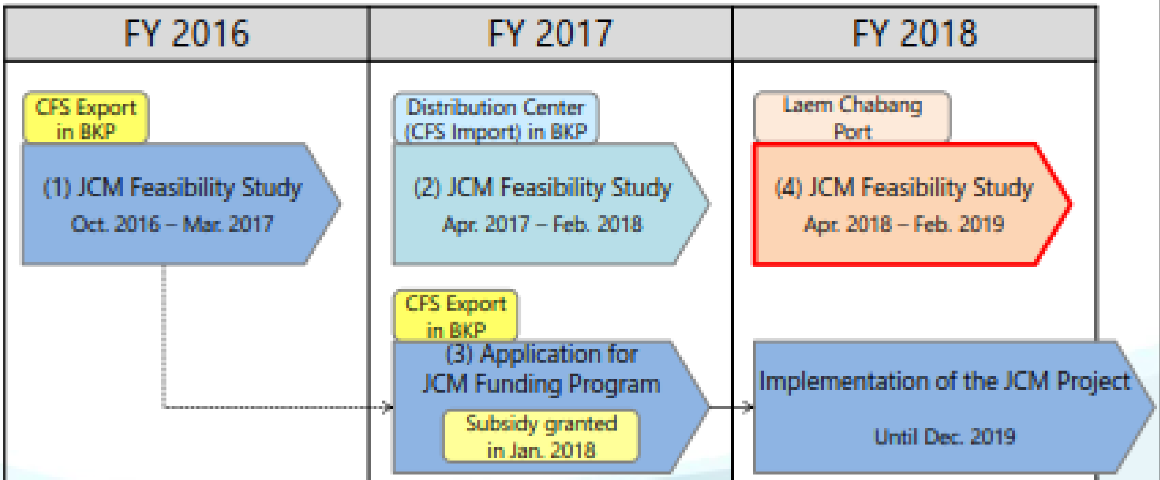
Partnership between PAT and City of Yokohama
- "Memorandum of Understanding" for partnership (2014)
- "Letter of Intent of the Implementation of the MOU" (2015)

- To support PAT's "**Green Port Project**", the CoY and YPC have suggested to PAT to utilize JCM funding program provided by the Japanese government, and YPC and PAT have been studying the program since 2015.
- YPC utilizes its knowledge and experiences about carbon reduction gained through environmentally friendly measures introduced at the Yokohama Port.

Advantages for PAT by utilizing JCM Funding Program
- JCM is subsidy program by the Ministry of the Environment, Japan
- PAT can introduce **highly efficient and reliable** low carbon equipment at **reasonable cost by utilizing JCM subsidy.**
- It will make progress toward achieving the goal of the Green Port Project.

History of JCM Initiatives by PAT and YPC

- Since FY 2016 PAT and YPC launched JCM Feasibility Study
- We applied to JCM funding program in FY2017 based on the F/S implemented in FY 2016
- JCM subsidy was granted for CFS Export Project in Bangkok Port in Jan 2018



JCM (Joint Crediting Mechanism) by Ministry of the Environment, Japan

JCM Funding Program: JCM Model Projects by MOEJ

The budget for projects starting from FY 2017 is 6.0 billion JPY (approx. USD 60million) in total by FY2019

(1 USD = 100 JPY)

※Includes collaboration with projects supported by JICA and other governmental-affiliated financial institute.

Government of Japan

Finance part of an investment cost (**less than half**)

Conduct MRV and expected to deliver at least half of JCM credits issued

To attain the subsidy, we need to apply for the Program and pass an examination.

International consortiums (which include Japanese entities)

Funded facilities must be used continuously for the period of legal durable years. Otherwise MOEJ may request to reimburse the given grant.

Source: Recent Development of the JCM Oct 2017, Government of Japan

- Scope of the financing: facilities, equipment, vehicles, etc. which reduce CO_2 from fossil fuel combustion as well as construction cost for installing those facilities, etc.
- Eligible Projects : starting installation after the adoption of the financing and finishing installation within three years.

*MRV : Measurement, Reporting and Verification

JCM Partner Countries

JCM Partner Countries

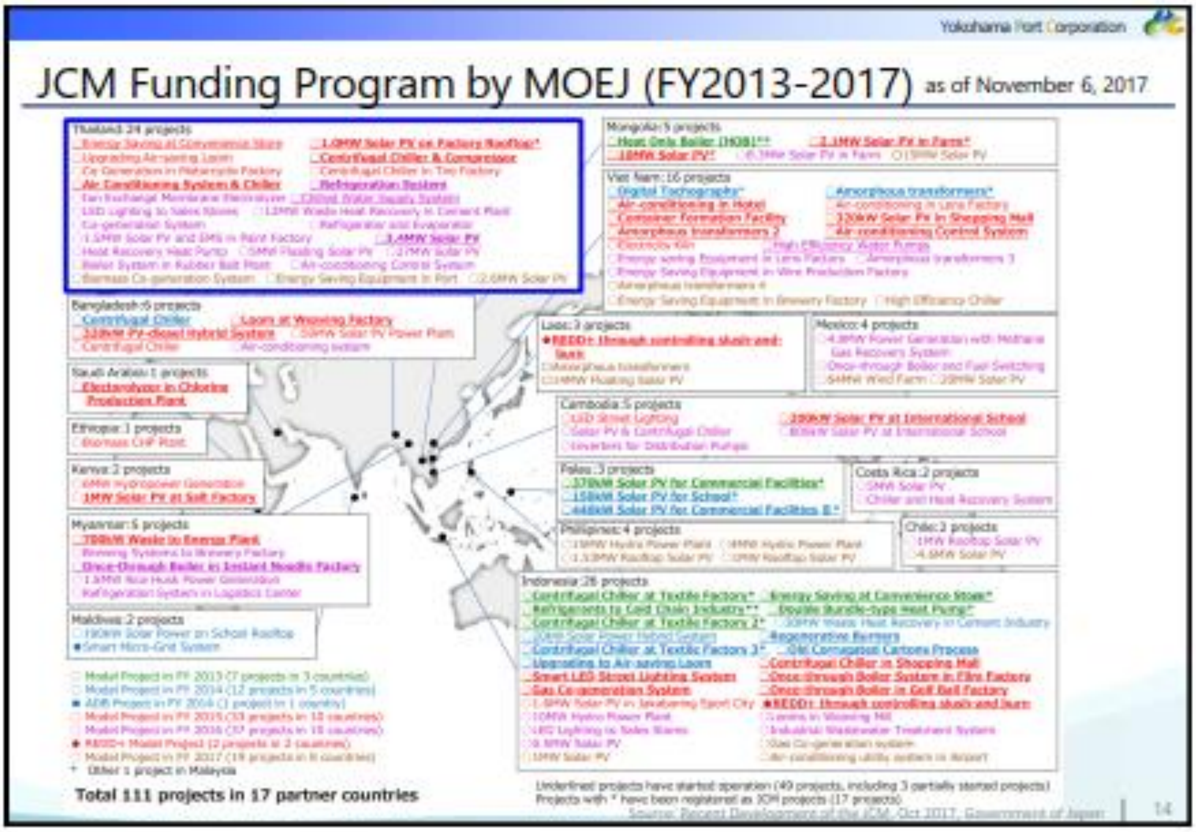
- Japan has held consultations for the JCM with developing countries since 2011 and has established the JCM with Mongolia, Bangladesh, Ethiopia, Kenya, Maldives, Viet Nam, Lao PDR, Indonesia, Costa Rica, Palau, Cambodia, Mexico, Saudi Arabia, Chile, Myanmar, Thailand and the Philippines.

Mongolia Jan. 8, 2013 (Ulaanbaatar) | Bangladesh Mar. 19, 2013 (Dhaka) | Ethiopia May 27, 2013 (Addis Ababa) | Kenya Jun. 12,2013 (Nairobi) | Maldives Jun. 29, 2013 (Okinawa) | Viet Nam Jul. 2, 2013 (Hanoi)

Lao PDR Aug. 7, 2013 (Vientiane) | Indonesia Aug. 26, 2013 (Jakarta) | Costa Rica Dec. 9, 2013 (Tokyo) | Palau Jan. 13, 2014 (Ngerulmud) | Cambodia Apr. 11, 2014 (Phnom Penh) | Mexico Jul. 25, 2014 (Mexico City)

Saudi Arabia May 13, 2015 | Chile May 26, 2015 (Santiago) | Myanmar Sep. 16, 2015 (Nay Pyi Taw) | Thailand Nov. 19, 2015 (Tokyo) | the Philippines Jan. 12, 2017 (Manila)

Source: "Recent Development of The Joint Crediting Mechanism (JCM)" January 2017



Yokohama Port Corporation

JCM Funding Program by MOEJ (FY2013-2017)

24 projects in Thailand were adopted for JCM funding program from FY 2013 through FY2017.

Thailand:24 projects

- ○Energy Saving at Convenience Store
- ○1.0MW Solar PV on Factory Rooftop*
- ○Upgrading Air-saving Loom
- ○Centrifugal Chiller & Compressor
- ○Co-Generation in Motorcycle Factory
- ○Centrifugal Chiller in Tire Factory
- ○Air Conditioning System & Chiller
- ○Refrigeration System
- ○Ion Exchange Membrane Electrolyzer
- ○Chilled Water Supply System
- ○LED Lighting to Sales Stores
- ○12MW Waste Heat Recovery in Cement Plant
- ○Co-generation System
- ○Refrigerator and Evaporator
- ○1.5MW Solar PV and EMS in Paint Factory
- ○3.4MW Solar PV
- ○Heat Recovery Heat Pump
- ○5MW Floating Solar PV
- ○27MW Solar PV
- ○Boiler System in Rubber Belt Plant
- ○Air-conditioning Control System
- ○Biomass Co-generation System
- ○Energy Saving Equipment in Port
- ○2.6MW Solar PV

Red: FY 2015
Purple: FY 2016
Brown: FY 2017

JCM Project in Bangkok Port

15

Yokohama Port Corporation

JCM Project in Bangkok Port: 1) CFS Export

16

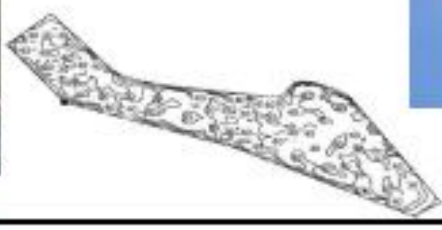
Yokohama Port Corporation

JCM Project in Bangkok Port: 2) Container terminal

- Introduce LED Yard Lighting (260 units) in the container terminal at the East Quay of Bangkok port.
- Confirmed by illuminance calculation that sufficient illuminance for terminal operation will be ensured.
- Yokohama Port has adopted LED Yard Lightings since 2015.

LED Yard Lighting in Yokohama Port

Illuminance calculation for Bangkok Port



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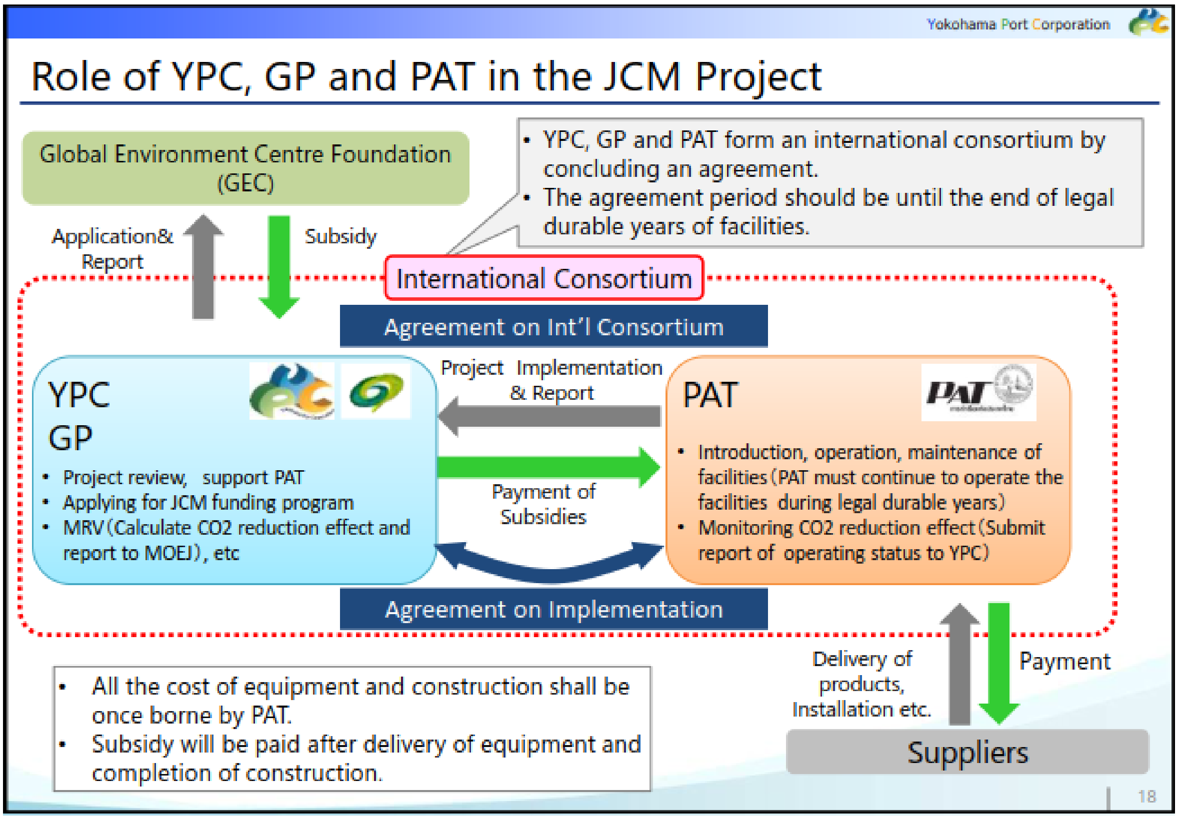

Overview of the JCM Feasibility Study (F/S) in FY 2018

This JCM F/S is conducted as an entrusted study from Ministry of the Environment, Government of Japan (MOEJ) for the 3rd consecutive year.

Outline

- Investigate the feasibility of potential projects for JCM in Laem Chabang Port by studying project costs, CO2 reduction, etc.
- Examine mainly the advanced low-carbon technologies and products which have been verified by YPC at Yokohama Port.

Participants
- Yokohama Port Corporation (YPC)
- City of Yokohama (CoY)
- Green Pacific Co., LTD (GP)
- Overseas Environmental Cooperation Center (OECC)

Period
- From Apr 2018 to Feb 2019

Cost
- Funded by MOEJ (and YPC & GP)

- ➢ There is no obligation to form JCM project based on this F/S.
- ➢ We are truly grateful for your kind cooperation. Your continued supports is highly appreciated.

Steps of the JCM initiatives by PAT and YPC

PAT's "Green Port Project" Term (2015 ~ 2019)

Phase 1 (Bangkok Port)	Phase 2 (Bangkok Port and Laem Chabang Port)	Phase 3
We applied for JCM subsidy in FY 2017 for CFS Export in BKP and the subsidy was granted (JCM Project Name) "Introduction of Energy Efficient Equipment to Bangkok Port" Project realized	Based on the achievement in Bangkok Port, expand the initiative to Laem Chabang Port We discuss potential projects with PAT and with terminal operators as well.	Long term study for the future (e.g.) ✓ Carbon reduction at local ports under PAT control ✓ Introduction of hydrogen technology

Applicable Low-carbon technologies to LCP (Example)

- Study potential projects with both PAT and terminal operators

Electric or Hybrid RTG

Electric Forklift

Indoor LED Lighting

Yard LED Lighting

PV system with batteries

High Efficient Transformer

https://www.kyocera.co.jp/solar/es/case/009680.html

2) 10th September 2018

JCM Feasibility Study in Laem Chabang Port

10th Sep 2018
Yokohama Port Corporation
City of Yokohama
Green Pacific Co., Ltd.
Overseas Environmental Cooperation Center, Japan

横浜港埠頭株式会社
Yokohama Port Corporation

Agenda

1. Review of the previous meeting
2. Interim Report
3. Schedule of the Feasibility Study
4. Points for JCM application

1 Review of the previous meeting

JCM (Joint Crediting Mechanism) by Ministry of the Environment, Japan

JCM Funding Program: JCM Model Projects by MOEJ

The budget for projects starting from FY 2017 is <u>6.0 billion JPY</u> (approx. <u>USD 60million</u>) in total by FY2019

(1 USD = 100 JPY)

Government of Japan

※Includes collaboration with projects supported by JICA and other governmental-affiliated financial institute.

Finance part of an investment cost (<u>less than half</u>)

Conduct MRV and expected to deliver at least half of JCM credits issued

To attain the subsidy, we need to apply for the Program and pass an examination.

International consortiums (which include Japanese entities)

Funded facilities must be used continuously for the period of legal durable years. Otherwise MOEJ may request to reimburse the given grant.

Source: Recent Development of the JCM, Oct 2017, Government of Japan

- Scope of the financing: facilities, equipment, vehicles, etc. which reduce CO_2 from fossil fuel combustion as well as construction cost for installing those facilities, etc.
- Eligible Projects : starting installation after the adoption of the financing and finishing installation within three years.

*MRV: Measurement, Reporting and Verification

Overview of the JCM Feasibility Study (F/S) in FY 2018

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- Investigate the feasibility of potential projects for JCM in Laem Chabang Port by studying project costs, CO2 reduction, etc.
- Examine mainly the advanced low-carbon technologies and products which have been verified by YPC at Yokohama Port.

Participants

- Yokohama Port Corporation (YPC)
- City of Yokohama (CoY)
- Green Pacific Co., LTD (GP)
- Overseas Environmental Cooperation Center (OECC)

Period

- From Apr 2018 to Feb 2019

Cost

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➢ We are truly grateful for your kind cooperation. Your continued supports is highly appreciated.

Steps of the JCM initiatives by PAT and YPC

PAT's "Green Port Project" Term (2015 ~ 2019)

Phase 1	Phase 2	Phase 3
Bangkok Port	Bangkok Port and Laem Chabang Port	
We applied for JCM subsidy in FY 2017 for CFS Export in BKP and the subsidy was granted (JCM Project Name) "Introduction of Energy Efficient Equipment to Bangkok Port" Project realized	Based on the achievement in Bangkok Port, expand the initiative to Laem Chabang Port We discuss potential projects with PAT and with terminal operators as well.	Long term study for the future (e.g.) ✓ Carbon reduction at local ports under PAT control ✓ Introduction of hydrogen technology

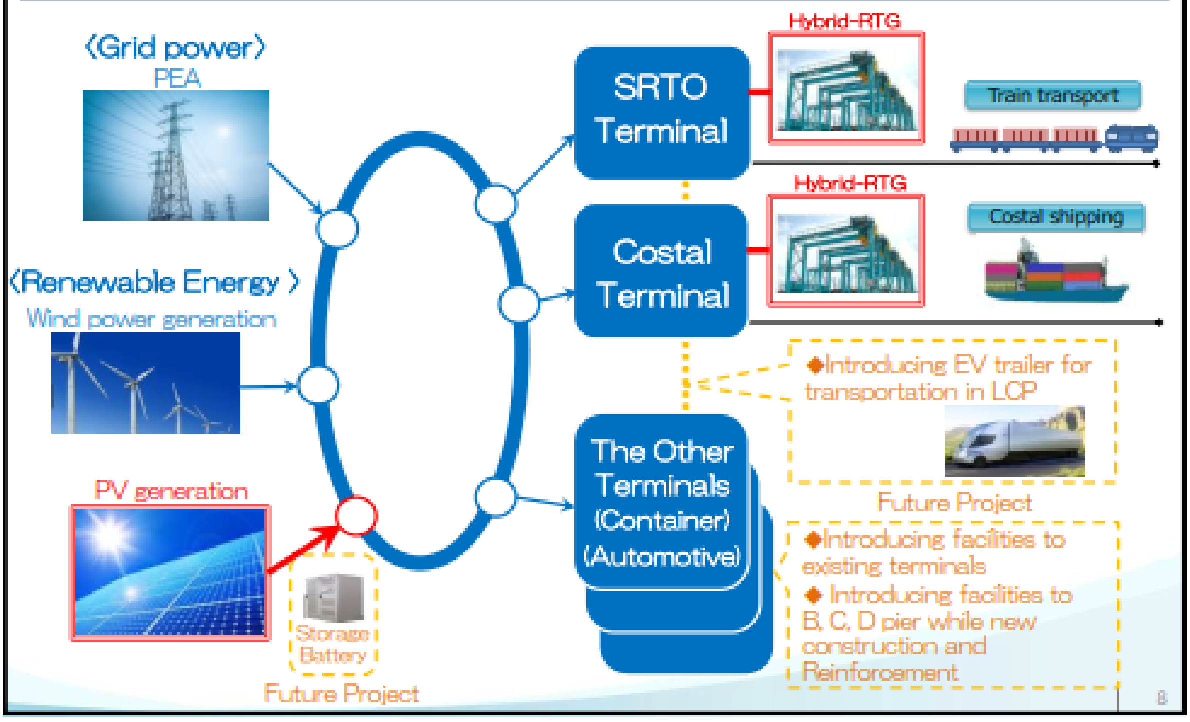


Summary of the discussion at the previous meeting

- The followings facilities were listed to study possibility of utilization of JCM
  1) Low Carbon RTG (SRTO and Coastal Terminal)
  2) PV generation around area of the port tower
  3) Waste treatment plant
- YPC also considered how this JCM project can contribute to the Green Port Project and promotion of modal shift by PAT
- We found that the waste treatment plant seems not to be eligible for JCM

2 Interim Report

Proposal from YPC: *"Smart Port"* concept for Laem Chabang Port



Basic rules of JCM funding program

1. Monitoring period
   – PAT is responsible for operating the funded facilities and conducting monitoring CO2 emissions for legal durable years of the facilities stipulated by the Japanese law.
     - RTG : 12 years
       – In case of conversion, the legal durable year would newly start after the completion of conversion
     - P V : 17 years

2. Upper limit of subsidy amount
   – Subsidy rates which are decided by the applied technology
     - RTG : Less than 40%
     - P V : Less than 30%
   – Cost effectiveness (subsidy amount per ton-CO2)
     - RTG : Less than 4,000JPY / t-CO2 (about 1,176THB / t-CO2)
     - P V : Less than 3,000JPY / t-CO2 (about 882THB / t-CO2)

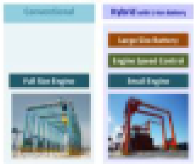
whichever is lower will be applied as the upper limit for subsidy amount

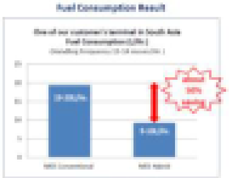
Yokohama Port Corporation

Low Carbon RTG（Hybrid-RTG）

Estimated figure

Estimation on Hybrid RTG for SRTO and Coastal Terminal





	SRTO (New purchase)	Coastal Terminal (New purchase)	Coastal Terminal (Conversion)
CO_2 reduction	**6,712**t-CO_2 in 12years (3 units)	**4,475**t-CO_2 in 12years (2 units)	**4,475**t-CO_2 in 12years (2 units)
Cost saving (total in 12 years)	approx. **66,604,000THB**	approx. **44,402,000THB**	approx. **44,402,000THB**
Percentage of Subsidy	5.6%	6.1%	32.3%
Amount of JCM subsidy	**7,873,000THB (total of 3 units)**	**5,249,000THB (total of 2 units)**	**5,249,000THB (total of 2 units)**

10

Yokohama Port Corporation

Low Carbon RTG（Hybrid-RTG）

Estimated figure

・Estimate condition: working time 365day/year, 18hour/day

・Fuel consumption: normal RTG 22L/hour, Hybrid RTG 11L/h

	SRTO Terminal (New purchase)	**Coastal** Terminal (New purchase)	**Coastal** Terminal (Conversion)
Legal durable years	**12** years	**12** years	**12** years
Quantity	**3** units	**2** units	**2** units
Estimated Price (A)	**138,915,000**THB	**85,995,000**THB	**16,213,000**THB
JCM subsidy (B)	**7,873,500**THB	**5,249,000**THB	**5,249,000**THB
Estimated price after subsidy (C=A-B)	**131,041,500**THB	**80,746,000**THB	**10,964,000**THB
Fuel cost saving (12 years)	**66,604,000**THB	**44,402,000**THB	**44,402,000**THB
CO_2 reduction	6,712*t-CO2* *(559.3-CO2/year)*	4,475*t-CO2* *(372.9-CO2/year)*	4,475*t-CO2* *(372.9-CO2/year)*
Percentage of subsidy	5.6%	6.1%	32.3%
JCM cost effectiveness	1,173THB / *t-CO2*	1,173THB / *t-CO2*	1,173THB / *t-CO2*
JCM cost saving(Total)	**74,477,500**THB/12years	**49,651,000**THB/12years	**49,651,000**THB/12years

11

Yokohama Port Corporation

Photovoltaic generation system

Estimated figure

Estimation on PV generation system on adjacent yard of LCP

Capacity of PV system		2.71MW	
CO2 reduction (0.000556 t-CO2 /kWh)		33,870t-CO2 / 17years	
Cost saving	PV system	2.1THB/kWh	115,743,000 THB/17years
	PV system with JCM subsidy	1.6THB/kWh	146,202,000 THB/17years
Feasibility of JCM utilization		30% of initial investment is expected to be covered by JCM subsidy. The amount of the subsidy will be **27,000,000THB**.	

PV Photo: https://www.kyocera.co.jp/solar/es/case/009660.html

Yokohama Port Corporation

Photovoltaic generation system

Estimated figure

Legal durable years	17 years
Site area	27,000m²
Installation area （60% of site area）	16,200m²
Generation Capacity	2.71MW
Electric power	60,917,506 kWh-17years
CO2 reduction (0.000556 t-CO2 /kWh)	33,870 t-CO2-17years
Approximate cost (A)	112,060,000THB
Covered by JCM subsidy (B)	90,000,000THB
Not covered by JCM subsidy	22,058,800THB
JCM subsidy (30%) (C=B×30%)	27,000,000THB
Approximate cost (=A-C) with JCM subsidy (30%)	85,060,000THB
Running cost （17years）	16,840,000THB
Total cost （17years）	101,900,000THB

Electricity cost by PV system	2.1 THB/kWh
Electricity cost by PV system (with JCM subsidy for 30% of investment)	**1.6THB/kWh**
Cost saving PV system	115,743,000 THB/17years
Cost saving with JCM subsidy	146,202,000 THB/17years

<Remarks>

・Only PV panel and electrical equipment will be covered by JCM subsidy, therefore mounting structure and foundations will NOT be covered.

・Renewal cost of electrical equipment is included in running cost (once during legal durable years)

・Electricity rate :4.0THB

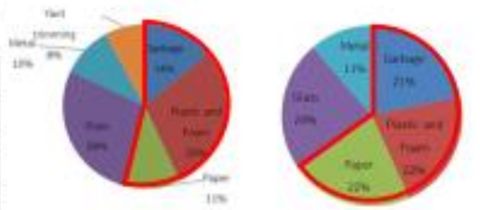
Waste treatment plant

- There are 2 types of plant, "Generation" or "Fuelization"
- Our study indicates that more than 50 – 100t of waste is needed for efficient operation of Waste treatment plant
- Based on the data from PAT, the waste volume within LCP is approx. 800t / day, and ratio of combustible waste is approx. 60%

  => approx. 1.3t / day
- To form the project with surrounding region is more effective than PAT's independent project for low carbonization

Table 1 Generated wastes within Laem Chabang ports during 2011-2015, reported by Laem Chabang Municipality

Fiscal year	Total weight (tons)
2015	805
2014	716
2013	659
2012	496
2011	768



a) Waste from office b) Wastes from terminal

Figure 1 Waste component from Laem Chabang Port

Source: "Status of waste management of Laem Chabang Port"

Summary of the study

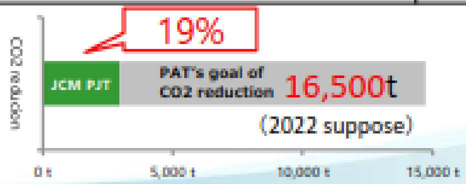
Estimated figure

Terminal	RTG			PV
	SRTO (New purchase)	Coastal (New Purchase)	Coastal (Conversion)	
	Hybrid	Hybrid	Hybrid	
Legal durable years	12	12	12	17
Quantity	3	2	2	1 set (2.71MW)
Initial cost (A)	138,915,000THB	85,995,000THB	24,806,250THB	112,060,000THB
Percentage of subsidy (B)	5.6%	6.1%	32.3%	30 %
JCM subsidy (C)	7,873,500THB	5,249,000THB	5,249,000THB	27,000,000THB
CO2 reduction (D)	6,712*t-CO2* *(559.3t-CO2/year)*	4,475*t-CO2* *(372.9t-CO2/year)*	4,475*t-CO2* *(372.9[t-CO2/year])*	33,870*t-CO2* *(1,992.3t-CO2/year)*
JCM cost effectiveness (C)/(D)	1,173THB/*t-CO2*	1,173THB/*t-CO2*	1,173THB/*t-CO2*	797THB/*t-CO2*
Eligibility for JCM (<1,176THB)	**Good**	**Good**	**Good**	**Good**
JCM Cost saving	74,477,500THB	49,651,000THB	49,651,000THB	146,202,000THB
Year of recovery	1year	1year	3years	7years
Overall evaluation				

Total benefits gained from these projects in 2020 ~ 2022

Estimated figure

(2020~2022) Laem ChabangPort		Total CO2 Reduction	Total JCM Cost saving
1) PV Panels	Apply in 2021~2022	1,992.3t/Year	8,600,000 THB/year
2) Hybrid RTG for SRTO	Apply in 2020~2021	559.3t/Year	6,206,000 THB/year
3) Hybrid RTG for Domestic Terminal (New Purchase)	Apply in 2020~2021	372.9t/Year	4,137,000 THB/year
4) Hybrid RTG for Domestic Terminal (Conversion)	Apply in 2020~2021	372.9t/Year	4,137,000 THB/year
Total		3,297.4t/Year	23,080,000 THB/year



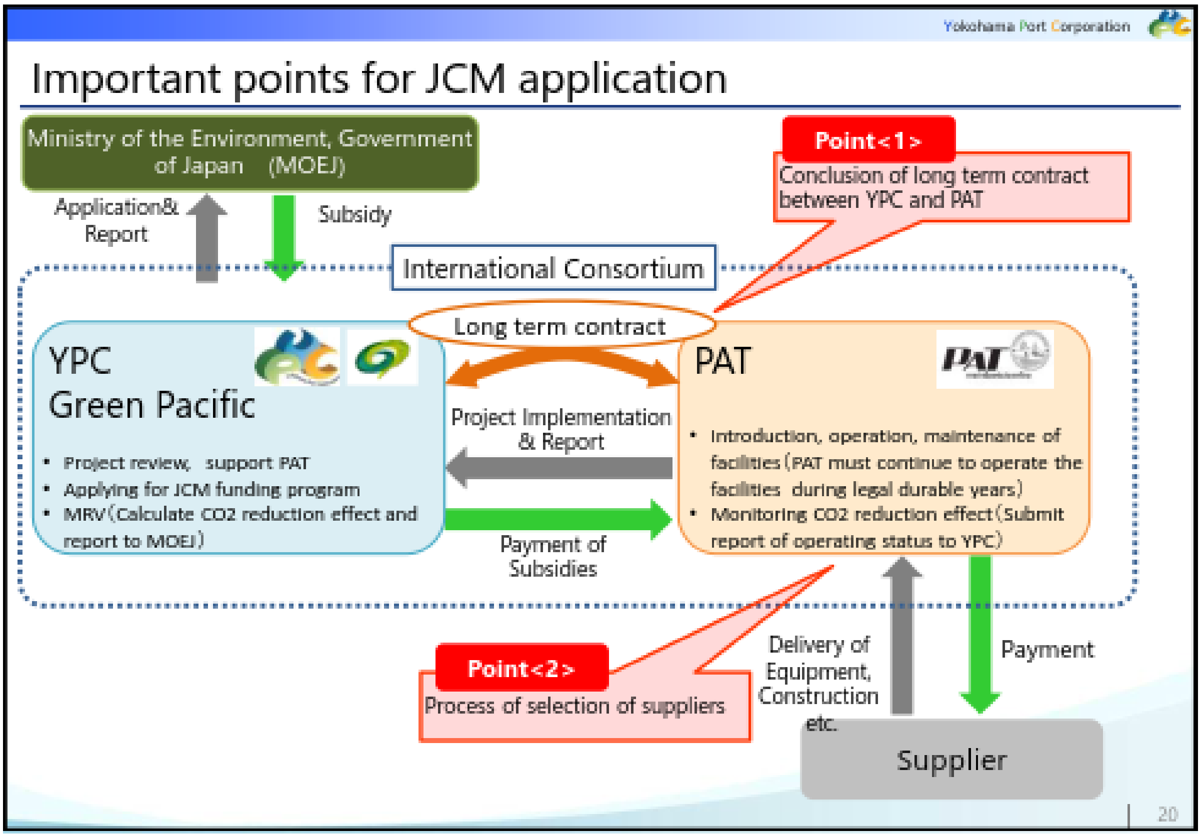
3 Schedule of the Feasibility Study

Schedule of the Feasibility Study

	'18 Jul	Aug	Sep	Oct	Nov	Dec	'19 Jan	Feb	Mar	Apr
PAT & YPC Meeting			Today		Preparation		final presentation			
PAT & YPC Adjustment			Question Answer							
YPC Consideration										
JCM workshop in Japan				10/25・26						
YPC Submitting the final report to the MOEJ								Feb 28 (Deadline)		

*The above schedule is tentative and subject to change

4 Points for JCM application


Yokohama Port Corporation
Important points for JCM application
Ministry of the Environment, Government of Japan (MOEJ)
Application& Report
Subsidy
Point<1>
Conclusion of long term contract between YPC and PAT
International Consortium
Long term contract
YPC
Green Pacific
• Project review, support PAT
• Applying for JCM funding program
• MRV (Calculate CO2 reduction effect and report to MOEJ)
Project Implementation & Report
Payment of Subsidies
PAT
• Introduction, operation, maintenance of facilities (PAT must continue to operate the facilities during legal durable years)
• Monitoring CO2 reduction effect (Submit report of operating status to YPC)
Point<2>
Process of selection of suppliers
Delivery of Equipment, Construction etc.
Payment
Supplier
20

3) 30th January 2019

JCM Feasibility Study in Laem Chabang Port

Final report

30th Jan 2019
Yokohama Port Corporation
City of Yokohama
Green Pacific Co., Ltd.
Overseas Environmental Cooperation Center, Japan

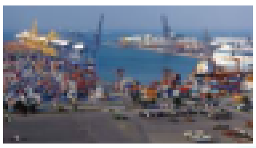
横浜港埠頭株式会社
Yokohama Port Corporation

1 Introduction

Steps of the JCM initiatives by PAT and YPC

PAT's "Green Port Project"
Term (2015 ~ 2019)

Phase 1	Phase 2	Phase 3
Bangkok Port	Bangkok Port and Laem Chabang Port	
We applied for JCM subsidy in FY 2017 for CFS Export in BKP and the subsidy was granted (JCM Project Name) "Introduction of Energy Efficient Equipment to Bangkok Port" Project realized	Based on the achievement in Bangkok Port, expand the initiative to Laem Chabang Port We discuss potential projects with PAT and with terminal operators as well.	Long term study for the future (e.g.) ✓ Carbon reduction at local ports under PAT control ✓ Introduction of hydrogen technology



Overview of the JCM Feasibility Study (F/S) in FY 2018

This JCM F/S is conducted as an entrusted study from Ministry of the Environment, Government of Japan (MOEJ) for the 3rd consecutive year.

Outline

- Investigate the feasibility of potential projects for JCM in Laem Chabang Port by studying project costs, CO2 reduction, etc.
- Examine mainly the advanced low-carbon technologies and products which have been verified by YPC at Yokohama Port.

Participants
- Yokohama Port Corporation (YPC)
- City of Yokohama (CoY)
- Green Pacific Co., LTD (GP)
- Overseas Environmental Cooperation Center (OECC)

Period
- From Apr 2018 to Feb 2019

Cost
- Funded by MOEJ (and YPC & GP)

➢ There is no obligation to form JCM project based on this F/S.

➢ We are truly grateful for your kind cooperation. Your continued supports is highly appreciated.

Meetings in this FS

Summary of major meetings

2018.5

·Kick off meeting

-Introduction of Yokohama Port and JCM

-JCM Initiatives with PAT (BKP)

-Discussion approx. target technology

-Field survey (Outline)

2018.9

·Interim report

-Result of rough estimation (RTG and PV)

-Field survey (Detail)

2018.10

·Visit Yokohama by PAT

-Seminar on City-to-City Collaboration for Creating Low-Carbon Society

2019.1

·Final report (Today)

2 Points for JCM application

Important points for JCM application

JCM Funding Program: JCM Model Projects by MOEJ

The budget for projects starting from FY 2017 is 6.0 billion JPY (approx. USD 60million) in total by FY2019

(1 USD = 100 JPY)

Government of Japan

※Includes collaboration with projects supported by JICA and other governmental-affiliated financial institute.

Finance part of an investment cost (**less than half**)

Conduct MRV and expected to deliver at least half of JCM credits issued

Point 1

Funded facilities must be used continuously for the period of legal durable years. Otherwise MOEJ may request to reimburse the given grant.

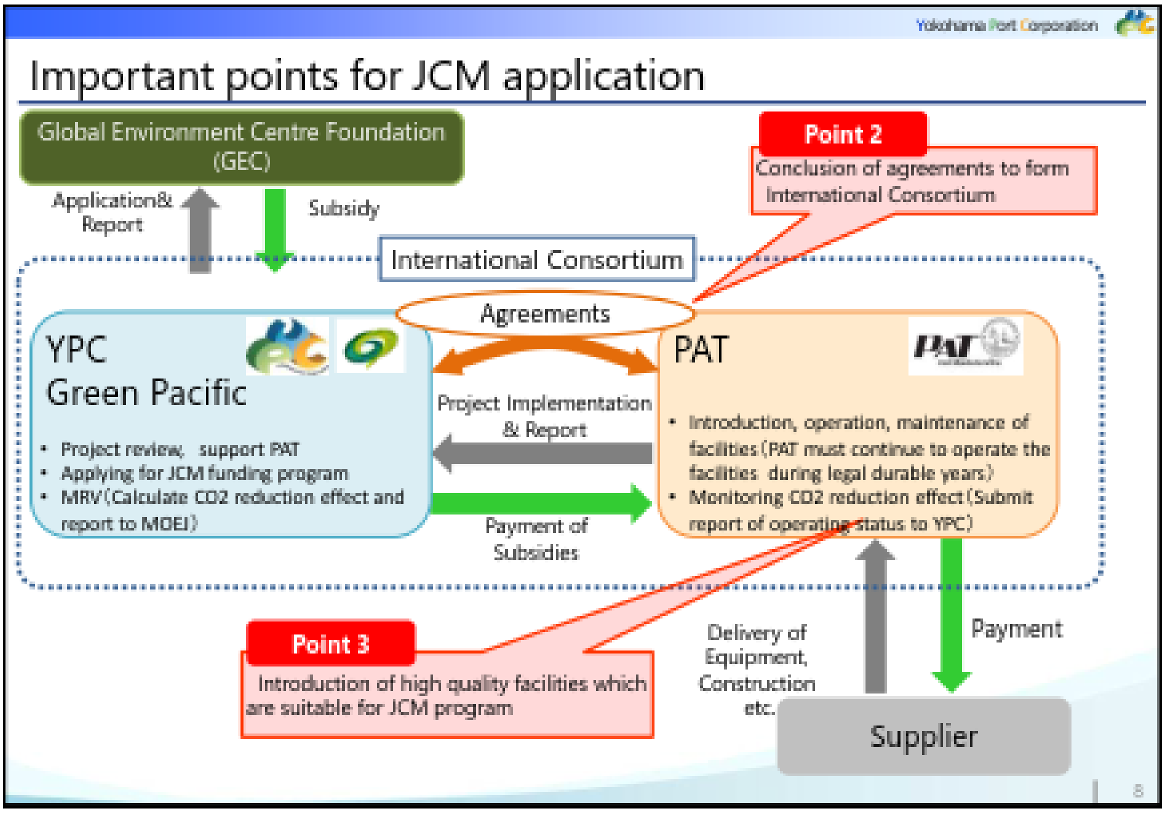
To attain the subsidy, we need to apply for the Program and pass an examination.

International consortiums (which include Japanese entities)

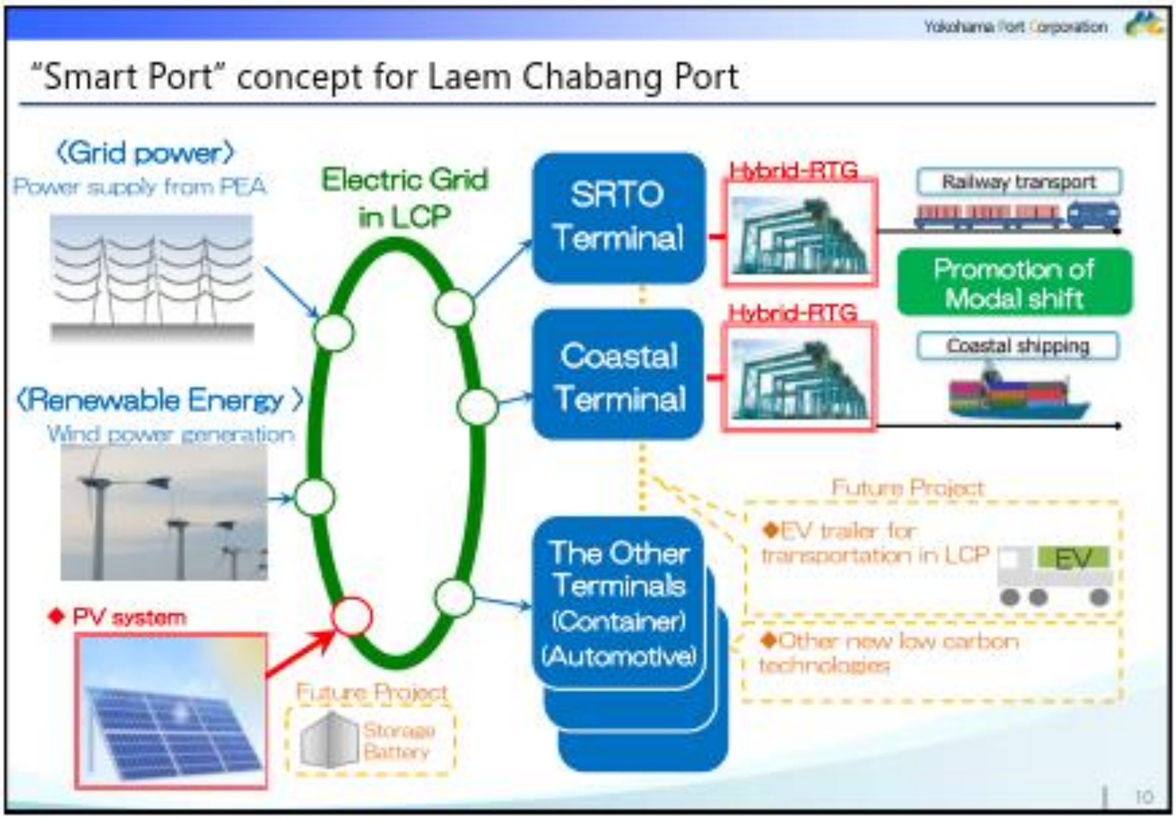
Source: Recent Development of the JCM Oct 2017, Government of Japan

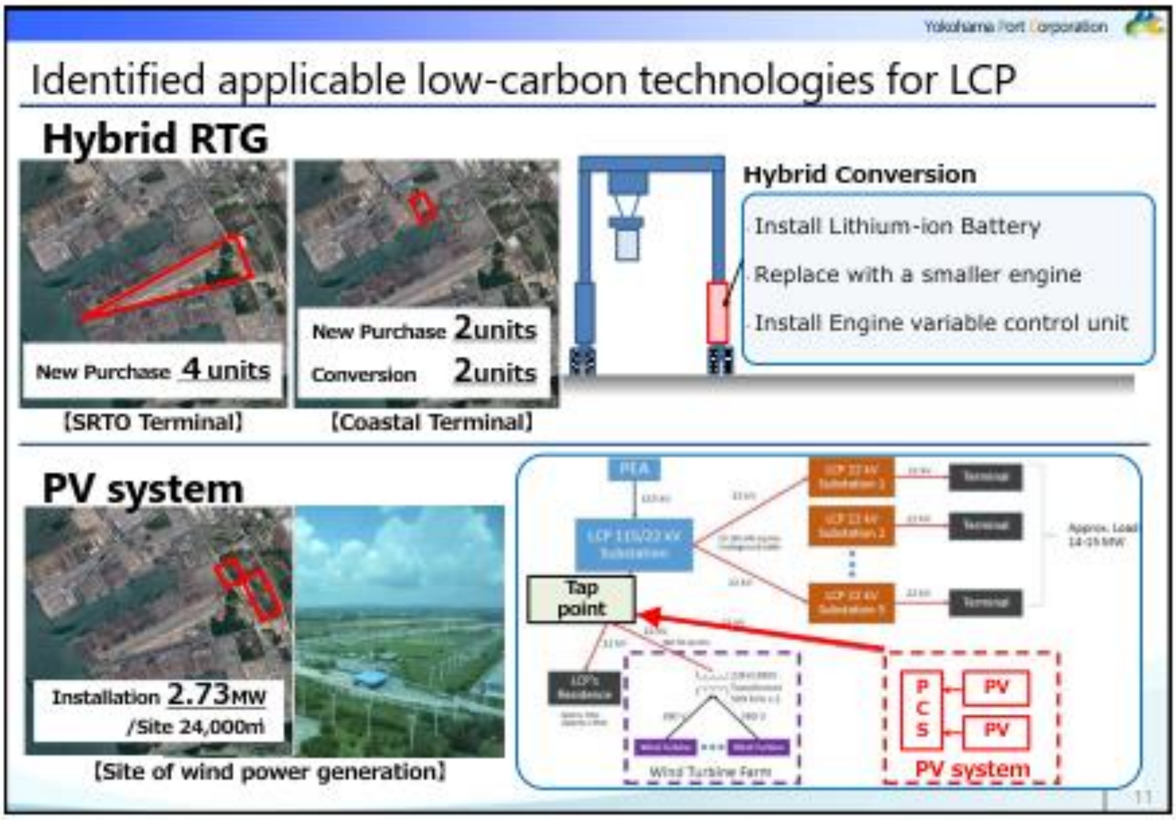
- Scope of the financing: facilities, equipment, vehicles, etc. which reduce CO_2 from fossil fuel combustion as well as construction cost for installing those facilities, etc.
- Eligible Projects : starting installation after the adoption of the financing and finishing installation within three years.

*MRV: Measurement, Reporting and Verification



3 Result of the F/S





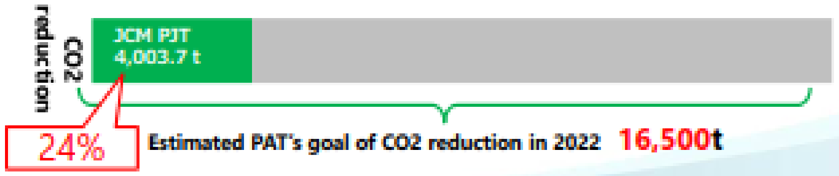
Attachment 35

Total benefits gained from JCM projects

Estimated figure

Laem Chabang Port	CO2 Reduction /Year	JCM subsidy
1) Hybrid RTG for SRTO Terminal (New Purchase 4units)	**961.6**t/Year	**13,348,000** THB
2) Hybrid RTG for Coastal Terminal (New Purchase 2units)	**480.8**t/Year	**6,674,000** THB
3) Hybrid RTG for Coastal Terminal (Conversion 2units)	**480.8**t/Year	**6,457,000** THB
4) PV System (Capacity approx. 2.73MW)	**2,080.5**t/Year	**27,615,000** THB
T o t a l	**4,003.7**t/Year	**54,094,000** THB

Rate :1THB=3.42JPY



*Estimated by YPC based on 'PAT Emission Reduction Target'

Basic rules of JCM funding program

1. Monitoring period

– PAT is responsible for operating the funded facilities and conducting monitoring of CO2 emissions during legal durable years of the facilities stipulated by Japanese law.

Facility		Years	Remarks
RTG		12	In case of conversion, the legal durable year would newly start after the completion of conversion
PV	On Ground	17	Regarded as power generation facility
	On Roof (* JCM in BKP)	12	Regarded as warehouse facility

2. Upper limit of subsidy amount

Facility	Subsidy rates (Decided by the applied technology)	Cost effectiveness (Subsidy amount per ton-CO2)
RTG	Less than 40%	Less than 4,000JPY / t-CO2 (approx. 1,169THB / t-CO2)
PV	Less than 30%	Less than 3,000JPY / t-CO2 (approx. 877THB / t-CO2)

whichever is lower will be applied

*The above conditions are present condition, subject to change by MOEJ

1) Hybrid RTG

SRTO Terminal

Coastal Terminal

Result of the study on Hybrid RTG

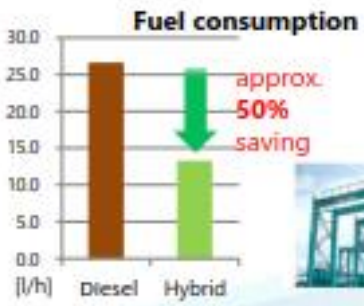
Estimated figure

Fuel	Diesel _ 26.6 l/h	17,896 kl/12years
	Hybrid_ 13.3 l/h	8,948 kl/12years
Fuel saving (Diesel→Hybrid)		8,948 kl/12years
Fuel cost saving (Diesel→Hybrid)		**229,054,000** THB/12years
CO2 reduction (2.58 t-CO2/kl)		**23,080**t-CO2 / 12years (1,923.3t-CO2 / year)
Feasibility of JCM utilization		Approx. **9.4%** of initial investment is expected to be covered by JCM subsidy. The amount of the subsidy will be **26,479,000 THB**.

Rate :1THB=3.42JPY

【SRTO Terminal】

【Coastal Terminal】



Result of the study on Hybrid RTG

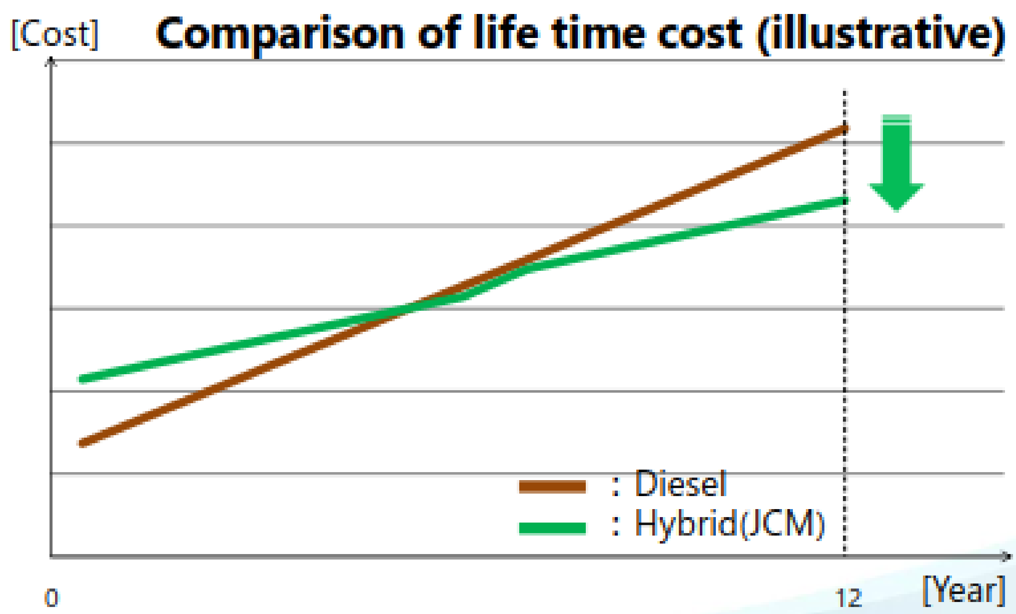
Estimated figure

	Total	SRTO (New purchase)	Coastal (New Purchase)	Coastal (Conversion)
Legal durable years	12			
Quantity	8	4	2	2
Initial cost	**279,622,000** THB	175,652,000 THB	87,826,000 THB	16,144,000 THB
JCM subsidy	**26,479,000**THB	13,348,000 THB	6,674,000 THB	6,457,000 THB
Percentage of subsidy	**9.4**%	7.6%	7.6%	40.0%
CO2 reduction / 12years	**23,080**t-CO2 *(1,923.3t-CO2/year)*	*11,540t-CO2 (961.6t-CO2/year)*	*5,770t-CO2 (480.8t-CO2/year)*	*5,770t-CO2 (480.8[t-CO2/year])*
Fuel cost saving (Diesel→Hybrid)	**229,054,000** THB /12years	114,528,000 THB /12years	57,263,000 THB /12years	57,263,000 THB /12years

Condition of Consideration

- Spec(Head, Length)： Head_1over6， Length6＋1
- Working time　　：365 days,　19.2 hours/day
- Fuel price：25.6THB/L
- 6 new RTGs shall be shipped and delivered together at once. They shall move from quay to yard by themselves.
- Running cost：Fuel cost and Lithium-ion Battery replacement cost within the legal durable year.

Effect of cost saving by Hybrid RTG

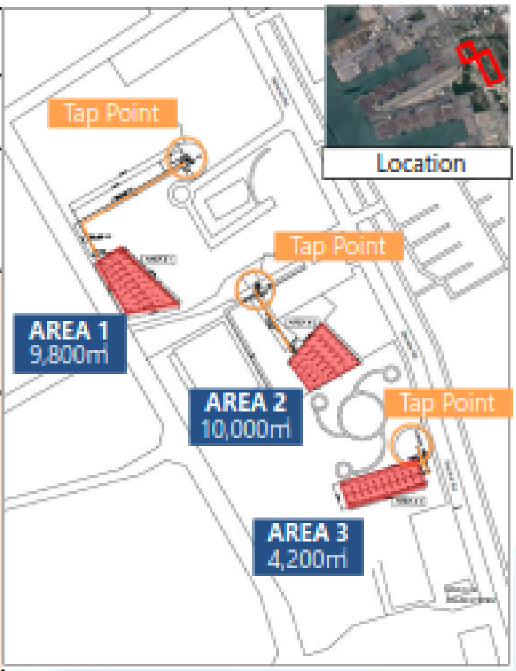


2) PV system

Result of the study on PV system

Estimated figure

Total capacity		**2.73**MW	
CO_2 reduction (0.000556 t-CO_2 /kWh)		**35,370**t-CO_2 / 17years	
Electricity Cost	PV system only	3.5⇒2.2 THB/kWh	81,238,000 THB/17years Saving
	PV system with JCM Subsidy	3.5⇒**1.7** THB/kWh	**112,484,000** THB/17years Saving
Feasibility of JCM utilization Rate :1THB=3.42JPY		Approx. **24%** of initial investment is expected to be covered by JCM subsidy. (30% of JCM eligible cost) The amount of the subsidy will be **27,615,000THB**.	



Details of the PV system

Estimated figure

Generation Capacity	**2.73**MW
Electric power	62,491,387 kWh-17years
CO_2 reduction (0.000556 t-CO_2 /kWh)	**35,370** t-CO_2-17years
Approximate cost (A)	115,065,000 THB
Covered by JCM subsidy(B)	92,052,000 THB
Not covered by JCM subsidy(C)	23,013,000 THB
JCM subsidy (D=B×30%)	27,615,000 THB
Approximate cost with JCM subsidy (E=A-D)	87,450,000 THB
Running cost (17years)	22,460,000 THB
Total cost (17years)	109,910,000 THB

Legal durable years	17 years
Site area	24,000m²
Installation area (67% of site area)	16,300m²
Electricity cost by PV system	2.2 THB/kWh
Electricity cost by PV system with JCM subsidy	**1.7** THB/kWh
Cost saving PV system only	81,238,000 THB/17years
Cost saving PV system with JCM subsidy	**112,484,000** THB/17years

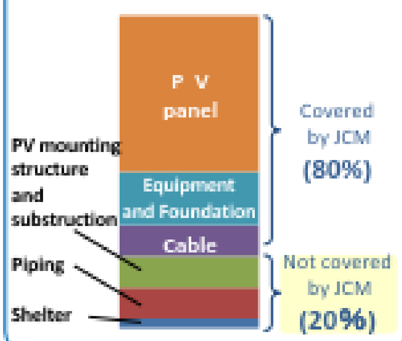
・Renewal cost of electrical equipment is included in running cost. (once during legal durable years)
・Electricity price :3.5THB/kWh

Cost and subsidy coverage for PV system

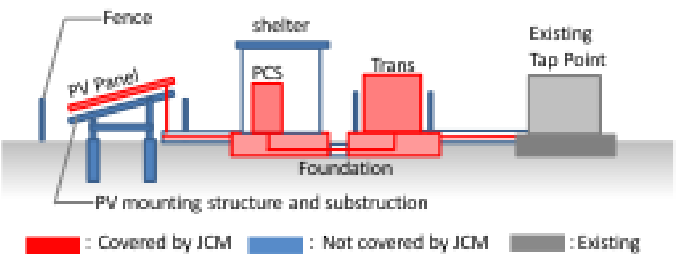
(Premises)

・PV generated power will be connected to existing tap point to use for terminals.
・The new power transmission cables will be wired on the ground.
・More detailed considerations will be needed for facility introduction such as installation of Reverse Tidal Current Preventive Device, Power Load of existing facilities, etc.

Breakdown of Initial cost



Coverage of JCM subsidy



・Only PV panel, Electrical equipment and equipment Foundation will be covered by JCM subsidy.
・Mounting structure and substruction will NOT be covered.

Summary of the study

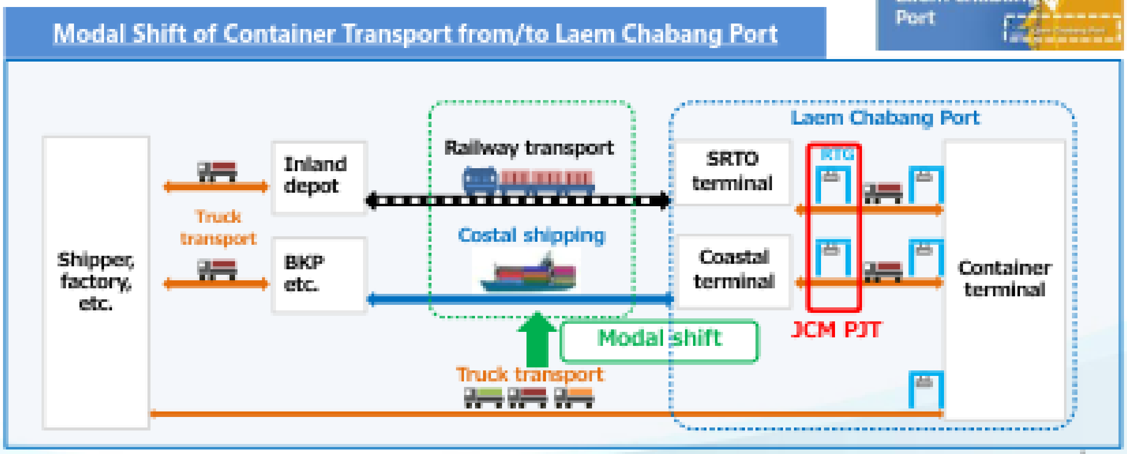
Estimated figure

	RTG	PV
Legal durable years	12	17
Quantity	New Purchase 6units , Conversion 2units	1 set (2.73MW)
Initial cost (A)	279,622,000 THB	115,065,000 THB
JCM subsidy (B)	26,479,000 THB	27,615,000 THB
Percentage of subsidy (C)	9.4%	24.0 %
CO_2 reduction (D)	23,080t-CO_2 / 12years *(1,923.3t-CO_2/year)*	35,370t-CO_2 *(2,080.5t-CO_2/year)*
JCM cost effectiveness (B)/(D)	1,147THB/t-CO_2	779THB/t-CO_2
Cost saving	229,054,000 THB	112,484,000 THB
	Apply in 2020~2021	**Apply in 2021~2022**
Total JCM subsidy	54,094,000 THB (185,001,480 JPY)	
Total Percentage of subsidy	Approximate 13.7 %	

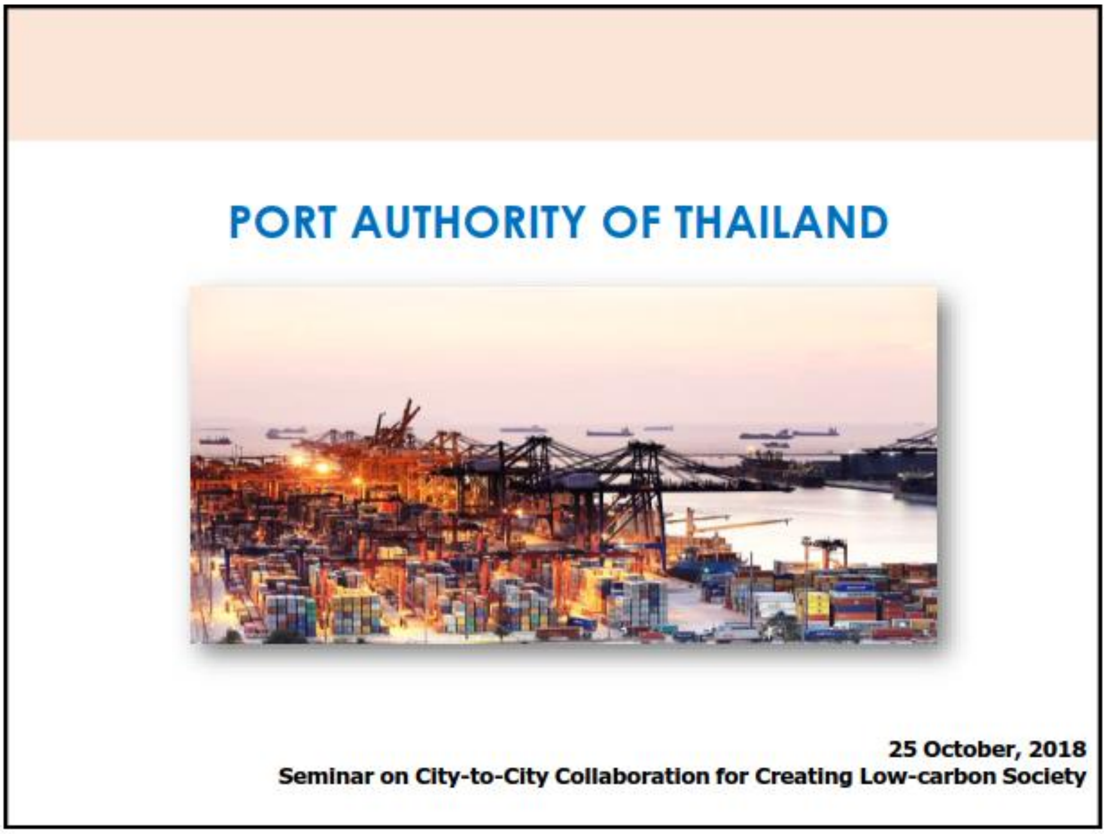
4 Others

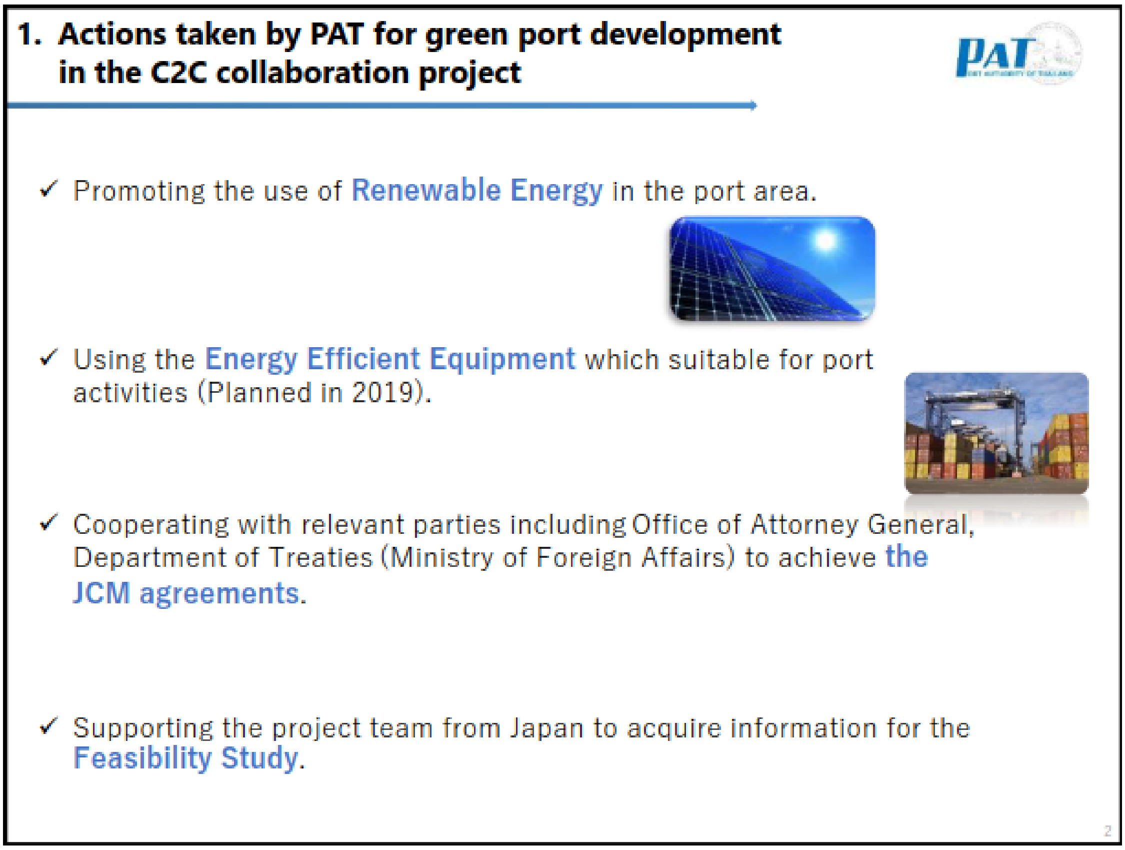
Additional Option

We further study the possibility of counting the GHG reduction effect by modal shift as the total effect of introduction of Hybrid RTG under JCM program.



(3) Ministry of the Environment Seminar on City-to-City Collaboration: Presentation by PAT (Presentation in Japan in initiatives for city-to-city collaboration)





2. Actions for the future

- ✓ To renew MOU between PAT and Yokohama City in 2019

- ✓ Budgets will be prepared for **the Low-Carbon Technologies and/or Energy Efficiency Initiatives** in the port which will be able to support JCM model's projects.

    - Installation of PV in Laem Chabang Port
    - Purchasing of Container Handling Equipment (RTG) in Single Rail Transfer Operator (SRTO) Laem Chabang Port
    - Modification of current Container Handling Equipment in Coastal Terminal, Laem Chabang Port
    - LED lighting system/Hybrid handling equipment in Bangkok Port Distribution Park.
    - Automated Terminal with Fully Electric Handling Equipment in Bangkok Port.

3

3. What kinds of challenges does PAT face in the C2C collaboration project?

1. Implementation of C2C collaboration project for State Enterprise in Thailand is still difficult:

    - There are many processes for agreements consideration/approval in Thai regulations for State Enterprise.
    - PAT can not control the relevant Thai Governmental parties to return their consideration of agreements. It affects the timeframe of JCM implementation.
    - Bidding process of the state enterprise is fall to the Regulation of Thai laws regarding the general purchasing standard. That means the State Enterprise could not specify the special specification which benefits the projects.

2. Understanding on JCM model's projects need to be enhanced:

    - Officials and relevant stakeholders in the port need to understand more about a JCM model's projects.

4

Thank you for your kind attention

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