Project Commissioned by the Ministry of the Environment in FY 2023

FY 2023 Commissioned Task for a City-to-City Collaboration Project for Actualizing a Decarbonized Society

（City-to-City Collaboration for realizing a decarbonized and circular society by Ehime Prefecture and Ben Tre Province）

Report

March 2024

JAPAN NUS Co., Ltd.
Ehime Prefecture

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1. Background, Objectives, and Implementation Structure of Project

1.1. Background and Objectives

This project targets Ben Tre Province, which is located in the Mekong Delta region, southeast of Ho Chi Minh City in the southern part of the Republic of Vietnam. Ben Tre Province was ranked 8th in the 2020 Provincial Competitiveness Index, ranking it ahead of Vietnam's capital city of Hanoi. The province is building industrial parks one after another. It has established the Ben Tre Startup and Investment Promotion Center (SIPC Ben Tre) and is building a support system for investors to attract investment from various countries. Furthermore, agriculture (rice cultivation, fruit cultivation, etc.) in the province is thriving due to the warm climate throughout the year. Tourism is also booming due to the abundance of tourist resources and historical and cultural attractions.

Figure 1-1 Location of Ben Tre Province (left) and map of province (right)

Figure 1-2 Main industries of Ben Tre Province

While Ben Tre Province is achieving remarkable economic development, environmental measures have lagged behind. In addition to problems with waste and wastewater treatment, the province is dependent on coal for energy and also the efforts to address climate change are falling behind in the business sector. As environmental awareness in Vietnam increases and local governments are asked to take measures toward decarbonization, there is an urgent need to establish systems and formulate environmental plans within the province.

Furthermore, Ben Tre Province is a region vulnerable to climate change. The province is suffering significant damage from saltwater intrusion due to the effects of the rising sea level. The "Ben Tre Water Management Project by JICA" is implementing measures such as the development of a saltwater intrusion control system and support projects including construction of water gates.

Figure 1-3 Issues of saltwater intrusion and waste

Ehime Prefecture and Vietnam have maintained a good relationship since 2013, when the then Vietnamese Ambassador to Japan paid a courtesy visit to the Governor of Ehime Prefecture. In order to further strengthen the relationship, Ehime Prefecture is planning to establish an airline route between Ho Chi Minh and Matsuyama, and has entered into a cooperative relationship with Vietjet Air. The Vice Chairman of Vietjet Air is from Ben Tre Province. Upon receiving a request from Ben Tre Province for support in regard to economic cooperation, Ehime Prefecture signed a memorandum of understanding in regard to economic cooperation in August 2022. In addition to investment and support for technology introduction by companies in Ehime Prefecture, consideration has begun on economic partnership which would include exporting products from Ben Tre Province to Ehime Prefecture. The memorandum of understanding in regard to economic cooperation between Ehime Prefecture and Ben Tre Province is shown in Reference Material 1.

Figure 1-4 Background of cooperation between Ehime Prefecture and Vietnam/Ben Tre Province

In consideration of these exploring measures to promote economic cooperation, Ehime Prefecture prepared its own budget and implemented the “FY 2022 Vietnam Regional Collaboration Business Development Support Project.” This project included business matching between companies in Ehime Prefecture and companies in Ben Tre Province, and discussions related to economic cooperation between the governments of Ehime Prefecture and Ben Tre Province. These efforts have led to multiple trade negotiations for agricultural and fishery products, as well as active exchanges in private business, including companies from Ehime Prefecture considering the entry into industrial parks in Ben Tre Province. The outline of this project is shown in the figure below.

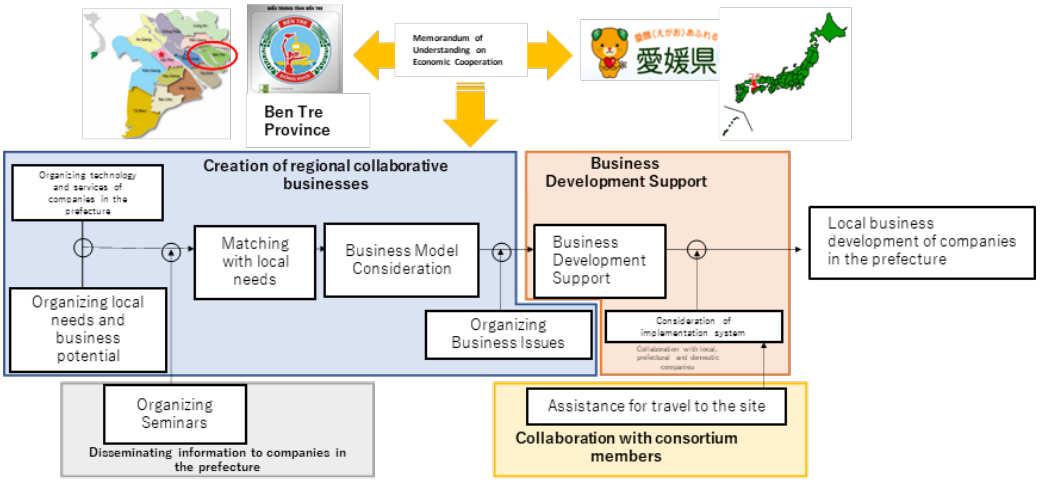


Figure 1-5　Outline of results of project by Ehime Prefecture

On the other hand, repeated on-site surveys and discussions have confirmed the need to resolve environmental issues in Ben Tre Province; for example, decarbonization and treatment of waste and wastewater. While actively working to attract foreign companies, Ben Tre Province must respond to the sustainability policies of these companies and follow initiatives toward decarbonization and environmental improvement as promoted by the central government. The province has expressed high expectations for support from Ehime Prefecture in understanding these issues and formulating countermeasures.

Therefore, in order to contribute to the realization of decarbonization by utilizing systems such as Joint Crediting Mechanism (JCM), we have proposed the following consideration through the City-to-City Collaborative Project. Specifically, we will consider measures that can be realized in Ben Tre Province, mainly in the field of decarbonization, and implement policy support to promote those measures.

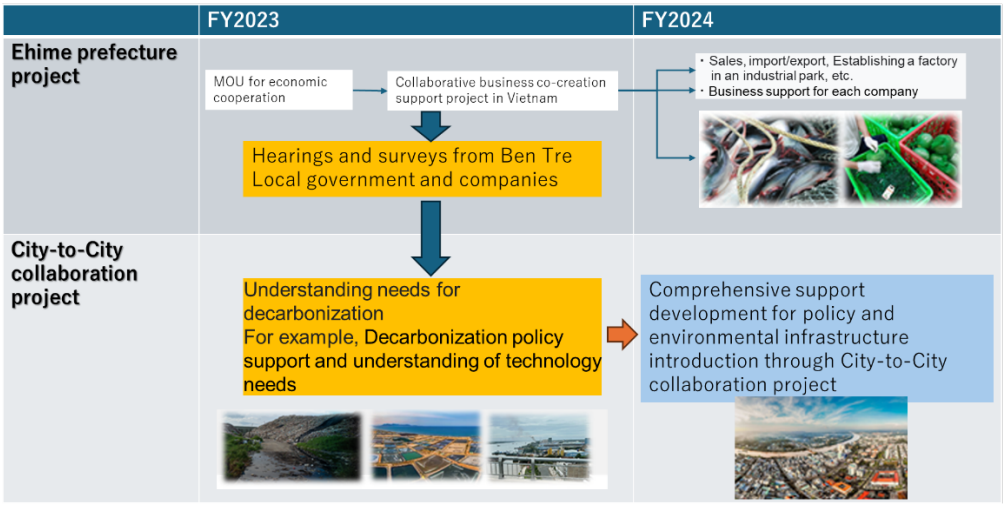


Figure 1-6　Independent projects by Ehime Prefecture and position of the City-to-City Collaboration Project

1. 2. Implementation structure and details of this task

The task implementation structure for this fiscal year is shown in the figure below.

Based on the memorandum of understanding in regard to economic cooperation between Ehime Prefecture and Ben Tre Province, the Department of Natural Resources and Environment (DONRE) of Ben Tre Province will serve as the point of contact for sharing know-how and supporting policy planning for the development of projects and related polices in areas such as decarbonization of industrial parks, which is one of the targets of the City-to-City Collaborative Project, hydrogen energy utilization, waste plastic fuel conversion, and wastewater treatment.

When considering commercialization, when selecting a company from Ehime Prefecture for collaboration, we selected Miura Co., Ltd., which is the largest boiler manufacturer in Japan. Miura Co., Ltd. also possesses the Miura Institute of Environmental Science, which has advanced environmental analysis technology, and the Miura Environmental Science Institute. We also decided to collaborate with Advantech Co., Ltd., which possesses expertise in introducing energy management systems that combine solar power and storage batteries. Japan NUS Co., Ltd. is responsible for the overall management of the City-to-City Collaborative Project, including information gathering related to city-to-city collaboration, support for various surveys, and liaison and coordination with related organizations and companies.

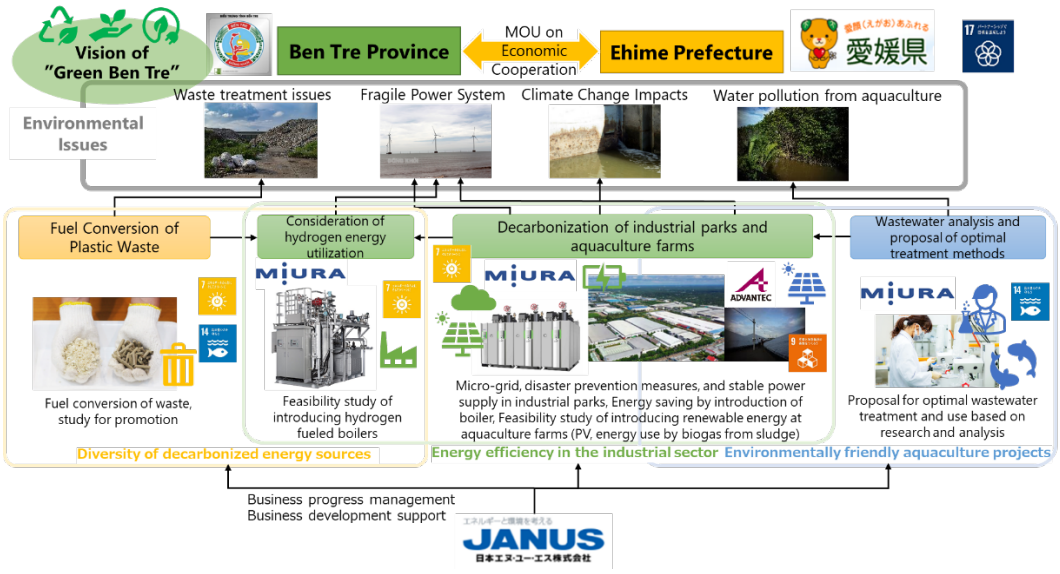


Figure 1-7　Diagram of implementation structure

2.　Formulation of a commercialization plan

2. 1. Connection between Ehime Prefecture's climate change measures and Ben Tre Province

Exchanges between Ehime Prefecture and Vietnam began in 2010, when the Ehime Prefecture SME Association and the Embassy of Vietnam in Japan held a seminar on the

Technical Intern Training Program. In 2013, Ambassador Extraordinary and Plenipotentiary (at that time) Doan Thi Huong paid a courtesy visit to the Governor of Ehime Prefecture. In addition to the courtesy visit with the Governor, the Ambassador's visit to Ehime Prefecture provided an opportunity to explore various possibilities for collaboration between Vietnam and Ehime, including company tours, a courtesy visit to the President of Ehime University, and a lecture by the Ambassador.

In FY 2014, four economic exchange missions were carried out under the slogan of "All Ehime," which refers to collaboration between industry, government, academia, and finance. Since then, business matching was held every year until 2018, and business exchanges between companies in Ehime Prefecture and companies in Vietnam were actively promoted. To date, 75 companies from Ehime Prefecture have participated in these business exchanges [1].

In 2018, Ehime Prefecture and Vietnam's Dong Nai Province signed a memorandum of understanding on economic cooperation. By working closely with provinces in Vietnam, we are taking steps to build more concrete partnerships. In conjunction with the signing of the memorandum of understanding with Dong Nai Province and the promotion of business exchange between Vietnamese companies and companies in Ehime Prefecture, Ehime Prefecture signed a memorandum of cooperation with Vietjet in 2022 to establish regular airline routes with the aim of attracting a direct flight route between Tan Son Nhat International Airport (Ho Chi Minh) and Matsuyama Airport (Ehime Prefecture). Although no regular flights have been operated to date, two charter flights were operated in December 2022 and January 2023.

As part of establishing a collaborative relationship with VietJet Air, an opportunity arose to request support for economic cooperation with the Vice Chairman's hometown, Ben Tre Province. Seizing this opportunity, Ehime Prefecture strengthened its collaboration with Ben Tre Province, becoming the second local province after Dong Nai Province. In August 2022, both parties signed a Memorandum of Understanding on economic cooperation.

In the same year, the "FY 2022 Vietnam Regional Collaboration Business Development Support Project" was started with Ehime Prefecture's own budget. This project provides investment and technical support for companies in Ehime Prefecture, as well as economic partnership projects such as importing products from Ben Tre Province to Ehime Prefecture. The memorandum of understanding in regard to economic cooperation between Ehime Prefecture and Ben Tre Province is shown in Reference Material X. Within the aforementioned project, we were conducting research and consideration with a focus on economic partnership. During repeated discussions with the government of Ben Tre Province and companies within the province, we received a request for support in regard to various activities toward

[1] Website of the Ehime Prefecture-Vietnam Exchange Association https://ehime-vn.org/gaiyo/

decarbonization. As the Vietnamese government moves toward its goal of net zero in 2050, local ministries are being asked to take on more responsibility and obligations. Local ministries that do not have experience or technology in decarbonization are faced with the difficult course of balancing economic growth and decarbonization. Consequently, these ministries requested cooperation from Ehime Prefecture, which possesses knowledge in these fields. The flow from economic cooperation to decarbonization support will enable the balance of regional economic development and decarbonization support, and there are high expectations from Ben Tre Province. Furthermore, the "FY 2022 Vietnam Regional Collaboration Business Development Support Project" is continuing today in fiscal 2023 as the "FY 2023 Vietnam Regional Collaboration Business Co-Creation Support Project." Continuing from last year, we are holding business exchanges between companies in Ehime Prefecture and Ben Tre Province, and are considering the possibility of supporting decarbonization for companies in the province. In response to requests for decarbonization support, the City-to-City Collaborative Project is being positioned as a future JCM project, and is being executed as an independent project while aiming for synergistic effects with the aforementioned business exchange projects.

Upon the adoption of the City-to-City Collaborative Project, a delegation from Ben Tre Province and Vietnamese Ambassador to Japan Pham Quang Hieu visited Ehime Prefecture in June 2023. They paid a courtesy visit to the Governor, exchanged opinions with the Chairman of the Ehime Prefectural Assembly, visited companies participating in the City-to-City Collaborative Project, and paid a courtesy visit to the President of Ehime University. These meetings helped foster understanding of Ehime Prefecture's decarbonization efforts and the City-to-City Collaborative Project. In addition, when Ambassador Pham Quang Hieu spoke at the Ben Tre Province Investment Attraction Seminar, he discussed the promotion of stronger collaboration in various fields, including building a cooperative system for the City-to-City Collaborative Project and building a cooperative system for strengthening cooperation with Ehime Prefecture[2].

2.2. Technologies with possibility of implementation and survey results

2.2.1. Renewable energy fields including hydrogen and solar power

(1) Survey on trends in related policies and systems

1) Policies and systems related to the spread of renewable energy

1. Eighth National Power Development Plan

In Vietnam, on May 15, 2023, the Prime Minister finalized the decision (No.500/QD-TTg) to

[2] Embassy of the Socialist Republic of Vietnam in Japan 2023 visit to Ehime Prefecture by Vietnamese Ambassador to Japan Pham Quang Hieu
https://vnembassy-jp.org/ja/

adopt the Eighth National Power Development Plan (PDP8), which stipulates national power development guidelines in Vietnam from 2021 to 2030. The decision took effect immediately.

Due to the growing international public opinion calling for decarbonization and energy transition, as well as the soaring energy prices triggered by the Russia-Ukraine conflict, PDP8 underwent a series of revisions and reviews which resulted in promulgation being delayed by two and a half years from the original schedule. Perhaps in consideration of the restart of projects that had been suspended in Vietnam during this period, the proportion of plans to introduce renewable energy has increased even more than at the time of the original draft. The Vietnamese government has also established a vision for long-term goals to realize the international commitment for achieving carbon neutrality in 2050 at COP26. Accordingly, PDP8 also incorporates interim goals to be achieved by 2030. The following table shows the actual results in 2020, which was the final year of PDP7, the power generation capacity for each power generation method in 2030, and the range of target values for 2050.

Table 2-1 Results and targets for power generation capacity in each fiscal year (created by JANUS with reference to materials[3] created by JOGMEC)

Power generation equipment capacity composition (GW)		2020 (results)		2030 (plan values)		2050 (target values)			
						Lower limit		Upper limit	
Coal-fired power		21.5	31.0%	30.1	20.0%	0.0		0.0	
	Shift to biomass/ammonia	0.0		0.0	0.0%	25.6	5.3%	32.4	5.5%
Domestically-produced natural gas		8.9	12.8%	14.9	9.9%	0.0		0.0	0.0%
LNG		0.0		22.4	14.9%	12.4	2.5%	16.9	2.9%
Hydrogen		0.0		0.0	0.0%	23.4	4.8%	27.9	4.7%
Renewable energy		17.5	25.3%	45.7	30.5%	335.3	68.9%	409.4	69.0%
	Wind power	0.5		27.9	18.6%	130.1	26.7%	168.6	28.5%
	Onshore			21.9	14.6%	60.1	12.3%	77.1	13.0%
	Offshore			0.6	4.0%	7.0	14.4%	91.5	15.4%
	Sunlight	16.6		12.8	8.5%	186.8	34.6%	189.3	32.0%
	Biomass	0.4		2.3	1.5%	6.0	1.2%	6.0	1.0%
	Storage battery	0.0		0.3	0.2%	30.6	6.3%	45.5	7.7%
	Pumped hydropower	0.0		2.4	1.6%	0.0	0.0%	0.0	0.0%
Water power		20.8	30.0%	29.4	19.6%	36.0	7.4%	36.0	6.1%
Other*		0.0		2.7	1.8%	46.4	9.5%	61.7	10.4%

[3] JOGMEC June 2, 2023 https://oilgas-info.jogmec.go.jp/info_reports/1009585/1009795.html

Imports	0.6	0.9%	5.0	3.3%	8.0	1.6%	8.0	1.4%
Total (GW)	51.2		101.9		143.8		174.9	
Rate of increase (compared to 2020)		1.00		2.16		7.03		8.55

*"Other" includes cogeneration systems and power generation using waste heat, blast furnace gas, etc.

It should be noted that Vietnam has set a goal of increasing its total power generation capacity by approximately 7 to 9 times by 2050 compared to 2020. This is necessary in order to respond to the significant increase in power demand associated with Vietnam's rapid economic growth. Also worth noting is the ambitious goal of completely abolishing coal-fired power and increasing the share of renewable energy from the target of approximately 30% in 2030 to approximately 70% by 2050.

Among renewable energy sources, it can be seen that the proposed increase in wind power generation is particularly large. Wind power generation has not been developed as of 2020, and the power generation amount is 520,000 kW, which accounts for only 0.7% of the total power source. However, the power generation amount as of 2030 as shown in PDP8 is approximately 27.9 million kw, which means that the ratio has been raised to 18.5%. Wind power generation can be divided into onshore and offshore. Vietnam has a large amount of room for development in offshore wind power generation, and will promote this as the center of its future development efforts.

Gas-fired power generation in 2030 is set to quadruple from 2020 to 2030 and reach 37.3 GW. Moving forward, 13 projects are planned to be operated at gas-fired power plants, including imported LNG (total of 22.5 GW). The Vietnamese government plans to develop and increase LNG-fired power generation through 2030, but then plans to keep the amount of LNG-fired power generation flat until 2050.

Numerical targets were the main content of the PDP8 announcement. It is expected that supplementary explanations about the content and the basis for setting numerical targets will be provided in the future.

On the other hand, although no concrete plans have been announced based on MOIT or PDP8, based on the results of on-site surveys and interviews with the government of Ben Tre Province and EVN, we were able to confirm that allocations for renewable energy implementation targets have been made in response to requests from the central Vietnam government to provincial governments.

According to the Ben Tre Province Department of Industry and Trade (DOIT), the MOIT has notified Ben Tre Province to secure 17 MW of allocated solar power generation capacity by 2030. According to an interview with Green Electric Investment, a solar power generation equipment EPC operator that is part of EVN, PDP8 recommends the introduction of residential solar power

generation equipment, but does not mention industrial solar power generation equipment. Furthermore, of the allocated equipment capacity, the breakdown of the installation target for residential use and industrial use is currently unknown.

2. Policy trends in regard to hydrogen use

Currently, hydrogen energy use is attracting attention on a global scale as a new energy source that contributes to decarbonization. There are expectations for its potential use in both developed countries and developing countries. Hydrogen is a secondary energy that requires production, but when produced using only renewable energy, it is considered to be energy without CO_2 emissions. In Vietnam, hydrogen energy is an energy source that is expected to contribute to achieving decarbonization goals by 2050. Consequently, it is an area with great potential for future development.

The Vietnamese government's commitment to hydrogen energy promotion can be observed in the 'Political Bureau Resolution on the Direction of Vietnam's National Energy Development Strategy until 2030 with a Vision to 2045' (No.55-NQ/TW) and the 'Government Resolution on the Announcement of the Action Program to Implement Political Bureau Resolution No.55-NQ/TW on the Direction of Vietnam's National Energy Development Strategy until 2030 with a Vision to 2045' (No.140/NQ-CP). These resolutions highlight that hydrogen, being a clean and renewable energy source with long-term potential, is a significant energy focus for Vietnam.

The aforementioned PDP8 emphasizes the importance of promoting the development of hydrogen energy during the period from 2031 to 2050. According to the Vietnam Petroleum Institute (VPI), two green hydrogen production methods are being considered to utilize hydrogen energy in Vietnam. Details are summarized in the table below. [4]

Table 2-2 Hydrogen production methods being considered in Vietnam[4]

Production Method	Overview of Technology	Materials	Notes
Conversion to biomass gas	Manufactured from a synthetic gas of hydrogen and carbon monoxide produced by gasifying biomass at high temperatures	・ Agriculture and forestry waste ・ Waste ・ Gas generated at landfills, wastewater treatment plants, etc.	・ Materials are plentiful and relatively inexpensive
Electrolysis	Uses electric current to split water into hydrogen and oxygen	・ Water	・ High cost ・ Requires a large amount of renewable energy

[4] VietBiz (August 30, 2023 issue)
https://vietbiz.jp/20230830-breakingnews-vn/

Vietnam’s topographical features include a long coastline, an annual average wind speed of over 10 m/s, and long average sunshine hours of 1,700 to 2,500 hours. This makes Vietnam ideal for renewable energy such as wind and solar power generation. There is also high potential for producing green hydrogen using the power generated from those forms of renewable energy. The utilization of renewable energy, such as wind and solar power, is constrained by the instability of these sources, requiring enhancements to the power grid and overall control technologies. Therefore, there is an expectation for maximizing the use of renewable energy through the conversion to hydrogen energy, given the constraints in the development caused by the need for power grid reinforcement and system-wide control technologies.

On the other hand, the initial investment in equipment and the cost of operating hydrogen production are high. Therefore, careful consideration is required from the perspectives of investing, selecting introduction sites, securing end users, and building a supply chain.

In the Mekong Delta region, where primary industries thrive, effective utilization of agricultural and forestry residues as biomass is possible, indicating a high manufacturing potential for biomass gasification. This makes it theoretically feasible to produce green hydrogen from the generated gas. However, whether biomass will be utilized for hydrogen production depends on the establishment of an environment ensuring economic viability in hydrogen production. This relies on the development of infrastructure and legal frameworks by provincial governments. Local surveys confirm that agricultural residues obtained in Ben Tre Province are mostly used as fuel in local factories or exported as biomass fuel overseas.

Despite numerous challenges, the Vietnamese government is strengthening efforts in research, development, and practical application of hydrogen energy technology as the next-generation energy source. The focus is on improving hydrogen energy technology domestically, with active collaboration with local research institutions, universities, and international cooperation, including technology transfer and joint research projects with Japan and European countries.

Moreover, the Prime Minister's Decision on the 'List of High-Tech Technologies Prioritized for Development Investment and the List of High-Tech Products Encouraged for Development' (No.38/QD-TTg) designates hydrogen energy technology as a high-priority advanced technology for development investment. This category includes green hydrogen production technology, hydrogen transportation and storage technology, and hydrogen utilization technology. Projects applying hydrogen energy technology are eligible for investment incentives.

Against this backdrop, in the southern provinces of Ben Tre and Tra Vinh in Vietnam, plans are underway for the manufacturing of a green hydrogen plant through a collaboration between local companies and the German big steel company, ThyssenKrupp AG. The project details were discussed in a hearing with The Green Solutions (TGS), a local Vietnamese company participating in the project, to explore potential collaboration. Details of the aforementioned will

be provided later.

3. Policy trends towards reducing emissions

On January 18, 2022, in the "Decision on Promulgating the List of Sectors, Greenhouse Gas-emitting Establishments Subject to Greenhouse Gas Inventory" (No.01/QD-TTG), the Vietnamese government announced a list of fields and gas-emitting business that must create a list of GHG inventory. This decision defined the requirement for specific entities to create a GHG inventory and work to reduce GHG as based on the Law on Environmental Protection (No.72/QH14) and the "Decree on Mitigation of Green House Gas (GHG) Emissions and Protection of Ozone Layer" (No.06/ND-CP) that was issued by the Vietnamese government on January 7, 2022. In addition, the "Decree on Mitigation of Green House Gas (GHG) Emissions and Protection of Ozone Layer" (No.06/ND-CP) stipulates that GHG inventory is "the activity of collecting information and data on GHG emission sources and calculating GHG emissions and removals in a particular region and year according to methods and processes issued by competent authorities."

The "Decree on Mitigation of Green House Gas (GHG) Emissions and Protection of Ozone Layer" (No.06/ND-CP) requires the compilation of GHG inventory by the six sectors of energy, transportation, construction, industrial processes, agriculture, and forestry. A total of 1,912 companies are required to prepare GHG inventories. Businesses that emit GHGs of 3,000t- CO_2e or more per year are required to create an inventory. Inventories are also required of businesses that meet the conditions shown in Table 2-3. Additionally, related regulations and standards in regard to mandatory inventory preparation are shown in Tables 2-4 and 2-5.

Table 2-3 Business required to create inventory

Target business	Fuel consumption amount	Unit (per year)
Thermal power generation	1,000	TOE
Manufacturing industry	1,000	TOE
Cargo transportation	1,000	TOE
Commercial building	1,000	TOE
Waste treatment	65,000 or more (processing amount)	t

Table 2-4 Laws related to mandatory inventory creation

No. of law	Contents
Decree 06/ND-CP	Decree on Mitigation of Green House Gas (GHG) Emissions and Protection of Ozone Layer
Decision 01/QD-TTG	Decision on Promulgating the List of Sectors, Greenhouse Gas-emitting Establishments Subject to Greenhouse Gas (GHG) Inventory
Decision 2626/QD-BTNMT	Decision on Publishing List of Emission

	Factors Serving Greenhouse Gas (GHG) Inventory Development
Circular 17/TT-BTNMT	Circular on Methods for Measurement, Reporting, Appraisal of Reduction of Green House Gas (GHG) Emissions and GHG Inventory Development in Waste Management
Circular 96/TT-BTC	Circular Guiding the Disclosure of Information on the Securities Market

Table 2-5 Standards related to mandatory inventory creation

No. of standards	Contents
TCVN ISO 14064-1:2011	Specification With Guidance at the Organization Level for Quantification and Reporting of GHG Emissions and Removals
TCVN ISO 14064-2:2011	Specification With Guidance at the Project Level for Quantification, Monitoring and Reporting of GHG Emission Reductions Removal Enhancements
TCVN ISO 14064-3:2011	Specification With Guidance for the Validation and Verification of GHG Assertions

Even in Ben Tre Province, there are companies that are required to prepare inventories by the central Vietnamese government. In 2023, the People's Committee of Ben Tre Province announced the “Report on Project to Confirm Businesses Required to Conduct GHG Inventory in Ben Tre Province.” The contents of this report will be discussed later in this report together with the energy plan of Ben Tre Province.

2） Survey on power usage status, etc., in Ben Tre Province

Plan 551/KH-UBND dated February 10, 2020 summarizes the energy conservation plan of Ben Tre Province until 2030 based on power consumption data from 2015 to 2019. According to data of the Ben Tre Electric Company, the plan also describes the amount of power used commercially in Ben Tre Province. Table 2-6 summarizes the power usage by sector in Ben Tre Province from 2015 to 2019.

Table 2-6 Power usage by sector in Ben Tre Province from 2015 to 2019 (created by JANUS)

Sector	**2015**	**2016**	**2017**	**2018**	**2019**
Agriculture, forestry and fisheries	60.48	88.91	146.88	190.97	233.83
Industry	369.20	393.30	400.39	445.63	516.67
Commercial facilities, hotels, restaurants	27.5	33.75	40.00	49.45	52.75
Housing	575.35	636.36	689.86	742.72	823.37

Others	44.96	52.25	58.09	62.57	66.64
Total	1,077.48	1,204.58	1.335.21	1,491.34	1,693.27

The table shows that power consumption by sector increased at a rate of 11.43% from 2015 to 2019. The population and number of tourists are expected to increase with future economic development. Consequently, the total power consumption of residential buildings, commercial facilities, hotels, and restaurants is expected to increase in Ben Tre Province. In Ben Tre Province's power development plan, which is for 2016 to 2025 and looks ahead to 2035, the growth rate of total power consumption is 11.69%. The growth rate is 9.66% from 2021 to 2025 and 8.38% from 2026 to 2030.

According to Table 2-6, residential power consumption in Ben Tre Province accounts for 50% of the total consumption, while the industrial sector accounts for 30%. From this, it can be said that energy conservation measures in Vietnam's housing and industrial sectors are also important. This plan describes the content that should be implemented in each period from 2020 to 2025 and from 2025 to 2030. Excerpts from the plan are listed below.

1. Period from 2020 to 2025

- The growth rate of total power consumption from 2020 to 2025 will be limited to 5% to 7% compared to the predicted growth rate (9.66%).
- Transportation businesses exceeding a certain scale will create operational programs for the utilization of energy-saving vehicles.
- 70% of companies operating in industrial parks and 50% of companies operating in industrial clusters will strive to devise and apply solutions to achieve energy savings.
- Major energy consuming facilities will strive to operate appropriate energy management systems.

2. Period from 2025 to 2030

- We will strive to the province's total energy consumption rate from 2025 to 2030 with 8% to 10% compared to the projected increase rate (8.33%).
- 90% of companies operating in industrial parks and 70% of companies operating in industrial clusters will strive to devise and apply solutions to achieve energy savings.
- Each major energy-consuming facility will strive to have at least one trained and certified energy management or energy audit professional.

In addition, "Vision 2030: Program for the Development of Major Industries and Enterprise Capability in Ben Tre Province from 2020 to 2025" (No. 08 Ctr-TU) mainly includes content related to renewable energy, especially wind power, in the province's

power development plan, as well as content on the development of a supply network for that energy. Ben Tre Province is said to have great potential for the development of clean energy (especially gas power generation, LNG, wind power generation, and solar power generation) by taking advantage of its 65 kilometer coastline. Currently, the capacity of approved energy projects has reached 1.08 million MW. The plan is to develop at least 1,500MW of renewable power by 2025. The amount of power produced will account for approximately 15% of the province's total industrial production. The plan also calls for the creation of an environment for investment in LNG projects in Ben Tre Province, with investments in 220kV and 500kV power grid infrastructure connecting coastal bases to be completed by 2025. As a result, it should be possible to secure power transmission capacity for renewable energy projects in this region, and the region can be described as actively working to grow LNG projects in the future. and it can be said that the company is proactive in developing LNG projects in the future. A partial excerpt from the plan is given below.

In regard to the energy industry, we will promote the implementation of wind power projects according to the planned schedule, with the aim of generating 1,500MW of power by 2025. We will also facilitate the planning, investor selection, and implementation processes for LNG power generation projects. We will promote technical research and rational development in the field of power generation from waste and biomass. In addition, we will construct, repair, improve, and develop new high-voltage, medium-voltage, and low-voltage power transmission networks, ensure stable and safe power transmission and supply, and aim for economic development in various industrial fields. We propose solutions and mechanisms for companies implementing the solar power industry to eliminate legal issues and obstacles that are faced when seeking smooth implementation and operation.

The basic development content for "Vision 2050: Approval of Ben Tre Provincial Planning for the Period 2021 to 2030" (No. 1399/QD-TTg), which approved the plan of Ben Tre Province in "Vision 2030: Program for the Development of Major Industries and Enterprise Capability in Ben Tre Province from 2020 to 2025" (No. 08 Ctr-TU) is the same as for No.08 Ctr-TU. No. 1399/QD-TTg approves the plan and gives an even more specific development plan. In particular, it describes a promotion plan for industries related to green hydrogen, and shows specific plans for wind power plants to be developed for green hydrogen production. Furthermore, in accordance with the perspectives, goals, direction, and power supply and power grid development plan as PDP8, as well as the plans and

contents of "Vision 2050: Approval for Planning for Development of the Mekong Delta Region for 2021 to 2030," etc., the plan approved by No. 1399/QD-TTg focuses on the development of power sources and power supply networks. The following are some excerpts from statements related to these matters.

"Development of renewable energy sources, clean energy, and new energy"

We will focus on developing renewable energy sources, clean energy, and new energy. Investments in power development in Ben Tre Province must comply with the implementation plan for which rules were set following discussion at PDP8 and approved by the competent authorities.

"Power supply network development plan"

To respond to the increasing power load in industrial parks and industrial clusters in Ben Tre Province, we are continuing to construct, upgrade and renovate substations, 500kV, 220kV and 110kV transmission lines, and medium and low voltage lines connected to new power sources. Moreover, we will promote the undergrounding of electric cables in existing medium and low voltage power networks in stages. The development of these power supply networks will ensure a safe and stable power supply.

In the document No. 1399/QD-TTg, potential areas for power development and the development of the power supply network in Ben Tre Province are outlined. The plan includes the following renewable energy projects:

- Wind Power (Onshore, Offshore, Coastal, with a total capacity of 12,913 MW)
- Biomass Power (30 MW)
- Waste-to-Energy (18 MW)
- Gas Power (3,000 MW)

It is noted that while these power generation facilities are planned to be grid-connected, there is a possibility that the following capacities may be utilized for the Green Hydrogen production plan in Binh Dinh Province, rather than being grid-connected:

- Solar Power (Ba Tri District, 300 MW)
- Wind Power (Two locations in Ba Tri District, totaling 849.5 MW)

On the other hand, No.08 Ctr-TU notes that the Ben Tre Province People's Committee

has stated that the development of the power supply network is an issue. No.1399/QD-TTg lists specific plans for the development of substations and transmission lines. In regard to power supply facilities, there are plans to construct one 500kV substation, six 220kV substations, and 26 110kV substations in Ben Tre Province. There are also plans to construct one 500kV transmission line (60km), nine 220kV transmission lines (206km in total), and 33 110kV transmission lines (44.05km in total). Based on the above, it is expected that the convenience of power usage and supply of clean energy will improve in Ben Tre Province by increasing power generation capacity of renewable energy and strengthening power transmission facilities toward 2030.

(2) Basic survey for formulating a commercialization plan

1） Survey on the feasibility of introducing renewable fuels to replace fossil fuels

1. Energy planning in Ben Tre Province

In Ben Tre Province, Decision 811/QD-UBND of the Ben Tre Province People's Committee dated April 13, 2021 states that projects will be undertaken for realizing the Green Ben Tre Concept, based accelerating efforts aimed at implementing climate change countermeasures, preventing environmental pollution, and protecting natural resources in Ben Tre Province. This Concept and the Decision by Ben Tre Province applies to nine sectors such as schools, housing, government institutions, offices, medical institutions, markets, cultural and historical sites, and tourism, but does not mention reduction targets in the industrial sector or energy measures. Even though there is no mention of the industrial sector in the Green Ben Tre Concept, it can be confirmed that the Ben Tre Province People's Committee is trying to improve environmental awareness throughout the province.

In regard to the decarbonization of industrial parks, based on the results of interviews with Ben Tre provincial government agencies (DONRE, DOIT, and DARD), the Ministry of Planning and Investment of the Vietnamese government is collaborating with the United Nations Industrial Development Organization (UNIDO) to convert conventional industrial parks into an Eco-Industrial Park (EIP). As a model district, the city of Haiphong is collaborating with the city of Kitakyushu to implement initiatives towards the Eco-Industrial Park Concept. In relation to the Eco-Industrial Park Concept, Decision No. 35/ND-CP was enacted by the Vietnamese government in May 2022, and efforts are being made to reduce pollution sources in industrial parks and to promote recycling-oriented production and decarbonization. Policy formulation aimed at promoting the Eco-Industrial Park policy is clearly stated to be the responsibility of each local province, and is therefore an issue that must be addressed by Ben Tre Province. Since many of the companies located in industrial parks export products to major apparel and food companies in regions such as Europe, they

receive requests and recommendations in regard to decarbonization and environmental consideration goals. The Decarbonized Industrial Park Declaration will lead to increasing the value of the industrial park and is expected to attract more companies to locate in the industrial park. As a result, Ben Tre Province is also actively considering the declaration.

As mentioned earlier, in Vietnam, businesses that emit large amounts of waste are required to create an inventory. In 2023, the Ben Tre Province People's Committee published the "Report on Business Confirmation Projects Requiring GHG Inventory in Ben Tre Province." In this report, the Ben Tre Province People's Committee lists businesses within the province that are required to create an inventory. We are conducting interviews with each business operator in regard to the details of their production activities, annual fuel usage, and emissions. The contents of the interviews are summarized in Table 2-7.

Table 2-7 Businesses required to create inventories in Ben Tre Province [5]

Company name	**Address**	**Production activities**	**Fuel usage amount (per year) (2022)**	**Emissions (t-CO_2/year)**
Công ty TNHH MTV Đầu tư Cocovina	Ấp Hội thành, xã Tân Hội, huyện Mỏ Cày Nam, tỉnh Bến Tre	Agricultural products processing (coconut fiber/coco peat)	Diesel oil, heavy oil, etc.: 92,000L Gasoline: 1230L Rice husk: 2,874t	6,523
Công ty TNHH May mặc Alliance One	Lô B1, B2, B5 - B12 Khu Công nghiệp Giao Long, xã An Phước, huyện Châu Thành, tỉnh Bến Tre.	Sewing, printing, and textile industries	Diesel oil, heavy oil, etc.: 24,798L Gasoline: 21,147L	6,116
Công ty TNHH MTV NidecTosok Precision Việt Nam	Lô E1, E2, E3, E12 Khu Công nghiệp Giao Long, huyện Châu Thành, tỉnh Bến Tre	Manufacturing of metal parts	Diesel oil, heavy oil, etc.: 750,000L LPG: 5,451t	15,709
Công ty TNHH Thế Giới Việt	Lô A5, A6, A7 khu A1 Khu Công nghiệp Giao Long, huyện Châu Thành, tỉnh Bến Tre	Food processing	Coal: 6,581t Diesel oil, heavy oil, etc.: 48,920L Gasoline: 13,364L	28,408
Công ty Cổ phần Đông Hải Bến Tre	Lô AIII, Khu Công nghiệp Giao Long, huyện Châu Thành, tỉnh Bến Tre	Paper manufacturing industry	Steam purchased from Công ty Cổ phần dịch vụ năng lượng Thành Công	92,911

[5] Created by JANUS based on the "Report on Project to Confirm Businesses Required to Conduct GHG Inventory in Ben Tre Province." A dash (-) denotes that data was not available at the time of creating materials.

Nhà máy xử lý rác thải Bến Tre	Xã Hữu Định, huyện Châu Thành, tỉnh Bến Tre	Waste treatment	-	75,000t (processing amount)
Công ty TNHH chế biến thủy sản Hùng Vương Bến Tre	Lô A6, A7 Khu Công nghiệp An Hiệp, huyện Châu Thành	Marine products processing (Pangasius)	-	4,129
Công ty TNHH chế biến dừa Lương Quới	Lô A36-37 Khu Công nghiệp An Hiệp, huyện Châu Thành	Agricultural products processing (coconut related products)	-	53,083
Công ty Cổ phần chăn nuôi C.P Việt Nam - CN sản xuất kinh doanh thức ăn thủy sản Bến Tre	Lô A21-A35 Khu Công nghiệp An Hiệp, huyện Châu Thành	Production of marine seasonings	-	56,298
Công ty Cổ phần chăn nuôi C.P Việt Nam - CN Thủy sản đông lạnh Bến Tre	Lô A21-A35 Khu công nghiệp An Hiệp, huyện Châu Thành	Marine products processing	Heavy oil: 129,014L Light oil: 6,640L	12,670
Công ty Cổ phần thủy sản Hải Hương	Lô A8-A9 Khu công nghiệp An Hiệp, huyện Châu Thành	Marine products processing (Pangasius)	-	14,758
Công ty TNHH MTV Gò Đàng Bến Tre	Lô CX-2 Khu công nghiệp An Hiệp, huyện Châu Thành	Marine products processing	-	-
Công ty TNHH Coronet Việt Nam	Lô EI-7, EI-8, EI-9 Khu công nghiệp Giao Long huyện Châu Thành	Manufacturing of synthetic leather	-	3,122
Công ty Cổ phần dịch vụ năng lượng Thành Công	Lô DN Khu công nghiệp Giao Long huyện Châu Thành	Supply of industrial steam	Coal: 132,973t	339,021
Công ty TNHH Chế biến nông sản Thuận Phong	Ấp Long Hòa, Xã Giao Long, huyện Châu Thành	Marine products processing	-	10,766
Công ty Cổ phần Cấp thoát nước Bến Tre	Số 103, đường Nguyễn Huệ, phường An Hội, thành phố Bến Tre	Water and sewer management	-	7,571
Công ty Cổ phần XNK Bến Tre - Nhà máy Thành Công	Lô K, Cụm Công nghiệp Phong Nẫm, huyện Giồng Trôm	Agricultural products processing (coconut related products)	-	23,917
Công ty Cổ phần Bia Sài Gòn- Bến Tre	Ấp Phước Hậu, Xã An Phước, huyện Châu Thành	Liquor production	-	3,140

According to the "Report on Business Confirmation Projects Requiring GHG Inventory in Ben Tre Province," businesses that are required to create an inventory in Ben Tre Province must report their annual emissions status to the Ben Tre Province People's Committee. The People's Committee is required to compile data and submit it to the Ministry of Natural

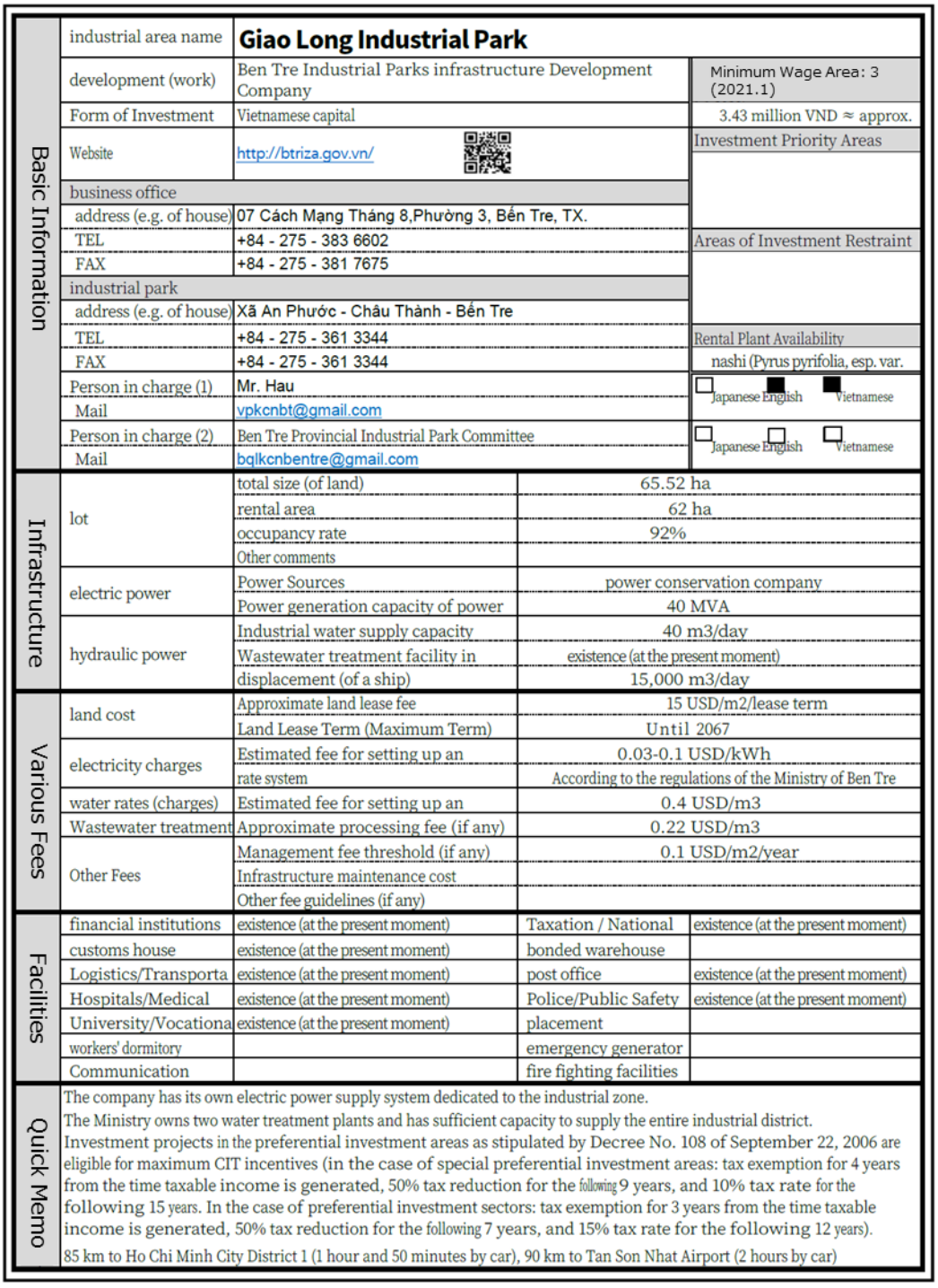
Resources and Environment every two years. Support for these activities are requested in this project.

2. Considering where to introduce alternative fuels

In this project, we are exploring the possibility of introducing alternative fuels such as hydrogen for major emitters, particularly those in the manufacturing industry with boilers, as a substitute for heavy oil and coal. As part of the current survey, we conducted interviews with businesses operating in industrial parks, as listed in Table 2-7, to investigate their initiatives towards alternative fuels and decarbonization. The focus was on assessing the feasibility of introducing alternative fuels.

As mentioned earlier, industrial parks in Ben Tre Province host companies responding to global decarbonization demands. To further advance the Eco-Industrial Park concept proposed by the central government, this project is expected to construct a decarbonization model and develop a dissemination scenario, contributing to the promotion of decarbonization in the region.

In Ben Tre Province, there are two industrial parks in operation, one park under construction, and four semi-industrial zones. The companies which we interviewed are located in Giao Long Industrial Park in Chau Thanh District. The following is information on Giao Long Industrial Park from the “Data Collection of Industrial Parks and Rental Factories in Proximity of Ho Chi Minh City, Vietnam" compiled by the JETRO Ho Chi Minh Office.



Basic Information	industrial area name	**Giao Long Industrial Park**		
	development (work)	Ben Tre Industrial Parks infrastructure Development Company		Minimum Wage Area: 3 (2021.1)
	Form of Investment	Vietnamese capital		3.43 million VND ≈ approx.
	Website	http://btriza.gov.vn/		Investment Priority Areas
	business office			
	address (e.g. of house)	07 Cách Mạng Tháng 8,Phường 3, Bến Tre, TX.		
	TEL	+84 - 275 - 383 6602		Areas of Investment Restraint
	FAX	+84 - 275 - 381 7675		
	industrial park			
	address (e.g. of house)	Xã An Phước - Châu Thành - Bến Tre		
	TEL	+84 - 275 - 361 3344		Rental Plant Availability
	FAX	+84 - 275 - 361 3344		nashi (Pyrus pyrifolia, esp. var.
	Person in charge (1)	Mr. Hau		☐ Japanese ■ English ■ Vietnamese
	Mail	vpkcnbt@gmail.com		
	Person in charge (2)	Ben Tre Provincial Industrial Park Committee		☐ Japanese ☐ English ☐ Vietnamese
	Mail	bqlkcnbentre@gmail.com		
Infrastructure	lot	total size (of land)	65.52 ha	
		rental area	62 ha	
		occupancy rate	92%	
		Other comments		
	electric power	Power Sources	power conservation company	
		Power generation capacity of power	40 MVA	
	hydraulic power	Industrial water supply capacity	40 m3/day	
		Wastewater treatment facility in	existence (at the present moment)	
		displacement (of a ship)	15,000 m3/day	
Various Fees	land cost	Approximate land lease fee	15 USD/m2/lease term	
		Land Lease Term (Maximum Term)	Until 2067	
	electricity charges	Estimated fee for setting up an	0.03-0.1 USD/kWh	
		rate system	According to the regulations of the Ministry of Ben Tre	
	water rates (charges)	Estimated fee for setting up an	0.4 USD/m3	
	Wastewater treatment	Approximate processing fee (if any)	0.22 USD/m3	
	Other Fees	Management fee threshold (if any)	0.1 USD/m2/year	
		Infrastructure maintenance cost		
		Other fee guidelines (if any)		
Facilities	financial institutions	existence (at the present moment)	Taxation / National	existence (at the present moment)
	customs house	existence (at the present moment)	bonded warehouse	
	Logistics/Transporta	existence (at the present moment)	post office	existence (at the present moment)
	Hospitals/Medical	existence (at the present moment)	Police/Public Safety	existence (at the present moment)
	University/Vocationa	existence (at the present moment)	placement	
	workers' dormitory		emergency generator	
	Communication		fire fighting facilities	
Quick Memo	The company has its own electric power supply system dedicated to the industrial zone. The Ministry owns two water treatment plants and has sufficient capacity to supply the entire industrial district. Investment projects in the preferential investment areas as stipulated by Decree No. 108 of September 22, 2006 are eligible for maximum CIT incentives (in the case of special preferential investment areas: tax exemption for 4 years from the time taxable income is generated, 50% tax reduction for the following 9 years, and 10% tax rate for the following 15 years. In the case of preferential investment sectors: tax exemption for 3 years from the time taxable income is generated, 50% tax reduction for the following 7 years, and 15% tax rate for the following 12 years). 85 km to Ho Chi Minh City District 1 (1 hour and 50 minutes by car), 90 km to Tan Son Nhat Airport (2 hours by car)			

Figure 2-1 Overview of Giao Long Industrial Park

Figure 2-2 Exterior of candidate for introduction of alternative energy (Thanh Cong Energy Service Corporation)

For our survey, from among businesses required to create inventories, we targeted Công ty Cổ phần dịch vụ năng lượng Thành Công (hereinafter referred to as "Thanh Cong Energy Service Corporation"), which is located in an industrial park in Ben Tre Province and emits a large amount of emissions (339,021 tons/year). The company supplies industrial steam and electricity to an adjacent corrugated board manufacturer (Dong Hai Joint Stock Company of Ben Tre; hereinafter referred to as "DOHACO"), and operates a 60-ton power generation boiler and a 40-ton steam supply boiler. As shown in Table 2-7, in a preliminary interview conducted by the Ben Tre Province People's Committee, Thanh Cong Energy Service Corporation responded that they use coal as their main fuel. This makes the company an appropriate target for considering the introduction of decarbonized fuels.

Figure 2-3 60-ton boiler for power generation

Figure 2-4 40-ton boiler for supplying steam

The following is a summary of the results of the interview with Thanh Cong Energy Service Corporation.

- Currently, the 60-ton power generation boiler uses a mixture of rice husk and coal, and the 40-ton supply boiler uses a 6:4 mixture of waste and coal. Currently, rice husks are used as fuel due to their low price and are not included in emissions reductions.
- Thanh Cong Energy Service Corporation supplies electricity and the above to six

companies in the industrial park. As customers and the company become increasingly environmentally conscious, they are considering switching from coal to natural gas or biomass for fuel.

- There are no natural gas pipelines installed within Ben Tre Province. This means that natural gas must be transported, which raises economic concerns.
- The company plans to establish a new factory, and plans to install a steam supply boiler of the same size.

Figure 2-5 Waste (left) and rice husks (right) used as fuel

As a result of the interview, we learned that Thanh Cong Energy Service Corporation is considering introducing alternative fuels to coal due to the growing environmental awareness of its customers. In regard to the use of rice husks as fuel, the company has received information that due to the increasing demand for biomass fuel, there are inquiries not only from within Japan but also from overseas, so the price may rise in the future. Considering this situation, it is believed that there is a strong demand for the introduction of a decarbonized boiler in the construction of the company's new factory. The company has expressed a positive response and welcomed proposals. Therefore, in this survey, we conducted an assessment of the feasibility of introducing alternative fuels, including hydrogen.

3. Creation/selection of commercialization model and trial calculation of introduction effects

As an alternative fuel to achieve decarbonization, hydrogen emerges as a candidate. Miura Industries, Ltd., a participant in this project, has developed a recirculating boiler that utilizes hydrogen. In January 2017, they successfully commercialized the first product in Japan capable of 100% hydrogen combustion. Miura's boilers, specifically the small-scale recirculating boilers, offer a solution for large-scale consumers by maximizing operational efficiency through the installation of multiple units. To achieve the highest operational

efficiency (100% operation) of the boilers, which requires adapting to the varying steam demand, multiple small continuous-flow boilers are efficiently controlled. This allows for higher operational efficiency compared to large fire tube boilers.

The same concept has been applied to the development and commercialization of hydrogen boilers, offering the following lineup.

	Unit	SI-2000AS	AI-2500 16S	SU-250H※
Boiler Type	–	Small boiler (Multi-pipe once-through boiler)	Boiler (Multi-pipe once-through boiler)	Simple Boiler (Multi-pipe once-through boiler)
Handling Qualifications	–	Persons who have taken "special training" by the employer	Completion of boiler handling skills training	No qualification required
Maximum Pressure	MPa	0.98	1.57	0.98
Operating pressure range	MPa	0.49～0.88	1.08～1.41	0.49～0.88
Equivalent evaporation	kg/h	2000	2500	250
Hydrogen usage	Nm3/h	451.8	576.8	58.2
Combustion method	–	High-speed continuous control	3-position control	On-off control
Turndown ratio	–	1:4	1:2	–
Boiler efficiency	%	95	93	90
Boiler Dimensions (W×D×H)	–	1,875×3,750×2,730	2,660×3,945×3,245	2,235×2,300×3,110

Figure 2-6 Hydrogen Boiler Lineup of Miura Industry Co., Ltd.

Although the challenge in hydrogen utilization lies in the supply, in Ben Tre Province and Tra Vinh Province, the production of green hydrogen plants is planned in collaboration with local company TGS and German steel giant Thyssenkrupp. This project is a widely known topic in Japan due to being featured in JETRO's business report. The report states that trial operations are expected to begin in the first quarter of 2024. The factory will start producing 24,000t/year of green hydrogen and 150,000t/year of ammonia. After expanding its facilities, it plans to produce 60,000t/year of green hydrogen and 375,000t/year of ammonia. On the other hand, there was no mention of how the produced hydrogen would be used or its selling price, and it was unclear whether it could be used within the provinces. Therefore, in this project, we interviewed a company located in Ho Chi Minh City about a green hydrogen production plant planned to be built in Ben Tre Province. A summary of the interview results is given below.

- The planned hydrogen production plant in Ben Tre Province is scheduled to begin operations in 2027. The wind power generation facility that will generate the electricity used to produce

green hydrogen is listed in PDP8. Construction of this facility will begin soon. In regard to the solar power generation equipment, we have applied to the Ben Tre Province People's Committee for the project to install solar power generation equipment, and are currently awaiting permission.

- The selling price of hydrogen has not been determined at this time. Presently, we are envisioning collaboration with various partners. In particular, there are many unclear points regarding transportation costs, and it is necessary to consider prices as well as transportation routes.
- Currently, the hydrogen produced is expected to be used in the existing steel industry and in storage batteries, while the ammonia is expected to be used in fertilizer plants. On the other hand, if the issues of economic efficiency and transportation routes can be resolved, there is room to consider use with Ben Tre Province.
- Construction has already begun for the project in Tra Vinh Province and is scheduled to be completed in 2026. Trial and commercial operations are also scheduled to begin within 2026.

Figure 2-7 Exterior of TGS Ho Chi Minh Office

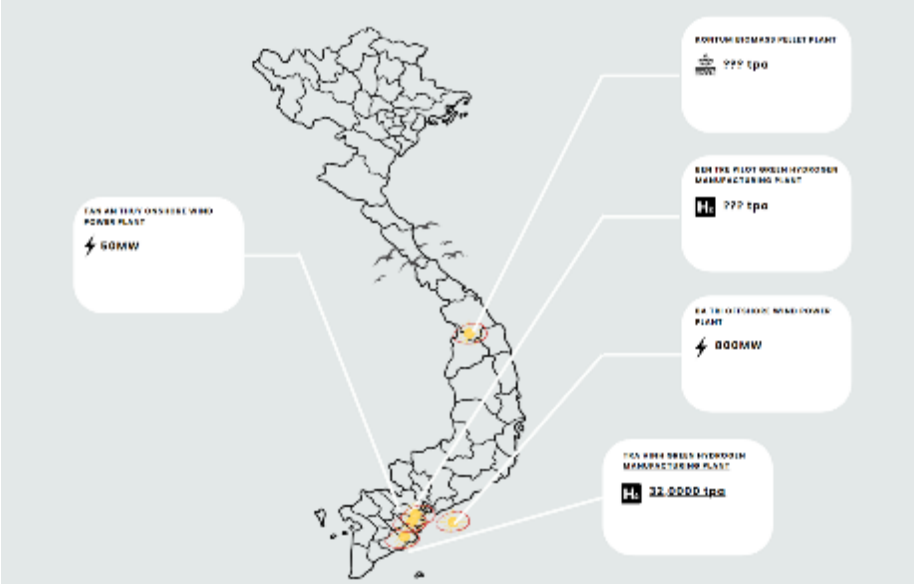


Figure 2-8 List of projects operated or planned by TGS

Based on the above results, it can be confirmed that the plan to construct a green hydrogen production plant in southern Vietnam is currently in progress. Furthermore, the plan in Ben Tre Province is in the pre-construction stage and the project will be used for green hydrogen production. In this way, it can be seen that the construction of facilities that generate renewable energy has either been approved or is in the application process. Considering the schedule, it would be difficult for the aforementioned Thanh Cong Energy Service Corporation to use green hydrogen as an alternative fuel for trial use in the boilers they are installing in their new factory. On the other hand, since this is a project to establish a large-scale green hydrogen production base, there is room to consider the possibility of collaboration outside of this project.

Since it has been confirmed that it is difficult to use hydrogen as an alternative fuel, it is necessary to consider other alternative fuels. As mentioned in (1)1)①, the Vietnamese government plans to operate gas-fired power plants including imported LNG in 13 projects (22.5 GW in total) by 2030. Foreign companies are interested in exploring this possibility and are currently expanding into Vietnam. In southern Vietnam, an LNG carrier docked at the Thi Vai LNG receiving terminal on July 10, 2023, and startup has begun. The regasified gas will be transported through pipelines and supplied to domestic power plants, while CNG trailers will supply industrial customers. As the use of natural gas is expected to expand in Vietnam in the future, the Japanese gas company Toho Gas leveraged know-how acquired from its city gas business in Japan to establish Phuc Sang Minh Trade Engineering Services Joint Stock Company (PSE) in 2006. Through its base in Ho Chi

Minh City, PSE sells CNG and LPG, and designs, manufactures, and sells gas equipment to commercial customers. Toho Gas will use PSE to expand the use of gas in Vietnam. As of February 2023, 40% of capitalization was completed. PSE possesses the subsidiary JPS (established in 2007), which designs, constructs, and operates and maintains facilities such as gas pipelines and decompression equipment. Vietnam's natural gas consumption in 2022 was 7.8 Bcm, with 5.6 Bcm (72%) for power generation, 1 Bcm (13%) for industrial use, and 1.2 Bcm (15%) for fertilizer industry. CNG accounted for 42% of industrial use, of which PSE's share is 17%. CNG has smaller price fluctuations than LPG, with the difference between summer and winter being around 3% to 5%, thereby ensuring price stability. In regard to future gas prices, consideration is being given to setting prices by considering crude oil prices, and then revising the set prices every six months.

Figure 2-9 Exterior of Thi Vai LNG Receiving Base[6]

In regard to CNG supply, a company called CNG Vietnam was established in 2007 under the state-owned PetroVietnam. There is the possibility that CNG Vietnam will be able to supply CNG. To date, the company has been selling CNG as Vietnamese domestic gas mainly to industrial customers in the surrounding area, and has also supplied gas to PSE. Sales in 2021 were 275Mm^3, and sales are steadily increasing with an average sales increase rate of 18% from 2016 to 2021. The number of customers is now over 120. CNG Vietnam's CNG mother station fills CNG cylinders (a set of 6 to 12 cylinders) with gas up to 250 bar, then delivers the cylinders to the customer by towing it with trailers (20 ft, 40

[6] Latest Trends in Natural Gas and LNG - Europe is out of a tight spot and emerging Asian countries are expanding their use of LNG (Activities of the three major Japanese gas companies) - | JOGMEC website "Oil and Natural Gase Materials and Information"

ft). The company engages in sales and supply by replacing empty cylinders that have deteriorated to a pressure of approximately 20 bar due to usage. The gas transport capacity is 18 to 40 m^3 at a time. Operation is performed 24 hours a day, which makes it possible to transport up to 250 km in a single day. In particular, as shown in Figure 2-9, the distance from the Thi Vai LNG receiving terminal to the Giao Long Industrial Park, where the target business operator is located, is 148 km one way according to Google Maps. This makes it possible to supply CNG gas.

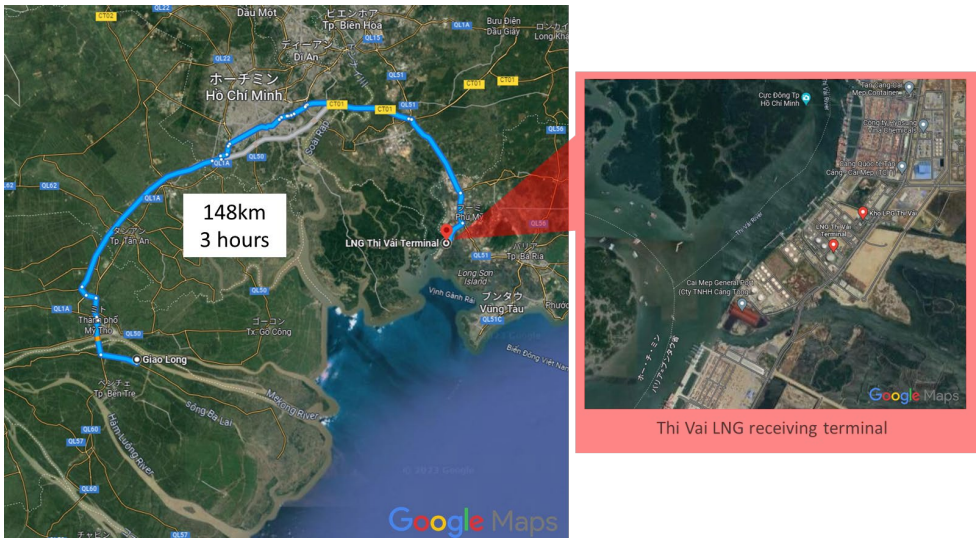


Figure 2-10 Distance from Thi Vai LNG Receiving Base to Giao Long Industrial Park (created by JANUS from Google Maps (Google (n.d). [Google Maps directions for driving from LNG Thị Vải Terminal to Khu Công Nghiệp Giao Long]. Retrieved February 29, 2024, from https://x.gd/eDtwx))

From this situation, it can be said that the supply of CNG gas is a highly feasible alternative fuel for businesses located in industrial parks in Ben Tre Province to introduce decarbonization and low carbonization. By combining the boiler replacement technology of Miura Co., Ltd., a participant in this year's projects, with Toho Gas's CNG supply network, it is possible to build a low-carbon model using CNG gas as shown in Figure 2-10.

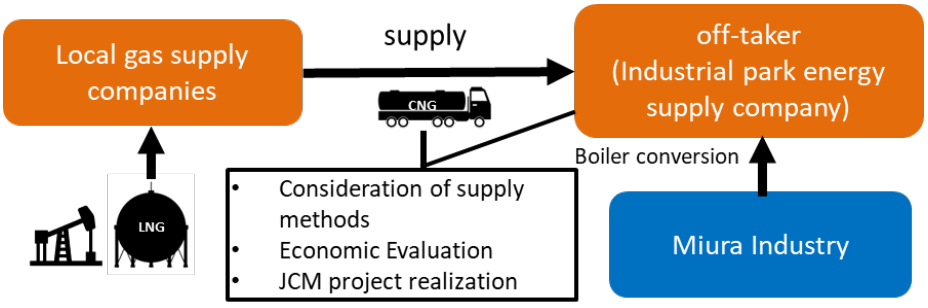


Figure 2-11 Anticipated low-carbon model for businesses located in industrial parks using CNG gas

In this study, the reduction amount if Thanh Cong Energy Service Corporation converts all of its current coal usage (132,973 tons) to CNG can be estimated as follows. We have also received information from an interview with the Ben Tre provincial government that the annual emissions from the company's current use of coal is 339,021t-CO_2. However, in order to calculate a more accurate reduction amount, we have aligned the sources of these figures. [7]

Calorific value due to current use of coal =
132,973 (coal usage amount (t)) × 26.6 (unit calorific value of coal (GJ/t)) = 353,702 GJ

CO_2 emissions due to current use of coal =
132,973 (coal usage amount (t)) × 26.6 (unit calorific value of coal (GJ/t)) × 0.0247 (CO_2 emissions coefficient of coal (t-CO_2/ GJ)) × 44/12=320,342 (t-CO_2)

CO2 emissions when using CNG to obtain the same calorific value＝
353,702 (GJ) × 0.0135（CO_2 emissions coefficient of LNG (t-CO_2/GJ)) × 44/12= 175,086 (t-CO_2)

Annual emissions reduction amount when introducing CNG=
320,342 (t-CO_2) - 175,086 (t-CO_2) = 145,256 (t-CO_2)

Based on the above, the introduction of CNG boilers is expected to result in an annual reduction of 145,256 t-CO_2. Considering the intended use of the facility, the boiler's useful life is deemed to correspond to "Reference Material No. 2: List of Calculation Formulas

[7] Calculated using LNG values from "Reference Material No. 2: List of Calculation Formulas and Emission Coefficients for Calculating Greenhouse Gas Emissions" published by the Ministry of Natural Resources and Environment.
https://www.env.go.jp/earth/ondanka/suishin_g/3rd_edition/ref2.pdf

and Emission Coefficients for Calculating Greenhouse Gas Emissions" applicable to heat supply equipment. Applying the set life of 17 years for this facility, the total emission reduction amounts to 2,469,352 t-CO_2.

The cost-effectiveness exceeds the upper limit of 2 billion yen set by the JCM Facility Subsidy Program. Since this is the second energy-saving project in Vietnam involving boiler fuel substitution, the subsidy cap is 40%. Going forward, careful consideration of these subsidy effects will be taken into account during the project cost estimation process.

2） Survey on possibility of introducing solar power generation systems

In regard to the possibility of introducing solar power generation systems, since last year we have been conducting a survey through the Ben Tre provincial government on the installation needs of companies in the province. During the field survey in February 2023, we received introductions from the Department of Industry and Trade (DOIT) to businesses that consume large amounts of energy. Through interviews with twelve companies within the province that are large consumers of energy, we identified the need to introduce solar power generation systems. We received inquiries from five companies. The details of the interviews with each company are shown below.

Table 2-8 Meetings with businesses with high needs for introducing solar power generation in Ben Tre Province

No	Company name	Industry	Scene of meeting
1	Vietcoco	Coconuts processing	
2	Betrimex	Coconuts processing	
3	Alliance One Apparel	Apparel	

4	Thang Cong	Steam supply	
5	Viet World	Coconuts processing	

According to the Ben Tre provincial government, many companies have already introduced solar power generation as an energy-saving measure. The five companies mentioned above with whom we have held individual consultations have extensive needs for improving power generation efficiency and installing additional facilities in new factories. We held individual discussions and interviews on the topics such as installation needs, scale of installation, and desired timing of installation. Based on the results of an interview with Advantech and aerial photos from Google Maps, we estimated the power generation capacity using the assumed area of the installation site. The following table shows the results of trial calculations.

Table 2-9 Results of visits to companies with needs to introduce solar power generation in Ben Tre Province (February 2023)

No	**Company name**	**Capacity (kW)**	Google map	Notes
1	VIETCOCO (coconuts processing company)	1,600	https://www.google.com/maps/@10.2683901,106.2812604,410m/data=!3m1!1e3?entry=ttu	Area of 20,000 m2 at time of meeting
2	BETRIMEX (trading company)	1,086	https://goo.gl/maps/gdSx7cFaMap8x24z9	

3	Alliance One (apparel manufacturing company)	3,894	https://goo.gl/maps/Rbp3b45cCCqDy98G7	
4	Thanh Cong (energy services)	248	https://goo.gl/maps/vpsr5WZpzemmUk8Q8	
5	VietWorld (coconuts processing company)	800	https://goo.gl/maps/M3W9wgjdVw5FY5Wy9	Roof area of 10,000 m2 for new factory at time of meeting
Total		7,628		

Furthermore, in November 2023, we once again visited sites with solar power generation to collect further information. The following table shows the results of Advantech's trial calculations of power generation capacity.

Table 2-10 Results of visits to a company with needs to introduce solar power generation in Ben Tre Province (November 2023)

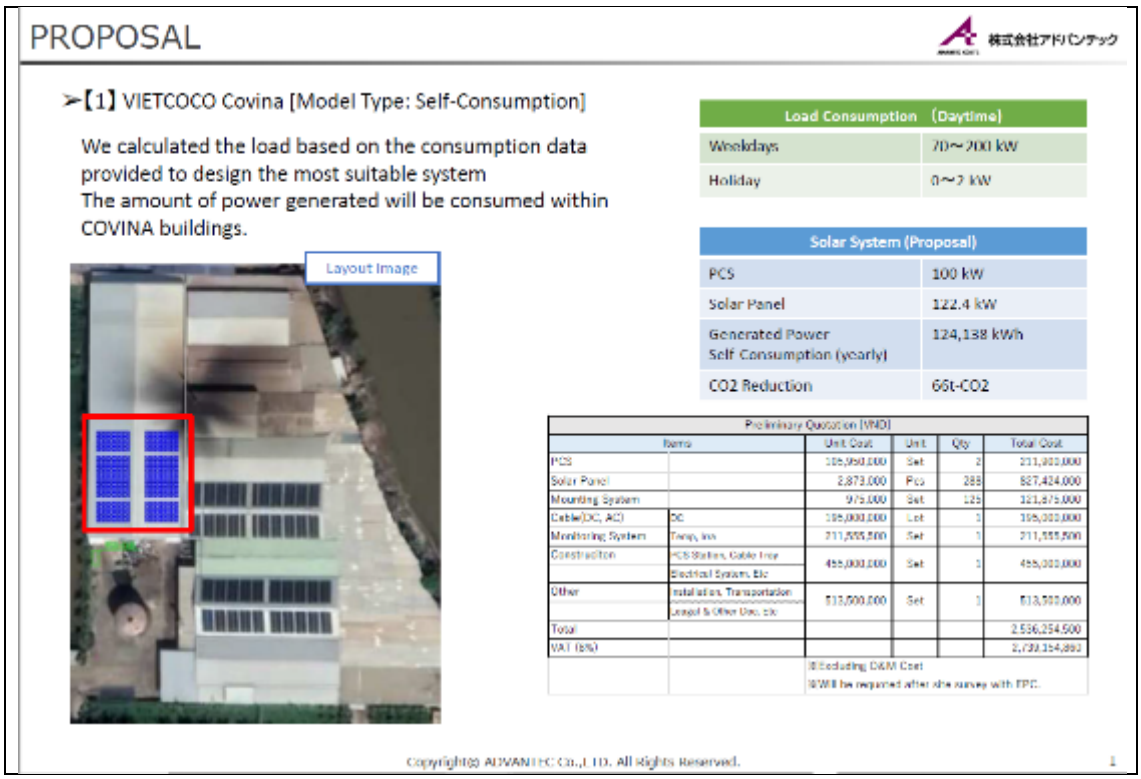
	Destination	Level of accuracy of introduction	Assumed installed capacity	Scheduled introduction period	Sales model	Remarks
1	**Vietcoco, Inc.** [Food Manufacturing Company]	high	1,000 kW	Fiscal Year 2024	clearance (Private consumption + electricity sales)	Proactive requests for detailed design
2	**TUFOCO, Inc.** [Food Manufacturing Company]	low	2,000-4,000kW	From FY2025 onward	clearance (Private consumption)	
3	**TC-ENERGY, Inc.** [Electric power generation company].	low	2,000-4,000kW	From FY2025 onward	clearance (Private consumption)	
4	**Son Ca Kindergarten**	middle	20kW	Fiscal Year 2024	PPA	Difficulty in cost due to private school

Based on the results of the aforementioned two on-site surveys in February and November 2023, we have started considering concrete implementation at VIETCOCO, which is considered to have a high probability of implementation. Therefore, we are considering the use of the JCM financing program for equipment through introduction of solar power generation to VIETCOCO, and have estimated the implementation effect and cost effectiveness as follows.

VIETCOCO is a food manufacturing company with a track record of exporting to Europe and America, and primarily handles processed coconut products. The company has a policy of working toward decarbonization and low carbonization in response to the needs of European and American companies, which are its customers, and showed a strong interest in the introduction of Advantech's solar power generation system from the beginning of discussions.

Advantech is currently proposing to VIETCOCO an energy management system (hereinafter referred to as “EMS”) that combines solar power generation and storage batteries. The power generation capacity and CO_2 reduction amount of this system is approximately 1,000 kW and 528 t-CO_2/year. Since the solar panel system has a lifespan of 17 years, the reduction in CO_2 emissions over the service life is approximately 9,000 t- CO_2.

As for the system’s cost-effectiveness, since the estimate is currently being reconsidered by Advantech, we will recalculate the scale of equipment costs eligible for subsidy based on the expected cost-effectiveness value (4,000 yen/t-CO_2) for the JCM equipment financing program equipment subsidy project. Multiplying the aforementioned reduction effect of 9,000 t-CO_2 by 4,000 yen results in 36 million yen. Since this is the second solar power generation facility in Vietnam, the maximum subsidy rate will be 30%. If this amount is rebated at 30%, the target cost will be approximately 120 million yen, so this study will examine the feasibility of a system that limits the scope of equipment eligible for the JCM financing program to approximately 120 million yen or less. The details of Advantech’s proposal to VIETCOCO are shown below (as of August 2023).



PROPOSAL

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➢【2】VIETCOCO Factory1 [Model Type: Self-Consunmption]

We calculated the load based on the consumption data provided to design the most suitable system.
The amount of power generated will be consumed within Factory 1 buildings.

Load Consumption (Daytime)	
Weekdays	175～500 kW
Holiday	0～41 kW

Solar System (Proposal)	
PCS	100 kW
Solar Panel	122.4 kW
Generated Power Self-Consumption (yearly)	112,110 kWh
CO2 Reduction	59t-CO2

Layout Image

Preliminary Quotation [VND]					
Items		Unit Cost	Unit	Qty	Total Cost
PCS		185,960,000	Set	2	211,920,000
Solar Panel		2,873,000	Pcs	288	827,424,000
Mounting System		975,000	Set	125	121,875,000
Cable(DC, AC)	DC	195,000,000	Lot	1	195,000,000
Monitoring System	Tems, Ins	211,555,500	Set	1	211,555,500
Construction	PCS Station, Cable Tray	455,000,000	Set	1	455,000,000
	Electrical System, Etc				
Other	Installation, Transportation	513,500,000	Set	1	513,500,000
	Legal & Other Doc, Etc				
Total					2,536,354,500
VAT (8%)					2,739,354,860
		※Excluding O&M Cost			
		※Will be requested after site survey with EPC.			

PROPOSAL

株式会社アドバンテック

➢【3】VIETCOCO Factory2 [Model Type: Self-Consunmption]

We calculated the load based on the consumption data provided to design the most suitable system.
The amount of power generated will be consumed within Factory 2 buildings.

Load Consumption (Daytime)	
Weekdays	265～441 kW
Holiday	59～188 kW

Solar System (Proposal)	
PCS	200 kW
Solar Panel	214.2 kW
Generated Power Self Consumption (yearly)	275,193 kWh
CO2 Reduction	146t-CO2

Layout Image

Preliminary Quotation [VND]					
Items		Unit Cost	Unit	Qty	Total Cost
PCS		105,950,000	Set	4	423,800,000
Solar Panel		2,873,000	Pcs	504	1,447,992,000
Mounting System		975,000	Set	225	219,375,000
Cable(DC, AC)	DC	307,125,000	Lot	1	307,125,000
Monitoring System	Tems, Ins	333,190,000	Set	1	333,190,000
Construction	PCS Station, Cable Tray	716,625,000	Set	1	716,625,000
	Electrical System, Etc				
Other	Installation, Transportation	808,767,500	Set	1	808,767,500
	Legal & Other Doc, Etc				
Total					4,356,869,500
VAT (8%)					4,697,419,060
		※Excluding O&M Cost			
		※Will be requested after site survey with EPC.			

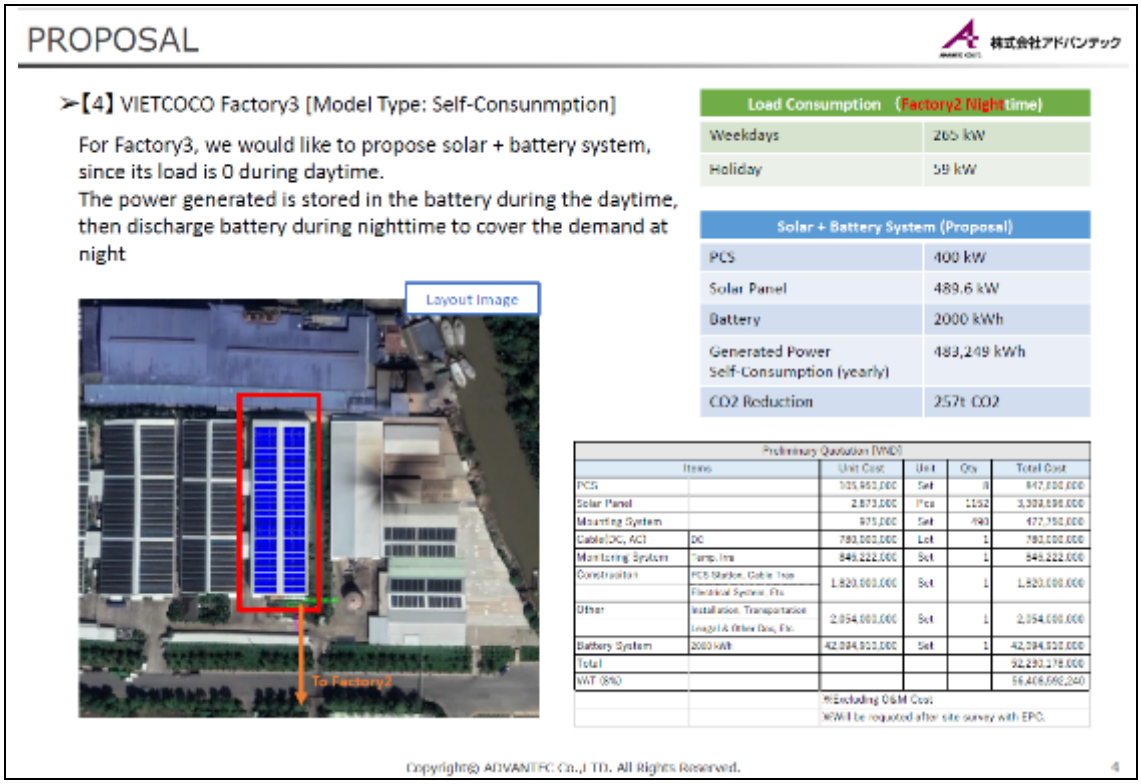

Figure 2-12　Overview of proposal to VIETCOCO by Advantech

We have agreed with VIETCOCO that we will proceed with the detailed design and final estimate after signing an NDA with VIETCOCO, presenting a provisional estimate, and conducting an on-site survey with the local EPC company. Furthermore, while continuing to exchange information regarding other candidate companies, we will also discuss the power source composition with the aim of achieving decarbonization in industrial parks, in consultation with the Ben Tre provincial government.

(3) Formulation of business model proposal

1） Renewable fuels as alternatives to fossil fuels

As mentioned above, by combining the boiler replacement technology of Miura Co., Ltd., a participant in this year's project, with the CNG supply network of Toho Gas, it is possible to build a low-carbon model using CNG gas.

While the possibility of introducing CNG is foreseeable, there are also anticipated challenges with LNG supply. One is that Vietnam does not have a fuel cost adjustment system, and there are concerns that costs will rise in the short term if there are sudden increases in the price of spot LNG. Another challenge is the lack of a clear legal framework for the construction, participation, and operation of LNG import terminals. Going forward, it will be necessary to hold on-site surveys to resolve these issues.

2） Solar power system

Currently, many JCM projects are being implemented by Japanese companies at their local subsidiaries or local factories. Since there are few Japanese companies operating in the Ben Tre Industrial Park, it is difficult to introduce solar power generation equipment through Japanese companies.

In order to expand JCM projects in the future, it is important that Japanese solar power generation equipment manufacturers introduce the equipment to local companies in Vietnam. By building such a scheme, it will be possible for businesses that manufacture Japanese solar power generation equipment to be deployed to local companies, thereby promoting a wider range of JCM projects than currently available.

In this project, Advantech will procure panels, etc., build a system to introduce solar power generation systems in cooperation with local EPC companies, and propose equipment installation to local companies that are not Japanese companies. Through these activities, we aim to expand the scheme discussed above. Furthermore, during interviews with local EPC operators, there was mention of the need for a local subsidiary related to the implementation of solar power generation projects. We plan to gather information on the above matters in conjunction with building a project implementation system.

2.2.2. Waste processing field

(1) Analysis of trends in related policies and systems

The foundation of Vietnam's environment-related policies and systems, including the waste treatment field, is the Law on Environmental Protection (No. 72/2020/QH14), which came into effect on January 1, 2022. This law has been enforced since 1994, and was amended and put into operation in November 2005 and June 2014. However, on November 17, 2020, the National Assembly of Vietnam passed a new Law on Environmental Protection, and, after amendments in 2014, the new law remains in effect today. The new law consists of 16 chapters and 171 articles, the structure of which is shown in the table below. As shown in Figure 2-12, Vietnam's laws and regulations consist of the constitution, laws, government ordinances, ministerial ordinances, and official letters.

Table 2-11 Overview of the Law on Environmental Protection in Vietnam (2020 revision)

Chapter 1	General	
Chapter 2	Protection of Environmental Components and Natural Heritage Sites	
	Section 1	Water Protection
	Section 2	Air Protection
	Section 3	Soil Protection
	Section 4	Natural Heritage Site Environment Protection
Chapter 3	Strategic Environmental Assessment, Environmental Impact Assessment and Environmental Licenses	
Chapter 4	Section 1	Strategic Environmental Assessment
	Section 2	Environmental Criteria for Investment Project Classification, Preliminary Environmental Impact Assessment
	Section 3	Environmental Impact Assessment
	Section 4	Environmental License
Chapter 5	Environmental Protection During Production, Business Operation and Service Provision; Environmental Protection in Some Fields	
	Section 1	Environmental Protection During Production, Business Operation and Service Provision
	Section 2	Urban and Rural Environmental Protection
	Section 3	Environmental Protection in Certain Fields
Chapter 6	**Waste Management and Control of Other Pollutants**	
	Section 1	**General Regulations on Waste Management**
	Section 2	**Domestic Solid Waste Management**
	Section 3	**Normal Industrial Solid Waste Management**
	Section 4	**Hazardous Waste Management**
	Section 5	**Wastewater Management**
	Section 6	**Management of Dusts, Exhaust Gases and Other Pollutants**
Chapter 7	Response to Climate Change	
Chapter 8	Environmental Technical Regulations and Environmental Standards	
Chapter 9	Environmental Monitoring, Environmental Information and Data and Environmental Reporting	
	Section 1	Environmental Monitoring
	Section 2	Information Systems and Environmental Database
	Section 3	Environmental Reporting
Chapter 10	Environmental Emergency Prevention and Response and Compensation for Environmental Damage	
	Section 1	Environmental Emergency Prevention and Response
	Section 2	Compensation for Environmental Damage
Chapter 11	Economic Instruments, Policies and Resources for Environmental Protection	
	Section 1	Economic Instruments for Environmental Protection
	Section 2	Policies to Provide Incentives and Assistance and Develop Environmental Economy
	Section 3	Resources for Environmental Protection

Chapter 12	International Integration and Cooperation in Environmental Protection
Chapter 13	Responsibilities of Vietnamese Fatherland Front, Socio-political Organizations, Socio-political-professional Organizations, Socio-professional Organizations and Residential Communities for Environmental Protection
Chapter 14	Environmental Screening, Inspection, Auditing, Penalties for Violations, Environmental Disputes, Complaints and Denunciations
Chapter 15	Responsibility for State Management of Environmental Protection
Chapter 16	Implementation Clause

Source: Created by JANUS based on the Law on Environmental Protection

Figure 2-13 System diagram of laws in Vietnam [8]

In the field of waste, Chapter 6 of the Law on Environmental Protection defines waste management and control of other pollutants. These requirements are divided into the six categories of 1) General Regulations on Waste Management, 2) Domestic Solid Waste Management, 3) Normal Industrial Solid Waste Management, 4) Hazardous Waste Management, 5) Wastewater Management, and 6) Management of Dusts, Exhaust Gases and Other Pollutants. Article 3 of Chapter 1 defines "waste" in Vietnam as follows.

- "Waste" means any matter in a solid, liquid or gaseous form or other form which is discharged from production, business operation, service provision or living activities or from other activities.
- "Solid waste" means any waste in a solid form or sludge.

8 JERO July 2018

https://www.jetro.go.jp/ext_images/_Reports/02/2018/fb58bdd9f9dd9980/vn201807.pdf

・“Hazardous waste” means any waste that exhibits any one or more of the following characteristic properties: toxicity, radioactivity, infectivity, ignitability, reactivity or corrosivity or exhibits any other hazardous characteristic properties.

Section 1 (General Regulations on Waste Management), Chapter 6 of the Law on Environmental Protection states the following in regard to reuse including fuel conversion.

“The State shall introduce a policy to encourage private sector involvement in collection, transport, reuse, recycling and treatment of waste and recovery of energy from the treatment of waste; apply advanced and environmentally-friendly technologies for waste management and best available techniques in order to minimize and control the generation of secondary waste, minimize solid waste ending up buried; encourage the co-processing of waste and use of waste as substitute materials, fuels and materials.”

From this description, it can be confirmed that Vietnam encourages the conversion of waste into fuel, which is being considered in this project.

The main changes between the revised Law on Environmental Protection and the former Law on Environmental Protection are as follows.[9]

・Requirement for sorting of general waste (categorization of waste into three types)
・Clarification of promotion for recycling measures
・Addition of definition of industrial waste sorting
・Clarification of promotion for recycling measures
・Addition of definition of hazardous waste

In the revised Law on Environmental Protection, a clause regarding plastics has been added to Article 73 “Reduction, reuse, recycling and treatment of plastic waste, prevention and control of ocean plastic waste pollution.”

1. Entities shall **reduce, classify** and dispose of waste that is single-use plastic products and non-biodegradable plastic packaging according to regulations; not discharge plastic waste directly into the systems for drainage of water to rivers, ponds, lakes, channels and oceans.
2. Plastic waste generated from marine tourism and services, maritime economy, extraction of oil and gas and marine mineral resources, aquaculture and commercial fishing must be **collected, stored and transferred to facilities licensed for recycling and treatment**.
3. Environmentally-friendly products, single-use plastic alternatives and non-biodegradable plastic packaging alternatives that have been certified are entitled to **incentives and assistance as prescribed by law**.

[9] Japan International Cooperation Agency “Information gathering and confirmation survey regarding urban environmental management project plan for Hanoi City, Vietnam (Urban Environmental Management) (2021)”

4. Plastic waste must be collected and sorted for reuse, recycling or processing in accordance with the law. Non-recyclable plastic waste must be processed by a business that has processing capabilities that comply with regulations. Plastic waste generated from economic activities at sea must be collected for **reuse, recycling or treatment** and must not be discharged into the sea.
5. The State shall encourage the **reuse and recycling of plastic waste** in service of production of goods and building materials and construction of traffic works; encourage the research and development of systems for collecting and treating plastic waste floating at sea and in the ocean; introduce policies to **promote reuse and recycling of plastic waste**.
6. Provincial People's Committees shall **organize** the collection and treatment of plastic waste within their provinces; **encourage** the reduction of non-biodegradable plastic packaging and single-use plastic products; **disseminate information** about harmful effects of dumping of fishing gear into the sea and plastic waste on the ecosystem.
7. The Government shall **introduce a roadmap** for reducing production and import of single-use plastic products, non-biodegradable plastic packaging and products and goods containing microplastics.

Source: Created by JANUS based on the Law on Environmental Protection

Article 73 provides incentives for the reduction of waste from single-use plastic products and non-biodegradable plastics, as well as for the proper collection, treatment, and alternative products of plastic waste resulting from marine economic activities. The duties of the People's Committee in each province are to conduct public awareness activities and formulate roadmaps.

A law related to waste management is the "Decision to Approve Adjustments to National Strategy for General Management of Solid Waste to 2025 With Vision Towards 2050" (Prime Minister Decision No. 491/QD-TTg; dated May 7, 2018). In order to minimize the amount of waste going to landfill by 2050, depending on the actual situation of each local government, the decision clearly states that each local government will strive to achieve the goal of "using advanced environmentally-friendly technology to collect, reuse, recycle, and dispose all types of solid waste. "The decision also states that local governments will promote private sector involvement and attract investment from private and foreign organizations in household solid waste management. Furthermore, the goal to be achieved by 2025 is that 90% of household solid waste generated in urban areas will be properly collected and processed, and then reused, recycled, or processed in combination with energy recovery or fertilizer.

On the other hand, when referring to the target value before the revision in 2009, the target value in 2020 for the collection, transportation, and treatment rate in urban areas is 90%. This indicates that no progress has been made in waste management measures from 2009 to 2018.

Table 2-12 Decision No. 2149/QD-TTg - Approving the National Strategy for Integrated Management of Solid Waste up to 2025, with a Vision to 2050 (2009)

	(Data) Item	2015	2020	2050
1	Rate of collection, transportation, and disposal in urban areas	85%	90%	100%
2	Recycling, energy recovery, and composting in item 1	65%	85%	90%
3	Collection, transportation, and disposal rate of construction waste	50%	80%	90%
4	Percentage of recycled use out of item 3	30%	50%	60%
5	Sludge collection rate in second-tier cities	30%	50%	100%
6	Sludge recovery rate in second-tier cities and below	10%	30%	50%
7	Percentage of plastic bags that are non-nylon	40%	60%	85%
8	Percentage of equipment installed at source of discharge	50%	80%	100%
9	Non-hazardous industrial waste collection and disposal rate	80%	90%	100%
10	9 Recycling rate	70%	75%	-
11	Hazardous industrial waste disposal rates in industrial parks	60%	70%	100%
12	Non-hazardous medical waste disposal rate	85%	100%	-
13	Hazardous medical waste disposal rate	70%	100%	-
14	Collection and disposal rates in rural residential areas	40%	70%	90%
15	Land appropriation of site of a landfill site that has already been issued an improvement order	100%	-	-

Source: Ministry of the Environment, Report on Feasibility Study on Programmatic CDM for Municipal Solid Waste Composting in Vietnam, March 2011 (Ichikawa Kankyo Engineering)

Furthermore, in regard to the marine plastic problem, which has been attracting worldwide attention in recent years, the “National Action Plan on Marine Plastic Debris Management” (Prime Minister's Decision No. 1746/QD-TTg) was issued in 2019. The goal is to reduce plastic waste entering the country by 75% by 2030, to completely eliminate single-use plastic products and non-biodegradable plastic bags in tourist areas, and to eliminate plastic waste from marine protected areas. Moreover, the aforementioned amendments to the Law on Environmental Protection stipulate appropriate disposal, including reuse and recycling, and clarify responsibilities regarding sorting and disposal.

Furthermore, Chapter 6 of the Law on Environmental Protection describes the use of waste energy. It also gives incentives for investment in waste power generation. Specifically, there is a provision under the FIT system (feed-in tariff system) that states that if a power generation company generates electricity using waste as fuel, the Vietnam Electricity Corporation (EVN) will purchase the entire amount of electricity for 20 years. The Prime Minister’s Decision on the FIT system for waste power generation (No.31/2014/QD-TTg) was established in 2014. The decision establishes a fixed price of 10.05 US cents/kW for direct combustion and 7.28 US cents/kWh for combustion gas collected from landfills. Other incentives include the following burden reductions:

Tax Benefits	・Reduction of corporate tax (20%) Years 1 to 4: 0%, Years 5 to 13: 5%, Years 14 and 15: 10% ・Import tax exemption for high-tech equipment (furnaces, boilers, generators, and turbines) (Article 15 and Article 16 of the Vietnamese Law on Investment) ・ Exemption from land usage fees for 11 years (No.35/2017/ND CP)

As a policy in regard to converting waste into fuel, the "policy of increasing the proportion of municipal waste used as an energy source to 20% in 2020, 70% in 2030, and 100% in 2050" was promulgated in November 2015 (No. 1) (No.2068/QD TTg). Looking at the related revision of the National Power Development Plan 7 in March 2016, it states that the "target value for biomass power generation, including solid waste power generation, has been set at 1% of the total power generation in 2020, 1.2% in 2025, and 2.1% in 2030" (revised PDP7, No.428/QD TTg). However, in PDP8 for 2023, the target value for biomass power generation was set as "0.82% in 2020, 1.5% in 2030, and 1.0% to 1.3% in 2050."

Due to such policy promotion and incentive systems, the introduction of waste power generation equipment is progressing. One example is a mixed incineration power generation project by JFE Engineering Corporation that processes 500 tons of general and industrial waste per day in Bac Ninh Province in northern Vietnam. The outline of the project is as follows.

Business system	A joint venture between Thuan Thanh, the largest waste processing company in northern Vietnam, and T&J Green Energy Co., Ltd. (Investment: TT 55%, JFE Engineering 45%)
Facilities overview	Stoker method: 500 tons/day (1 furnace, dry-type exhaust gas treatment) Power generation output: approx. 11.6MW (estimated annual power generation amount: 91,872 MWh)
Waste processed	General waste: Daily amount of 350t Industrial waste: Daily amount of 150t Total: Daily amount of 500t
Electricity sales	FIT application: 10.05 USD cents/kWh (paid in dong), fixed for a 20-year period
Funding	Japanese government subsidy: "Equipment Subsidy Project of Bilateral Credit System Financial Support Project" JCM Equipment Subsidy Project) Financing: Loans from the World Bank Group's International Finance Corporation (IFC) and the Finland-IFC Blended Finance for Climate Program
CO_2 reduction	Expected to reduce GHG emissions by approximately 600,000 tons over 15 years Reduction of methane generation from waste that was previously disposed of in landfills and reduction of GHG emissions by generating electricity without using fossil fuels (alternative to electricity)
Business period	Construction: January 2022 to January 2024 Operation: from February 2024 (20-year period)

From materials provided by JFE Engineering Corporation

(2) Basic survey on formulation of commercialization plan

1) Assessment of fuel conversion potential for waste plastics

As mentioned above, we confirmed that the conversion of waste into fuel, which will be studied in this project, is not currently subject to regulation and it is not within the context of waste power generation under the laws and systems related to waste management in Vietnam, and that investment is being recommended. This section summarizes the potential for converting waste into fuel based on the waste generation situation in Ben Tre Province.

① Situation of waste generation in Ben Tre Province

Ben Tre Province is faced with the challenge of processing increasing amounts of household garbage and industrial waste. According to the "Report on the Status of Waste Management and Processing in Ben Tre Province" dated March 5, 2023, which was sent by the Ben Tre Province People's Committee to the Ben Tre Province Party Committee, the amount of domestic waste and general waste generated per day in 2022 was 1,011 tons. The report estimates that this amount will increase to 1,815 tons by 2030 as the population increases. Currently, waste in Ben Tre Province is collected once every two days by government corporations in Ben Tre Province. According to the opinion of the Ben Tre provincial government, the majority of waste is collected (collection rate 94%) and disposed of in landfills. Collection is conducted by the service department of Ben Tre Province in areas where the amount collected is approximately 7 to 15 tons per day. In other areas, collection is contracted out to two private companies and the waste is disposed of in a local landfill. On the other hand, the processing capacity of the disposal site is a total of 419 tons per day, and the current situation is that disposal cannot keep pace with the amount of waste collected. Furthermore, the percentage of households that separate waste is extremely low, estimated at around 15% in 2022. In the suburbs, waste is basically disposed of by individual households. Although efforts are being made to collect waste that does not decompose naturally, the collection rate remains at 64% due to factors such as poor transportation.

The amount of industrial waste generated was approximately 200 tons in 2022, and is expected to increase to approximately 1,500 tons in 2030. Additionally, 10 to 12 tons of hazardous waste, including medical waste, was generated per day in 2022. Since there is no disposal site within Ben Tre Province, this industrial waste and hazardous waste are collected by businesses outside the province and transported to Ho Chi Minh City for processing.

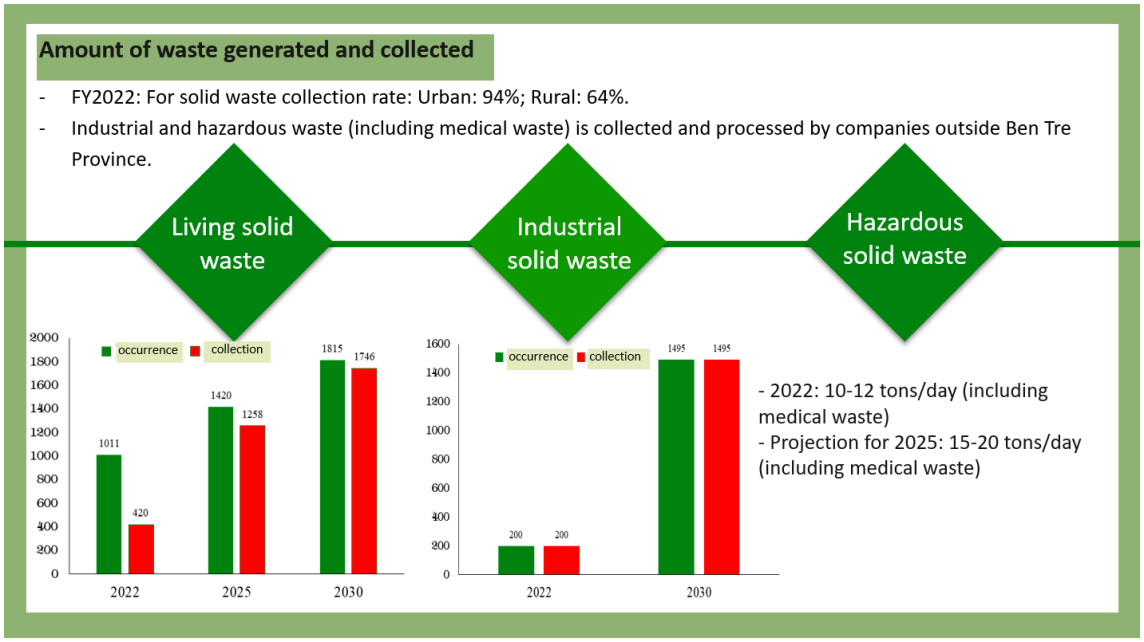

Figure 2-14 Waste generation amount and future trends in Ben Tre Province (provided by Ben Tre provincial government)

② Actual status of waste treatment in Ben Tre Province

The collected municipal solid waste is transported to the following seven disposal sites established in each district, and is disposed of in landfills at locations other than the disposal sites in Chau Thanh and Thanh Phu districts.

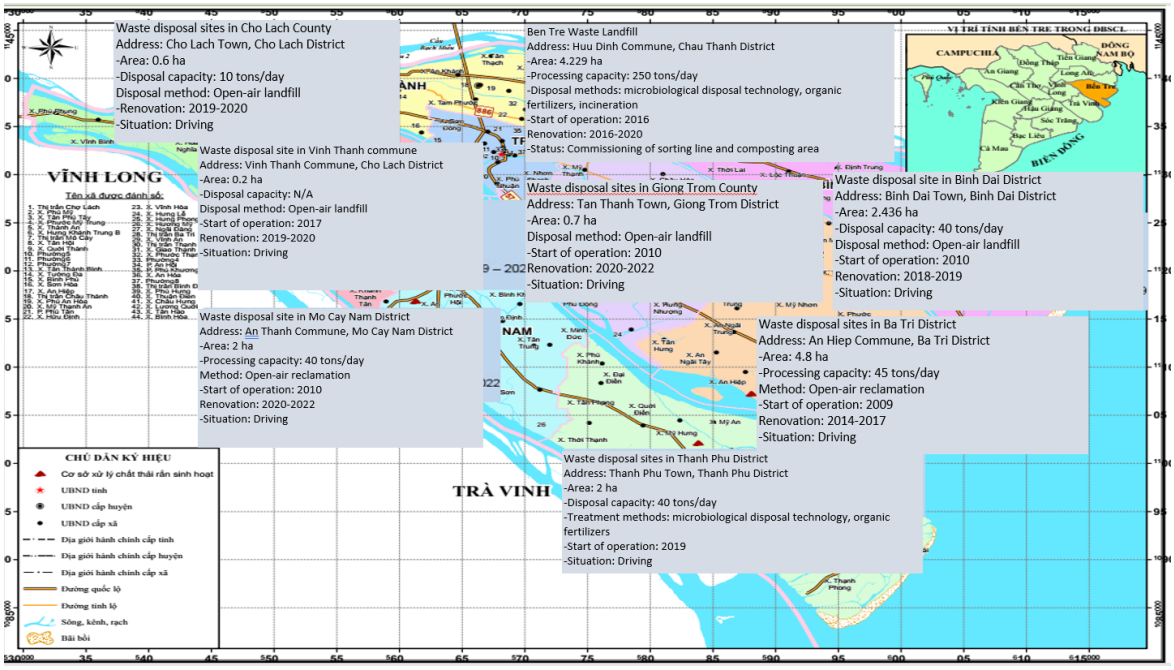

Figure 2-15 Overview of waste treatment sites in Ben Tre Province (provided by Ben Tre provincial

government)

On the other hand, the largest disposal site in Ben Tre Province (250 tons per day), located in Chau Thanh District, has previously solicited business rights from disposal companies, including foreign companies. Thai and Chinese companies have acquired business rights for power generation and installed incinerators and waste power generation equipment. However, the project did not proceed as expected, leading to withdrawal by these companies, and abandoned waste is now piling up at the site of the project. Currently, waste is simply disposed of in an adjacent landfill, but because it is not a controlled disposal site, it causes leachate and waste to disperse and run off.

Figure 2-16 Situation of disposal sites located in Chau Thanh District (photograph in November 2011)

As of December 2023, the above-mentioned disposal site is still not operating and conditions are quite serious. Disposal sites in other regions are also expected to cause similar environmental issues because are simple landfills.

③ Future waste management plan in Ben Tre Province

According to Decree No. 107/2020/ND-CP, which took effect on September 14, 2020, waste management was transferred from the Ministry of Construction to the Ministry of Natural Resources and Environment. However, reports indicate continued challenges in establishing systems and securing labor for waste management in each province.

The Ben Tre provincial government is also concerned about this situation and is currently planning the construction of additional waste disposal sites with an eye on 2030 and 2050. Details are shown below.

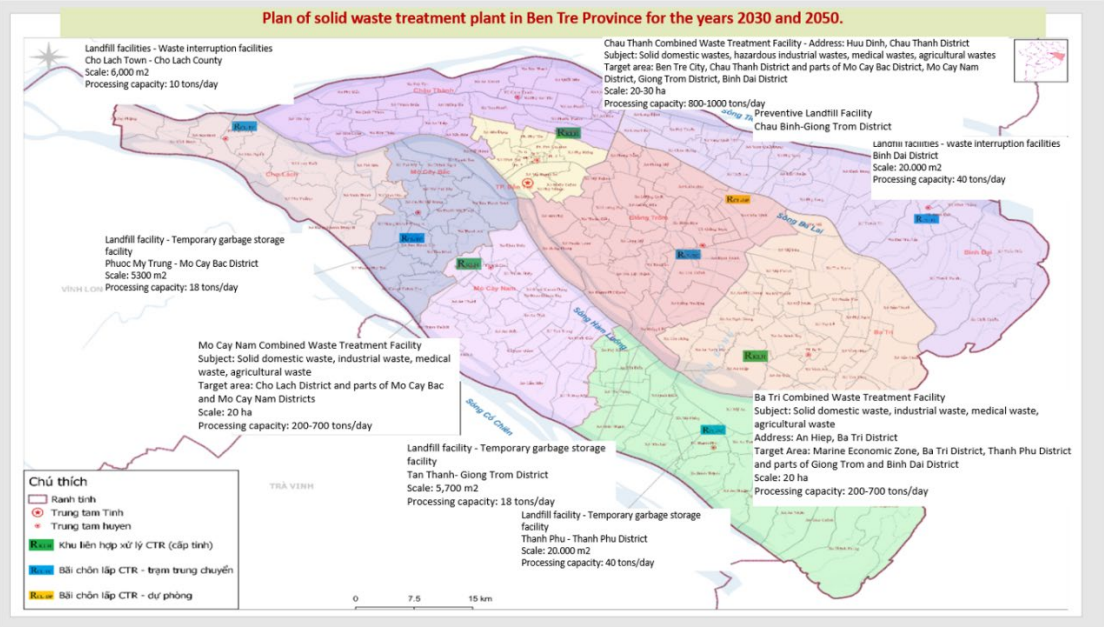

Figure 2-17 Construction plan for waste disposal sites (provided by the Ben Tre provincial government)

In a March 5, 2023 report addressed to the Ben Tre Province Party Committee on the situation of waste management and processing in Ben Tre Province, the following three investment plans have been established regarding waste management.

The plans call for “continuous improvement of waste management regulations and policies” in accordance with the development status of the province and current legislation. Also, in terms of “strengthening of waste management capacity,” the plans clearly state initiatives such as formulating and implementing construction plans for the aforementioned waste disposal sites in Ben Tre Province by 2026 at the latest. Additionally, as part of the “investment plan for waste treatment in Ben Tre Province,” the plans propose measures such as the outsourcing of waste treatment to the AMACAO Group, which is involved in the waste power generation and renewable energy businesses in Vietnam, and the introduction of waste power plants. Details of the plans are shown in the table below.

Table 2-13 Investment plan of the Ben Tre provincial government in regard to waste management

Field	Investment plan
Continuous improvement of waste management regulations and policies	・ Continue to improve the regulatory and policy system related to waste management in accordance with the development status of Ben Tre Province; for example, the formulation and promulgation of current laws and regulations such as solid waste management activities in Ben Tre Province and selection criteria for waste treatment investment business operators ・ Update guidebooks on waste collection/transportation and

	waste sorting at source, create guidebooks on waste management and priority regulations, support environmental protection activities (including waste management) within the province ・ Secure financial resources for environmental protection
Strengthening of waste management capacity	・ Formulate and immediately implement a plan to restart the waste disposal site in Ben Tre Province by 2026 and accept waste from within the province ・ Consider the application of standards and the selection of waste collection vehicles and transportation operators that meet environmental technical regulations; organize the conditions for proceeding with source sorting in accordance with the Law on Environmental Protection (2020 edition) ・ Establish a bidding system to select waste collection and transportation operators ・ Continue to strengthen public education on environmental protection and extensive waste management
Investment plan for waste treatment in Ben Tre Province	・ Outsource waste processing in Ben Tre Province to AMACAO Group Joint Stock Company ➢ AMACAO Group Joint Stock Company will reconstruct waste treatment sites (including energy-from-waste plants) ➢ Pricing for general waste disposal services: Agreed to a provisional price of $20.50 per ton of waste ➢ Total invested capital: 1.5 trillion VND (includes own capital and mobilized capital from other financial institutions) ➢ Project operation period: 50 years from June 2012 (same as the remaining period of the investment certificate). ➢ Implementation and completion period ✧ Q1/2023 - Q3/2024: Completion of investment legal procedures ✧ Q3/2024 - Q3/2026: Completion of construction ✧ Q4/2026: Start of plant operation ・ AMACAO Group Joint Stock Company requests the Ben Tre provincial government to provide approximately 500 tons of waste each day and night (approximately 1,000 tons per day)

While such plans exist, the introduction of a waste-to-energy plant requires large-scale investment, and recovery of that investment is expected to be difficult due to the scale of waste generated in Ben Tre Province and the unit processing cost. Therefore, measure through other methods would be effective.

Since waste is not sorted, it is assumed that material recycling, which requires sorting and cleaning, will be difficult from an economic standpoint. As with other emerging countries, taking some time to introduce waste sorting habits and establish appropriate collection systems is necessary in order to achieve the ideal of horizontal recycling.

Converting waste into fuel is an appropriate technology to address current issues. Organic waste

and plastic waste are crushed and kneaded to produce a fuel called RPF (Refuse derived Paper and plastics densified Fuel; hereinafter referred to as “RPF”), which can be used as an alternative fuel to coal.

RPF is a high-grade solid fuel that is mainly made from used paper and waste plastics, which are types of industrial waste that are difficult to recycle. In order to equalize the amount of heat used in manufacturing, it is necessary to adjust the ratio of organic waste to plastic waste, which requires a certain amount of sorting and adjustment. It is expected that sorting domestic waste will be costly. Therefore, this project will start with industrial waste, which can be collected with relatively uniform properties.

④ Actual situation of plastic waste in Ben Tre Province

Records are kept for the amount of plastic waste, which is the raw material for the above-mentioned RPF, generated in household general waste. According to 2023 data, the proportion of plastic waste is 7.9% of general waste, which is equivalent to 79.9 tons per day. On the other hand, there is no information on the amount of plastic waste among industrial waste.

This is because companies within the industrial park contract directly with waste collection companies outside the province, which collect waste and dispose of it in locations such as Ho Chi Minh City. As a result, the Ben Tre provincial government is unable to fully grasp the actual situation of waste. On the other hand, the Ben Tre provincial government is also summarizing information regarding recycling rates. It is clear that there are more than 100 plastic collection companies in Ben Tre Province, and we were able to confirm the existence of a recycling business in which these companies buy plastic waste from residents and companies, and then sell that plastic to recycling companies. The recycling rate is approximately 15% of plastic waste.

The Ben Tre provincial government plans to collect data on the actual situation of plastic waste generation by 2024 and announce a plan to reduce marine plastics by 2030. The provincial government has requested support from Ehime Prefecture in formulating the plan.

According to the action plan for plastic waste in Ben Tre Province from 2022 to 2025, the following three achievements have already been realized.

- Heightened awareness, changed behavior, etc., for residents and businesses
- Reduced plastic waste and usage amount
- Improved efficiency of cleaning activities and collection of plastic waste

These achievements have mainly focused on plastic waste from households. Interviews with the Ben Tre provincial government have revealed that plastic waste is dirty due to a lack of sorting at the source and that plastic waste is difficult to recycle. There are many issues related to household plastic

waste; for example, illegal dumping of marine plastics and pollution of the surrounding environment.

Basically, each company individually contracts with a collection and treatment company to process the industrial plastic waste generated from industrial parks. However, according to the "2022 Report on Implementation Results of the Ben Tre Province Action Plan to Solve Plastic Waste Issues," which was sent to the Ben Tre Province People's Committee by the Ben Tre Province Department of Natural Resources and Environment, illegal dumping of industrial plastic waste and violation of treatment rules are occurring. We envision that there will be issues in collecting and processing industrial plastic waste, similar to domestic plastic waste.

Figure 2-18 Discussion with the Department of Natural Resources and Environment of Ben Tre Province (September 26, 2023)

In industrial parks in Ben Tre Province, some companies are already working to produce fuel using plastic waste. However, due to the instability of the waste properties and the difficulty of handling, Ehime Prefecture is currently receiving requests for support.

The next section presents the results of interviews with businesses already engaged in RPF manufacturing in the aforementioned industrial parks.

⑤ Estimation of RPF manufacturing potential and introduction effect at industrial park in Ben Tre Province

The company for which we identified the need for RPF manufacturing is a Vietnamese company that collects waste at the aforementioned Giao Long Industrial Park. The company converts some of the collected waste into fuel and provides steam to surrounding companies. The company mutually owns shares with an adjacent corrugated board manufacturing business (Dong Hai Joint Stock Company of Ben Tre; hereinafter referred to as "DOHACO"), and receives approximately 95 tons (75 tons of plastic, 20 tons of pulp) of waste per day from DOHACO during the corrugated manufacturing process. This waste is homogenized by a shredder, and then manufactured into pellet-shaped RPF fuel,

which is used as fuel for a 40-ton steam production boiler. The steam is then supplied to six companies in the industrial park. The fuel ratio is generally 60% coal and 40% waste material (RPF)。 This ratio is changed depending on the needs of the end user. On the other hand, as mentioned above, due to the instability of waste characteristics and the difficulty of handling, there is a need to switch to more efficient RPF manufacturing technology. There are also plans for next year to construct a factory of the same scale and the same type of work in the adjacent semi-industrial area. Therefore, there is room to consider the introduction of new RPF manufacturing technology.

Figure 2-19 Discussion with Thanh Cong Energy Service Corporation (September 2023)

Figure 2-20 RPF manufacturing material

RPF generally mixes plastic waste and organic waste at a ratio of 6:4 and can be used as a fuel with a calorific value of 4,000 kcal/kg to 9,000 kcal/kg.[10] The amount of industrial waste handled by the company annually is 27,375 tons of plastic and 7,300 tons of organic waste such as pulp. Assuming

[10] National Industrial Waste Federation Recycling Promotion Committee (July 2010) "Basic survey results report on RPF production - Aiming to promote the production and use of RPF" https://www.zensanpairen.or.jp/wp/wp-content/themes/sanpai/assets/pdf/activities/report_RPF_22.pdf

that all organic waste can be used for fuel production, it is possible to produce approximately 50 tons of fuel per day x 365 days = 18,250 tons/year.

Currently, only coal is used as fuel for steam production boilers. Assuming the use of RPF as an alternative fuel to coal, the amount of CO_2 reduction can be estimated as follows.

Amount of CO_2 emissions reduction =
18,250 (RPF usage amount (t)) × 29.3 (RPF standard calorific value (MJ/kg)) × 0.0247 (coal CO_2 emission factor (tCO_2/GJ))[10] = approx. 13,200t-CO_2

Since RPF is made from fossil fuel-derived plastic, it emits fossil fuel-derived CO_2 when incinerated. According to the Japan RPF Industry Association, using RPF reduces CO_2 emissions by approximately 33% compared to coal in the process of recovering the same amount of heat during combustion. Therefore, here we assume that the RPF emission reduction is 33% of the approximately 13,200 t-CO_2/year calculated above. However, it should be noted that detailed consideration, including the development of methodology, is required in the future.

33% of 13,900 t- CO_2/year is approximately 4,360 t. If we use 15 years as the useful lifespan of "cooling, heating, ventilation, or boiler equipment" based on the ministerial ordinance regarding the useful life of depreciable assets, the amount of CO_2 emission reduction during the project period will be 65,400 t- CO_2.

In regard to cost-effectiveness, the scale of equipment costs to be subsidized will be calculated from the expected cost-effectiveness value (4,000 yen/t- CO_2) in the JCM equipment financing program based on the above CO_2 emission reduction amount. Multiplying 65,400 t- CO_2 by the cost-effectiveness of 4,000 yen/t- CO_2, the maximum subsidy amount based on this emission reduction amount is approximately 262 million yen. Since this is the first waste plastic fuel conversion facility in Vietnam, the upper limit of the subsidy rate is 50%. The project cost is approximately 523 million yen, with the repaid subsidy amount of 50% being approximately 262 million yen. Therefore, as a guideline for the cost of equipment eligible for the JCM equipment financing program, this study will examine the feasibility of creating a system that costs less than 523 million yen.

In Giao Long Industrial Park, an increasing number of end users are showing a strong interest in switching to RPF fuel. This interest is the result of soaring coal prices, movement toward decarbonization by local companies, and the Green Ben Tre Policy of the Ben Tre provincial government. In next year's project, we will introduce RPF manufacturing technology by a company in Ehime Prefecture as described in the next section, estimate the introduction effect based on the current waste characteristics and amount, and conduct an economic evaluation using the JCM equipment financing program. We hope that these efforts will lead to specific proposals.

2） Organizing candidate technologies, manufacturers, etc., for fuel conversion equipment

① Domestic paper industry and fuel manufacturers

Ehime Prefecture has a thriving paper manufacturing and paper processing industry centered on Shikokuchuo City, which has the largest concentration of paper manufacturing companies in Japan. Fuel manufacturing companies that use waste generated by paper manufacturing companies have been established in the prefecture.

Compared to other major industries such as non-ferrous metals, transportation machinery, petroleum/coal, and chemicals, the paper industry in Ehime Prefecture is dominated by SMEs. In addition to pulp producers and integrated paper manufacturers such as Daio Paper Corporation and Marusumi Paper Co., Ltd., there is also a wide variety of paper processing manufacturers are concentrated in the prefecture. Due to the distance from urban areas and high transportation costs, and because companies have been working to develop high value-added products from an early stage, companies in the region are able to manufacture all paper products except stamps and banknotes. The development of the paper industry in Ehime Prefecture has been further promoted by the presence of the Ehime Paper Industry Research Center, one of only four paper industry research centers in Japan, and the presence of testing and research institutions. [11]

The paper industry is an energy-intensive industry that requires a lot of heat and electricity for the cooking and drying processes in the manufacturing process. As such, the paper industry accounts for 6% of total industrial CO_2 emissions. After experiencing two oil shocks, the paper industry has promoted fuel conversion over the past 20 years, along with the introduction of energy-saving equipment and improvements to operating methods. [12]

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[11] "Regional agglomeration of pulp and paper industry" (Shigeru Suzuki, Matsuyama University) https://x.gd/6aoWG

[12] Shikokuchuo City Carbon Neutrality Council "Roadmap for Achieving Carbon Neutrality in Shikokuchuo City" (March 30, 2023) https://www.city.shikokuchuo.ehime.jp/uploaded/life/34190_54992_misc.pdf

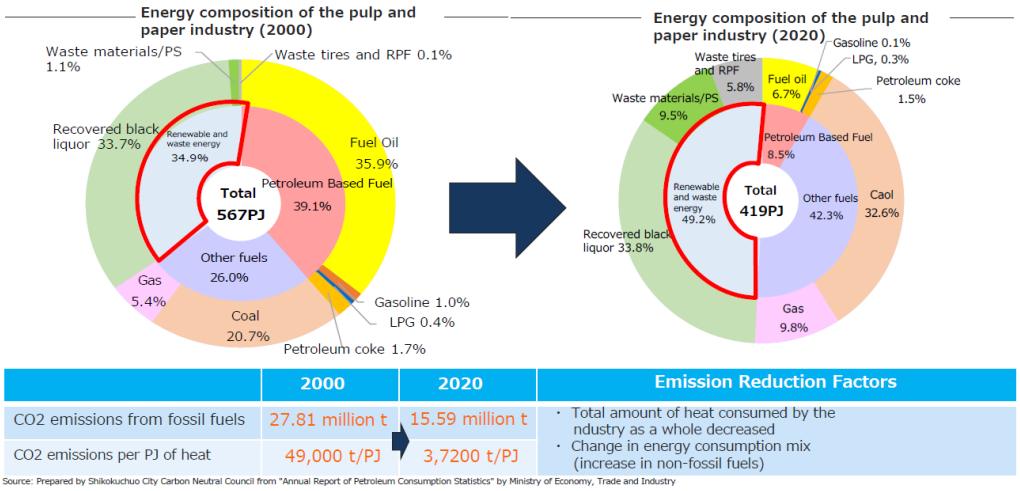

Figure 2-21 Changes in the energy composition of the paper industry from 2000 to 2020

Efforts to use waste as energy are developing along with the paper industry. From the perspective of effective resource use, the proportion of waste as energy is expected to maintain or increase in the future. According to the Japan RPF Industry Association, new RPF demand exceeding 400,000 tons is expected from 2023 to 2030, and the stable supply of venous resources including waste plastic will be an issue in Japan going forward. [13]

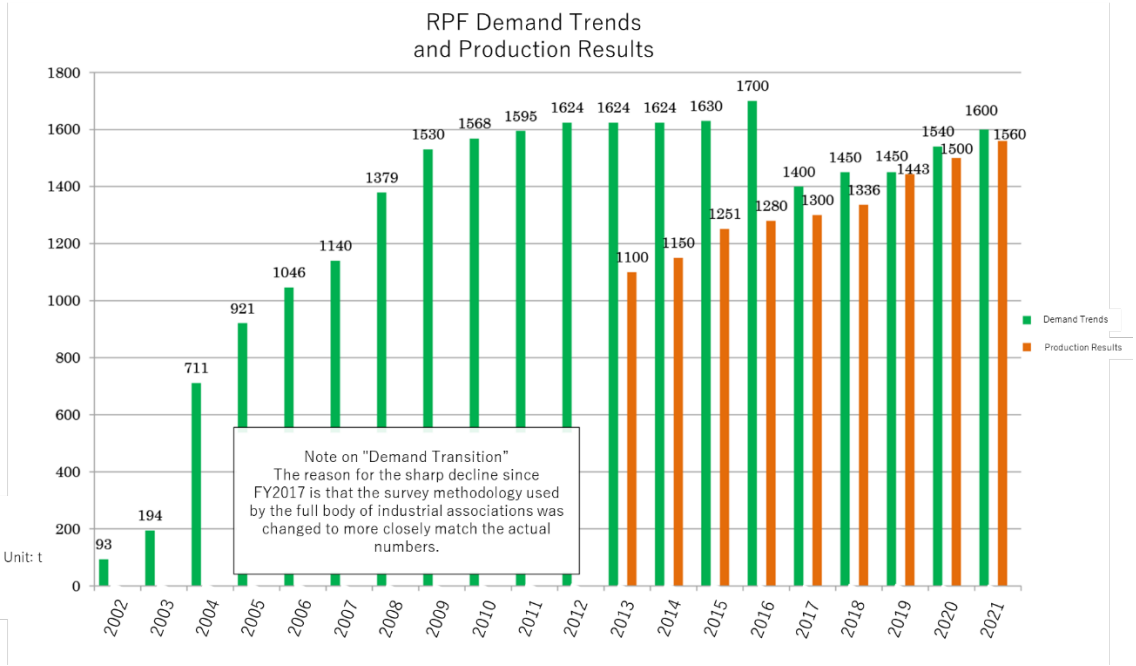

Figure 2-22 RPF demand trends and production results

[13] Japan RPF Industry Association website “RPF Demand Trends and Production Results” https://www.jrpf.gr.jp/rpf-1/rpf-6

From among the 80 full members of the Japan RPF Industry Association, the following three companies have their head office or factory in Ehime Prefecture.

Table 2-14 RPF manufacturing businesses in Ehime Prefecture that belongs to the Japan RPF Industry Association (full members only)

Company name	Address	Company website
EGS Co., Ltd.	3-1-39 Shindencho, Niihama City, Ehime Prefecture (head office)	https://egs21.co.jp/
Ebisu-Siryou Co., Ltd.	4087-3 Kawanoe-cho, Shikokuchuo City, Ehime Prefecture (factory)	https://ebisu-eco.co.jp/
Kaneshiro Shoji Co., Ltd.	10-7 Toiya-cho, Matsuyama City, Ehime Prefecture (head office)	http://www.kaneshiro.co.jp/

② Overview of candidate technology

RPF is an acronym for "Refuse derived Paper and plastics densified Fuel." It is a solid fuel made primarily from industrial waste, such as waste paper and waste plastics for which material recycling is difficult. The following seven characteristics of RPF are listed on the website of Ebisu-Siryou Co., Ltd. [14]

Table 2-15 Characteristics of RPF

Easy handling	・ RPF is solid and has high density, so it offers convenience at the same level of coke, pulverized coal, etc., and has excellent storage characteristics
Quality stability	・ Quality is stable because RFP uses industrial waste with a clarified generation history and selected general waste (conforming to classification standards) as raw materials
Controllable heat amount	・ Depending on the specifications of the boiler, etc., it is easy to change the amount of heat simply by changing the mixing ratio of waste paper and waste plastic
High calorie	・ Since RFP uses plastic, it has a high calorific value and can be used as a fossil fuel substitute comparable to coal and coke
Easily measures exhaust gas in combustion furnaces such as boilers	・ Quality is stable and there is little contamination due to impurities, so there is almost no boiler corrosion due to chlorine gas generation or dioxin generation ・ Generates a small amount of sulfur gas, so treatment of exhaust gas is easy
Economical compared to other fuels	・ The price is 1/3 to 1/2 that of coal and the ashing rate is less than 1/3 compared to coal, so ash processing costs can be reduced
Alternative to fossil fuels	・ Lower cost than fossil fuels, contributing to resource saving,

[14] Ebisu-Siryou Co., Ltd. website
https://ebisu-eco.co.jp/recycling/%e5%9b%ba%e5%bd%a2%e7%87%83%e6%96%99%ef%bc%88rpf%ef%bc%89%e3%81%ae%e8%a3%bd%e9%80%a0/

	energy saving, and CO_2 emission reduction

The waste paper and waste plastic used as raw materials are listed below. [15]

Table 2-16 Waste paper that can be sued as RPF materials

Used paper type	Classification
Special paper	Processed paper, laminated paper, paper containers, aluminum evaporated paper, thermal paper, carbon paper, release paper, OHP, sheets, photographs, window envelopes, non-woven fabrics (no macromolecular absorbents), bags of raw materials (powdery) (paper tubes are not acceptable), paper tubes
Roll paper	Paper cut-offs, films
Plain paper loss	Paper cuttings, films
Adhesive tape	Labels, stickers, tapes, etc.
Paper containers and packaging	Items conforming to classification standards under the Law for Promotion of Sorted Collection and Recycling of Containers and Packaging

[15] Soocheol Lee (November 2006) "Global Warming Countermeasures and RPF, a New Type of Waste Solid Fuel: Based on RPF Implementation in the Japanese Paper Industry" https://wwwbiz.meijo-u.ac.jp/SEBM/ronso/no7_3/08_LEE.pdf

Table 2-17 Waste plastics used as RPF materials

	Main raw material name	Possibility	Example
Thermoplastic resin	Polyethylene (PE)	○	Supermarket shopping bags, plastic tanks, mayonnaise bottles, packaging Aluminum film (packaging material), aluminum evaporated paper, laminate, electric wire coverings Containers for covering materials, chemicals, etc.
	Polypropylene (PP)	○	Buckets, cartons, packing straps, snack bags, pudding cups, and aluminum deposited paper
	Polyethylene terephthalate (PET)	○	PET bottles (containers for soft drinks and alcoholic beverages), photographic film, and Carpets, clothing, etc.
	Polycarbonate (PC)	○	AV equipment, copy machines, cell phone bodies, etc.
	Acrylic butadiene styrene (ABS)	○	Furniture parts, home appliances, auto parts, etc.
	Nylon	○	Synthetic fibers, packaging materials for retort pouch, fasteners
	Acrylic (esp. acrylic fiber, fiber)	○	Lenses, etc.
	Polystyrene (PS)	○	Fullboard trays, Styrofoam, plastic models, CD cases, etc. Aluminum vapor deposited paper, home appliance bodies, toy bodies, etc.
	Polyvinyl chloride (PVC)	×	Agricultural vinyl, human-made materials, human-made turf, electric wire coating, water pipes, etc. Full wrap films, component trays, egg cartons, rains, etc. coat
Thermosetting resin	Polyurethane	○	Sponges, soles, cushions, mattresses
	Unsaturated polyester resin (FRP)	×	Tubs, helmets, boats, fishing rods
	Phenol resin	×	Distribution board body, glass epoxy board

Waste paper and waste plastics received as raw materials are processed into RPF products through sorting, crushing, and molding processes. The raw materials used for RPF are clearly-sourced industrial waste and selected general waste. This creates the advantage of simplifying the manufacturing process by eliminating the need for pretreatment such as drying. An example of the RPF manufacturing flow of Japan Waste Co., Ltd., which accounts for 17% of the domestic RPF share, is shown below. [16]

[16] Brochure of Japan Waste Co., Ltd. https://japanwaste.jp/jw/wp-content/themes/japan-waste/pdf/company_3.pdf

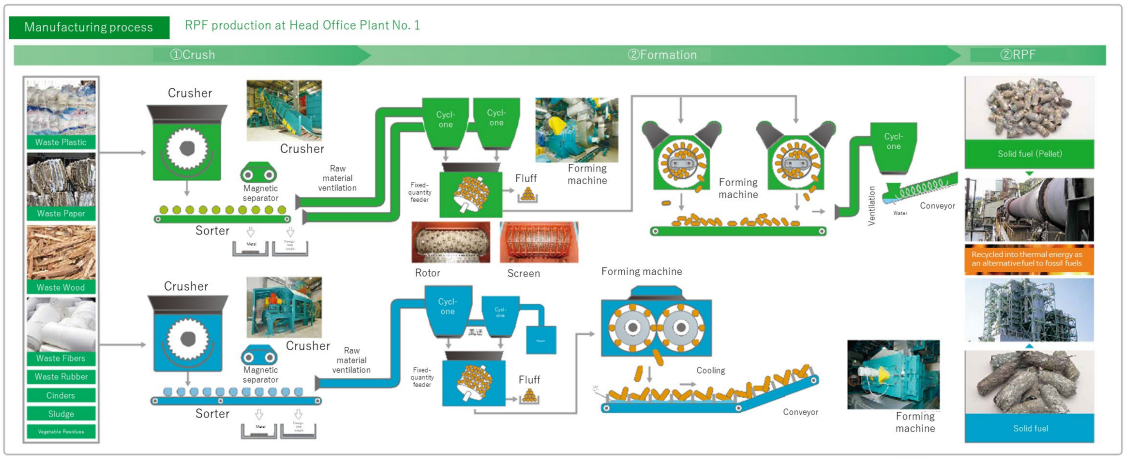

Figure 2-23 Manufacturing flow at Japan Waste Co., Ltd.

The quality of RPF is defined as shown in the following table by JIS Z7311:2010 “Refuse derived Paper and plastics densified Fuel (RPF).” [17]

Table 2-18 RPF quality

Quality/grade	RPF-coke *RPF with a high calorific value equivalent to coke	RPF *RPF with a high calorific value equivalent to coal			Measurement method
		A	B	C	
High calorific value MJ/kg	33 or lower	25 or higher	25 or higher	25 or higher	JIS Z7302-2
Moisture mass percentage (%)	3 or lower	5 or lower	5 or lower	5 or lower	JIS Z7302-3
Ash mass percentage (%)	5 or lower	10 or lower	10 or lower	10 or lower	JIS Z7302-4
Total chlorine mass percentage (%)	0.6 or lower	0.3 or lower	Greater than 0.3 and 0.6 or lower	Greater than 0.6 and 2.0 or lower	JIS Z7302-6

Since its founding, Ebisu-Siryou Co., Ltd., headquartered in Kagawa, has been working on material recycling of paper raw materials and plastics, and recycling such as converting those materials into solid fuel. The Ehime Plant, located in Shikokuchuo City, mainly collects industrial waste such as waste plastics and waste paper from the Shikoku region and sells it to surrounding paper manufacturers for RPF production as an alternative to coal. With the restarting of the Ehime Plant from March 2022,

[17] Japan RPF Industry Association website “Quality Standards” https://www.jrpf.gr.jp/rpf-1/rpf-4

the Ebisu Group's overall RPF production capacity is approximately 6,000 tons/month. The group's business activities are shown below. [18]

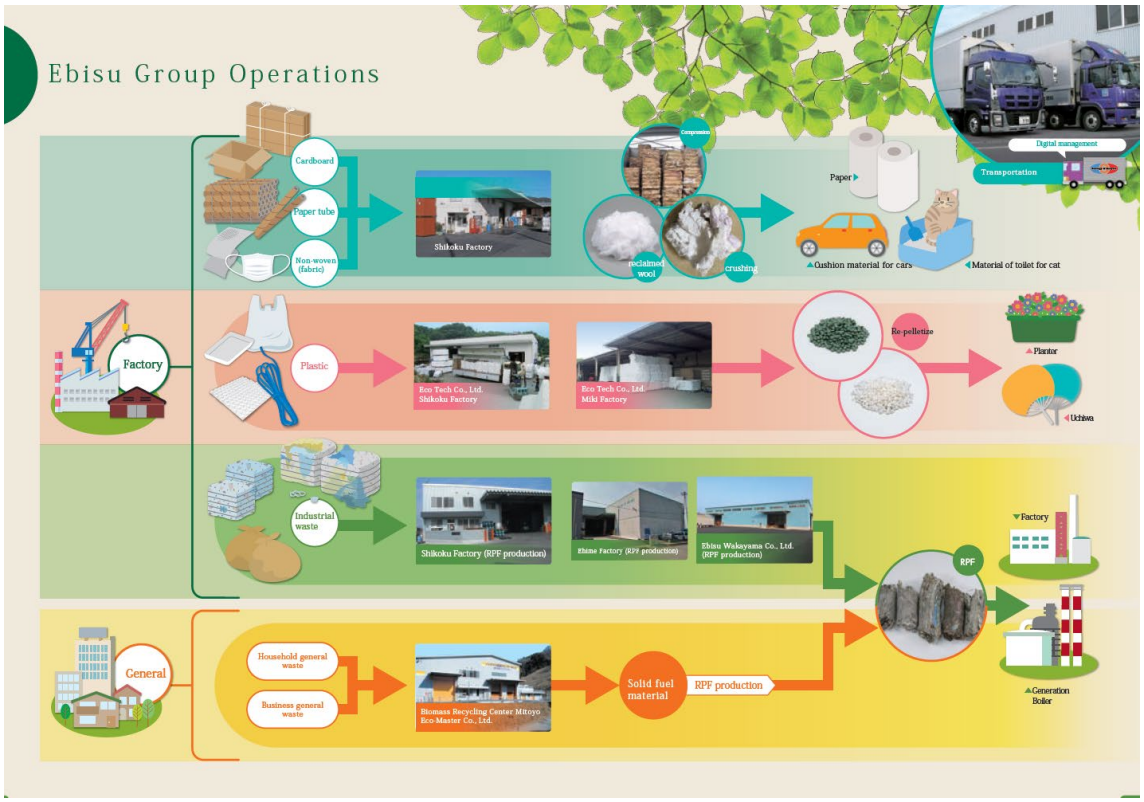

Figure 2-24 Overview of recycling business by Ebisu-Siryou Co., Ltd.

③ Review items for introducing technology in Ben Tre Province

When introducing equipment, it is necessary to clearly understand and set the requirements on the raw material side and fuel user side, reflect these requirements in the technical examination of the equipment, and verify the feasibility of introduction as a system. Requirements are considered for each of the three stages shown below.

- Raw materials (conditions for receiving waste)

When introducing equipment, receiving conditions are set by considering the actual state of waste treatment, process, and output. Conditions include the waste discharge status, Waste characteristics, identification of unsuitable materials, and collection form.

- Process conditions (design conditions for processing technology)

[18] Local SDGs Shikoku "Member Information: Ebisu-Siryou Co., Ltd." https://ls459.net/wp-content/uploads/2022/10/%E3%82%A8%E3%83%93%E3%82%B9%E7%B4%99%E6%96%99.pdf

These are the specific conditions necessary when designing equipment. These conditions determine the basic performance of equipment that satisfies input and output, and take into account regulatory standards and emergency response.

- Output (conditions for fuel usage)

These are the conditions required for using the RPF fuel produced as a result of processing. In addition to the quality and quantity required for fuel, there are also factors such as the method of transportation to the destination, the transportation route, and seasonal fluctuations in demand.

One input requirement is that a certain amount of sorting is required to adjust the ratio of organic waste to plastic waste in order to equalize the amount of heat used in manufacturing. If the raw material contains materials such as vinyl chloride or metals, those materials must be removed in a pretreatment process. The inclusion of chlorine creates the problem of corrosion of attached equipment such as boiler piping. Therefore, the necessity of chlorine removal depends on the output requirements (furnace type and presence/absence of desalination equipment).

The following table summarizes the specific contents of the aforementioned three stages of requirements as currently envisaged.

Table 2-19 Specific content of requirements for introducing equipment

Requirement classification	Details of requirement	
Input (conditions for receiving waste)	Waste discharge status	・ Amount of plastic/organic waste discharge ・ Emission characteristics (daily variation, seasonal variation, etc.) ・ Discharge source
	Waste characteristics	・ Plastic ➢ Composition and amount by material ➢ Presence or absence of vinyl chloride ➢ Degree of contamination, etc. ・ Organic waste ➢ Composition and amount by type ➢ Moisture content (%), etc. ・ Presence or absence of change in waste quality (seasonal change, etc.)
	Identification of materials unsuitable for processing	・ Type, contamination rate (%)
	Collection form	・ Collection method ・ Collection days/delivery days (t/week), annual delivery plan, etc.
Processing conditions (design conditions for processing	Location conditions of planned construction site	・ Distance from main emission source ・ Site area, topography, geology, climate conditions ・ Legal regulations, surrounding

technology)		environment, access ・ Status of electricity, water, etc.
	Processing capability	・ Processing capacity (t/day) ・ Number of working days per year (days/year) ・ Acceptance and storage facility capacity (response to maximum incoming volume)
	Operating time by process	・ Pre-processing, etc. (hrs/day)
	Pollution prevention standards, etc.	・ Regulatory standards ・ Presence of request criteria for surrounding residents, etc.
	Pre-processing	・ Need for pre-processing equipment and treatment method
	Use of processed products (recycled materials)	・ Product properties, amount generated, usage method, amount used ・ Processing of surplus product
	Disposal of unsuitable materials	・ How to dispose of materials (metals, etc.) that are unsuitable for processing
Output (fuel usage conditions)	Fuel usage	・ Power generation usage: power supply destination, power supply method, power supply capacity, power sales (power sales unit price, etc.) ・ Heat utilization: Utilization destination, conditions of use, amount of heat supplied, supply medium (hot water, steam)
	RPF fuel distribution	・ Channels, transportations routes, transportation methods, etc., for fuel sales

2.2.3. Wastewater treatment field

Ben Tre Province is one of the leading aquaculture industry areas in Vietnam. Aquaculture of shrimp and pangasius [19] is particularly popular. However, in recent years, with the expansion of the aquaculture industry, environmental pollution due to large amounts of wastewater and sludge discharged from aquaculture facilities has become a problem. The Ben Tre provincial government closely observing the situation while monitoring water quality. In terms of actual pollution countermeasures, improvement measures such as total volume control in public waters are expected. However, in order to implement effective regulations, it is necessary for each aquaculture facility to conduct individual wastewater management. However, the lack of knowledge on waste water management techniques at many small-scale aquaculture businesses causes environmental pollution due to untreated wastewater being released into the environment. The situation has reached the point where Ben Tre Province is requesting support. Based on these circumstances, we have decided to implement the following items for this fiscal year under the project.

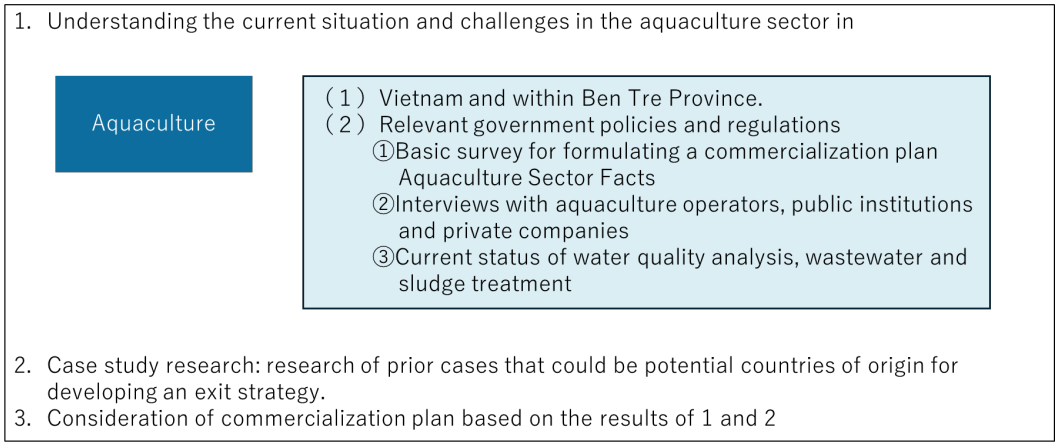

Figure 2-25 FY 2023 implementation items for environmentally-friendly aquaculture business

As shown above, we began by understanding the current situation and issues of the aquaculture field in Vietnam and Ben Tre Province. Specifically, we examined the state of government policies, laws, and regulations related to the environmentally-friendly aquaculture that is the goal of Ben Tre Province. We also gathered and organized information on issues such as wastewater and water pollution in the aquaculture field, as well as needs for water quality analysis. This process was done through desk research and interviews with local aquaculture farmers, public institutions, and private companies.

[19]Pangasius: A type of catfish (order Catfish, family Pangasius). In recent years, it has been farmed on a large scale, processed into fried white fish, and exported in large quantities to North America and Japan.

(1) Trend analysis for related policies and systems

The following section is a summary of policies for the agricultural field as set by Ben Tre Province in order to spread environmentally-friendly aquaculture, as well policies and systems related to processing of waste such as wastewater, sludge, and other wastes that pose a problem in the aquaculture field, and related to water quality analysis required in conjunction with said waste processing.

1） Policies in aquaculture section of Ben Tre Province

Ben Tre Province announced Program No. 08-CTr/TU at the Party Congress in 2021. The program is titled "Vision 2030: A Program for Development of Main Industries and Enterprise Power in Ben Tre Province from 2020 to 2025." In addition to identifying the main industries of the coconut production and processing industry, the fisheries processing and production industry, supporting industries, and renewable energy, it also sets the goal of fostering approximately 5,000 new businesses, including 100 leading businesses. Table 2-1 shows the current status and issues of the fisheries sector mentioned in this program.

Table 2-20 Current status and issues of aquaculture as stated in No. 08-CTr/TU

Achievement status	✓ Aquaculture area: 45,000 ha ✓ Total production: 500,000 t/year ✓ Seafood processors: 38 companies
Issues	✓ Industry is in a developing stage ✓ Lack of large seafood companies ✓ Aquaculture industry is small-scale with limited spread of advanced technology ✓ Lack of fishing technology and preservation technology ✓ Does not meet requirements for food export
Causes	✓ Lack of focus on technology development and technology transfer for aquaculture ✓ No robust policies in place to support aquaculture businesses
Forecast	✓ Develop the aquaculture industry and expand the area, focusing on shrimp and pangasius production that complies with European and American standards

Table 2-21 shows targets for 2025 and 2030 in the aquaculture industry.

Table 2-21 2025 and 2030 aquaculture industry targets as stated in No. 08-CTr/TU

2025 targets	✓ Average annual growth rate of export value of 72.64%, approximately 1.2 billion dollars
2030 targets	✓ Average annual growth rate of export value of 15.81%, approximately 2.5 billion dollars
Tasks for achieving targets	✓ Attract investment projects for large-scale export seafood processing in the shrimp processing industry ✓ By 2025, establish large-scale high-tech shrimp

	aquaculture areas utilizing the latest technology and aquaculture methods in Thanh Phu, Binh Dai, and Ba Tri provinces ✓ Aim for a total area of 4,000 ha or more for high-tech shrimp aquaculture

To summarize the above, the Ben Tre provincial government has set the policy of increasing production volume and export value by conducting efficient production through the spread of high-tech promoting efficient production by promoting high-tech shrimp aquaculture that incorporates cutting-edge technology. The use of technology is necessary because it is becoming impossible to expect any further increase in production through expansion of aquaculture area.

On the other hand, with the expansion of shrimp aquaculture, the spread of diseases has become a problem in recent years. Acute hepatopancreatic necrosis disease (AHPND) in shrimp, also known as early mortality syndrome (EMS), was confirmed in Vietnam in 2010. In 2012, it spread to approximately 39,000 ha of shrimp aquaculture facilities in the Mekong Delta basin, and 50% of released shrimp were affected. This resulted in a huge extinction loss. [20] The epidemic is still ongoing. According to the Ben Tre Department of Agriculture and Rural Development, more than 700 hectares of shrimp aquaculture facilities will be affected by the epidemic in 2023. [21] The aquaculture facilities where the disease occurred are discharging contaminated water and untreated sludge. This leads to secondary damage such as contamination of aquaculture ponds in tributaries. In order to respond to this situation, the Ben Tre provincial government conducts environmental monitoring of surface waters such as rivers, takes measures such as predicting the occurrence of disease and issuing warnings, and conducts water quality tests in fish aquaculture facilities to prevent damage and stop the spread of environmental pollution. The following section summarizes the laws and testing standards that form the basis for environmental monitoring and water quality testing at aquaculture facilities.

2） Law on Environmental Protection

The basis of policies and systems related to water environment protection in Vietnam is the Law on Environmental Protection (Law No. 72/2020/QH14), which came into effect on January 1, 2022. Article 7 “General regulations on surface water protection” states the following.

Article 7　General regulations on surface water protection 1. Quality of surface water, sediments and aquatic environment must be monitored and evaluated; surface water carrying capacity must be calculated, determined and announced. 2. Sources of waste discharged into surface water must be managed in a manner that is appropriate

[20] To et al. (2020) https://www.mdpi.com/2079-7737/9/10/312

[21] Nongnghiep.vn：https://vietnamagriculture.nongnghiep.vn/diseases-in-farmed-shrimp-in-the-mekong-delta-are-complicated-d370277.html

to intended use and carrying capacity of surface water. Result of appraisal of the environmental impact assessment report shall not be approved for or environmental license shall not be issued to the new investment project that discharges wastewater directly into the surface water that has reached its carrying capacity as announced by a competent authority, except for the case in which the investment project owner has adopted a scheme to treat wastewater in accordance with technical regulation on environment regarding quality of surface water before discharging it into a water body or has adopted a circulation or recycling scheme in order not to generate more wastewater or the case where the project aims to deal with pollution and improve quality of the environment in a pollution area.
3. River water shall be protected by applying the principles of integrated river basin management and associated with biodiversity conservation, aquatic environment protection, management of water source protection corridors, and reasonable extraction and use of water.

Article 8 "Surface water protection activities" states the following.

Article 8 Surface water protection activities
1. Surface water protection shall focus on:
a) Statistically reporting, assessing, minimizing and treating wastewater discharged into surface water;
b) Monitoring and assessing quality of surface water, sediment and aquatic environment and publishing information in service of management, extraction and use of water surface;
c) Investigating and assessing carrying capacity of surface water; announcing areas where the surface water has reached its carrying capacity; assessing quotas for discharge of wastewater into the surface water;
d) Eliminating pollution, remediating and improving polluted surface water;
e) Monitoring and assessing quality of surface water and sediments of international rivers and sharing information in accordance with regulations of law on environmental protection, law and international practice.

Article 8 defines the responsibility of the Ministry of Natural Resources and Environment and People's Committees as follows.

2. The Ministry of Natural Resources and Environment has the responsibility to:

a) provide guidance on assessing surface water carrying capacity of rivers and lakes; provide guidance on assessing surface water quality;

b) organize assessment of surface water and sediment quality, surface water carrying capacity of inter-provincial rivers and lakes; organize inventorying and assessment of waste sources and pollution level, and organize elimination of inter-provincial river and lake pollution; formulate and submit to the Government a surface water quality management plan for inter-provincial rivers and lakes that play a key role in socio-economic development and environmental protection;

c) inspect the implementation of the surface water quality management plan for inter-provincial rivers and lakes and measures to prevent and mitigate water pollution and improve water quality in inter-provincial rivers and lakes.

3. People's Committees have the responsibility to:

a) determine provincial rivers and lakes and other surface water sources in areas that play important role in socio-economic development and environmental protection; determine

domestic water safeguard zones and water source protection corridors within provinces; determine aquatic areas;

b) publish information about sources of waste discharged into the surface water within provinces; collect information and data on state of surface water, waste sources and total amount of waste discharged into surface water in inter-provincial rivers and lakes within provinces under the guidance of the Ministry of Natural Resources and Environment; direct organizations to assess damage caused by pollution and remediate surface water pollution within provinces as prescribed;

c) prevent and control sources of waste discharged into surface water sources within provinces; take measures to prevent and minimize surface water pollution, improve surface water quality within provinces according to the surface water quality management plan; d) organize assessment of surface water and sediment quality, carrying capacity and quotas for discharge of wastewater with respect to the surface water sources mentioned in Point a of this Clause; publish information about areas where surface water has reached its carrying capacity;

e) promulgate and organize the implementation of the plan for management of quality of surface water mentioned in Point a of this Clause; organize implementation of the surface water quality management plan for inter-provincial rivers and lakes within provinces.

Article 61 “Environmental protection in agricultural production” states the following.

Article 61. Environmental protection in agricultural production
1. Every entity that produces, imports, sells and/or uses chemicals, agrochemicals, veterinary drugs and fertilizers must comply with regulations of law on environmental protection regulations and other relevant regulations of law.
2. It is required to register, inventory, control, manage information about, assess and manage risks and handle chemicals, agrochemicals and veterinary drugs that are highly toxic, persist, spread and accumulate in the environment resulting in adverse impacts on environment and human health.
3. Expired fertilizers, environmental remediation products in livestock production, agrochemicals, veterinary drugs, aquaculture feeds and environmental remediation products in aquaculture must be managed in accordance with relevant regulations of law. Containers of fertilizers, animal feeds, aquaculture feeds, agrochemicals, veterinary drugs, environmental remediation products in aquaculture and products for livestock waste treatment after use, and sludge and feeds accumulated after cleaning of aquaculture ponds must be managed in accordance with waste management regulations. Sludge dredged from channels and hydraulic structures must be collected, reused, recycled and managed as prescribed by law. Dead animals must be collected and dealt with in accordance with regulations on hazardous waste management and preventive medicine.
4. Agricultural by-products must be collected to manufacture products and goods, used as raw materials and fuels, used for production of fertilizers and energy or managed as prescribed; by-products of plants must not be burned in the open air to avoid causing environmental pollution.
5. The use of livestock waste as organic fertilizers or for plant watering or for other purposes must comply with the Government’s regulations.
6. The State shall introduce policies to encourage innovation of models and methods for agricultural production in a sustainable and climate-resilient manner that saves water and restricts the use of inorganic fertilizers, agrochemicals and environmental remediation products in agriculture; develop environmentally-friendly agriculture models.

Article 61 defines the responsibility of the Ministry of Agriculture and Rural Development as follows.

7. The Ministry of Agriculture and Rural Development shall direct and organize management of sludge dredged from channels and hydraulic structures in compliance with environmental protection requirements.

Furthermore, Article 72 "Waste management requirements" states the following in regard to the waste management regulations stated in Article 61, Paragraph 3 "…sludge and feeds accumulated after cleaning of aquaculture ponds must be managed in accordance with waste management regulations."

2. General requirements for waste management are as follows: a) Wastewater must be collected and treated according to technical regulations on environment before being discharged into the receiving bodies; b) It is advisable to reuse wastewater that satisfies environmental protection requirements and serves intended purposes; c) Wastewater whose environmental parameters exceed the permissible levels must be managed in accordance with hazardous waste management; d) The discharge of treated wastewater into the environment must be managed in accordance with regulations of law on environmental protection and relevant to the carrying capacity of receiving water bodies;

Article 97 "Environmental technical regulations" states the following in regard to national technical standards (QCVN) when conducting environmental monitoring (the following is an excerpt of related items).

1. Environmental technical regulations on ambient environment quality, including: b) Environmental technical regulations on surface water, groundwater and seawater quality; 2. Environmental technical regulations on waste, including: a) Environmental technical regulations on wastewater; 3. Environmental technical regulations on waste management, including: a) Environmental technical regulations on hazardous waste;

Based on the above, the scope of environmental protection laws in the aquaculture field can be broadly classified into two categories, each of which is managed by different administrative agencies.

(1) Surface water such as external rivers connected to fisheries (Ministry of Natural Resources and Environment [MONRE]/Ben Tre Province Department of Natural Resources and Environment [DONRE])
(2) Aquaculture water and sludge from aquaculture facilities (Ministry of Agriculture and Rural Development [MARD]/Ben Tre Province Department of Agriculture and Rural Development [DARD])

Regarding (1) above, monitoring methods, etc., are stipulated in No.10/2021/TT-BTNMT.

Circular on providing for environmental monitoring techniques and management of environmental quality monitoring information and data (No.10/2021/TT-BTNMT)

- No.10/2021/TT-BTNMT, which was issued by the Ministry of Natural Resources and Environment (MONRE) in 2021, states the following for environmental monitoring technology and the management of environmental quality monitoring information and data. No.10/2021/TT-BTNMT is attached in the appendix as reference material.

  - ✓ Implementation of periodic quality monitoring for surface water

    Article 8 "Monitoring of surface water quality" in Chapter 2 "Periodic environmental monitoring technology" requires periodic environmental monitoring of surface water such as rivers.

Article 8 Monitoring of surface water quality 1. Parameters and methods for surface water quality monitoring are specified in Appendix 2.2. Other parameters are specified in national technical regulations on surface water quality or required by environmental quality monitoring programs. 2. The national environmental quality monitoring program and environmental quality monitoring program of provinces and centrally affiliated cities should at least monitor the following parameters: pH, TSS, DO, COD, BOD5, NH^{4+}, total nitrogen or NO^{3-}, total phosphorous or PO_4^{3-}, and total coliforms. Monitoring should be conducted at least every two months (6 times/year). Depending on the purpose of the monitoring program and the characteristics of the monitoring location, other parameters may need to be selected and included in the monitoring program in order to achieve monitoring at an appropriate frequency.

Aquaculture water used in aquaculture facilities and sludge generated in those facilities are under the jurisdiction of the Ministry of Agriculture and Rural Development (MARD). The National Technical Standards for water quality analysis are shown below.

3） National Technical Standards for water quality analysis of aquaculture water in aquaculture facilities

- ✓ National Technical Standards on shrimp aquaculture facilities (QCVN02-19:2014/BNNPTNT)

  These standards place the following regulations on water supplied to ponds, wastewater discharged from ponds, and waste.

2.3.1.2 The quality of water supplied to the pond must satisfy the parameter values specified in Table 1 of Appendix 1. 2.4.1 Water from wastewater treatment ponds may be discharged into the surrounding environment

only if the parameter values specified in Table 2 of Appendix 1 are satisfied.

Table 1 of Appendix 1 from 2.3.1.2 is shown below.

Table 2-22 Water quality of black tiger and whiteleg shrimp culture ponds and aquaculture water supplied to the culture ponds

No.	Parameter	Unit	Allowable level
1	Dissolved Oxygen (DO)	mg/l	≥ 3.5
2	pH		7 - 9, the daily fluctuation is not more than 0.5
3	Salinity	s	5 ÷ 35
4	Alkalinity	mg/L	60 ÷ 180
5	Clarity	cm	20 ÷ 50
6	NH_3	mg/l	< 0.3
7	H_2S	mg/l	< 0.05
8	Temperature	°C	18 ÷ 33

Table 2 of Appendix 1 from in 2.4.1 is shown below.

Table 2-23 Water quality in wastewater treatment ponds before being discharged into the external environment

No.	Parameter	Unit	Allowable level
1	pH		5.5 - 9
2	BOD_5 (20°C)	mg/l	≤ 50
3	COD	mg/l	≤ 150
4	Floating solids	mg/l	≤ 100
5	Coliform	MPN/100ml	≤ 5,000

- ✓ National Technical Standards for Pangasius Aquaculture Facilities (QCVN02-20:2014/BNNPTNT)

These standards place the following regulations on water supplied to ponds, wastewater discharged from ponds, and waste.

2.3.1.2 The quality of water supplied to the pond must satisfy the parameter values specified in Table 1 of Appendix 1.

2.4.1 Water from wastewater treatment ponds may be discharged into the surrounding environment only if the parameter values specified in Table 2 of Appendix 1 are satisfied.

Table 1 of Appendix 1 from 2.3.1.2 is shown below.

Table 2-24 Pangasius aquaculture pond and aquaculture water quality supplied to the pond

No.	Parameter	Unit	Allowable level
1	Dissolved Oxygen (DO)	mg/l	2.0
2	pH		7 - 9
3	Alkalinity	mg $CaCO_3$ /l	60 ÷ 180
4	NH_3	mg/l	≤ 0.3
5	H_2S	mg/l	≤ 0.05
6	Temperature	°C	25 ÷ 32

Table 2 of Appendix 1 from in 2.4.1 is shown below.

Table 2-25 Water quality in wastewater treatment ponds before being discharged into the external environment

No.	Parameter	Unit	Allowable level
1	pH		5.5 - 9
2	BOD_5 (20°C)	mg/l	≤ 50
3	COD	mg/l	≤ 150
4	Floating solids	mg/l	≤ 100
5	Coliform	MPN/100ml	≤ 5,000

- Compatibility of Vietnamese standards (TCVN) and Japanese standards (JIS)

  One thing to keep in mind when introducing Japanese water quality analysis technology to Vietnam is that the standards serving as a basis for analysis are different. Monitoring and analysis methods in Vietnam are set based on the USEPA. There is a possibility that the technology built based on Japan's domestic standard JIS will not comply with local standards. Therefore, compatibility must be checked when introducing Japanese technology.

(2) Basic survey on formulation of commercialization plan

1） Assessment of potential for introducing water quality analysis technology

In order to understand the issues and water quality analysis needs of the aquaculture industry in Ben Tre Province, we started by conducting a survey of the actual situation in the local aquaculture field.

① Survey on situation of aquaculture in Ben Tre Province

The following is a summary of the current status of aquaculture in Vietnam and Ben Tre Province based on statistical data.

- ✓ Comparison with global aquaculture

In regard to the scale of Vietnam's aquaculture industry compared to the rest of the world, according to the 2019 White Paper on Fisheries[22], Vietnam's aquaculture production was the fourth largest in the world as of 2018, following China, Indonesia, and India. As of 2022, Vietnam is producing approximately 5.23 million tons annually [23] (Figure 2-1-a). Production in the aquaculture industry has increased rapidly in recent years, by approximately 1.3 million tons annually over the past five years (2017 to 2022).

- ✓ Production volume by region in Vietnam

Much of Vietnam's aquaculture production is concentrated in the southern Mekong Delta, where Ben Tre Province is also located. As of 2022, 70.3% of total production was in this region. The 13 provinces in the Mekong Delta region are producing approximately 3.68 million tons per year as of 2022, with Ben Tre Province's annual production ranking 6th out of those provinces at 290,000 tons (approximately 7.9% of the entire Mekong Delta region). [24]

- ✓ Production volume of aquaculture by fish species

According to the General Statistics Office of Vietnam, the aquaculture industry in Vietnam is broadly divided into two types: fish and shrimp. In 2022, Vietnam's annual production of fish will be approximately 3.5 million tons, and production of shrimp will be approximately 1.15 million tons. In addition, among fish, pangasius (Pangasianodon hypophthalmu) accounts for the majority of the production, with the commercial cultivation area as of 2022 being approximately 5,500 ha and the production amount being approximately 1.6 million tons. This accounts for approximately 46% of the total fish production volume. [25]

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[22] Fisheries Agency: https://www.jfa.maff.go.jp/j/kikaku/wpaper/r01_h/trend/1/t1_3_1.html

[23] Viet Nam General Statistics Office「STATISTICAL YEARBOOK OF 2022」: https://www.gso.gov.vn/en/data-and-statistics/2023/06/statistical-yearbook-of-2022/

[24] Viet Nam General Statistics Office: https://www.gso.gov.vn/en/agriculture-forestry-and-fishery/

[25] Poste-vn: https://poste-vn.com/news/2022-12-20-13825

Annual production in the Mekong Delta region as of 2022 was approximately 970,000 tons of fish (approx. 84.4% of the national total) and approximately 2.48 million tons of shrimp (approx. 70.9% of the national total).

As of 2022, Ben Tre Province's annual production was approximately 120,000 tons of fish (approx. 12.3% of the entire Mekong Delta region) and approximately 150,000 tons of shrimp (approx. 5.9% of the entire Mekong Delta region).

✓ Status of agriculture industry in Ben Tre Province

Aquaculture facilities are concentrated in the estuary area of Ben Tre Province. As shown in Figure 2, there are many aquaculture facilities located along the estuary coast, such as in Thanh Phu District, Binh Dai District, and Ba Tri District.

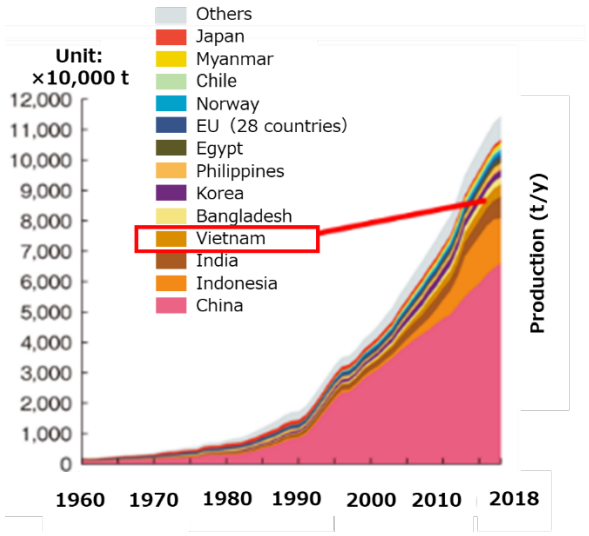
In 2021, the annual production by district in Ben Tre Province was 36,509 tons in Thanh Phu District, 90,237 tons in Binh Dai District, and 26,063 tons in Ba Tri District.

The total aquaculture area in Ben Tre Province was 44,863 ha in 2021. Reports indicate that this area will reach 47,800 ha in 2023. [26] On the other hand, according to the Department of Agriculture and Rural Development (DARD), which is in charge of aquaculture in Ben Tre Province, the total area available for aquaculture in Ben Tre Province is 50,000 ha, which is approaching the upper limit.

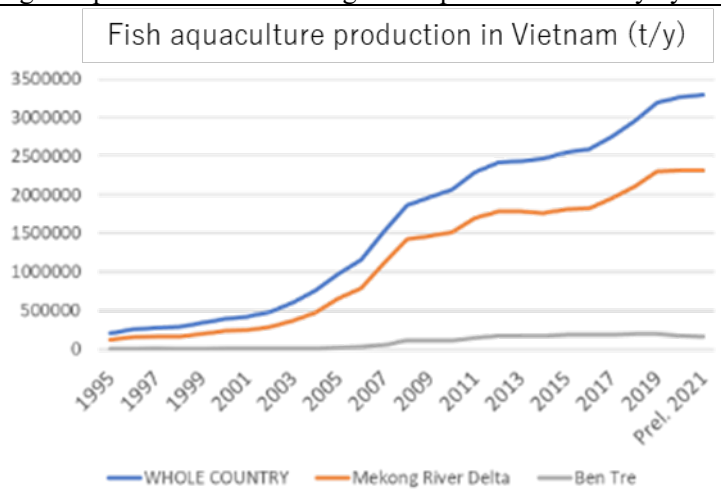
According to the Ben Tre Provincial Statistical Office, the aquaculture area in each district of Ben Tre Province in 2021 was 18,210 ha in Thanh Phu District, 19,650 ha in Binh Dai District, and 5,140 ha in Ba Tri District. Together, these three districts account for more than 96% of the aquaculture area of the entire province.

Shrimp cultivation accounts for the majority of the aquaculture area. As 2021, it occupied approximately 36,000 ha (approximately 80% of Ben Tre Province), of which 2,568 ha were high-tech shrimp facilities that had introduced advanced technology. The Ben Tre provincial government is planning conversion into high-tech aquaculture facilities. The area used in aquaculture of other major fish species was 840 ha for pangasius, 5,200 ha for molluscs (bivalve molluscs), and 1,800 ha for crayfish.

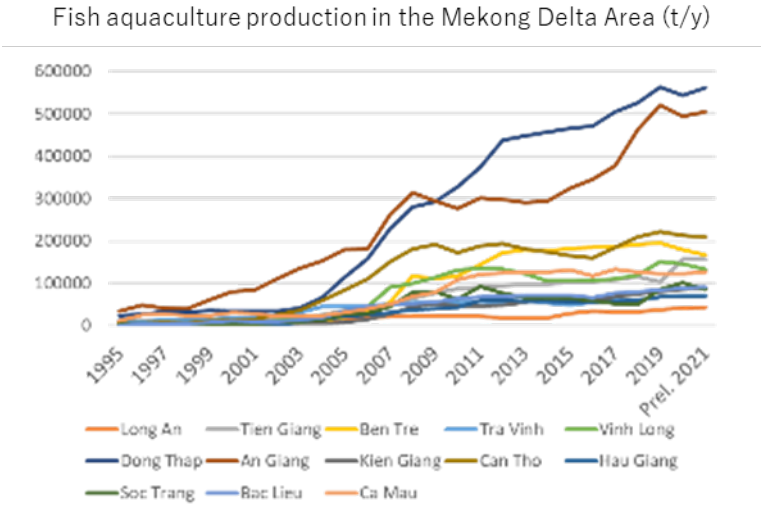
[26] VOV.VN: https://vov.vn/kinh-te/nguoi-nuoi-thuy-san-ben-tre-co-lai-trong-boi-canh-kho-khan-post1070281.vov



Changes in production volume of global aquaculture industry by country

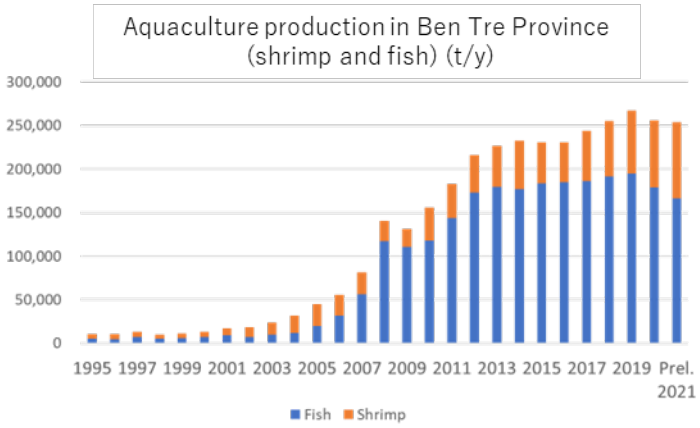


Fish production in Vietnam and fish production in Mekong Delta/Ben Tre Province

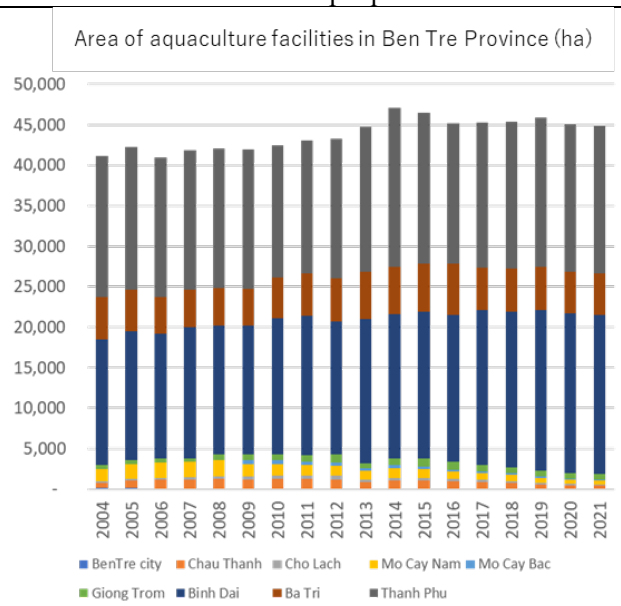


Fish production by province in the Mekong Delta

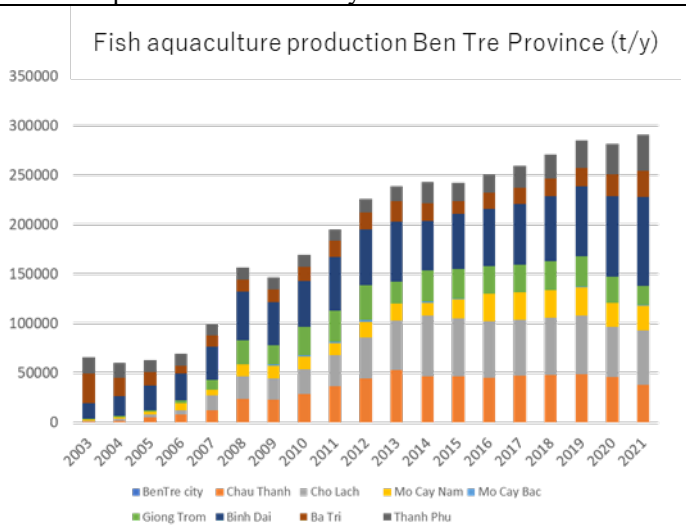
Figure 2-26 Aquaculture statistics in Vietnam and Ben Tre Province (1)



Production volume of fish and shrimp aquaculture in Ben Tre Province

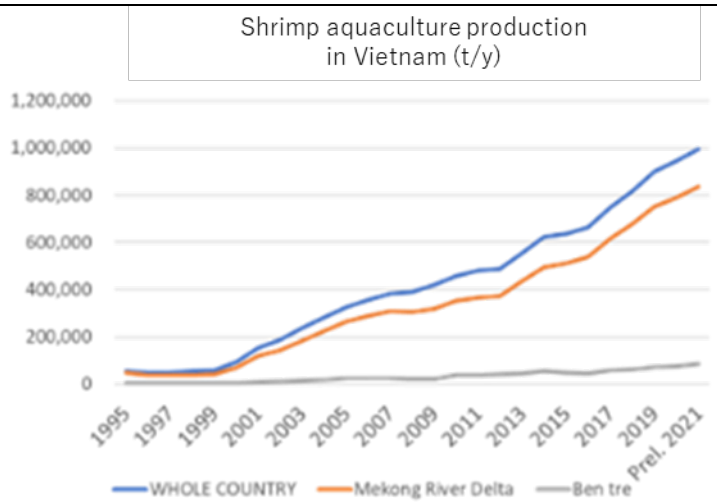


Area of aquaculture facilities by district in Ben Tre Province

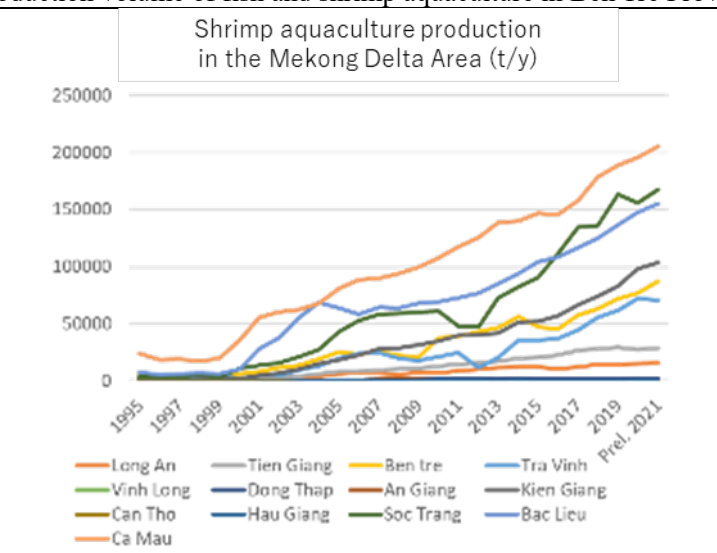


Aquaculture production by region in Ben Tre Province

Figure 2-27 Aquaculture statistics in Vietnam and Ben Tre Province (2)



Production volume of fish and shrimp aquaculture in Ben Tre Province



Shrimp aquaculture production by province in the Mekong Delta

Figure 2-28 Aquaculture statistics in Vietnam and Ben Tre Province (3)

a. Administrative divisions (districts) of Ben Tre Province

b. Satellite photo of coastal are in Thanh Phu District

Figure 2-29 Aquaculture facilities in estuary coastal areas

② Interviews with aquaculture farmers, public institutions, and private companies

In September 2023, we traveled to Ben Tre Province and conducted interviews with local related organizations and companies in regard to needs for water quality analysis in the aquaculture industry. The list of organizations and companies with whom we conducted interviews is shown below, and the results of individual interviews are attached as reference materials.

Table 2-26 List of interviewed public institutions and companies

No.	Interview date	Location of interview	Category	Overview of interview location
1	September 25	EATC (Environment Analysing and Technique., JSC) *Hanoi	Private	Has obtained an environmental monitoring license from MONRE.
2	September 25	RETAQ (Reference Testing & Agrifood Quality Consultancy Center) *Hanoi	Administrative (MARD)	Established with assistance from the Japanese government. Inspects the quality of exported agricultural products.
3	September 26	Ben Tre Province National Agro-Forestry-Fisheries Quality Assurance Department and Fisheries Branch (NAFIQAD: Fisheries Branch), Ben Tre Province	Administrative (MARD)	Regional branch of National Agro-Forestry-Fisheries Quality Assurance Department (NAFIQAD). Conducts analysis related to aquaculture.
4	September 26	AQUATEX BENTRE	Private	Conducts integrated complete aquaculture, processing and trading of pangasius.
5	September 27	Natural Resources and Environmental Monitoring Center (NREMC), Ben Tre Province	Administrative (MONRE)	Provides environmental monitoring sampling and analysis, as well as consulting on natural resources.
6	September 27	Extensive aquaculture facility in Binh Dai District	Private	Conducts extensive aquaculture.
7	September 27	Managed aquaculture facility in Binh Dai District	Private	Conducts managed aquaculture.
8	September 28	Research Institute for Aquaculture No. 2 (REA2) *Ho Chi Minh	MARD	Research Institute for Aquaculture under the Ministry of Agriculture and Rural Development. Has jurisdiction over southern Vietnam.

③ Issues in water quality analysis and treatment of wastewater and sludge in the aquaculture field

Based on the interviews with various organizations conducted in (2), we were able to organize issues and needs in the aquaculture field as follows.

［Implementation status of water quality analysis in the aquaculture field］

- Through interviews with RETAQ, NAFIQAD, and NREMC, we determined that the Vietnamese government basically conducts analysis of water quality test items as stipulated by law. Analysis is under the jurisdiction of the MARD, and the analysis of water quality in the environment outside of aquaculture facilities falls under the jurisdiction of the MONRE. On the other hand, water quality tests conducted by the government are the minimum necessary tests stipulated by law, and companies that handle marine products for export overseas use their own in-house or external testing institutions to check test items as required by export destinations.
- Test items for water quality analysis in the aquaculture field conducted by the government include residual pesticides, heavy metals, harmful substances, microorganisms and bacteria. Analysis items that require advanced analysis techniques, such as dioxins, are not required. MONRE's surface water monitoring is conducted about once every two months (six times a year), and MARD's aquaculture pond water quality monitoring is conducted about three times a month. Based on the test results, these institutions forecast the occurrence of disease in aquaculture, but they have not been able to prevent the occurrence of disease. Disease is a major concern for Ben Tre Province, where aquaculture is a major industry. The analytical laboratory within the DARD Department has test kits for various types of diseases and has created an environment in which tests can be quickly performed in the event that a fish farmer reports a disease outbreak
- Interviews with EATC revealed that, as a private analysis company in Vietnam, there is little need in Vietnam for water quality analysis by private analysis companies in the aquaculture field. Although there are cases where private companies perform analysis at the request of the government, the number of cases is small. In the event of a request from a private company such as a seafood processing company, EATC may analyze residual pesticides and dioxins. However, such analysis is often done at the request of a business partner. Furthermore, once testing has been performed, the testing results remain valid for a certain period (several years). As a result, there is little need for testing of water quality.
- We found that some aquaculture and processing companies in Vietnam conduct their own tests for microorganisms and bacteria on products destined for overseas export. Testing was conducted for seven items including salmonella, vibrio, and staphylococcus in products, water used during processing, and aquaculture ponds. Tests are outsourced every three months to external analytical institutions such as the Center for Analysis Service of Experiment (CASE). Testing can be

conducted by any institution that has been approved by MONRE. Although companies sometimes conduct additional tests in response to requests from business partners, but to date they have never received a request for analysis that could not be tested in Vietnam.

［Challenges in the aquaculture field］

- Current methods of disease control in shrimp aquaculture include sterilization using chlorine agents and sterilizers, and spraying of pesticides such as antibiotics. On the other hand, the cost of purchasing chemicals is extremely high. At the managed aquaculture facilities visited for the on-site survey, the annual cost of purchasing chemicals was 1,800 million VDN (approximately 10.67 million yen, converted at 1 VND = 0.0059 yen) per 10 ha of the facility. Additionally, three hypochlorous acid water generators have been installed at a cost of 400 million VND (approximately 2.37 million yen, converted at 1 VND = 0.0059 yen), and the operating cost (electricity bill) is approximately 1.26 million yen per year. This is expected to result in a large amount of wastewater treatment costs. There are also concerns about environmental problems caused by mass consumption of chemicals, and returned shipments of exported products are sometimes seen due to the detection of additives and pesticides in products that are prohibited in other countries.
- In response to frequent disease outbreaks in both extensive and managed shrimp aquaculture, Ben Tre Province is transitioning from managed shrimp aquaculture to high-tech shrimp aquaculture. Although high-tech shrimp aquaculture can greatly reduce the incidence of disease, the high-density aquaculture and use of large amounts of feed generate a large amount of sludge, which poses a challenge.
- Composting, methane fermentation, and biomass utilization are being considered as means to solve the problem of how to process the sludge generated in shrimp aquaculture. Among these, organizations such as REA2 are making progress in the research and development of biomethane fermentation technology. However, methane fermentation is difficult to advance in environments containing salt. The sludge generated from brackish water shrimp aquaculture contains salt, so methane fermentation using shrimp aquaculture sludge is considered difficult. Similarly, the salt content inhibits the growth of agricultural crops, making it impossible to use the sludge as fertilizer or compost.
- Local personnel are expected to be involved not only in water quality analysis but also in processes ranging up to waste treatment.

According to the results of interviews with various organizations, we determined that water quality analysis in the aquaculture field in Ben Tre Province is essentially carried out by the government. In some cases, companies independently add analysis items requested by customers for overseas export.

Even so, no need for water quality analysis could be identified. Furthermore, the Ben Tre provincial government is promoting a shift from extensive and managed aquaculture to high-tech shrimp aquaculture as a countermeasure against disease outbreaks, which is an issue in the aquaculture sector. We confirmed that the processing of the large amount of sludge generated from high-tech aquaculture is a new issue. Treatment technologies for wastewater containing sludge include methane fermentation, composting, and fertilizer. The introduction of these technologies will reduce the release of methane gas from wastewater that was previously discharged into the environment without treatment, thereby contributing to CO_2 reduction. On the other hand, the high salt concentration of sludge in shrimp aquaculture facilities is a barrier to the introduction of various technologies. With this in mind, we plan to conduct research on applicable technologies in the future.

2） Organization of water quality analysis technology, manufacturers, etc.

① Miura Institute of Environmental Science

Miura Co., Ltd., a co-proposer of this project, established the Miura Institute of Environmental Science to respond to the needs for water quality management such as boiler condensate water. In addition to handling various types of measurement certificate registration and work environment measurements, the institute is also registered as a designated investigation institution under the Soil Contamination Countermeasures Act of the Ministry of the Environment. In recent years, industry, government, and academia have been collaborating to conduct research on environmental technologies that are important issues in today's recycling-oriented society. Examples include measurement and countermeasure technologies for trace environmental pollutants such as dioxins and pesticides, and recycling of waste. In this way, Miura is developing services that can contribute to the future and providing advanced environmental analysis technology services.

For example, in order to address issues in environmentally friendly aquaculture, the institute performs a detailed analysis of wastewater including sludge. Based on the analysis results, the institute considers collaborating with other businesses to determine the optimal wastewater treatment technology. It considers the use of generated dioxin gas, including the use of the company's boilers, and aims to build an environmentally-friendly aquaculture business (Figure 2-10).

Figure 2-30 Analysis at the Miura Institute of Environmental Science (top), exterior of the Institute (bottom)

Source) Website of Miura Co., Ltd.[27]

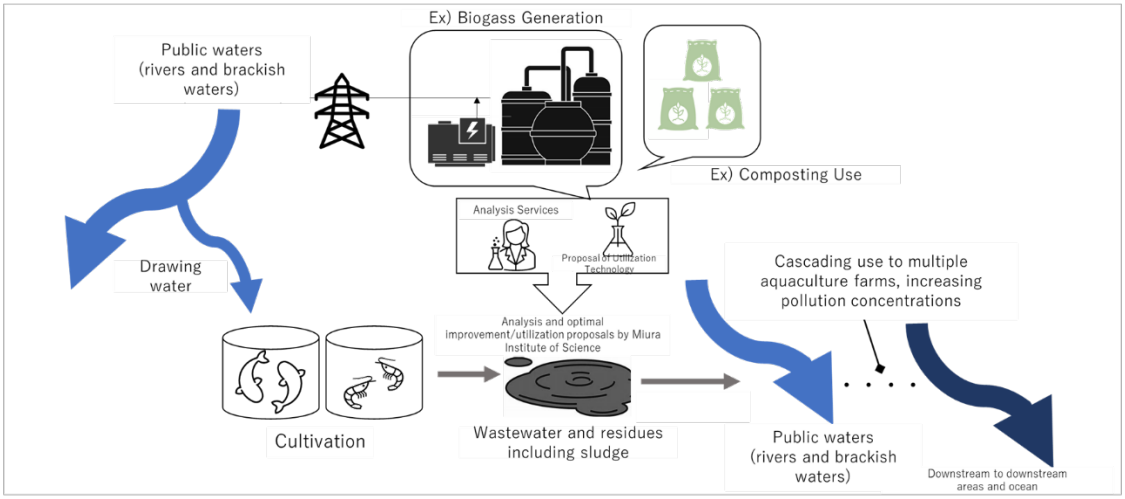


Figure 2-31 Image of contribution to aquaculture business by the Miura Institute of Environmental Science

② Issues for introducing technology to environmentally-friendly aquaculture and implementation details from next fiscal year onwards

In the on-stie survey discussed in 1), we confirmed that the treatment of sludge discharged from aquaculture facilities was an issue. However, the technology and equipment currently possessed by Miura is specialized for boilers. New technology development is required for wastewater discharged from aquaculture facilities, which contains a large amount of suspended solids such as sludge. Although it will take time to develop the technology, Miura has confirmed its continued commitment to finding solutions to sludge treatment issues at aquaculture facilities. For example, when searching for technologies that can be applied to sludge treatment, it is necessary to conduct detailed analysis of sludge component. It is expected that detailed analysis performed using Miura's analysis technology will make it possible to narrow down the candidate technologies. In the next fiscal year, we will

[27] https://www.miuraz.co.jp/e_science/departments/

conduct a detailed analysis of shrimp aquaculture sludge, examine applied technology using Miura's network, and summarize issues for commercialization.

③ Organization of technologies that can be used for environmentally-friendly aquaculture

We used the network of Miura Co., Ltd. to conduct interviews with experts regarding sludge treatment technology at shrimp aquaculture facilities. Below is a list of experts and businesses with whom we exchanged opinions. The results of the opinions exchanged are attached as reference materials.

Table 2-27 List of experts and businesses involved in exchange of opinions

No.	Experts and businesses	Opinions exchanged	Date
1	Professor Yusuke Shiratori Department of Mechanical Science and Engineering, School of Advanced Engineering, Kogakuin University of Technology & Engineering	Demonstration research on shrimp aquaculture system using biogas-powered solid oxide fuel cells and IoT	October 13
2	Professor Hidenori Yasui Faculty of Environmental Engineering, University of Kitakyushu	Conversion of aquaculture sludge into fertilizer	December 15
3	JAPAN UTS	Methane fermentation using aquaculture facility sludge	January 11

Through interviews with each business operator, we determined that measures had been suggested for the utilization of salt-containing sludge. Examples include removing salt through dehydration and washing, and lowering the salt concentration by mixing with other raw materials. However, we have received comments that demonstration experiments are required prior to commercialization. We will continue to collect information on applicable technologies in the next fiscal year, with an eye toward conducting demonstration experiments on the theme of decarbonization and low carbonization through the effective use of sludge.

2.2.4 City-to-city collaboration field

(1) Exchange of opinions on policies

Based on the memorandum of understanding regarding economic cooperation between Ehime Prefecture and Ben Tre Province, which was entered into in August 2022, we have been exchanging opinions with the Ben Tre provincial government from the beginning stages of the project. In June, to kick off the project, a delegation of approximately 20 people visited Ben Tre Province. The delegation included Ben Tre provincial government officials, officials of provincial companies, and Vietnamese embassy officials. In addition to visiting companies participating in this project and receiving technology introductions, Chairman Tam of Ben Tre Provincial People's Committee paid a courtesy visit to Governor Nakamura of Ehime Prefecture in order to confirm cooperation in the field of decarbonization based on this project. This is a major achievement related to strengthening collaboration between local governments. Furthermore, in September, the Ben Tre provincial government launched the City-to-City Collaboration Project Task Force, which includes the relevant departments as members. The task force is currently working to build a system for this project. Additionally, with the lifting of travel restrictions due to COVID-19, we were able to conduct on-site surveys three times in July, September, and November.

The following table shows a summary of main activities.

Table 2-28 Main activities related to city-to-city collaboration projects

Date of activity	Participants	Content of discussion
June 1, 2023	Miura, JANUS	Discussion on implementation contents for this fiscal year
June 1, 2023	Advantech, JANUS	Discussion on implementation contents for this fiscal year
June 8, 2023	Ben Tre Province DONRE, Ehime Prefecture, JANUS	Kick-off event for the project
June 25 to June 29, 2023	Ben Tre Province, Ehime Prefecture, Miura, Advantech, JANUS	Visit to Ehime Prefecture by officials from Ben Tre Province
July 6, 2023	Ministry of the Environment, Ehime Prefecture, Miura, Advantech, JANUS	Kick-off event by the Ministry of the Environment
August 7, 2023	Ehime Prefecture, JANUS	Discussion on traveling to site
September 1, 2023	Miura Institute of Environmental Science, JANUS	Discussion on traveling to site
September 5, 2023	Miura, JANUS	Discussion on traveling to site
September 8, 2023	Miura Institute of Environmental Science, JANUS	Discussion on traveling to site
September 24 to 29, 2023	Ehime Prefecture, Miura, JANUS	On-site survey
October 19, 2023	Ministry of Environment,	Midterm report by Ministry of the

	Ehime Prefecture, Miura, Advantech, JANUS	Environment
October 26, 2023	Miura, Toho Gas, JANUS	Discussion on results of on-site survey
November 1, 2023	Advantech, JANUS	Discussion on future policies
November 13, 2023	Advantech, JANUS	Discussion on traveling to site
November 26 to December 1, 2023	Advantech, JANUS	On-site survey

During each on-site survey, we share progress with the Ben Tre City-to-City Collaboration Project Task Force. In this section of the report, we will give a detailed explanation of the online kick-off meeting with the Ben Tre provincial government held on June 8.

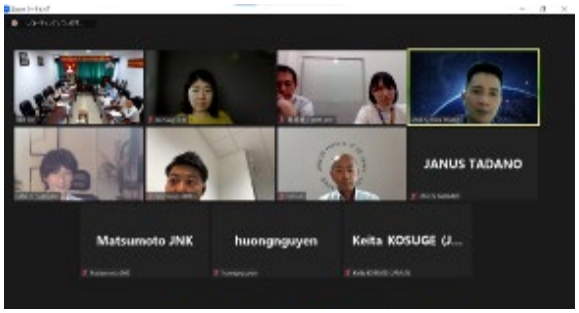


Figure 2-32 Kick-off event with Ben Tre provincial government (June 8, 2023)

Various sectors related to this project gathered on the day of the meeting. Attendees included DONRE, which is the counterpart of this project, DOIT, which has jurisdiction over the energy field, and DARD, which has jurisdiction over the agriculture and fisheries fields. Attendees provided information on what the Ben Tre provincial government hopes to achieve through this project. First, we received comments that the three themes covered by this project, “decarbonization of industrial parks,” “waste plastic fuel,” and “wastewater treatment,” meet the needs of the Ben Tre provincial government. Regarding the “decarbonization of industrial parks,” we received information on various renewable energy projects being implemented by the Ben Tre provincial government. We received comments indicating high expectations for collaboration with these projects and further decarbonization of companies in industrial parks. In regard to the theme of “waste plastic fuel conversion,” we received a request to include not only industrial waste but also general waste. The Ben Tre provincial government is also conducting a survey on the actual situation regarding waste plastics, and the results of that survey were also shared at a later date. For the theme of “wastewater treatment,” it was pointed out that there is no movement toward decarbonization related to aquaculture in Vietnam. However, we confirmed that he Ben Tre provincial government has the desire to promote decarbonization and low carbonization in aquaculture, which is a major industry. In addition to the three fields mentioned above, Ben Tre Province has a large amount of forest. Based on these characteristics, we confirmed new themes such as whether forest absorption through forest management can be counted as carbon credits.

We plan to continue exchanging opinions with the Ben Tre provincial government, and to promote this project and the formation of new projects in line with the province’s policies.

(2) Policy proposal activities

In this section, we will provide a detailed description of policy activities when the aforementioned delegation from Ben Tre Province visited Ehime Prefecture. The schedule of provincial officials during their visit is shown below.

Table 2-29 Schedule of visit to Ehime Prefecture by officials from Ben Tre Province

Month Day	Hours		Places to visit, etc.	
			Supporting member	The delegation
Thursday, June 22	21:00		Arrival at Ho Chi Minh City Airport	
Friday, June 23	0:10		Departure from Ho Chi Minh City Airport	
			Arrival at Kansai International Airport	
			Transfer to Matsuyama by bus	
	Lodging		ANA Crowne Plaza Matsuyama	
Saturday, June 24			Seminar Preparation	
	Lodging		ANA Crowne Plaza Matsuyama	Arrival at Ho Chi Minh City Airport
Sunday, June 25	0:10			Departure from Ho Chi Minh City Airport
				Arrival at Kansai International Airport
				Transfer to Matsuyama by car
	Lodging		ANA Crowne Plaza Matsuyama	
Monday, June 26	9:00		Departure from The Hotel	
	9:30	11:00	Company visit (Miura Kogyo Co., Ltd.: Horie, Matsuyama City)	
	12:00	13:00	Lunch (Akika: 3 Ohmachi-michi, Matsuyama City)	
	14:10	14:30	Courtesy visit to the Governor (Main Office)	
	15:30	17:00	Seminar (ANA Crowne Plaza Matsuyama)	
	18:00	20:00	Welcome Reception (ANA Crowne Plaza Matsuyama)	
	Lodging		ANA Crowne Plaza Matsuyama	
Tuesday, June 27	9:00		Departure from The Hotel	
	9:30	11:00	Company visiting (ATOM Group: 2 Tenzan, Matsuyama City)	
	12:00	13:00	Lunch (Daikokuya Dogo Restaurant: Dogo-kitamachi, Matsuyama City)	
	14:00	15:00	Ehime University (Dogohimata, Matsuyama City)	
	16:00	17:00	Company visiting (Tact Noda Co., Ltd.: Higashigakio-cho, Matsuyama City)	
	17:30		Arrival at The Hotel	
	Lodging		ANA Crowne Plaza Matsuyama	
Wednesday, June 28	8:45		Departure from The Hotel	
	10:00	11:00	Company visit (I' M Co., Ltd.: Shikokuchuo City)	
	12:00	13:00	Lunch (Er bisteccaro Ito: Saijo City (in Itomachi))	
	13:00	14:30	Company visiting (Advantech Co., Ltd.: Saijo City)	
	16:00	17:00	Company visiting (Rapport Co., Ltd.: Matsuyama City)	
	17:30		Arrival at The Hotel	
	Lodging		ANA Crowne Plaza Matsuyama	
Thursday, June 29	Morning		Departure from ANA Crowne Plaza Matsuyama	
			Transfer to Osaka by bus	
	Lodging		N GATE THE HOTEL OSAKA	
Friday, June 30			Departure from Kansai International Airport	
			Arrival at Ho Chi Minh City Airport	

The delegation visited Advantech and Miura, where they were introduced to each company's technology and implementation examples. Delegation officials expressed a strong interest in

introducing the companies' technology within Ben Tre Province. In addition to Ben Tre provincial government officials, there were many opportunities for participating companies from the province to individually ask companies located in Ehime Prefecture about the details of their technologies. Furthermore, in a meeting between Chairman Tam of the Ben Tre Provincial People's Committee and Governor Nakamura, Chairman Tam reaffirmed his expectations for cooperation in the field of decarbonization based on this project.

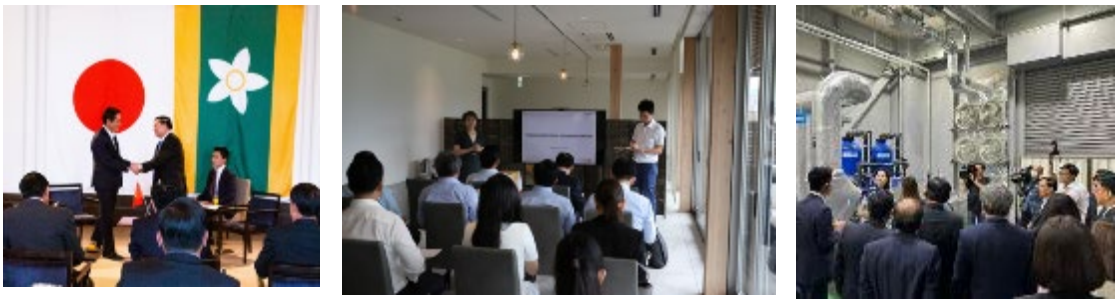


Figure 2-33 Scenes of visit to Ehime Prefecture (meeting between Governor Nakamura and Chairman Tam of Ben Tre Provincial People's Committee, tour of Advantech, tour of Miura)

3. Summary of results and policies for future activities

Based on the survey results of this fiscal year's city-to-city collaboration project, future plans are shown below.

［Application for JCM equipment financing program, etc.］

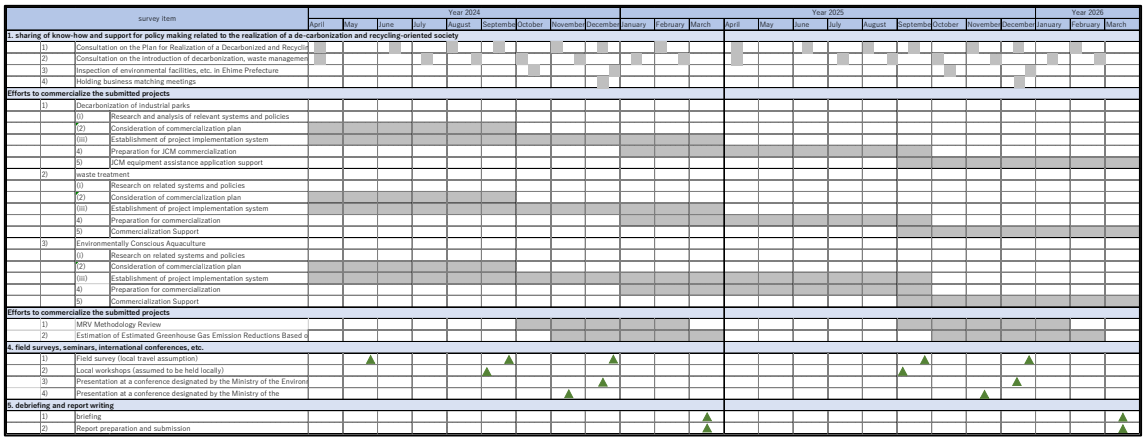
In this fiscal year's survey, we discovered potential projects, gathered information, and calculated costs and CO_2 emission reduction effects. Although the progress of each project differs depending on the presence or absence of policies in Ben Tre Province and the level of interest of business operators, we were able to confirm the implementation items for the next year with an eye on the business that will be the exit for each project. Going forward, we will continue to discuss the characteristics of each project with companies in the Ehime Prefecture, carry out detailed studies for commercialization in Ben Tre Province, and prepare to apply for the JCM equipment financing program.

［City-to-city collaboration activities］

As mentioned above, in Ben Tre Province, not only the government but also local business operators are highly interested in the introduction of greening and decarbonization technologies. There is also strong interest in Ehime Prefecture's efforts regarding policy transfer related to decarbonization. Ehime Prefecture launched the Zero Carbon Promotion Division from this fiscal year, and from next fiscal year onwards we will work together with this department to continue

providing support while further understanding the needs of the Ben Tre provincial government, including how to utilize Ehime Prefecture's policy planning know-how and implementation measures.

The future implementation schedule based on these developments is shown below.



(End)

Reference Material

Reference Material 1	Memorandum on Economic Cooperation Between Ehime Prefecture and Ben Tre Province
Reference Material 2	Circular on providing for environmental monitoring techniques and management of environmental quality monitoring information and data (No.10/2021/TT-BTNMT) Appendix 2.2.
Reference Material 3	Results of interviews on water quality analysis needs in the aquaculture industry (September 2023)
Reference Material 4	Results of interviews with experts in regard to effective use of sludge from shrimp aquaculture facilities

Reference Material 1

Ben Tre Provincial People's Committee of the Socialist Republic of Vietnam and Ehime, Japan Memorandum of Understanding on Economic Cooperation

Today, August 1, 2022, at the People's Committee of Ben Tre Province, A: People's Committee of Ben Tre Province, Socialist Republic of Vietnam

Representative: Mr. Tran Ngoc Tam Position: Chairman of Provincial People's Committee

Address : No.07, Cach Mang Thang Tam, An Hoi Ward, Ben Tre City, Ben Tre B: Ehime Prefecture, Japan

Representative: Tokihiro Nakamura

Position: Governor of Ehime Prefecture

Address: 4-4-1 Ichibancho, Matsuyama City, Ehime Prefecture

(hereinafter referred to as "Both Parties")

Upon consultation and discussion, the two parties shall conclude a Memorandum of Understanding (MOU) on economic cooperation as follows

Article 1 Cooperation Objectives

Overall Goals

Mutual economic development through the establishment and strengthening of sustainable economic cooperation based on compliance with the law 2.

The People's Committee of Ben Tre Province of the Socialist Republic of Vietnam and Ehime Prefecture of Japan, with the aim of promoting mutual economic development through the establishment and strengthening of sustainable economic cooperation, and subject to the laws of both countries, agree to cooperate in the following areas.

Article 2 Principles of Cooperation

- Both parties will cooperate in a spirit of equality and mutual benefit.
- The content of the cooperation between the two parties is subject to the provisions of the law.
- They shall cooperate within the scope of their respective functions, duties and authority.

Article 3 Contents of Cooperation

- The two sides will cooperate in the development of trade, industry, investment, technology, and human resource development to support mutual economic development and inter-regional exchange.
- Both parties will strive to promote the exchange of information and create business opportunities for mutual closeness and the development of the region and businesses.
- The two parties shall cooperate in organizing business exchange meetings, business talks, technical presentations, conferences, seminars, symposiums, etc.
- The two parties will give priority to promoting initiatives in areas of mutual interest, such as the processing industry for agricultural, forestry, and fishery products and SDG-related projects such as climate change countermeasures.

Article 4 Common Provisions

This Memorandum of Understanding does not create any legal obligation on the part of either party, nor does it constitute a binding commitment.

2. both parties agree to make mutual efforts to implement the cooperation contents of the MOU within the framework of existing laws. Each party shall bear its own costs in implementing the contents of the MOU.

3. the Ben Tre Provincial People's Committee will designate the Investment and Entrepreneurship Promotion Center and Ehime Prefecture will designate the Ehime Prefecture Industrial Policy Division as the contact points to facilitate communication between the two sides.

This MOU shall become effective upon signature of both parties and shall remain in effect for a period of three (3) years, and shall terminate when either party notifies the other in writing of the termination of this MOU. This MOU shall terminate on the 30th day after the date of receipt of the aforementioned notification. The termination of this MOU will not affect the respective cooperative activities already in progress. Any and all amendments or additions to this Memorandum of Understanding shall be made only by written agreement of both parties.

Two copies of this memorandum, one in Vietnamese and the other in Japanese, of equal value shall be prepared and kept in one copy each.

Ben Tre Province People's Committee Representative	Ehime prefecture (Shikoku) representa tive
Trần Ngọc Tam committee chairman	Governor Tokihiro Nakamura

Reference Material 2

Appendix 2.2. Monitoring method for surface water quality

1. On-site sampling and measurement

a) Methods of surface water sample collection, storage, and transportation must be selected in accordance with the applicable national standards (TCVN) or Table 3-1 below.

Table 3-1 Field sampling methods for surface water

No.	Sample type	Measurement method
1	River water/stream water	TCVN 6663-6:2018; TCVN 6663-1:2011; TCVN 6663-3:2016
2	Lake water	TCVN 6663-4:2018; TCVN 5994:1995
3	Microbiology	TCVN 8880:2011
4	Phytoplankton	SMEWW 10200.B:2017
5	Zooplankton	SMEWW 10200.B:2017
6	Benthic animals	SMEWW 10200.B:2017

b) On-site measurement of surface water parameters: Methods must be selected according to the applicable national standards (TCVN) or Table 3-2 below.

Table 3-2 Field measurement method for surface water

No.	Item	Measurement method
1	Water temperature	SMEWW 2550B:2017
2	pH	TCVN 6492:2011
3	DO	TCVN 7325:2016
4	EC	SMEWW 2510B:2017
5	Turbidity	SMEWW 2130B:2017; US EPA Method 180.1
6	Transparency	Measure using Secchi disk
7	TDS	Use measurement device
8	ORP	SMEWW 2580B:2017; ASTM 1498:2014
9	Sodium content	SMEWW 2520B:2017
10	Color	Use measurement device

2. Laboratory analysis: Methods must be selected according to the applicable national standards (TCVN) or according to Table 3-3 below.

Table 3-3 Laboratory analysis methods for groundwater parameters

No.	Item	Measurement method
1	Color	TCVN 6185:2015 (Method C); ASTM D1209-05;

		SMEWW 2120C:2017
2	Alkalinity	TCVN 6636:1-2000; SMEWW 2320.B:2017
3	Total hardness	TCVN 6224:1996; SMEWW 2340C:2017
4	TSS	TCVN 6625:2000; SMEWW 2540D:2017
5	BOD_5	TCVN 6001-1:2008; TCVN 6001-2:2008; SMEWW 5210B:2017
6	COD	TCVN 6491: 1999; SMEWW 5220.B:2017; SMEWW 5220.C:2017
7	TOC	TCVN 6634:2000; SMEWW 5310B:2017; SMEWW 5310C:2017
8	NH_4^+	TCVN 6179-1:1996; TCVN 6660:2000; SMEWW 4500-NH_3.B&D:2017; SMEWW 4500-NH_3.B&F:2017; SMEWW 4500-NH_3.B&H:2017
9	NO_2^-	TCVN 6178:1996; TCVN 6494-1:2011; SMEWW 4500-NO_2^-.B:2017; SMEWW 4110B:2017; SMEWW 4110C:2017; US EPA Method 300.0
10	NO_3^-	TCVN 6180:1996; TCVN 7323-1:2004; TCVN 6494-1:2011; SMEWW 4110.B:2017; SMEWW 4110.C:2017; SMEWW 4500-NO_3^-.D:2017; SMEWW 4500-NO_3^-.E:2017; US EPA Method 300.0; US EPA Method 352.1
11	SO_4^{2-}	TCVN 6200:1996; TCVN 6494-1:2011; SMEWW 4110.B:2017; SMEWW 4110.C:2017; SMEWW 4500-SO_4^{2-}.E:2017; US EPA Method 300.0
12	PO_4^{3-}	TCVN 6202:2008; TCVN 6494-1:2011; SMEWW 4110.B:2017; SMEWW 4110.C:2017; SMEWW 4500-P.D:2017; SMEWW 4500-P.E:2017; US EPA Method 300.0; US EPA Method 365.3
13	CN^-	TCVN 6181:1996; TCVN 7723:2007; SMEWW 4500-CN^-.

		C&E:2017; ISO 14403-2:2017
14	Cl^-	TCVN 6194:1996; TCVN 6494-1:2011; SMEWW 4110B:2017; SMEWW 4110C:2017; SMEWW 4500.Cl^-:2017; US EPA Method 300.0
15	F^-	TCVN 6195-1996; TCVN 6494-1:2011; SMEWW 4500-F^-.B&C:2017; SMEWW 4500-F^-.B&D:2017; SMEWW 4110B:2017; SMEWW 4110C:2017; US EPA Method 300.0
16	S^{2-}	TCVN 6637:2000; SMEWW 4500-S^{2-}.B&D:2017
17	Total N	TCVN 6624:1-2000; TCVN 6624:2-2000; TCVN 6638:2000; SMEWW 4500-N.C:2017
18	Total P	TCVN 6202:2008; SMEWW 4500P.B&D:2017; SMEWW 4500P.B&E:2017; US EPA Method 365.3
19	Na	TCVN 6196-1:1996; TCVN 6196-2:1996; TCVN 6196-3:1996; TCVN 6660:2000; TCVN 6665:2011; SMEWW 3111B:2017; SMEWW 3120B:2017; US EPA Method 200.7
20	K	TCVN 6196-1:1996; TCVN 6196-2:1996; TCVN 6196-3:1996; TCVN 6660:2000; TCVN 6665:2011; SMEWW 3111B:2017; SMEWW 3120B:2017; US EPA Method 200.7
21	Ca	TCVN 6201:1995; TCVN 6198:1996; TCVN 6660:2000; TCVN 6665:2011; SMEWW 3111B:2017; SMEWW 3120B:2017; US EPA Method 200.7
22	Mg	SMEWW 3111.B:2017; SMEWW 3120.B:2017; TCVN 6201:1995; TCVN 6660:2000; US EPA Method 200.7; US EPA Method 6020B

23	Fe	TCVN 6177:1996; TCVN 6665:2011; ISO 15586:2003; SMEWW 3500-Fe.B.2017; SMEWW 3111B:2017; SMEWW 3113B:2017; SMEWW 3120B:2017; US EPA Method 200.7; US EPA Method 6020B
24	Mn	TCVN 6002:1995; TCVN 6665:2011; ISO 15586:2003; SMEWW 3111B:2017; SMEWW 3113B:2017; SMEWW 3120B:2017; SMEWW 3125B:2017; US EPA Method 200.7; US EPA Method 200.8; US EPA Method 6020B
25	Cu	TCVN 6193:1996; TCVN 6665:2011; ISO 15586:2003; SMEWW 3111B:2017; SMEWW 3113B:2017; SMEWW 3120B:2017; SMEWW 3125B:2017; US EPA Method 200.7; US EPA Method 200.8; US EPA Method 6020B
26	Zn	TCVN 6193:1996; TCVN 6665:2011; ISO 15586:2003; SMEWW 3111B:2017; SMEWW 3113B:2017; SMEWW 3120B:2017; SMEWW 3125B:2017; US EPA Method 200.7; US EPA Method 200.8; US EPA Method 6020B
27	Ni	TCVN 6665:2011; ISO 15586:2003; SMEWW 3111B:2017; SMEWW 3113B:2017; SMEWW 3120B:2017; SMEWW 3125B:2017; US EPA Method 200.7; US EPA Method 200.8; US EPA Method 6020B
28	Pb	TCVN 6665:2011; ISO 15586:2003; SMEWW 3113B:2017; SMEWW 3125B:2017; SMEWW 3130B:2017; US EPA Method 200.8;

		US EPA Method 6020B
29	Cd	TCVN 6197:2008; ISO 15586:2003; SMEWW 3113B:2017; SMEWW 3125B:2017; US EPA Method 200.8; US EPA Method 200.7; US EPA Method 6020B
30	As	TCVN 6626:2000; ISO 15586:2003; SMEWW 3114B:2017; SMEWW 3114C:2017; SMEWW 3113B:2017; SMEWW 3125B:2017; US EPA Method 200.7; US EPA Method 200.8; US EPA Method 6020B
31	Hg	TCVN 7724:2007; TCVN 7877:2008; SMEWW 3112B:2017; US EPA Method 200.7; US EPA Method 200.8; US EPA Method 7470A
32	Total Cr (Cr)	TCVN 6222:2008; TCVN 6665:2011; ISO 15586:2003; SMEWW 3113B:2017; SMEWW 3120B:2017; SMEWW 3125B:2017; US EPA Method 200.8; US EPA Method 200.7; US EPA Method 6020B
33	Cr (VI)	TCVN 7939:2008; SMEWW 3500-Cr.B:2017
34	Coliform bacteria	TCVN 6187-2:1996; SMEWW 9221B:2017
35	Heat-resistant coliform bacteria	TCVN 6187-2:1996; SMEWW 9221:2017
36	Escherichia coli	TCVN 6187-2:1996; SMEWW 9221B:2017; SMEWW 9222B:2017
37	Oil and fats	TCVN 7875: 2008; SMEWW 5520B:2017; SMEWW 5520C:2017
38	Total phenols	TCVN 6216:1996; SMEWW 5530 B&C:2017; US EPA Method 420.1; ISO 14402:1999
39	Organochlorine agrochemicals	TCVN 7876:2008; TCVN 9241:2017; SMEWW 6630B:2017; SMEWW 6630C:2017; US EPA Method 8081B;

		US EPA Method 8270D;
40	Organophosphorus agrochemicals	US EPA Method 8141B; US EPA Method 8270D
41	Total radioactivity α	TCVN 6053:2011; TCVN 8879:2011; SMEWW 7110B:2017;
42	Total radioactivity β	TCVN 6219:2011; TCVN 8879:2011; SMEWW 7110B:2017
43	Polyclobiphenyl (PCB)	TCVN 9241:2012; SMEWW 6630C:2017; US EPA Method 1668B; US EPA Method 8082A; US EPA Method 8270D
44	Dioxin/furan (PCDD/PCDF)	US EPA Method 1613B; US EPA Method 8290A
45	Dioxin-like polychlorinated biphenyls (dl-PCB)	US EPA Method 1668C
46	Decabromodiphenyl ether (DBDE)	US EPA Method 1614A
47	Hexabromobiphenyl (HBB)	US EPA Method 8270D
48	Hexabromodiphenyl ether and heptabromodiphenyl ether (HBDE)	US EPA Method 1614A
49	Hexachlorobutadiene (HCBD)	US EPA Method 524.4; US EPA Method 8270D
50	Pentachlorobenzene (PeCB)	US EPA Method 8270D
51	Pentachlorophenol (PCP) and its salts and esters	US EPA Method 1653A; US EPA Method 1624/1625
52	Perfluorooctane sulfonic acid (PFOS), its salts and perfluorooctane sulfonyl fluoride (PFOSF)	US EPA Method 533; US EPA Method 537.1
53	Polychlorinated naphthalene (PCN)	US EPA Method 8270D
54	Short-chain chlorinated paraffins (SCCPs)	National and international standards
55	Tetrabromodiphenyl ether and Pentabromodiphenyl ether (POP-BDE)	US EPA Method 1614A
56	Hexabromocyclododecane (HBCDD)	National and international standards
57	Perfluorooctanoic acid (PFOA), its salts and PFOA-related compounds	US EPA Method 533; US EPA Method 537.1; DIN 38407-42:2010; CEN/TS 15968 :2010; ISO 25101:2009
58	Surfactants	TCVN 6622-1:2009; SMEWW 5540 B&C:2017
59	Phytoplankton	SMEWW 10200:2017
60	Zooplankton	SMEWW 10200:2017
61	Zoobenthos	SMEWW 10500:2017

Reference Material 3

[1] EATC (Environment Analysing and Technique., JSC)

[Contents/Objective]

EATC is a purely private company with equipment and technology at the level of developed countries. We understand that it is important to obtain the latest information from the company, so we visited with the purpose of exchanging information regarding current analysis methods and analysis needs in Vietnam.

[Exchange of Opinions]

- What items does your analysis focus on?
  - Our focus is environmental analysis such as air pollution, water quality analysis, PM2.5, dust, and POPs.
- Have you ever received an order for analysis in the fisheries industry?
  - We do not conduct analysis in the aquaculture field and our unfamiliar with the aquaculture situation. In the past, we have conducted aquaculture water quality analysis for DONRE in Nghe An Province, but we are not conducting such analysis at the present time. There is little need for analysis in the fisheries industry in the northern region of Vietnam.
- Are we correct in our understanding that the analysis of environmental monitoring in Vietnam is mainly performed using the budget of MONRE?
  - Some rivers are managed by People's Committees, while others are managed by private organizations. Analysis is requested by various parties, so it cannot be said that analysis is performed using the MONRE budget. However, reports are submitted to MONRE in many cases.
  - However, if regulations such as EIA apply to the private sector, monitoring and analysis will be performed using the private sector's budget.
- When an aquaculture facility wishes to request analysis, since such facilities (for example, shrimp aquaculture) are managed by the Ministry of Agriculture and Rural Development (MARD), are we correct in our understanding that the facility should consult with MARD or the Ministry's Department of Agriculture and Rural Development (DARD)?
  - It is our understanding that the analytical institution will be determined by an introduction from the person in charge of the ministry or local ministry. Therefore, it is important for private companies to have relationships with public institutions.
- What kinds of pesticides do you analyze?
  - We measure pesticide residues in soil and water. In addition to pesticide residues, we also measure heavy metals for water supplies.
  - Separate standards are set for rivers, sea areas, waste, and sludge.

- Which ministries and agencies have jurisdiction over pesticide residues?
  - Pesticide residues are the jurisdiction of various ministries and agencies.

[2] Reference Testing and Agrifood Quality Consultancy Center (RETAQ)

[Contents/Objective]

The Reference Testing and Agrifood Quality Consultancy (RETAQ) Center, whose research building was just completed in July 2023 with assistance from the Japanese government, is a facility that will serve as a base for quality, etc., related to the export of agricultural products, which is Vietnam's main industry.[28] Also, according to the latest information, there was information that advanced analysis of dioxins, etc., had begun, so we visited the facility and exchanged information regarding analysis methods and analysis needs in Vietnam.

[Exchange of Opinions]

- What items does your analysis focus on?
  - The center measures all items related to food safety. We test for pesticide residues, heavy metals, harmful substances from seafood processing, antibiotics from livestock farming, and other drugs, as well as microorganisms and bacteria. There are two types of inspection: one based on QCVN standards and one based on export standards. The standards for export are based on the standards of the exporting country.
- Can private companies issue certification?
  - Private companies can also issue certificates if they have a license.
- Are there any test items that are generally in high demand?
  - There are no sudden changes in needs.
- What is the process when new analytical methods are introduced in Vietnam? Have you heard that the Vietnam Academy of Science and Technology (VAST) will be involved in TCVN?
  - In addition to VAST, new analysis methods can be introduced if related ministries and agencies cooperate and obtain approval. For example, in the food industry, applications are submitted by MARD and decisions are not made solely by VAST.
- How often are exports suspended due to residual pesticides, antibiotics, etc., exceeding standard values?
  - Detailed information is provided on the website.
- About how many samples will be monitored?
  - Detailed information is provided on the website.

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[28]Embassy of Japan in Vietnam：https://www.vn.emb-japan.go.jp/itpr_ja/20230724_RETAQ_ja.html

- Other

➢ In addition to analysis, RETAQ also acquires technology from overseas, shares the know-how with the local NAFIQAD, and provides guidance on equipment installation.

➢ IR-MS and dioxin analyzers are scheduled to be introduced after fiscal 2025. Preparations are currently underway to introduce dioxin analyzers as part of a JICA project, and the equipment to be introduced is now being selected.

［Confirmed facilities and analysis items］

- Confirmed equipment: bioassay (detection of drug-resistant bacteria), standard product preparation room, radioactive material analyzer, LC-MS/MS (quadrupole and TOF, fluorescence, diode array), GC-MS/MS, Spectrophotometer, IC (analyzes preservatives, nitrogen compounds, PO4, etc. contained in water and wastewater), ICP, and all other equipment necessary for pretreatment (ultrapure water production equipment, autoclave, fume hood, clean bench, grinder)
- Analysis items

・ GC-MS can measure 100 compounds simultaneously. However, depending on the combination of columns and analysis conditions, it is capable of measuring 300 compounds. It performs targeted and non-targeted analysis of substances contained in agricultural products.

・ Multiple residual compounds

・ Animal antibiotics/insecticides

・ Substances containing N and P, substances containing S and P

・ Chlorine compounds (PCA, PCB)

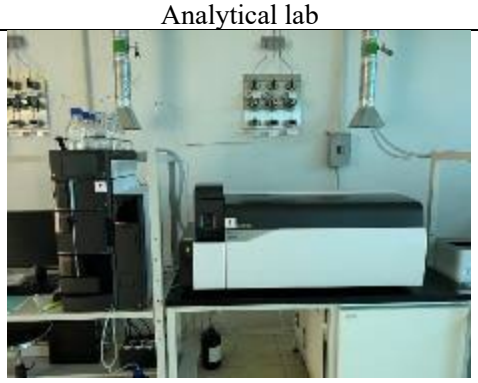
・ Although a dioxin analyzer is scheduled to be introduced in the future, the reason why dioxins are not analyzed using existing analyzers is that dioxin has a low detection limit and contamination is likely to occur if the equipment is shared with other analyzers. Therefore, dioxin requires a dedicated analyzer.

Exterior of RETAQ Center

Discussion


Analytical lab


Analytical lab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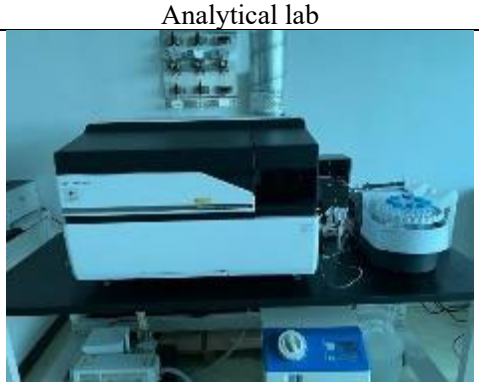
ICPMS

Figure 3-1 Visit to RETAQ

[3] Ben Tre Province National Agro-Forestry-Fisheries Quality Assurance Department and Fisheries Branch

[Contents/Objective]

This organization is a fisheries branch bureau under the Department of Agriculture and Rural Development of Ben Tre Province. The branch conducts analysis related to aquaculture. We visited the facility and exchanged information regarding analytical methods and analytical needs in Vietnam.

[Exchange of Opinions]

- In regard to growth strategies and plans for the aquaculture sector, are there any concrete plans or numerical targets for moving shrimp aquaculture facilities from extensive facilities to managed facilities?
  - There are three plans: (1) 09/NQ-HDND, (2) 2018-2020, (3) 2021-2030.
  - 3004/KH-UBND presents a development plan for shrimp aquaculture until 2025. The plan is to develop 4,000 ha of aquaculture ponds by 2025. 3,036 ha of these ponds have been developed as of 2023. The area will be expanded to 3,067 ha in 2024.
- In regard to the transition to managed facilities, does the Ben Tre provincial government offer a subsidy system or attraction for investment?
  - We are attracting investment based on our investment attraction policy. Agriculture-related budgets are being prepared. The state-owned bank Agribank and other banks have signed

memorandums of understanding with DARD to facilitate financing. DARD provides information on aquaculture facilities to banks.

- Are there any inspection items that you focus on to ensure safety and high quality when exporting marine products such as shrimp produced in Ben Tre Province to Japan, Europe, or the United States?
  - Response from NAFIQAD: Since there is no processing factory for overseas export in Ben Tre Province, the processing is done in other provinces. Since we do not have a processing plant, they analyze seafood for heavy metals, antibiotics, and harmful substances. Dioxins and harmful substances are included in the analysis items.
- Is there an obligation to analyze dioxins in seafood?
  - Presently, there is no obligation to analyze dioxins in seafood.
- Which ministry or agency will conduct the analysis in aquaculture? Will a different government agency be placed in charge of analysis from processing onward?
  - Aquaculture is under the jurisdiction of DARD. If a processing factory were to be constructed in the future, DARD will also be in charge. Drainage would be under the jurisdiction of DONRE.
- Is analysis performed for domestically distributed products?
  - Analyzes is performed for products and aquaculture facilities intended for the domestic market. Analysis consists of visiting shrimp aquaculture facilities and taking samples. Periodic analysis is performed for aquaculture pond sections, water supply sections, and aquaculture products (shrimp).
  - Administrative guidance will be issued if the standard values set by QCVN are exceeded.
- Is guidance provided on aquaculture methods and is the acquisition of various certifications such as ASC certification[29] encouraged in order to increase the unit price by branding and adding value to aquaculture products?
  - Ben Tre Province is encouraging aquaculture companies to obtain ASC certification, Viet GAP[30], etc.
  - ASC certification has been obtained for 250 ha of brackish water area in the province.
  - BAP certification[31] has been obtained for 230 ha of brackish water area within the province.
  - Seminars are held periodically to explain the certification system.
- Are there any standards for the use of pesticides and antibiotics in feed used at aquaculture

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[29] ASC certification: Certification system aiming to solve sustainability and environmental problems of seafood products

[30] Viet GAP: Agricultural production management standards established by the Ministry of Agriculture and Rural Development of Vietnam with reference to ASEANGAP

[31] BAP certification: A system to certify aquaculture products produced using safe, responsible and ethical methods

facilities?

- MARD published a list of substances for which use is prohibited. The feed company is responsible for satisfying the standards, so it is not a concern for aquaculture facilities.

- Are there any adverse effects caused by sludge at aquaculture facilities? What methods are currently implemented to treat sludge? Also, are there any technologies that you plan to introduce in the future?

- There are some harmful effects caused by sludge, but we have not introduced any technology at the present time.
- In the case of freshwater aquaculture for products such as pangasius, sludge is dried for use as fertilizer and as a material for banks.
- Shrimp aquaculture is performed in brackish water. The high salt content of brackish water makes use as fertilizer or biomass difficult. Ben Tre Province is currently considering ways to treat brackish water.
- In the past, people used to dump sludge into rivers and oceans. However, that practice is now illegal and is disappearing.

- What about sludge from pangasius aquaculture?

- Pangasius are cultivated in fresh water, so the sludge is a valuable resource. Since a large amount of sludge is produced, there is a sludge management area. After harvesting, the sludge is taken ashore and used as fertilizer.

- Is wastewater treatment required even for extensive aquaculture facilities?

- Extensive aquaculture farmers in Ben Tre Province often operate on a small scale of 1 to 2 ha, so there is no need for wastewater treatment. If the area is 3 ha or more, an environmental license is required. EIA certification is required for areas of 100 ha or more.

- Are we correct in our understanding that the analysis organization is responsible for analysis related to the aquaculture field?

- The role of the Fisheries Branch is to monitor the environment during aquaculture. Environmental monitoring related to aquaculture is being conducted based on MARD notifications. Some of the measurements are now done automatically. In accordance with QCVN, there are 13 analysis items including water temperature, salinity, pH, moisture content, BOD, and indicators related to fish diseases.
- In regard to monitoring in the environmental field, the Ben Tre Province Department of Natural Resources and Environment (DONRE) conducts fixed-point observations. However, we, the DARD organization, perform monitoring of aquaculture ponds. We analyze water supply sources, etc., about three times per month.
- Sampling is done manually. Although we would like to automate sampling, we don't have the budget. There are 37 monitoring points.

- Are you using the national budget?
  - We make and implement plans at the beginning of each fiscal year based on the national budget. We do not collaborate with private analytical institutions.
- Is there entry by private corporations?
  - We are conducting analysis in this field only by ourselves. No private companies have entered the field.
- Is the monitoring area limited to shrimp aquaculture or does it include other aquaculture areas as well?
  - 37 sites are brackish water aquaculture such as shrimp aquaculture facilities. In addition, there are six monitoring points for freshwater aquaculture facilities, which are carried out by the Fisheries Research Institute II (REA2) under the Ministry of Agriculture and Rural Development in Ho Chi Minh City.
- ASC certification is spreading in the world's marine products industry. However, are there any requests for analysis or inquiries from companies that want to obtain certification?
  - There are no requests for analysis for ASC certification. Since the items that can be analyzed at the Fisheries Branch are limited, we refer inquiries to certification bodies when we receive inquiries. We once received a request for Best Aquaculture Practices (BAP) certification for 70 hectares from the major seafood processing company Minhu. In the future, we would like to increase the number of items that can be analyzed by the Fisheries Branch.

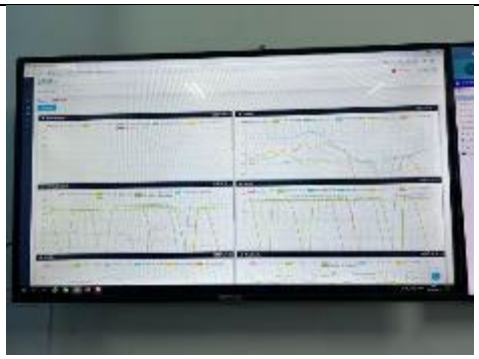
*BAP certification is characterized by certifying the aquaculture supply chain at each stage. Certification targets four locations: hatcheries, feed factories, aquaculture facilities, and processing factories. This targets all players involved in the production process of aquaculture products.

- At what point in shrimp cultivation do you perform fish disease analysis?
  - Fish disease analysis at aquaculture facilities is the task of the Disease Control Office of the Department of Animal Health. We go to aquaculture facilities and take samples when requested by aquaculture companies.

［Confirmed facilities and analysis items］

- Confirmed facilities: Remote sensing monitoring facilities, clean bench, thermal cycler (PCR)
- Analysis items: Virus testing (test kit EHP microsporidian parasite Enterocytozoon hepatopenaei, IHHNV infectious subcutaneous hematopoietic organ necrosis, AHBND acute hepatopancreatic necrosis, WSSV white spot syndrome)

Remote sensing monitoring room



Monitoring data (partial)

Analytical lab

Test kits for 4 types of diseases

Figure 3-2 NAFIQAD: Visit to analysis facility of fisheries branch

[4] AQUATEX BENTRE（Bentre Aquaproduct Import and Export., JSC）

[Contents/Objective]

The purpose of this visit was to understand the actual situation of private companies, as this company also handles everything from complete aquaculture to processing and trading of pangasius.

[Exchange of Opinions]

- Company overview
  - In recent years, the company has been focusing on pangasius and clam aquaculture and products. Currently, processed clam and pangasius products are exported to Japan, Europe, the Middle East, and Australia. For Japan, they export pangasius fillets and value-added pangasius (fried foods, etc.).
  - We handle everything from seedlings to processing in-house.
  - The annual production volume is 9,000 tons and export value are 20 million dollars.
- What kind of analysis do you perform in-house?

- There are two types of analysis patterns for environmental monitoring of aquaculture facilities. The first is a pattern that is inspected by a government agency. The second pattern is to conduct voluntary inspections in-house. Monitoring is conducted based on the regulations of the Ministry of Natural Resources and Environment (MONRE). We conduct microbial analysis in our in-house laboratory. We test the microorganisms in Pangasius (products) and E. coli in the water at the facility, and verify the efficacy of antibiotics. We are also conducting PRC tests for COVID-19 on our employees.
- Our in-house environmental monitoring includes measurement of pH. If requested by a business partner, we outsource checks for residual antibiotics and dioxins, but this is not normally done. We do not analyze dioxins often because once dioxins are tested, the results can be useful for several years.

- How do you treat wastewater?
  - We have installed large-scale wastewater treatment equipment and are capable of treating 1,000 tons of wastewater per day. In the future, we plan to automatically monitor water quality.
- To whom is the analysis outsourced?
  - NAFIQUAD4 (dioxin and fish diseases) ⇒ Isn't the number for dioxin "6"? ⇒We believe that it is "4." A single test for dioxin is valid for several years, so it is not often performed. ⇒Center of Analytical Services and Experimentation, Ho Chi Minh City (CASE): We have requested food analysis from the Center of Analytical Services and Experimentation, Ho Chi Minh City (CASE), but we have never requested dioxin analysis.
- Are there any analysis items for voluntary analysis? For example, are there any analysis items that the Vietnam Association of Seafood Exporters and Producers (VASEP) recommends for exports?
  - AQUATEX BENTRE tests for seven items including salmonella, vibrio, and staphylococcus. We also analyze microorganisms in processing water and water from aquaculture ponds. The equipment is also tested for microorganisms. These are analyzed according to Vietnamese regulations and customer requests.
  - There are no recommendations regarding analysis from VASEP. VASEP is an organization where trade discussions are primarily held.
- The terms of reference for Center of Analytical Services and Experimentation, Ho Chi Minh City (CASE) are as follows.
  - Analysis of aquafeed.
  - Analyzes pH, COD, BOD, etc., of wastewater from seafood processing. Although we carry out in-house monitoring, we outsource it to ensure a double check. Through these measures, we confirm operation of the wastewater treatment facility.
- About how often are national inspections performed?

- National inspections are conducted periodically, so there is no guarantee that our company will be inspected. AQUATEX outsources inspections to a private company (CASE) once every three months (national regulations). Although the request for inspection of aquaculture ponds and wastewater (factories and aquaculture ponds) is the same, the government jurisdiction is different.
- Monitoring can be outsourced to any organization that has been approved by MONRE.
- National inspection is conducted once a year. On-site inspections are conducted whenever there is a risk of environmental violations.

- How many locations do you inspect?
- There are seven aquaculture facilities and we inspect each of those facilities.

- Are there any analysis items requested by the customer that cannot be handled by a nearby laboratory?
- None in particular. Analysis can be performed at the Natural Environment Monitoring Center (Ben Tre Province), Can Tho City, Ho Chi Minh City, and Intertech. (a quite wide area)

［Confirmed facilities and analysis items］

- Confirmed facilities: Microbiology laboratory/biological laboratory, clean bench, lactobacillus culture equipment (improving shrimp health and strengthening disease resistance)
- Analysis items: E. coli, bioassy

[5] Natural Resources and Environmental Monitoring Center) (NREMC)

[Contents/Objective]

NRMEC is an analytical agency within the Department of Natural Resources and Environment. It provides sampling and analysis for environmental monitoring, as well as consulting on natural resources. We visited NRMEC and exchanged information regarding analytical methods and analytical needs in Vietnam.

[Exchange of Opinions]

- Overview of institution
- We provide sampling and analysis for environmental monitoring, and consulting on natural resources.
- The scope of our activities includes land, surface water, drainage, groundwater, coastal areas, sea areas, road environment, and exhaust gas.

- What kind of analysis do you perform?
- Our analysis method is based on Vietnamese standards and overseas standards. Examples include Vietnam's QCVN and USEPA, as well as methods used in Australia and New Zealand.

- Are you ever commissioned to conduct analysis from the private sector?
- Approximately 35% of analysis requests come from the private sector and 65% from the government. The majority of these private sector companies are within Ben Tre Province. We

receive requests from about 30 to 50 companies each year.

- Since we have a MONRE license, we can perform analysis after reaching an agreement with the customer.

- Do you measure hazardous substances that require advanced analysis techniques?
- Although we are capable of analyzing PCBs, our current analysis equipment can only analyze high concentrations of dioxins. Furthermore, we do not have pretreatment equipment for analyzing dioxin and are unable to install this equipment due to lack of budget. Furthermore, since there are no areas contaminated with high concentrations of dioxin within Ben Tre Province, there is no need for analysis that requires advanced analysis techniques. If there is a need for such analysis, it will be outsourced.
- For items which we are unable to analyze, we outsource analysis to an affiliated private analysis company (Vietin, a company in Ho Chi Minh City that has obtained a MONRE license).

- What new analysis items are you considering in the future?
- Contents that will be considered in the future include analysis of groundwater and rainwater in limestone caves, water quality testing for drinking water, water in aquaculture ponds, and pesticides in soil. For example, drinking water is currently being analyzed in Ho Chi Minh City, so we think it would be a good to perform analysis in our province.

- How many types of pesticides can you analyze?
- We are capable of analyzing the 35 types of pesticides stipulated by law (20 types of organochlorine pesticides and 15 types of organophosphate pesticides). These are representative substances.

- Up until now, our impression has been that pesticide residues were under the jurisdiction of DARD. Does DONRE also have jurisdiction over pesticide residues?
- It is said that MONRE will also take jurisdiction. The plan is to do this using the national budget.
- Will DONRE be responsible for pesticide testing from 2026 to 2030?
- Water is the main medium to be tested (soil is rarely tested).

- VOC analysis equipment is available and automatic measurement is possible. Samples are extracted from soil to be measured. Details are provided in QCVN05/2023 and QCVN08/2023.

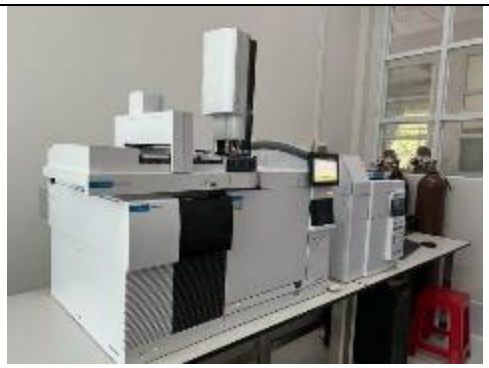
［Confirmed facilities and analysis items］

- Confirmed facilities: GCMS (Agilent 7000E Triple Quadrupole GC/MS, headspace sampler), atomic absorption spectrometry (Agilent 200 series AA), biological laboratory

- Analysis items
- Analysis of heavy metals. (The main target of analysis is water. Heavy metals are analyzed in areas in Ben Tre Province where calcareous soil is widespread.)
- E. coli test


Meeting


Laboratory


GCMS


Atomic absorption spectrometer


Experiment room


Biological laboratory

Figure 3-3 Visit to NREMC

[6] Extensive aquaculture facility in Binh Dai District

[Contents/Objective]

We visited aquaculture farmers in Ben Tre Province. There are three types of shrimp aquaculture: extensive aquaculture, managed aquaculture, and high-tech aquaculture. The facility that we visited uses extensive aquaculture, and the purpose of our study was to confirm the actual state of operation in extensive aquaculture.

[Exchange of Opinions]

- Overview of aquaculture facility
  - Area 12 ha, monthly yield 60 kg, annual yield approximately 720 kg. In addition to shrimp, crabs

and fish are also cultivated. The facility is run by two friends.

- There is only one sluice gate for water supply and drainage in one large pond, and it is directly connected to the river.

- How is water quality managed at the facility?
- Water quality analysis is not conducted in extensive aquaculture. Water is replaced by drawing water from the river using the tide level, and drainage is also carried out directly into the river.
- If DONRE monitoring indicates a problem, the water supply and drainage will be stopped and restarted after checking the situation.
- Due to the unstable water quality, diseases may occur from time to time.

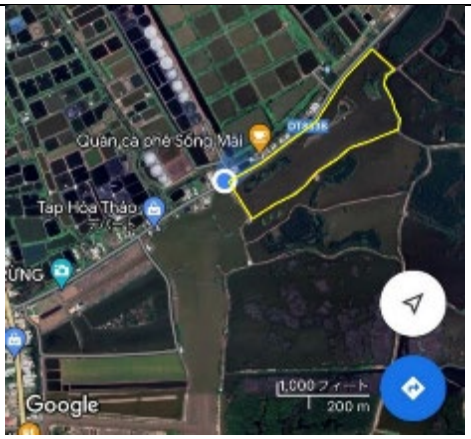
- Do you add young shrimp. Will they be eaten by other fish?
- We release young shrimp directly into the pond. We do not control fish reproduction.
- After releasing the young shrimp, coconut leaves are thrown into the pond to create a hiding place to prevent the young shrimp from being eaten by larger fish.

- Which do you want to do in the future, managed or extensive aquaculture?
- Management requires investment, and we have no budget. Also, the price of shrimp is higher for the extensive type, which creates sufficient income. (There is a difference depending on the size, but if wild shrimp is “4,” cultivated shrimp is about “3”). We also want to preserve extensive aquaculture in this region.

- Expenses
- It costs a lot for young shrimp and labor costs. There is also fuel money, and cutting coconut leaves to create a hideout for the shrimp. Since such work is outsourced, personnel costs are required.

- Harvesting method
- We utilize the tide level to open the floodgates and harvest the shrimp in baskets.

- Sludge processing
- We remove sludge once every two to three years. We use the removed sludge as reinforcing material for the bank of the aquaculture pond.



Satellite photograph of aquaculture site (area surrounded by yellow line) [32]

Extensive aquaculture site

Near the sluice gate where water is supplied and drained

Extensive aquaculture site

Figure 3-4 Visit to extensive aquaculture site in Binh Dai District

[7] Managed aquaculture facility in Binh Dai District

[Contents/Objective]

We visited aquaculture farmers in Ben Tre Province. There are three types of shrimp aquaculture: extensive aquaculture, managed aquaculture, and high-tech aquaculture. The facility that we visited uses managed aquaculture, and the purpose of our study was to confirm the actual state of operation in managed aquaculture.

[Exchange of Opinions]

- Overview of aquaculture facility

[32] https://maps.google.co.jp

- Total area of facility: 10 ha; area of aquaculture ponds: 2 ha (0.14 ha per pond, 6 in operation, 4 inactive); treatment ponds: 8 ha (water supply 6 ha, drainage 2 ha); water depth: approximately 3 m.
- Production volume: 200 tons annually (shrimp)

- Issues in managed aquaculture
  - There are issues with water supply. Diseases can spread through the water supply, so we take great care in cleaning our water supply. However, the amount of chemicals to be added for water purification varies based on experience. There are no drainage issues.
- Water supply
  - Water passes through four stages before being supplied to the aquaculture pond. Ponds that store water from rivers, sedimentation ponds, chemical treatment with $KMnO_4$, and chemical treatment with chlorine
  - We replace 500 tons of water per day. We reprocess and reuse aquaculture pond water.
- Water quality analysis
  - We haven't done much analysis other than simple analysis. When performing analysis, we have it done by the company from whom we purchased the chemical treatment.
  - Simple analysis uses kits that measure pH, nitrogen oxides, etc.
  - We want to know the test results quickly, so it would be convenient if there was a nearby location capable of conducting tests.
  - We want to know the salinity as soon as possible because we need to change the water supply amount.
  - Currently, it takes one day to obtain results if we suspect the occurrence of disease.
  - We do not inspect the shrimp (product), but inspections are performed by downstream companies such as trading companies that purchase the shrimp.
- Cost of pretreatment for water
  - We purchase chemicals about 3 times a year. Each purchase costs 600 million VND (approx. 3.56 million yen, converted at 1 VND = 0.0059 yen) and the annual cost is 1,800 million VND (approximately 10.67 million yen, converted at 1 VND = 0.0059 yen).
- Response to occurrence of illness
  - We remove the diseased individuals, and then harvest and sell the surviving ones. After all shrimp are removed, we perform chlorine disinfection for three days, and then drain and clean the water. As for sludge, we assume that disinfection has been completed after chlorination, and so we remove the sludge and store it in the storage pond.
  - The sludge storage pond is large enough to store 10 years worth of sludge.
  - Diseases are likely to occur because the purification power of water supply facilities is not stable.
- Sludge

- Sludge occurrence amount: We have never measured the amount. The area of the reservoir is 0.5 ha and the depth is 5 m.
- When the sludge storage pond is full, we dig a new hole. We leave the full pond unattended.

- Water purification facilities

- In order to reduce costs, we decreased the amount of chemicals used. We installed three hypochlorous acid water generators, but we have not yet seen any effects. The three units cost 400 million VND (approximately 2.37 million yen, converted at 1 VND = 0.0059 yen). We made the decision to install the generators after seeing them being installed by other companies in the same industry. We purchased the generators from a company that imports parts from Thailand, assembles the generators, and sells them in Vietnam.
- Electricity costs were calculated from the information obtained during the field survey and were as follows.

・Equipment operation status: Equipment (1)(2) 11V, 250A; Equipment (3) 11V, 600A
・Power: Equipment (1)(2) 11V × 250A × 2 units = 5.5kW; Equipment (3) 11V × 600A = 6.6kW
・Daily power consumption (24 hr operation): Equipment (1)(2) 132kWh, Equipment (3) 158kWh
・Daily electricity cost (average cost as of November 2023: 2,007VND/kWh):
Equipment (1)(2)(3) 290kWh × 2,007VND = 582,030VND (3,453 yen)
・Annual electricity cost: 582,030VND × 356 days = 212,440,950VND (1,260,480 yen)

Based on the above, we estimate that using the hypochlorous acid water generator will cost approximately 1.26 million yen per year.

- Installation of solar power at aquaculture facility

- If we were to introduce solar power generation, the shrimp would not be exposed to light. This would affect their color and appearance, which would lower the transaction price. Therefore, we are not considering solar power.

- Regarding the introduction of ASC certification system, Viet GAP, etc.

- Certification has not been acquired.

Interview with owners of managed aquaculture site

Satellite photograph of managed aquaculture site [33]

Managed aquaculture site

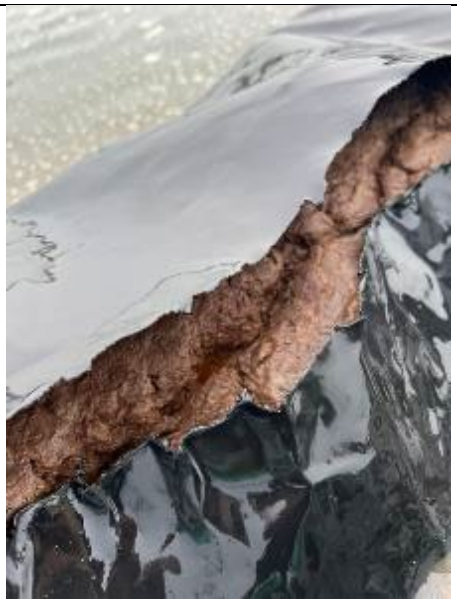
Water supply pond and chlorination shed (center)

Surveillance camera monitor

Hypochlorous acid water generator

[33] https://maps.google.co.jp

Chemical garbage area



Plastic sheet is placed to cover the bottom of the aquaculture pond

Figure 3-5 Visit to the managed aquaculture site in Binh Dai District

[8] Research Institute for Aquaculture No. 2 (REA2)

[Contents/Objective]

This institute is a national fisheries research institute under the Ministry of Agriculture and Rural Development. The institute has jurisdiction over southern Vietnam. For this reason, we visited Ben Tre Province to determine how the actual situation of aquaculture is perceived from the perspective of a research institution.

[Exchange of Opinions]

- Overview of REA2
  - REA2 has four branches.
  - We visited the Ho Chi Minh Research Center, which mainly conducts research on disease.
  - The main research themes of REA2 are diseases, feed nutrition, and biotechnology (microbiology and genomics research).
  - There is a breeding center for marine fish species in Vung Tau. There is a breeding center for freshwater fish species in Tien Giang Province. There is a laboratory in Ca Mau Province that conducts research on high-tech shrimp aquaculture.
  - REA2 provides aquaculture support and technical training throughout the southern Mekong Delta.
- Current issues in aquaculture
  - We believe that the biggest problem in shrimp aquaculture is the problem of sludge. Compared to the past, aquaculture is becoming more intensive and efficient harvesting is possible in a smaller area. Basically, water is a recycling system, so we don't see drainage a problem. The wastewater is treated with chlorine, so it can be discharged. Sludge is generated because a large amount of food is fed in a limited area.
  - For example, 10 years ago, 70% of fish aquaculture facilities were extensive facilities and 30% were intensive facilities. However, the opposite is now true, and there are many intensive facilities. There has resulted in the issue of sludge. In recent years, the introduction of RAS (Recirculating Aquaculture Systems) has progressed.
- Recirculating Aquaculture Systems (RAS)
  - RAS research is being conducted at a research institute in Ca Mau Province, and 500 tons of fish are being cultivated. However, only large companies can implement RAS.
- Are you conducting sludge treatment projects with other countries?
  - We are only involved in small-scale projects. In the case of pangasius, the water is fresh so that it can be treated. Pangasius has a biogas project and an organic compost project.
- Two types of shrimp are cultivated in shrimp aquaculture: black tiger shrimp (cultivated using extensive aquaculture) and whiteleg shrimp. Currently, the above two species are moving towards indoor cultivation (high-tech cultivation). Although field surveys seem to indicate that there are

three types of aquaculture (extensive type, managed type, and high-tech type), the extensive type is not included in aquaculture. Therefore, generally speaking, it is better to think of aquaculture as managed type and high-tech type.

- Issues of high-tech (indoor) aquaculture
  - Wastewater, sludge, plastics (sheets from aquaculture facilities, chemical plastics). Among these, sludge is an issue.
  - For outdoor (managed type), sludge is a problem, and we are considering methane gasification through methane fermentation and biofloc culture[34] that can suppress sludge generation. Our goal is to reduce the use of chemical agents as much as possible.
  - Any method of wastewater treatment may be used to meet Vietnam's standards. Cost is the most important factor. Mechanical treatment equipment is expensive, so a treatment method using microorganisms (biofloc) is practical.
- Do you conduct research on plankton and algae culture?
  - Currently, we do not use plankton as bait for shrimp; instead, we use pellets. Plankton are cultivated only as maintenance of plankton species.
- Do you do business with government agencies in other countries?
  - We conducted research on pangasius vaccines with the University of Stirling and the United Kingdom, research on fish nutrition with Australian universities, research on shrimp aquaculture with the University of New South Wales in Australia, and joint research on nutrition with Kyoto University.

[34] Biofloc culture: A farming method that purifies the water while suspending aggregates of microorganisms (bioflocs) in a closed aquaculture pond, and raises shrimp without changing the breeding water. The amount of seawater used for breeding and the amount of water discharged are significantly smaller, reducing environmental impact. It is also said that there is no need for antibiotics or other medications because the risk of pathogens entering from the outside is reduced.

Reference Material 4

[1] Professor Yusuke Shiratori, Kogakuin University of Technology & Engineering

[Contents/Objective]

We exchanged opinions on sludge treatment and utilization methods in Ben Tre Province with Professor Yusuke Shiratori of Kogakuin University, who is running a project to recover biogas from sludge and organic waste to operate a fuel cell in Tien Giang Province, Vietnam.

[Exchange of Opinions]

- Projects implemented by Ben Tre Province in the past

  In Ben Tre Province, the Science and Technology Research Partnership for Sustainable Development (SATREPS) was implemented for five years from 2015 to 2020. The research topic of the partnership was "building a local energy circulation system that combines high-efficiency fuel cells and recycled biogas." The research project was carried out in collaboration with the Institute of Nanotechnology of Vietnam National University, Ho Chi Minh Branch. [35]

- Overview of current projects in Tien Giang Province

  A NEDO project is supporting the operation of a recycling-type shrimp aquaculture facility in Tien Giang Province from 2022 to 2025. [36]The current project is expected to introduce advanced technology. The project targets companies among local managed fish aquaculture facilities that are particularly interested in advanced initiatives, are profitable, and have financial resources. If funds are limited or if the introduction is intended for an extensive fish agricultural facility, there will be gaps in awareness, technology, and money, and introduction will be difficult.

- Overview of the shrimp aquaculture system to be demonstrated [37]

  We will construct and demonstrate a shrimp aquaculture system that integrates a green power supply using biogas solid oxide fuel cells (SOFC) and a shrimp production system using IoT water management (Figure 2-11). In green power supply, unused local biomass (lemongrass leaves) and shrimp aquaculture sludge are fed into a resin methane fermentation tank to produce biogas. The biogas will be supplied to a SOFC to generate high-efficiency power, and a circulating system will be demonstrated in which the green electricity is used as a power source to supply air to the aquaculture pond (necessary for cultivating shrimp).

  On the other hand, the shrimp production system utilizes IoT to constantly monitor and adjust the water quality of the aquaculture pond and aquaculture-related equipment. The system also has a microbubble diffuser that maximizes aquaculture production through heightened shrimp survival rate and growth rate by using fine air bubbles to increase dissolved oxygen concentration.

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[35] SATREPS: https://www.jst.go.jp/global/kadai/pdf/h2602_final.pdf

[36] NEDO：https://www.nedo.go.jp/activities/AT1_00175.html

[37] atPress: https://www.atpress.ne.jp/news/333309

IoT will also be used for management of SOFC operation.

In other words, the system combines “power generation from aquaculture sludge and biomass waste” and “shrimp aquaculture controlled by IoT.” This is the world’s first empirical study of this combination.

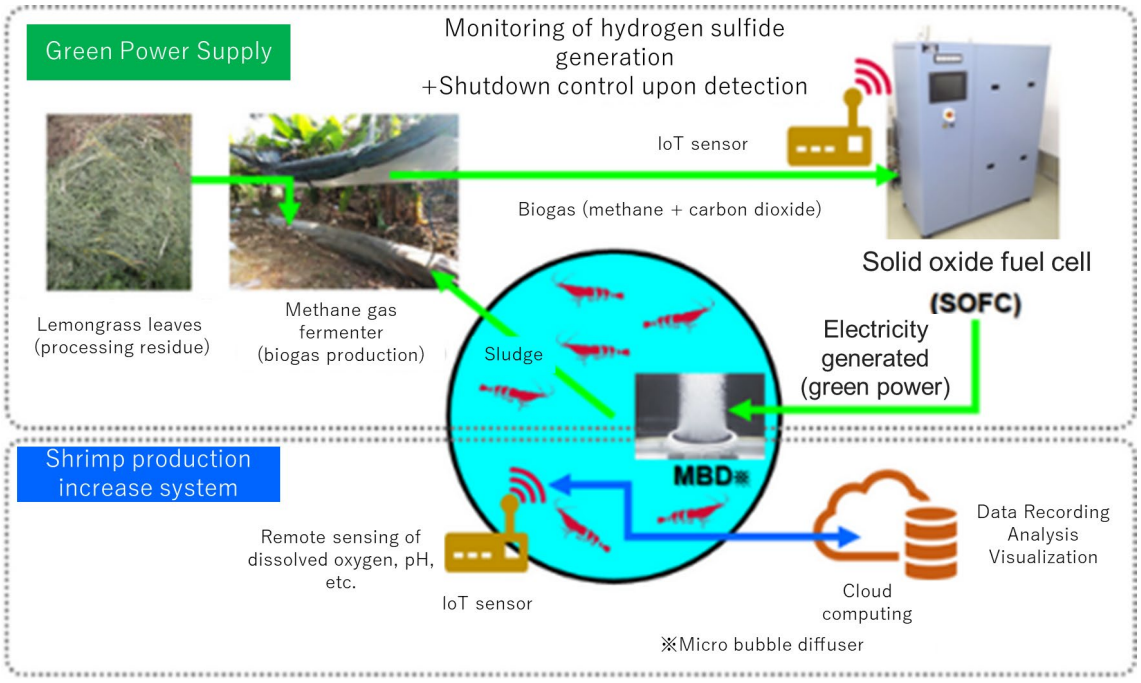

Figure 3-6 Schematic diagram of a shrimp aquaculture system incorporating biogas-powered fuel cells and IoT

- Method for utilization of sludge in this technology

  Sludge from shrimp aquaculture facilities is a starter for methane fermentation. Since it is not the main ingredient in fermentation, the influence of salt contained in shrimp aquaculture sludge has not been taken into account. The main source of fermentation is local unused biomass; for example, rice straw, coconut pomace, and bagasse in Ben Tre Province.

- Utilization of fuel cells

  When looking at the spread of fuel cells around the world, Japan is the only country where fuel cells are being introduced in the form of household fuel cells. Since it is common for households to operate on city gas, I believe that commercial-level operation of fuel cells which use biogas has not yet been implemented. In order to promote the use of fuel cells, it is necessary to establish a stable supply system for biogas and solve cost issues, as well as to make the market recognize the true value of fuel cells and to promote the use of cells.

[2] Professor Hidenori Yasui, University of Kitakyushu

[Contents/Objective]

Professor Yasui specializes in treatment technology development and computing for organic waste and wastewater, etc. He is familiar with activated sludge treatment processes, methane fermentation processes, and nutrient removal technologies. We exchanged opinions with Professor Yasui on sludge treatment and utilization methods in Ben Tre Province.

[Exchange of Opinions]

- Method for utilization of sludge containing salt

  Although sludge containing salt may have the potential to be used as fertilizer depending on its salt concentration, it is necessary to conduct demonstration tests to verify that potential. If a certain amount of salt needs to be removed, the salt can be removed by washing with water in a tank, etc. However, once solidified, a certain amount of nitrogen and phosphorus will be retained in the sludge, so there is potential for using the sludge as fertilizer.

  In addition to using sludge as fertilizer, there are utilization methods such as methane fermentation through anaerobic digestion, and solidification using a dehydrator or dehydrating agent.

[3] Japan UTS

[Contents/Objective]

JAPAN UTS is a company that supports the introduction of biogas systems. We exchanged opinions with the company on sludge treatment and utilization methods in Ben Tre Province.

[Exchange of Opinions]

Although various data are unknown, we received comments from JAPAN UTS regarding the possibility of methane fermentation using shrimp aquaculture facility sludge.

- Biogas utilization of shrimp aquaculture facility sludge
  - Point 1: Salt

    Salt contained in shrimp aquaculture facility sludge inhibits methane fermentation, so it is necessary to reduce the salt concentration. According to a report in Aichi Electric Technical Report No. 41 (2020), the number of days for fermentation increases when the salt concentration is 0.5%. However, there are also reports that fermentation recovers with acclimatization, so even if the salt concentration is 0.5%, it is the limit for methane fermentation. In this case, when using fresh water to dilute seawater with a salinity of 3%, 5 tons of fresh water will be required for every 1 ton of seawater. The solid content concentration is also important for methane fermentation. Although typical wet fermentation is often operated at a solid content of 3% to 10%, the solid content concentration decreases after fresh water is added, so we expect the amount of methane gas generated to be extremely

small. It is possible to improve the salinity and solids concentrations by dehydrating the organic residue and injecting fresh water, but this would require larger equipment and significantly increase the amount of work.

- Point 2: Ration of CHNO

When introducing biomethane fermentation, the CHNO composition of the sludge to be used is important. In particular, it is important to understand the C/N ratio.

The C/N ratio is the mass ratio of carbon C to nitrogen N in a substance, and it greatly influences fermentation efficiency.

Methods for measuring CHNO include measurement with a CHNO recorder, estimation from nutritional components, estimation from CODcr values, and estimation from the measurement results of the Kjeldahl method.

- Types of methane fermentation methods

There are two types of methane fermentation: wet and dry. Dry fermentation can be further divided into continuous and batch. [38]

• Wet

Problems such as pipe clogging and reduced gas generation due to excessive input of raw materials are likely to occur, so knowledge and experience are required. In the unlikely event that adverse conditions occur that would be fatal to fermentation, it would be necessary to completely replace the fermentation solution in the fermenter, and it would take one to two months for gas to be generated. Therefore, the risk is high unless a skilled service team can respond quickly.

• Dry (continuous)

Breakdown and maintenance of the agitator is a major issue. The agitator is installed inside the fermenter, so if it breaks down or needs to be replaced, the fermenter must be emptied first. The agitator uses a large amount of energy. Therefore, there is a risk that repairing breakdowns will require a large amount of cost and effort.

• Dry (batch)

Since there are almost no moving parts, there is almost no maintenance required after the equipment is left unused for about four weeks following the addition of raw materials. Even if a problem should occur, it is easy to repair. Therefore, the equipment is easy to handle even for staff with little knowledge and experience in issuing biogas.

[38] NEDO: https://www.nedo.go.jp/content/100932093.pdf

(Data) item	Wet process	ry process (Continuous type)	(Reference) Dry type (Batch type)
General view			<NASKEO>  <BEKON> 
Raw material concentration	2-20%.	20-50	20-50
Sludge concentration	2-10% (2-10%)	15-30%.	15-30%.
Process Overview	Floating methanogens at low sludge concentrations play and process	High sludge concentration treated by methanogenic bacteria (in neo-Confucianism) the underlying principles of the cosmos	High sludge concentration treated by methanogenic bacteria (in neo-Confucianism) the underlying principles of the cosmos
Feature	Easy operation management No need to dispose of digested liquid (when using liquid fertilizer)	Capable of handling solid waste No wastewater treatment required Gas generation per unit weight of raw material Increased production	Capable of handling solid waste No wastewater treatment required Gas generation per unit weight of raw material Increased production
Main customers	Business and household food waste Food processing residues Livestock manure Sewage sludge	Municipal Solid Waste Solid waste	<NASKEO> Municipal Solid Waste Beef and cattle manure Sugar mill sludge, vegetable residue <BEKON> Woody shredded materials (Rootstock, branches and leaves) Livestock manure (cattle manure, chicken manure, sludge)
Track record	Numerous in Japan	Fewer in the country	Almost never in Japan.
Tolerance for mixing of unsuitable materials	small	big	big
Wastewater Treatment	Required (without liquid fertilizer treatment)	Not required (depends on raw material conditions)	Not required (depends on raw material conditions)
Fermenter maintenance	Regularly required	Almost never needed	Almost no mechanical parts other than pumps, so maintenance is virtually nonexistent. cornerstone

Figure 3-7 Overview of methane fermentation technology [39]

- Proposal method for utilization of salt-containing sludge in biogas fermentation

  In order to use raw materials containing salt for biogas fermentation, it is necessary to mix them with other raw materials in order to lower the overall salt concentration before fermentation.

  Furthermore, wet or continuous dry systems are unsuitable for avoiding the hassle of daily equipment maintenance (including specialized techniques) and aiming for stable operation.

  ［Proposal under current conditions］

  We believe that batch dry biogas fermentation is optimal.

[39] NEDO: https://www.nedo.go.jp/content/100932093.pdf

- ✧ Adding other raw materials to salty materials in order to lower the overall salt concentration
- ✧ Candidate raw materials for addition: Food residue, livestock manure, plant branches and leaves such as pruned branches
- ✧ After adding raw materials, there is no need to add raw materials for about four weeks.
- ✧ No need for complicated piping or pump interlocking.
- ✧ Fermentation residue can be used to produce organic fertilizer through aerobic fermentation (residual salt content is a consideration)

- Example of biogas utilization

  Biogas produced by methane fermentation can be used for a variety of purposes by purifying it as necessary to increase the gas concentration.

  - ➢ Example: Generators, fuel cells, boilers, etc.

- Technology of the Miura Institute of Environmental Science that can be used for environmentally-friendly aquaculture

  Since methane fermentation requires monitoring of the fermentation status, it is possible to use technology the Miura Institute of Environmental Science to manage the biomethane production process.