FY2022 Project for Ministry of the Environment Japan

City to City Collaboration for Zero-carbon Society in FY2022
Project to Promote the Formation of an Autonomous Decarbonized Society through City-to-City Collaboration between Hiroshima Prefecture and Soc Trang Province, Vietnam
Report

10 March 2023

E-Square Inc.
Hiroshima Prefecture

Table of contents

Tables and figures

1. Introduction

1.1. Background and purpose of the survey

All countries participated in the 21st Conference of the Parties (COP21) to the United Nations Framework Convention on Climate Change (UNFCCC) held in December 2015 in the suburbs of Paris, France, where the Paris Agreement, a legal framework for fair and effective climate action beyond 2020, was adopted, followed by the adoption of a rulebook at COP24 in Katowice, Poland, in December 2018, which sets out specific obligations for each country starting in 2020.

At COP21, where the Paris Agreement was adopted, it was decided to recognize the actions of non-state actors, including cities, and to welcome the efforts of all non-governmental actors (cities and other local governments, etc.) and invite them to scale up their efforts. Cities are places of activity that support socio-economic development and are inhabited by large numbers of people. About half of the world's population lives in urban areas, which account for 2% of the world's total land area, and this proportion is expected to increase to 70% by 2050. As of 2006, more than 70% of the world's CO2 emissions were estimated to come from urban areas. Urban areas play a significant role in mitigating climate change, and the steady implementation of climate change countermeasures in urban areas and the reduction of greenhouse gas emissions are important for achieving the goals of the Paris Agreement.

In this project, Japanese research institutes, private companies, universities, and other organizations, together with Japanese cities that have experience and know-how in the formation of a low-carbon society, will conduct research projects necessary to effectively and efficiently support efforts to form a low-carbon society in overseas cities.

This survey was conducted in Soc Trang Province, Socialist Republic of Vietnam, with the aim of reducing greenhouse gas emissions in the field of renewable energy, forming JCM projects that will contribute to such reduction, and strengthening cooperation among cities.

1.2. Survey overview

Basic research was conducted on the geopolitical and economic situation in the target country, Viet Nam, and Soc Trang Province, and on agriculture, especially rice cultivation. In addition, activities related to intercity cooperation between Hiroshima Prefecture and Soc Trang Province were carried out and two workshops/meetings were held locally. The possibility of reducing CO2 emissions through the use of rice husk solid fuel, waste-to-energy generation and solid waste-to-energy (RPF) utilisation was also studied.

(1) Basic survey of Soc Trang Province

Prepared based on JETRO Vietnam general overview, local interview surveys, etc., and the latest local information.

(2) Collaboration between Hiroshima Prefecture and Soc Trang Province

The know-how and knowledge possessed by Hiroshima Prefecture was compiled, communicated to

Soc Trang Province and the possibility of collaboration was discussed.

(3) Investigation of a project to convert coal boilers to fuel by using rice husk solid fuel.

A survey was conducted on the assumption that the rice husk solid fuel production equipment (curl chip production machine) of Tromso Co. Ltd, a company in Hiroshima Prefecture, would be introduced to the local area, and the feasibility of this was examined.

(4) Survey on projects to reduce greenhouse gas emissions through waste power generation, etc.

A feasibility study was conducted on the assumption that Ogawa Econos Inc, a company in Hiroshima Prefecture, would conduct a waste power generation business and a waste solidified fuel (RPF) production business locally, and the feasibility of such a business was investigated.

1.3. Survey structure

The structure of this survey is shown below.

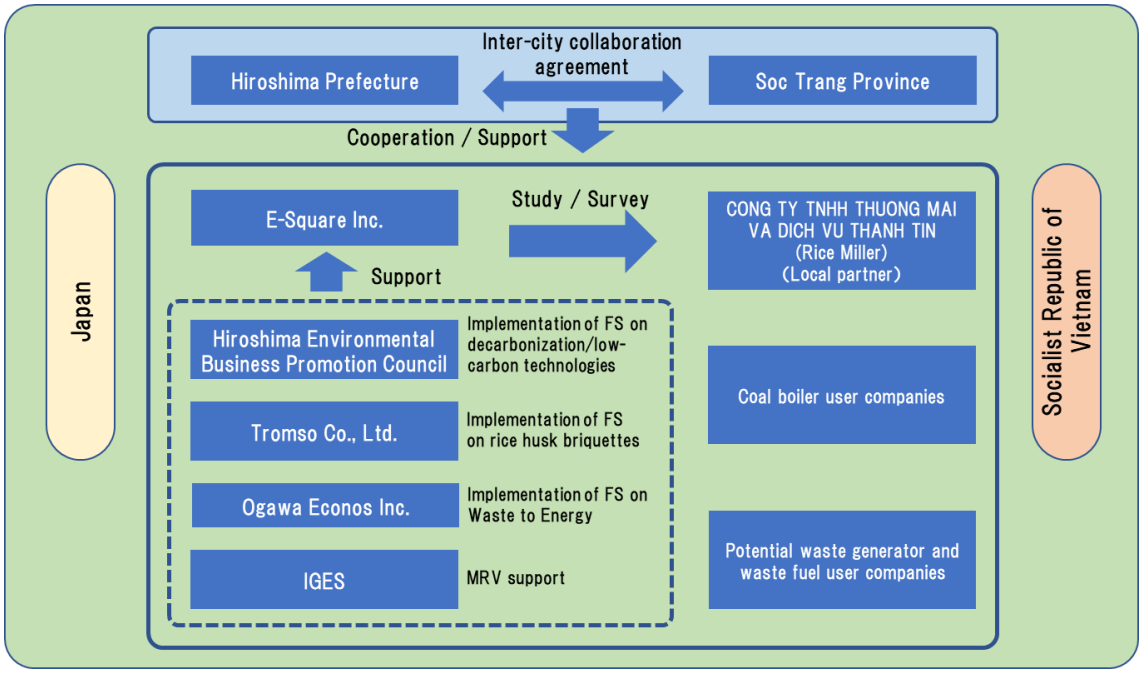


Figure 1 Survey structure

E-Square Inc. worked as the main implementer with Hiroshima Prefecture as the Japanese local government, Hiroshima Environmental Business Promotion Council, Tromso Co., Ltd., Ogawa Econos Inc., and Institute for Global Environmental Strategies (IGES) as the co-implementers.

1.4. Survey schedule

This study started in July 2022 and was completed in March 2023.

Item	2022						2023		
	7	8	9	10	11	12	1	2	3
Basic survey	→	→	→	→					
Collaboration with Soc Trang Province		→	→	→	→	→	→	→	
FS on rice husk sold fuel		→	→	→	→	→	→	→	
FS on WtE		→	→	→	→	→	→	→	
Mtg. / workshop				★			★		
Briefing to MOEJ						★		★	
Reporting					→	→	→	→	submission

Figure 2 Survey schedule

2. Basic Survey on Soc Trang Province

2.1. Overview of Vietnam

Vietnam is officially known as the "Socialist Democratic Republic of Vietnam" (hereinafter referred to as Vietnam). It is located on the east side of the Indochina Peninsula at latitudes 8.35-23.4 degrees north/longitudes 102.8-109.4 degrees east, bordered by Laos and Cambodia to the west, and the South China Sea to the east. The distance from Tokyo to Ho Chi Minh City is 4,336 km, and it takes about 6 hours by air.

Figure 3 Location of Vietnam and Japan

Figure 4 National flag of Vietnam

The political system is a socialist republic led by the Communist Party of Vietnam. The current system has been in place since the declaration of independence by Ho Chi Minh in 1945 (independence of the Democratic Republic of Vietnam), the Vietnam War, and the reunification of North and South Vietnam in 1976.

Vietnam has an area of 329,241 ㎢ (about 90% of the area of Japan), three quarters of which is mountainous. The country can be roughly divided into the northern, central, and southern regions. In

the north, the capital Hanoi is the political and cultural center. In the central region, tourism is becoming a major industry with Da Nang, the third largest industrial city after Hanoi and Ho Chi Minh. In the south, the former capital of South Vietnam, Saigon, has been replaced by Ho Chi Minh City as the commercial center of the country. The Mekong Delta region in the south is also the center of rice cultivation in Vietnam, where rice production is flourishing nationwide.

The population is approximately 99.46 million (in 2022). The Kinh account for about 86% of the population, and the rest is made up of 53 ethnic minorities. 35.7% of the population lives in urban areas such as Hanoi, Ho Chi Minh City and Can Tho City, and 64.3% in rural areas. The majority of the population is young, with a large number of working-age and reserve population under the age of 60, and there is ample room for population movement from rural to urban areas in the future.
The number of Japanese residents in Vietnam was 21,819 as of October 2022 (according to the Ministry of Foreign Affairs).

Table 1 Major indicators in Vietnam

Item	Content
Country name	Socialist Republic of Vietnam
Capital city	Hanoi
Area	329,241 ㎢（Equivalent to the area of Japan excluding Kyushu region）
Population	Approx.99.46 million （Estimation in 2021）
Religion	Urban area: Overall ratio 35.7% / Rural area: 64.3%
Language	Buddhism(80％), Christianity (9％)、others(Islam, Cao Dai etc.)
Administrative division	Official terminology：Vietnamese

Source：JETRO. The Ministry of Foreign Affairs

2.2. Overview of Soc Trang Province

Soc Trang Province, with which Hiroshima Prefecture has concluded an inter-city partnership agreement, is a municipality in the Mekong Delta region of southern Vietnam, facing the South China Sea. It has a population of about 2 million people, and is an area where agricultural production, mainly rice cultivation, and shrimp farming are flourishing, and where many food processing factories are located.

Figure 5 Location of Soc Trang Province

(1)Land use

The total area of Soc Trang Province is 331,176 ha. The land in Soc Trang Province is fertile and suitable for the cultivation of paddy rice, sugarcane, soybeans, corn, onions, garlic and other vegetables, grapefruit, mangoes, durian and other fruit trees. Agricultural land accounts for 205,748 ha (62.13%), forest land 11,356 ha (3.43%), aquaculture land 54,373 ha (16.42%), and salt production and other agricultural land 0.97%. Land for rice cultivation occupied 144,156 ha, land for other annual crops 21,401 ha, and land for perennial crops and fruit trees 40,191 ha. In particular, non-agricultural land is 53,963 ha and unused land is 2,536 ha[1].

(2)Climate

Soc Trang Province has a mild climate throughout the year, with an average weather temperature of 26.7℃, a maximum temperature of 28.2℃ (April), and a minimum temperature of 25.2℃ (January). Located in the Mekong Delta and facing the South China Sea, the average humidity is as high as 86%. Floods and typhoons are rare.

Soc Trang Province has a tropical monsoon climate, with a dry season from November to April and a rainy season from May to October, with an average annual rainfall of 1,779.5 mm. The average annual sunny hours is 2,372 hours, and the average annual solar radiation is 140-150 kcal/cm2.[2]。

[1] Portal site of Soc Trang Province
[2] Portal site of the Ministry of Planning and Investment, Vietnam

2.3. Economic situation in Vietnam

According to the General Department of Statistics of Vietnam, Vietnam's real GDP growth rate (estimated value) in 2022 was 8.02% y/y, achieving the government target of 6.0-6.5% announced at the beginning of 2022 and exceeding 8% for the first time since 1997, the highest growth rate in recent years. which was the lowest level between 2011 and 2008 due to the Corona disaster, but has achieved a V-shaped recovery.

By industry, agriculture, forestry, and fisheries accounted for 3.36%, mining and construction 7.78%, and services 9.99%. The agriculture, forestry, and fisheries industry showed a stable growth rate due to a stable supply of livestock products and an increase in the production and export value of aquaculture and fishery products. The mining and construction industry grew at nearly double the rate of the previous year, although not as fast as in 2019 before the pandemic of the novel coronavirus; the service sector, which accounts for about 40% of GDP, rebounded strongly and drove economic growth, rebounding from the slump during the pandemic of the novel coronavirus[3]。

2.4. Economic situation in Soc Trang Province

(1)Major industries

Soc Trang Province is a province with a thriving agricultural production and agro-fishery processing industry. The average annual production of rice is over 2 million tons, of which high-grade rice accounts for over 52% of the province's total rice production. The total annual volume of milled rice exceeds about 1 million tons/year, and the export value of rice reaches US$160 million (2020).

The total production of aquaculture in 2020 was 317,182 tons, with about 94,000 tons of processed frozen shrimp and 15,000 tons of frozen squid and fish; the export value of fishery products in 2020 was US$820 million.

(2)Economic growth rate

In Soc Trang Province, stable economic growth has continued (Table 2), with high positive growth in 2020 despite the impact of the novel coronavirus outbreak.

Table 2 Economic growth rate of Soc Trang Province

Year	Growth rate
2016	5.22%
2017	7.01%
2018	7.20%
2019	7.30%
2020	6.75%

[3] JETRO business news letter (January 10 2023)

Source: Soc Trang Province

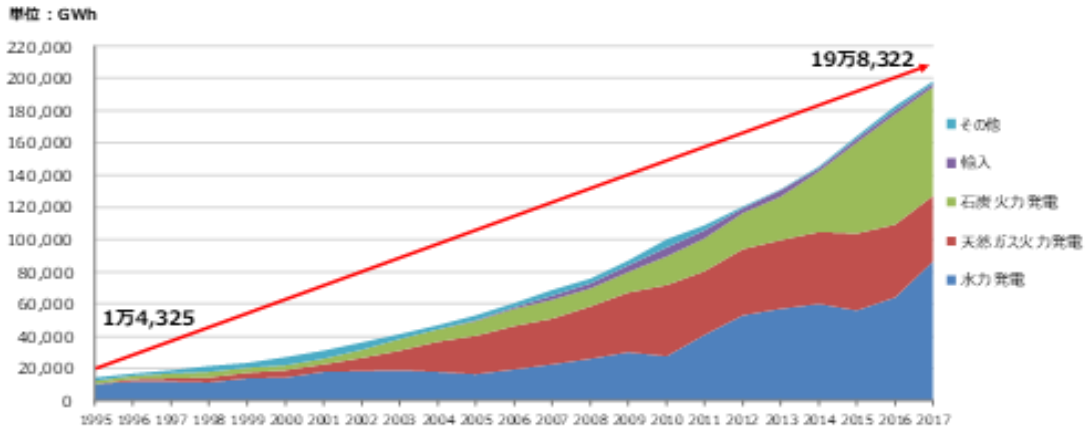
(3)Work force

Soc Trang Province has a population of about 2 million, with a population density of 362 persons/km2 , and a working population of about 658,000 persons aged 15 and over, of which 31.62% is urban and 68.38% is rural. The male to female ratio of the working population is 58.51% for males and 41.49% for females.

2.5. Electricity Situation in Vietnam

Vietnam's electricity demand has continued to grow in recent years, and total electricity generation has continued to increase substantially over the years: total electricity generation in 2017 increased by 8.4% year-on-year, nearly 14 times more than in 1995. The village electrification rate (penetration rate) reached 98.8% in 2015.

As of 2017, hydropower was the most common type of power generation in terms of both installed capacity and output, but since 2014 there has been a notable increase in coal-fired power generation. Since 2015, coal-fired power generation has surpassed hydropower generation as the largest amount of power generation, but in 2017, hydropower generation surpassed coal-fired power generation due to high precipitation and sufficient storage capacity in dams.



Source: JETRO Hanoi Office

Figure 6 Changes of total power generation

The electricity policy is being implemented in accordance with the revised Seventh National Electricity Master Plan (enacted on March 18, 2016) and the Revised Seventh National Electricity Master Plan (2011-2020 Electricity Development Plan with an eye on 2030).In FY2017, the total power generation capacity was 198,322 GWh and In FY2017, the total power generation was

198,322 GWh, and the power generation capacity was 45,410 MW, but the goal is to increase the total power generation to 572,000 GWh and the installed power generation capacity to 129,500 MW by 2030.

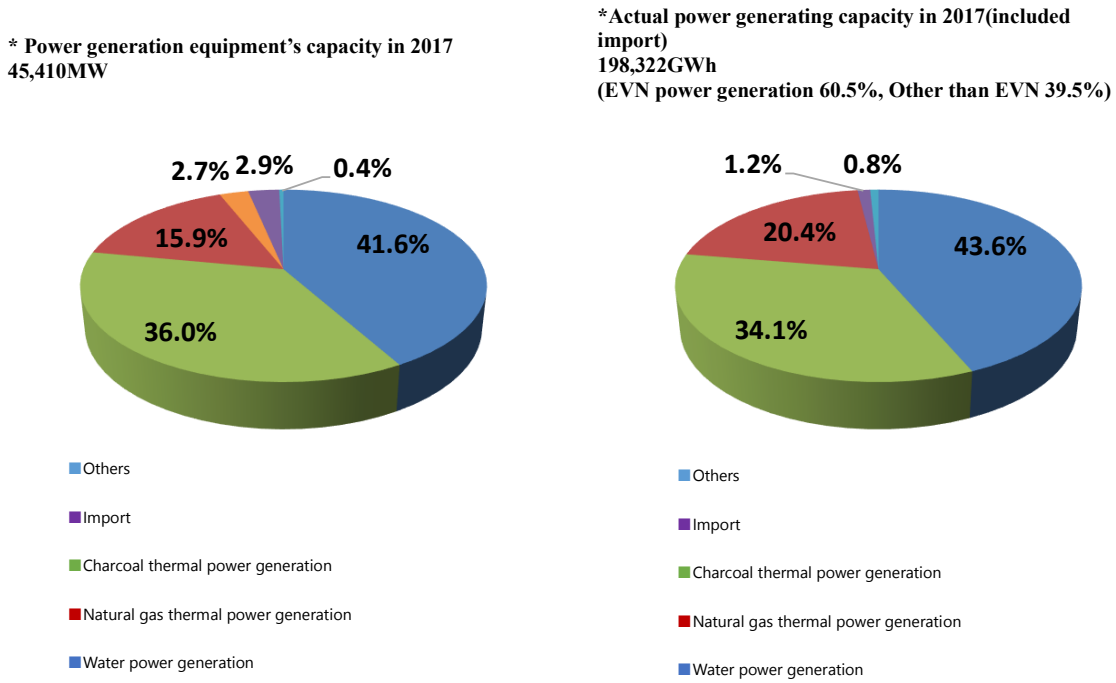


Figure 7 Total installed capacity and total power generation in Vietnam in 2017
Source: JETRO Hanoi Office

In the electricity system, the state-owned Electricity Generating Board of Vietnam (EVN), established in 1994, is responsible for the generation, transmission, supply, and trading of electricity. EVN has a monopoly on transmission and distribution of electricity.
The Vietnamese government is promoting the expansion of power generation from renewable energies, and has set a numerical target of 27,195 MW of installed capacity and 61,000 GWh of power generation by 2030. The target for biomass power generation by 2030 is 3,281 MW of installed capacity and 12,000 GWh of power generation.

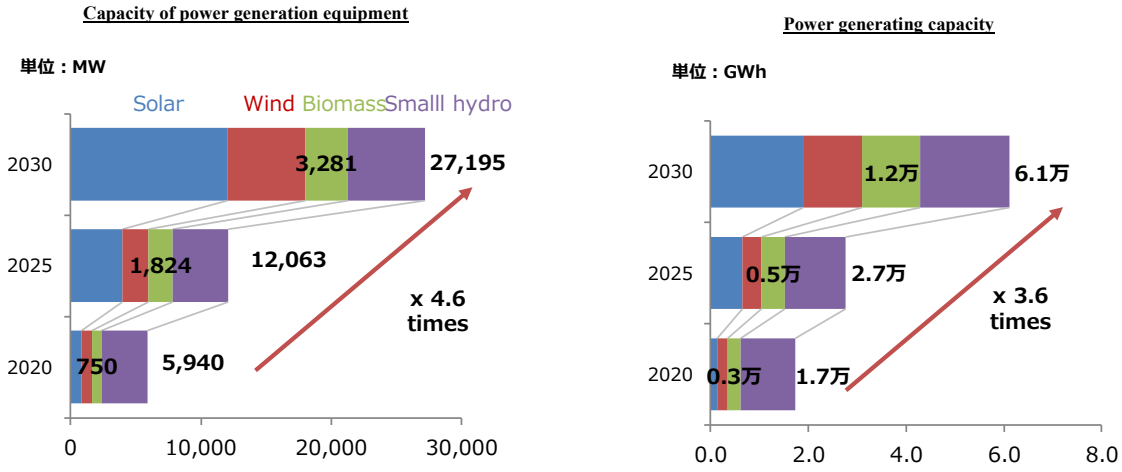


Figure 8 Renewable energy expansion targets in Vietnam

Source: JETRO Hanoi Office

In 2017, the ratio of thermal power generation using fossil fuels was nearly 60%, and the ratio of coal-fired thermal power generation was around 35%, so greenhouse gas emissions from power generation have remained high and need to be improved. The emission factor for electricity is 0.7 kg-CO2/kWh, which is higher than Japan's current factor of 0.55 kg-CO2/kWh, and an energy transition is required.

The price of electricity has been increasing year by year (Figure 9). The reason for the increase in electricity prices is the improvement in the EVN deficit and the increase in coal prices. By industry, electricity prices are higher for commercial, consumer, and industrial sectors, in that order.

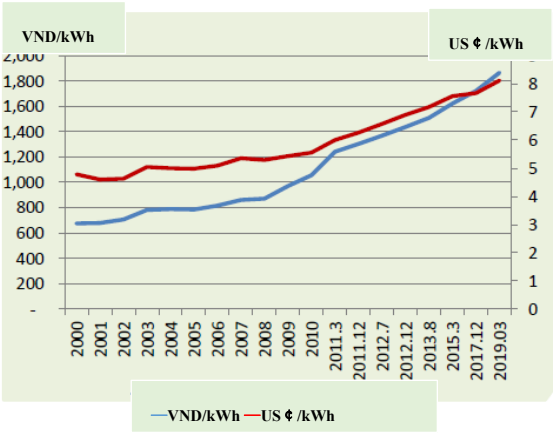


Figure 9 Changes in electricity charges （overall average）

Source：Survey on electricity in Vietnam by JETRO

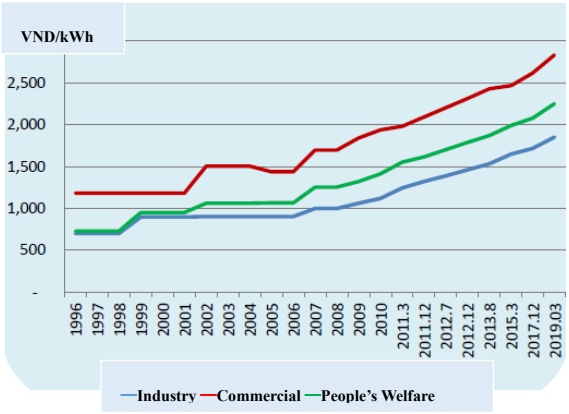


Figure 10 Changes in electricity charges （average of industries）
Source：Survey on electricity in Vietnam by JETRO

Vietnam does not have basic electricity tariffs like Japan, and industrial electricity tariffs consist of metered rates with three levels of unit prices by time of day.
On March 20, 2019, the Ministry of Industry and Trade of Vietnam promulgated Decision No. 648/QD-BCT of the Ministry of Industry and Trade on the increase of electricity tariffs, which will be increased by 8.36% on average. The average electricity tariff, excluding value-added tax, is now VND1,864.44 per kilowatt-hour (kWh), up from VND1,720.65 per kWh (about ¥8.1; 1 VND = about ¥0.0047). The price hike is the first since December 2017 and took effect on March 20, the day of the promulgation. Electricity tariffs were priced differently depending on usage and time of day, with prices in the industrial sector ranging from VND970 to VND3,076 per kWh.

Mr. Dinh Quang Chi, Vice President of the Electricity Generating Authority of Vietnam (EVN), pointed out that the main reason for the price hike was the rise in coal prices and the gap between the power trading prices. Vietnam has been increasingly relying on coal-fired power generation in recent years, but coal prices have been rising, increasing the cost of power generation. In addition, EVN purchases electricity from power producers, and the difference between the purchase price and the selling price is becoming substantial. In addition, payments for water resource development rights and rising natural gas prices have also contributed to the growing deficit in the power business. With this price hike, EVN will be able to pay its suppliers and deal with the increased cost of power generation, but further price hikes were necessary to improve power generation facilities and make new investments.
The electricity price hike will raise production costs in the manufacturing sector, and this has resulted in some companies having to consider whether to pass on the price hike to product prices or bear the cost themselves for the time being. The price hike was expected to raise the consumer price index (CPI) by 0.29 percent and push down GDP by 0.22 percent, according to estimates by the Ministry of Commerce and the General Administration of Statistics. The price hike was originally

scheduled to take place in 2018, but was postponed to 2019 after Prime Minister Nguyen Xuan Phuc indicated that he would not approve the price hike in order to achieve the CPI and GDP targets[4].

Table 3 The list of electricity charge in Vietnam(Revised on 20th March)

Unit:VND/kWh

Item by fields		Electricity charge	
		Pre-revision	Post-revision
1	Electricity charge in manufacturing industry		
1.1	Voltage: More than 110kV		
・General time a day		1,434	1,536
・Off-peak time a day		884	970
・Peak time a day		2,570	2,759
1.2	Voltage: 22kV to less than110kV		
・General time a day		1,452	1,555
・Off-peak time a day		918	1,007
・Peak time a day		2,673	2,871
1.3	Voltage: 6kV to less than 22kV		
・General time a day		1,503	1,611
・Off-peak time a day		953	1,044
・Peak time a day		2,759	2,964
1.4	Voltage: Less than 6kV		
・General time a day		1,572	1,685
・Off-peak time a day		1,004	1,100
・Peak time a day		2,862	3,076
2	Electricity charge in government and specialty		
2.1	Hospital, Nursery school, kindergarten and school		
2.1.1	Voltage: More than 6kV	1,531	1,659
2.1.2	Voltage: Less than 6kV	1,635	1,771
2.2	Public lighting, administrative business		
2.2.1	Voltage: More than 6kV	1,686	1,827
2.2.2	Voltage: Less than 6kV	1,755	1,902
3	Electricity charge in commerce		
3.1	Voltage: More than 22kV		
・General time a day		2,254	2,442

[4] JETRO Business Report

・Off-peak time a day		1,256	1,361
・Peak time a day		3,923	4,251
3.2	Voltage: 6kV to less than 22kV		
・General time a day		2,426	2,629
・Off-peak time a day		1,428	1,547
・Peak time a day		4,061	4,400
3.3	Voltage: Less than 6kV		
・General time a day		2,461	2,666
・Off-peak time a day		1,497	1,622
・Peak time a day		4,233	4,587
4	Electricity charge in People’s welfare		
4.1	Electricity charge in household		
0 to 50kWh		1,549	1,678
51 to 100kWh		1,600	1,734
101 to 200kWh		1,858	2,014
201 to 300kWh		2,340	2,536
301 to 400kWh		2,615	2,834
More than 401kWh		2,701	2,927

・Normal time (Monday to Saturday: 4:00am to 9:30am, 11:30am to 5pm and 8pm to 10pm
Sunday: 4am to 10pm)

・Off-peak time (10pm to 4am)

・Peak time (Monday to Saturday: 9:30am to 11:30am, 5:00pm to 8pmSunday: None)

Source: JETRO

Vietnam's Ministry of Industry and Trade announced in April 2020 that it will reduce and exempt electricity tariffs from April to June 2020 as an economic measure in response to the impact of the spread of the novel coronavirus. Electricity rates for industry and commerce will be reduced by 10 percent for all time periods, and tourism and accommodation facilities that have been hit hard will be subject to cheaper industrial electricity rates instead of the usual commercial rates.
Electricity tariffs for daily use for general households were reduced by 10% for households using less than 300 kilowatt-hours (kWh) per month, but households using more than 300 kWh were considered high-income households less affected by the novel coronavirus and were excluded from the reduction.

In December 2020, the Ministry of Industry and Trade of Vietnam decided to reduce or exempt electricity tariffs for October to December following April to June as a measure against the novel

coronavirus.

Electricity tariffs for daily use for general households were reduced by 10% for households using less than 300 kilowatt-hours (kWh) per month, while travel accommodations and warehouses with distribution stock were subject to cheaper industrial electricity tariffs instead of the usual commercial tariffs. In addition, facilities for the prevention and control of novel coronaviruses were exempted from electricity charges, except for facilities that charge for centralized isolation. Specifically, facilities for the centralized isolation and examination of persons infected or suspected to be infected with the novel coronavirus were exempted from all electricity charges. In addition, medical facilities where infected or suspected infected persons are diagnosed, examined, and treated have had their electricity rates reduced by 20%. (Note that the electricity rates for industry and commerce, except for the above, which were exempted in the first round, are not exempted in the second round.

2.6. Electricity situation in Soc Trang Province

In Soc Trang Province, the cumulative electricity output in 2020 reached 1,620.79 million kWh, an increase of 89.74 million kWh (5.86%) compared to 2019 (1,503.06 million kWh). Of this, commercial electricity consumption reached 1,512.26 million kWh, an increase of 94.12 million kWh (6.59%) compared to the same period in 2019 (1,427.14 million kWh).

As of December 2020, there were 386,437 electricity subscribers, with 352,717 residential customers (accounting for 91.27% of the total). The number of business customers is 33,720 (accounting for 8.73%).

Electricity projects (thermal, wind, etc.) in Soc Trang Province are under construction and have not yet been put into operation (generated electricity); the amount of solar power generated in 2020 is 9.4 million kWh.

In accordance with the decision of the Ministry of Industry and Trade (No. 2630/QĐ-BCT) on approving the power development plan for Soc Trang Province from 2016 to 2025, during the period 2021-2025, the power utility plans to invest in the power grid to ensure safe and continuous power supply for the development of the provincial economy.

2.7. Rice production in Vietnam

Vietnam is long and narrow from north to south, with three quarters of its land area consisting of mountains, hills, and plateaus, and its varied topography and climate produce a wide range of agricultural products.

Rice produced in the two fertile deltas of the Mekong (in the south) and the Red River (in the north) is the main agricultural crop, and is an important export. The country also produces sugarcane and cassava, and is the second largest coffee producer in the world after Brazil (2017).

Seafood, such as shrimp and tuna, is also a valuable export, and is often exported to Japan.

Table 4 Status of agriculture, forestry and fisheries in Vietnam and Japan in 2017

Unit: USD 100 million

	Vietnam		Japan	
	Nominal value	% of GDP	Nominal value	% of GDP
Gross Domestic Product (GDP)	2,238		48,724	
Agriculture, forestry and fisheries GDP	343	15	542	1.1
GDP per capita (USD)	2,342		38,220	

Source: Ministry of Agriculture, Forestry and Fisheries of Japan

Table 5 Production of major crops in Vietnam and Japan

Unit: 10,000 tons

	Vietnam					Japan
	2013	2014	2015	2016	2017	2017
Rice(Paddy)	4,404	4,497	4,509	4,311	4,276	978
Sugar cane	2,013	1,982	1,834	1,631	1,836	150
Other fresh vegetables	1,219	1,301	1,325	1,382	1,424	265
Cassava	976	1,021	1,074	1,091	1,027	-
Maize	519	520	529	524	511	0.02
Other fresh fruits	280	285	292	294	297	-
Banana	189	186	194	194	205	0.003
Caffee(raw beans)	133	141	145	146	154	-

Source: Ministry of Agriculture, Forestry and Fisheries of Japan

2.8. Rice production in Soc Trang Province

The area of paddy fields in Soc Trang Province is about 149,162 ha, and the area cultivated for rice in recent years has been between about 351,000 ha and 356,000 ha. The annual production of rice (unhulled) is about 2 million tons.

The annual amount of rice husk discharged accounts for about 400,000 tons (about 20% of unhulled rice). Currently, rice husks are used as fuel for rice dryers and industrial boilers, and as agricultural materials (subsoil, fertilizer, etc.) (interview with Soc Trang Province).

2.9. Environment and energy law of Vietnam

Laws related to renewable energy in Vietnam include the National Energy Development Strategy, the Electricity Law, and the Environmental Protection Law. The strategies and laws of Vietnam are set out in the following order: National Strategy, Laws, Decisions and Protocols, and Directives.

The basic plan is the Revised Seventh National Power Master Plan (Revised PDP7: REVISIONS TO THE NATIONAL POWER DEVELOPMENT PLAN FROM 2011 TO 2020 WITH VISIONS EXTENDED TO 2030). The 7th National Power Master Plan was revised on March 18, 2016. The revised PDP7 announces the plan for the period 2016-2030 and aims to achieve a total power generation capacity of 572,000 GWh and installed capacity of 129,500 MW by 2030. The plan also includes ensuring energy security, introducing energy-saving technologies, and protecting the environment.

In March 2021, the 8th draft version of Vietnam's Power Development Plan, "Vision to 2045, National Power Development Master Plan from 2021 to 2030 (PDP8)," was released. The plan promotes the development of renewable energy sources (other than hydropower), with the goal of increasing the share of renewable energy in domestic power sources to 13% in 2020, 30% in 2030, and 44% in 2045, one year later at the end of February 2022 As of the end of this year, the project has not yet been approved.

(1)Environmental laws

Environmental laws and regulations in Vietnam are shown in the table below.

Table 6 List of environmental laws and regulations in Vietnam

Item	Law
General environmental management	Law on Environmental Protection enforced in 2015(No.55/2014/QH13)
	Decree detailing the Implementation of a Number of Articles of the Law on Environmental Protection (Decree No.19/2015/ND-CP)
	Decree on the Sanction of Administrative Violations in the Domain of Environmental Protection (Decree No.179/2013/ND-CP)
	Decree on February 14, 2015 on Environmental Protection Planning, Strategic Environmental Assessment, Environmental Impact Assessment and Environmental Protection Plans (Decree No. 18/2015/ND-CP)
	Decree providing for Incentives and Supports for Environmental Protection Activities (Decree No.04/2009/ND-CP)
	Circular on December 31, 2015 on the Guidelines for the corporate income tax policies for environmental protection activities regulated at the government’s decree No. 19/2015/ND-CP（Circular 212/2015/TT-BTC）
	Decision approving the Strategy for Protecting the National Environment by 2020, and the Orientation towards 2030（Decision 1216/2012/QD-TTg）
	Decree on January 6, 2015 on Environmental Damage Assessment（Decree No. 03/2015/ND-CP）
	Decree on December 31, 2014 regulating the Requirements Applicable to Environmental Monitoring Service Activities（Decree No. 127/2014/ND-

	CP）
	Circular on December 8, 2015 on the Evaluation, Inspection, and Final Check and Acceptance of Projects on Application of Natural Resources and Environment Information Technology（Circular No. 58/2015/TT-BTNMT）
Air quality	National Technical Regulation on Ambient Air Quality (QCVN 05/2013/BTNMT)
	National Technical Regulation on Hazardous Substances in Ambient Air (QCVN 06/2009/BTNMT)
	National Technical Regulation on Industrial Emission of Inorganic Substances and Dusts (QCVN 19/2009/BTNMT)
	National Technical Regulation on Industrial Emission of Organic Substances (QCVN 20/2009/BTNMT）
	National Technical Regulation on Emission of Thermal Power Industry (QCVN 22/2009/BTNMT）
	National Technical Regulation on Road Vehicles - Maximum permitted limits of exhaust gases（TCVN 6438:2005）
	Circular on August 17, 2015 on the Technical Procedure on Monitoring Exhaust Gas（Circular No. 40/2015/TT-BTNMT）
Water quality	National Technical Regulation on Surface Water Quality (QCVN 08-MT:2015/BTNMT）
	National Technical Regulation on Domestic Water Quality (QCVN 02/2009/BTNMT)
	National Technical Regulation on Underground Water Quality (QCVN 09-MT:2015/BTNMT）
	National Technical Regulation on Coastal Water Quality (QCVN 10-MT:2015/BTNMT）
	National Technical Regulation on Domestic Wastewater (QCVN 14/2008/BTNMT）
	National Technical Regulation on Industrial Wastewater (QCVN 40/2011/BTNMT)
Waste	National Technical Regulation on Hazardous Waste Thresholds (QCVN 07/2009/BTNMT）
	Decree on April 24, 2015 on Management Of Waste And Discarded Materials（ Decree No.38/2015/ND-CP）
	Circular on June 30, 2015 on Management of Hazardous Wastes（Circular No.36/2015/TT-BTNMT）
	Decision on March 22, 2015 on the recovery and disposal of waste（Decision No.16/2015/QD-TTg）
Noise	National Technical Regulation on Noise (QCVN 26/2010/BTNMT)
Vibration	National technical Regulation on Vibration (QCVN 27/2010/BTNMT)
Soil	National Technical Regulation on the Allowable Limits of Heavy Metals in the Soils (QCVN 03/2008/TNMT)
Forest resources	Law on Forest Protection and Development（No.29/2004/QH11）
	Decree on the Implementation of the Law on Forest Protection and Development (Decree No.23/2006/ND-CP)
Biodiversity	Law on Biodiversity (No.20/2008/QH12)
Environmental assessment	Decree on February 14, 2015 on Environmental Protection Planning, Strategic Environmental Assessment, Environmental Impact Assessment

	and Environmental Protection Plans（Decree No. 18/2015/ND-CP）
	Circular on March 29, 2015 on Strategic Environmental Assessment, Environmental Impact Assessment and Environmental Protection Plans（Circular No. 27/2015/TT-BTNMT）
Land use and residents	Law on Land (No. 45/2013/QH13)
	Housing Law (No. 65/2014/QH13)
	Detail regulation on the Law on land (Decree No. 43/2014/ND-CP)
	Regulation on land price (Decree No. 44/2014/NĐ-CP)
	Law on Land lease, water lease (Decree No. 46/2014/NĐ-CP)
	Enforcement order on Housing Law (Decree No.90/2006/ND-CP)
	Law on Relocation, compensation, and support for land acquisition by the government (Decree No. 47/2014/NĐ-CP)
	Vocational training to Local residents until 2020 (Decision No.1956/2009/QD-TTg)
	Vocational training to farmer involved in farmland expropriation. (Decision No.52/2012/QD-TTg)
	The regulation of DONRE on Relocation, compensation, and support for land acquisition by the government (Circular No.37/2014/TT-BTNMT)
	The Ministry of Finance regulations on Establishment of fund and Accumulation on Relocation, compensation, and support for land acquisition by the government (Circular No.57/2010/TT-BTC)

Source： Ministry of Economy, Trade and Industry “Business FS for oversea expansion of high quality of energy infrastructure in 2017”

(2)Electricity law

Regarding renewable energy, the Law on Electricity (Luật Điện Lực, Electricity Law 28/2004/QH11) explicitly provides incentives for new energy and renewable energy source development project plans in relation to investment, taxes and electricity tariffs in accordance with the Ministry of Finance (MOF) policy (the basis for FIT) and encourages organizations and individuals to use renewable energy, especially for electrification of rural and remote areas.

(3)FIT

The Feed-in-Tariff (FIT) program was launched in 2011 and covers solar, wind, biomass, and waste energy, with a 20-year purchase period (Table 7).

Table 7 FIT (Feed-in Tariff) system in Vietnam

Category		FIT price (cent/kWh)	FIT introduction or FIT application period
Wind	Onshore	8.50	Introduced on August 20, 2011

	Offshore	9.80	Effective for projects that begin operation between November 1, 2018 and November 1, 2021 (no more effective)
Waste	Incineration	10.05	Introduced on June 20, 2014 (still effective)
	landfill gas	7.28	
Biomass	Cogeneration	7.03	Introduced on May 10, 2014 (ended) Introduced on April 25, 2020 (still effective)
	Others	8.47	
Solar	Onshore	7.09	Effective for projects that begin operation between June 1, 2017 and the end of June 2019 (ended) Effective for projects that begin operation between July 1, 2019 and the end of December 2020 (ended)
	Offshore	7.69	
	Rooftop	8.38	

Source: JAPAN ELECTRIC POWER INFORMATION CENTER

The FIT is being applied to solar power projects approved by December 31, 2020, but not to projects approved after that date. The FIT system is expected to shift to a bidding system (reverse auction) in the future, but details have not yet been announced by the Vietnamese government.

Major directives and decisions related to FIT include Decision 24/2014/QD-TTg (Decision on support mechanisms for the development of biomass The main directives and decisions related to biomass power projects in Vietnam are Decision 24/2014/QD-TTg (Decision on support mechanisms for the development of biomass power projects in Vietnam) and Decision 31/2014/QD-TTg (Decision on support mechanisms for the development of power generation projects using solid waste(s) in Vietnam). generation projects using solid waste(s) in Vietnam), Decision 31/2014/QD-TTg on support mechanisms for the development of power generation projects using solid waste in Vietnam (Decision on support mechanisms for the development of power generation projects using solid waste(s) in Vietnam) and Decision 37/2011/QD-TTg on support mechanisms for the development of (Decision on support mechanism for the development of wind power project).
In addition, the term "biomass for power generation" is defined in the current regulations of Vietnam. However, the definition does not mention any specific goods, such as which types are included in the definition. As for "biomass energy for power generation", Decision (24/2014/QĐ-TTg) on the support mechanism for the development of biomass power generation projects in Vietnam states that "by-products and wastes generated in agricultural production and processing and other cultivation in agriculture and forestry that can be used for power production". Waste".
In addition, Vietnam has a draft National Master Plan for Biomass Power Development by 2025 for the year 2035. This was drafted by the Energy Research Institute at the request of the Ministry of Industry and Trade, and although it was published in 2017, it has not yet been approved by law. However, this draft may be operationalized as a document for policy consideration for biomass

power generation. The draft focuses on two types of biomass (wood residues and agricultural crop residues) and mentions specific objects for each.

＜Wood residues>

Wood residues include woody fuels from forest trees, perennial industrial crops, and fruit trees (obtained from felling and pruning), as well as their wastes (from felling and pruning):

- Logs: from natural forests, populated forests, and scattered trees
- Shrubs: from forested areas
- Bamboo (Neohouzeaua, Bambusa nutans): from forested areas
- Periodically harvested logs and branches: from perennial industrial crops
- Prunings: of fruit tree origin
- Branches, stumps and bark: from harvested logs
- Wood residues (e.g. sawdust, wood chips, etc.): originating from wood processing
- Other (wood from construction work, house/furniture repair/renovation, where database is available or estimable)

＜Crop residues

Biomass derived from agricultural crops (by-products after harvest) and waste (generated during processing).

- Rice straw, rice husks
- Sugarcane bagasse, leaves and tips
- Stems, pods, and cobs
- Groundnut stalks and husks
- Soybean stalks and husks
- Cassava
- Coconut leaves, husks
- Shells: cashew nuts, coffee
- Other trees (if database is available or estimable)

It can be seen that rice husk, which is one of the targets of this project, is also recognized as biomass.

3. Collaboration between Hiroshima Prefecture and Soc Trang Province

3.1. Past collaboration between Hiroshima Prefecture and Soc Trang Province

The past collaboration between Hiroshima Prefecture and Soc Trang Province is as follows (for details, refer to the appendix at the end of the FY2020 report).

(1) Period of building a foundation for B-to-B business exchange between the two municipalities (2013-2016)

In Hiroshima Prefecture, there are many leading companies that are active in the global market and have distinctive products by using the technology and know-how cultivated in environment-related equipment and pollution prevention measures. As part of its industrial policy for the 2020 Challenge Vision, Hiroshima Prefecture is supporting the overseas expansion of environment-related industries in the prefecture, with the aim of promoting the concentration of environment-related industries in the prefecture, economic growth, and the resolution of environmental pollution and contamination overseas.

In order to smoothly promote industrial exchange with Vietnam and link it to concrete business results, Hiroshima Prefecture is aiming to organize and realize an environment-related project in southern Vietnam by concentrating the technologies of Hiroshima Prefecture's companies. In 2013, we used the overseas basic research project of JETRO's Regional Industry Tie-Up Project (RIT Project) to conduct research on organizations and companies that could cooperate with the project, as well as business fields and regions with potential needs.

During the survey, we received a very positive indication from Soc Trang Province that they would like to promote business exchange. We also interviewed the People's Committee and the Department of Natural Resources and Environment about the environmental issues in the province, and found that the needs for the following three items are extremely high, and that there are technologies in the province that can help solve these issues.

① Access to Clean Water in Rural Areas
② Effective use of rice husks in Soc Trang Province, one of Vietnam's leading rice-producing regions
③ Improving water pollution around shrimp farms, one of the most productive shrimp farms in the world

Therefore, for three years from 2014 to 2016, JETRO's Regional Industry Tie-Up Project (RIT Project) was utilized to start a business exchange with Soc Trang Province in order to solve the environmental issues faced by Soc Trang Province, mainly the three needs mentioned above, in a business sustainable manner. The counterpart was the Department of Natural Resources and Environment (DONRE), a department that understands the environmental issues faced by each company in Soc Trang Province and the environmental needs of Soc Trang Province itself

In the RIT project, DONRE compiled a list of local companies from Soc Trang Province that were facing environmental issues each year, and the prefecture's staff met with these companies to delve into their needs, and for projects with a high probability of business development, business matching was conducted by meeting with companies in Hiroshima Prefecture that had the corresponding technology. When discussing business with Soc Trang Province companies in Hiroshima, the prefecture's own budget was used to invite the vice chairman of Soc Trang Province's Personnel Committee and the director of DONRE, along with Soc Trang Province companies, to gain better understanding of Hiroshima Prefecture's environmental technologies and to hold a seminar in Hiroshima Prefecture to provide an opportunity to discuss environmental issues and needs in Vietnam. In addition, a seminar was held in Hiroshima Prefecture to create an opportunity for matching about environmental issues and needs in Vietnam.

In addition, in order to demonstrate the projects created by these matching opportunities and to lead to orders, we have been conducting demonstration experiments in the field while providing companies with the "Subsidy for Promotion of Environmental Business Cluster" of Hiroshima Prefecture. The results shown in the table blow have been produced so far.

Table8 Results of exchange between Hiroshima Prefecture and Soc Trang Province

Product/Service	Entities in Soc Trang Province that gave order	Year
Water Purifier	Soc Trang Province Water Purification Center	2015～
Water purification agent for shrimp cultivation	Shrimp cultivators	2019～
Water purification membrane for shrimp aquaculture	Shrimp aquaculture operators	2019～
Waste-derived organic fertilizer	Fertilizer wholesaler	2018～
Rice husk fermented liquid	Vegetable farmers	2016
Agricultural materials	fertilizer manufacturer	2016
Recycled plastic materials	Plastic molding companies	2016～

(2) B to B business + project projects (2017-2020)

After the completion exchange program by JETRO RIT project in 2016,we continued to discuss the scope of future collaboration by using Invitation Program for Promising Asian Leaders of CFIEC (Center for International Economic Collaboration, formerly known as Institute for International Studies and Training: IIST) and a Memorandum of Understanding (MOU) in the field of environmental remediation industry was signed with Soc Trang Province at the Mekong Delta Business Matching Seminar jointly held by Hiroshima Prefecture and Soc Trang Province in September 2017. In the MOU, in addition to the B-to-B business matching that has been actively promoted, the two regions have agreed to cooperate in organizing cooperative projects and holding regular meetings.

With the signing of this MOU, in addition to the introduction of individual companies from Soc

Trang Province, a cooperative system has been established to address and solve the environmental issues faced by Soc Trang Province as a project. At present, the two sides are cooperating on the following projects in order to solve the problems and create new values. In addition, in order to build on this cooperative relationship and turn the project into a business, a Vietnam Support Desk was established in 2018 in cooperation with Hiroshima Bank to provide support for companies entering the Vietnamese market. Some of the projects currently underway with Soc Trang Province are listed in a table below.

Table9 Project by Hiroshima Prefecture and Soc Trang Province

Project Name	Period	Summary
Project for purification of shrimp farm environment and branding of shrimp with low environmental impact	2018～	Project to use water purification products owned by companies in Hiroshima Prefecture to cultivate shrimp with reduced environmental impact that will not pollute the surrounding environment, and to brand and sell the shrimp in Japan and Vietnam. Tromso Co., Ltd. has developed a water purification agent using rice husks, and it is hoped that this product can be applied to shrimp farms in the future.
Efficient collection and transportation of general waste and waste treatment projects	2019～	Project to utilize know-how on efficient collection and transportation of general waste, waste collection services, and data collected during collection and transportation to construct optimal waste treatment facilities.
Water purification service business to reduce plastic waste	2020～	By installing water purifiers in each household's water supply, the project aims to reduce the large amount of plastic waste generated by the plastic bottled water service that is widely used in the region.

3.2. Creating a mechanism for continuous identification and formation of new projects through collaboration between Hiroshima Prefecture and Soc Trang Province

In order to continuously identify projects, a "Hiroshima- Soc Trang City to City Cooperation Council" was held twice in face-to-face matter as a mechanism to match seeds of Soc Trang Province as well as Hiroshima Prefecture.

Since this was the first face-to-face meeting in Soc Trang Province in three years, the two local governments once again agreed to cooperate to promote exchanges between companies in both regions and create projects that will address such issues as, global warming and environmental improvement; they also discussed projects that are undergoing feasibility study as part of this inter-city cooperation project.

In addition, although not directly related to decarbonization, a technology introduction seminar was held with the Ministry of Soc Trang, and technologies related to wind power generation and the treatment of sludge discharged by shrimp farmers were identified as new needs.

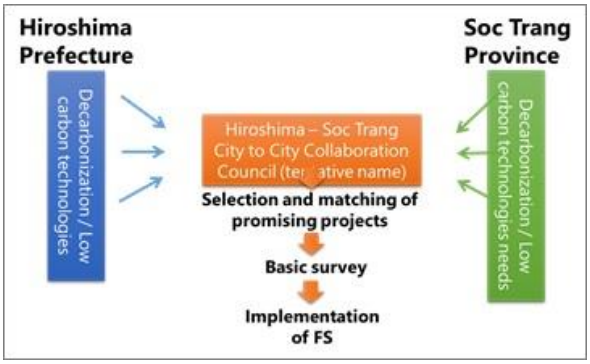


Figure 11 Mechanism for continuous identification and formation of new projects through collaboration

3.3. Hiroshima Prefecture's support for know-how on community-based renewable energy installation projects

Hiroshima Prefecture operates a mega solar power plant jointly with a local electric power company, and has the know-how to create and operate a system that returns part of the profits to the local community in the form of subsidies for the installation of renewable energy and energy-saving equipment (Started in 2013) (Figure12).

In 2021, as a part of City to City Collaboration Project, we held an online-style workshop to share with Seok Chan Province the know-how of Hiroshima Prefecture's community-reward renewable energy introduction project and exchanged opinions on the possibility of developing the project in Seok Chan Province but found that it was not feasible due to legal issues. Therefore, in 2022, we introduced the efforts of Hiroshima Prefecture to support environmental activities for residents and encourage environmental education as a mechanism to contribute to the community in order to build momentum for decarbonization in Soc Trang Province.

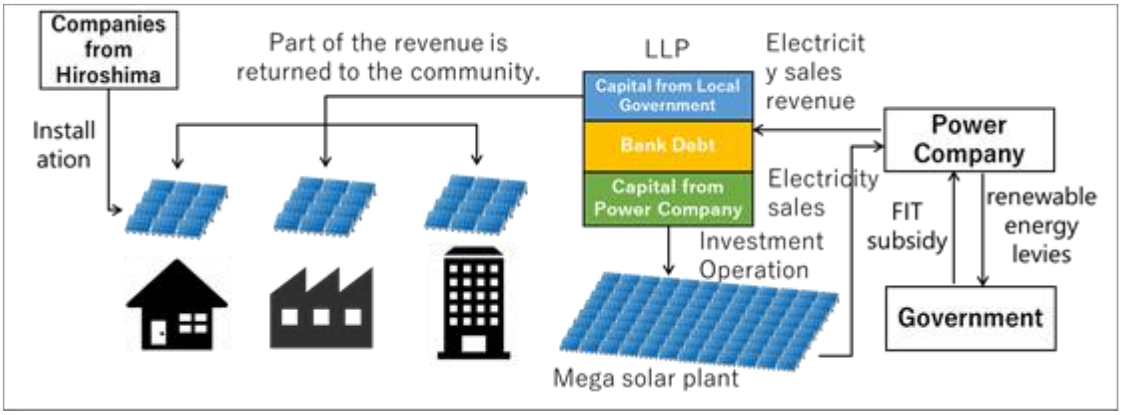


Figure12 Hiroshima Prefecture's community-based renewable energy project

3.4. Workshop between Hiroshima Prefecture and Soc Trang Province

(1) The 1st Hiroshima Environmental Business Promotion Council

Date/Time	October 11th, 2022 (Tue) 8:30～10:00
Style	Face-to-Face
Participants	＜Japan＞◆ Hiroshima Prefecture: Sorada, Chief of New Industries Creation, Matsubara, Manager , Ms. Honami Tarutani（Manager, Foreign Business Division, Commerce, Industry and Labor Bureau） Ogawa Econos Inc.: Ogawa, Managing Director, Oka, Department Director, Torii, General Manager, Fujimura, General Manager E-Square Inc.: Mr. Hiroyuki Yanagida, (Senior Manager) Thanh Mai（Translator）
	＜Vietnam＞◇ Nam, Deputy Chairman of the People's Committee Nhi, Deputy Secretary of Department of natural Resource and Environment Deputy Secretary, Department of Agriculture and Rural Development Deputy Secretary, Department of Investment Promotion Bureau Deputy Secretary, Department of Commerce and Industry Deputy Secretary, Department of Foreign Affairs CEO, Soc Trang Public Works Joint Stock Company (SPWC)
Program	Opening Remarks（Nam, Deputy Chairman of the People's Committee, Soc Trang Province） Exchange of opinions on waste disposal projects

Nam, Deputy Chairman of the People's Committee made following remarks.

- Due to the novel coronavirus outbreak, we have not been able to speak directly for a long period of time. However, I am personally happy that we have been able to resume our business exchange between Soc Trang Province and Hiroshima Prefecture and that we are now able to resume our exchange.
- We are grateful to Hiroshima Prefecture for co-hosting a seminar on sustainable shrimp farming in 2019 and to Tromso for installing 200 water purifiers in schools and hospitals in Soc Trang Province.
- Allow us to share an overview of Soc Trang Province with you once again as below.
    - ✧ Area: 3,311 ㎢ (70km of ocean frontage, divided into 11 zones)
    - ✧ Population is 1.2 million
    - ✧ There are also many ethnic minorities, including the Khmer.
    - ✧ The fisheries and rice industries are particularly strong, and a brand of rice called ST25 was rated the best in the world at a trade fair.
    - ✧ In the future, we would like to export rice-related processed products to foreign countries at the same level as processed marine products.
    - ✧ Rice exports: 25 million USD (2 million tons) / Shrimp exports: 100 million USD
- Wind power and other renewable energy sources are also increasing in the province. Twenty

wind farms are planned and 11 have been constructed. On the other hand, only four locations were able to connect to the power grid, generating a total of 110 MW.

- A highway from Ho Chi Minh City to Soc Trang is under construction, and plans are underway for a hub port in the Mekong Delta.
- On the other hand, the effects of climate change and environmental issues are also major challenges. One impact of climate change is land subsidence.
- In addition, environmental issues include waste and wastewater. In particular, waste disposal is a major problem, and through the waste problem, groundwater contamination is also an issue. Environmental pollution caused by waste is a major issue in Soc Trang Province, and we would very much like to cooperate with you in this area.
- In waste management, the People's Committee is also focusing on industrial waste, as well as domestic waste, because of its challenges.
- We would like to further promote exchanges between Soc Trang and Hiroshima Prefecture, especially in the environmental field.
- We will do our best to follow up on this City to City Collaboration Project study.

Explanation of RPF from Ogawa Econos Inc.

- Since the RPF project requires the cooperation of local companies and consumers who will be the users of the RPF, cooperation of Soc Trang Province was requested.

SPWC (Waste Management Corporation of Soc Trang Province) shared following issues.

- The biggest problem is the lack of garbage segregation (recycling)
- Another issue is the high-water content of the waste during the rainy season.
- Based on these considerations, we need to adapt the most appropriate technology and would like to consider four methods: fertilizer conversion, solid fuel conversion, incineration, and landfill.
- In particular, the ratio of landfill, which is now the mainstream disposal method in Vietnam, needs to be reduced.
- On the other hand, they are interested in converting to RPF because they are not comfortable with incineration.
- Since the Company was originally a public corporation but has since been privatized, joint investment by Ogawa Econos Inc. and SPWC is possible.
- We will provide you with any necessary data. Please feel free to contact us.
- Another challenge is the difficulty of waste collection. Road infrastructure is in poor condition and there are many waterways, there are many areas not covered for collection.

Communication mechanism for future waste projects

- Department of natural Resource and Environment will do its utmost to support the projects of companies in Hiroshima Prefecture. (Nhi, Deputy Secretary)
- Regarding information and data, please contact us through DONRE, as we are obliged to report to the People's Committee what kind of data we give to foreign companies.

The Waste Management Plan of Soc Trang Province

- There are 2 projects shown below.
  1. Industrial waste
  2. Collection/Processing of domestic waste (this needs to involve a power generation project = application to Department of Commerce and Industry of Vietnam is required).
- The theory is that bids will be taken when two or more firms submit proposals, but if only one firm's proposal is good, a decision will be made.
- Regarding 2, the potential proposer who is conducting the survey is unable to make a concrete proposal since Vietnam is currently in the process of switching standards for its FIT system and is unable to determine the FIT price.
- Currently, foreign companies are in the process of conducting research, and there are no concrete proposals from any company yet.
- There is no need to propose 1 and 2 together. If only 1 is proposed by Ogawa Econos Inc., it could be approved by the People's Committee as soon as submission.
- The proposal does not necessarily have to include SPWC.

Amount of waste in Soc Trang Province

- Domestic waste：831.9t/d (Plastic：72t、 hazardous waste：26t)
- Industrial waste：1,800t/d (Industrial：1,400t、Service Industry：400t)

Others

- The policy from the government is that waste sorting (3 types) will be mandatory by December 31, 2024.
- On the other hand, even if they are sorted at home, they will be put together again during collection and transportation under the current operation, so after 2024, it will be mandatory to separate them for collection and transportation.
- Although there is a national policy until 2024, there have been cases of failure in other provinces that have tried to sort waste, and we believe that separation is not the end of the story. (Soc Trang Province would like to incinerate all the waste without sorting and generate electricity if possible).
- For the processing fees of domestic waste, Soc Trang Province pays 359,000 VND/t to waste disposal companies.

Figure13 Meeting with the People's Committee, Soc Trang Province

Figure14 Meeting with DONRE, Soc Trang Province

(2) The 2nd Hiroshima Environmental Business Promotion Council

Date/Time	January 10th, 2023 (Tue) 8:30～11:30
Style	Face-to-Face
Participants	＜Japan＞◇ Hiroshima Prefecture: Ms. Honami Tarutani（Manager, Foreign Business Division, Commerce, Industry and Labor Bureau） Manufactures in Hiroshima Prefecture Thanh (Translator)
	＜Vietnam＞◆ Nam, Deputy Chairman of the People's Committee Nhi, Deputy Secretary of Department of natural Resource and Environment Deputy Secretary, Department of Investment Promotion Bureau Head of Waterworks Branch, Department of Agriculture and Rural Development Deputy Director of Water Purification Center, Department of Agriculture and Rural Development Manager, Department of Foreign Affairs
Program	• Opening Remarks（Nam, Deputy Chairman of the People's Committee, Soc Trang Province） • Explanation of past projects and exchange of opinions on plans for the next fiscal year and beyond • Introduction of Hiroshima Prefecture companies considering new business development in Soc Trang Province • Discussions on Tromso's project • Discussion on Ogawa Econos Inc.’s project • Introduction of activities to support environmental activities and encouragement of environmental education for residents of Hiroshima Prefecture • Discussion on Soc Trang Province's environmental issues and areas where matching with companies in Hiroshima Prefecture can be made.

The following is a given explanation about the projects to date and an exchange of views on plans for the coming year and beyond.

◆Regarding the waste treatment project, why not up to power generation, but only to RPF fuel conversion?

◇We made an initial projection after our last visit in October, and we expect that we will not be able to recover our investment with the expected amount of waste. Is it correct to understand that in Soc Trang Province, waste power generation is mandatory for the introduction of facilities for waste treatment?

◆That is correct.

◆What other costs are involved besides the RPF production equipment?

◇It depends on the state of sorting, but given the current situation, we believe that sorting machine is necessary.

◆We are in the process of receiving proposals from European companies for waste projects. We hope that you will consider power generation.

◆Vietnam is also aiming for zero carbon dioxide emissions by 2050. This year also marks the 50th anniversary of exchange between Vietnam and Japan, and the People's Committee will fully support the matching of companies in Soc Trang Province and Hiroshima Prefecture.

Introduction of Hiroshima Prefecture companies considering new business development in Soc Trang Province

- With the cooperation of Soc Trang Province Department of Agriculture and Rural Development, we are planning to introduce and interview a sluice gate design company, a sluice gate construction company, and a sluice gate operation and management company in Soc Trang Province. We would like to demonstrate sluice gate facilities in Vietnam and request introductions to appropriate locations and cooperating companies.

Discussions on Tromso's project

- Soc Trang Province produces 2 million tons of rice annually, and 1/3 of it is discharged as rice husks. On the other hand, there are few large-scale rice mills in Soc Trang Province, and most companies sell rice before milling to An Giang Province and Tien Giang Province and buy rice after milling, so there are few rice husks in Soc Trang Province.
- We have received several requests for referrals to companies in the province that could be potential recipients of Tromso's rice husk fuel, which currently uses coal, but there is no use at the corporate level in the province, except for residential use.
- Since there is more environmental awareness and the larger businesses that use large amounts of coal are not using as much coal, it is safe to assume that there is no demand for coal substitutes in Soc Trang Province.

Discussion on Ogawa Econos Inc.'s project

- The two projects that were open to request for proposal at the time of our last visit in October; ① industrial and hazardous waste, and ② general waste, are still open to the public. No deadline has been set for the RFP, so if you are interested, please consult with Department of Investment Promotion Bureau. Many companies are doing research, but none have made actual proposals.
- In accordance with the government's directive to implement general waste sorting by the end of 2024, Soc Trang Province plans to sort "recyclable waste," "organic waste," and "large waste" into three categories.
- Garbage collectors are unwilling to the necessity of sorted transportation of waste, and therefore, its feasibility by the end of 2024 is uncertain at this stage.
- Therefore, if we can generate electricity by incinerating waste as it is, we do not have to sort it, so we are focusing our efforts here. As for DONRE, the standard for garbage segregation must be submitted to the People's Committee by the end of 2023.

Introduction of activities to support environmental activities and encouragement of environmental education for residents of Hiroshima Prefecture

The presentation included an introduction of Hiroshima Prefecture's activities to support environmental activities for residents and to revitalize environmental education.

The summary of the exchange of opinions on this matter is as follows:

◆Do some of these initiatives involve actual activities by the prefecture's staff? Or are they mostly done as outsourced projects?

◇Sometimes, staff from Hiroshima Prefecture's Department of Environment and Citizenship, the equivalent of Soc Trang Province's DONRE, conducts classes at schools. In some cases, the lectures include a card game to deepen the children's understanding.

◆In Soc Trang Province, we have been educating students about garbage sorting in schools, but it has not been effective. We would like to see the introduction of such an educational program next year.

◇In Hiroshima Prefecture, local municipality have jurisdiction over the sorting of general waste, and Hiroshima Prefecture does not have the know-how to do this, however, we will share what we know with you.

Discussion on Soc Trang Province's environmental issues and areas where matching with companies in Hiroshima Prefecture can be made.

Issue 1 Processing Rice Straw

I have been trying to figure out how to dispose of the large amount of rice straw that becomes waste after the rice harvest. During a visit to Japan, I have observed the equipment used to convert it into fertilizer and would like you to introduce it to us.

Issue 2 Exhaust emission control for charcoal producers

There are nearly 1,000 households (small businesses) in the province that make charcoal from firewood, and since they have no emission control measures in place, emissions are an issue, and we believe this is an issue that will contribute significantly to climate change. We would like to be introduced to any equipment that could be retrofitted to the current manufacturing process as a countermeasure.

Issue 3 Sludge treatment for shrimp farming

Soc Trang Province ranks second in shrimp farming in Vietnam. In particular, Soc Trang Province is a mainstay of high-density Vannamei shrimp aquaculture with a very large amount of shrimp per unit area, so a large amount of leftover food and fecal matter are generated during aquaculture and released into rivers untreated. As a result, the river has become blocked by sludge in a short period of time, and dredging is expensive. We would like to be introduced to a company that has a specific solution for the disposal of the large amount of sludge generated by

this shrimp aquaculture business.

Areas of technologies in demand

Soc Trang has a 70 km coastline and many areas with strong winds, so there are many wind power generation projects. If you know of any companies that have technologies related to wind power generation, please introduce them to us.

3.5. Prospects for future collaboration

Since 2012, Hiroshima Prefecture has been supporting overseas business development in the environmental field, and since 2014 has been focusing on Vietnam, matching local environmental issues in the Mekong Delta area centered on Soc Trang Province with the products and services of local companies in the prefecture. In addition, since FY2020, the project has been awarded a City to City Collaboration Project, and it has been investigating the possibility of developing local businesses that contribute to decarbonization in the prefecture.

When considering business development in the environmental field in Vietnam, it is essential to collaborate with companies that can serve as partners for local companies in the province, in addition to receiving support from government agencies such as Soc Trang Province. It is necessary to design products and equipment that meet local needs and redesign the business model so that it will work as a business in the local market. This is because the support of companies familiar with local needs and issues is indispensable.

In addition, for business development in the area of environment, the support of local governments is important not only in complying with local laws and regulations and selecting demonstration sites, but also in making contacts with leading local companies.

For these reasons, initiatives such as the "Hiroshima Environmental Business Promotion Council" that promote cooperation between governments as well as between companies are a necessary scheme for creating local businesses.

On the other hand, in areas such as Soc Trang Province, there is a mountain of environmental challenges, and while there is a high level of interest from relevant provincial departments in these issues, compared to urban areas, there is a concentration of companies in the primary industry, but an overwhelming lack of companies that are potential users of decarbonization technologies, companies that can collaborate with local companies in decarbonization and environmental fields, and universities and research institutes that can conduct joint research and development.

For this reason, Hiroshima Prefecture has been taking advantage of its strong partnership with Soc Trang Province to build ties and relationships with local governments and companies in the surrounding area, such as by calling on other surrounding provinces jointly with Soc Trang Province when holding seminars to promote the prefecture's products, and widely publicizing the seminars not only to Soc Trang Province but also to related organizations and companies in other provinces.

This fiscal year, when a technology introduction seminar of companies with sluice gate-related technologies was held in January, participants came from five provinces in the Mekong Delta region. Another technology introduction seminar is scheduled to be held in March 2023 for the Mekong Delta region.

Due to the effects of COVID-19, we were unable to conduct the originally planned surveys during the first two years of City to City Collaboration Project in Soc Trang Province, and we have been conducting specific field surveys practically since this fiscal year. In order to go beyond research and materialize the project as a business, the possibility of collaboration with related departments of neighboring provinces and companies should be considered, based on the relationship with local municipalities such as Soc Trang Province and Can Tho City, which have strong relationships with Hiroshima Prefecture, to further increase the potential for business, which will lead to the prevalence of decarbonization technologies locally and to a decarbonization domino effect.

Hiroshima Prefecture has been promoting the "Hiroshima Green Ocean Project" since FY2021, which aims to create businesses that contribute to solving global environmental issues through the development and strengthening of the environmental and energy industries, taking advantage of the global trend toward carbon neutrality and the achievement of the SDGs.

The project aims to create businesses through open innovation, and as a part of this project, the "Hiroshima Prefecture Collaborative Demonstration Project for Overseas Startups," one of its business co-creation projects, aims to create businesses by combining the assets and technologies of Hiroshima Prefecture companies with startup companies and local university researchers who are working to solve environmental issues in Southeast Asia.

In the current fiscal year, the project is working on creation of real projects in the Philippines, Malaysia, and Vietnam, and in Vietnam, Hiroshima Prefecture is studying the agricultural use of technology owned by companies in the prefecture and the business of utilizing carbon dioxide credits in cooperation with a local start-up selling biochar and with university researchers who are conducting research on soil changes and crop growth conditions when biochar is used in agriculture. Although it is still difficult to link the research project in City to City Collaboration Project with this project at this fiscal year's stage, we have already received strong interest from Soc Trang Province in the agricultural use of biochar and the use of sludge generated from shrimp farming as a raw material for biochar through interviews.

In the next fiscal year, Hiroshima Prefecture will continue to deepen the research to date and expand the circle of co-creation with the "Hiroshima Environmental Business Promotion Council" by involving administrative agencies and businesses in the surrounding areas of Soc Trang Province, and accelerate efforts toward business development by effectively integrating the business co-creation project of Hiroshima Prefecture and City to City Collaboration Project, with a view to the next phase of the research.

4. Survey on fuel conversion of coal boilers using rice husk solid fuel

A field survey was conducted to study the feasibility of introducing a rice husk solid fuel production system (curl chip production machine) from Tromso Co., Ltd., a company in Hiroshima Prefecture, to Soc Trang Province. For the survey and analysis of coal and coal utilization equipment, we obtained the cooperation of the JAPAN COAL FRONTIER ORGANIZATION (JCOAL), which has expert knowledge.

4.1. Field survey schedule

This year, as the impact of the novel coronavirus has calmed down, we conducted a survey with field trips. The field survey was conducted as follows.

Date		
October 3rd, 2022	Mon	Visit to Thanh Thin Company, Chau Hung company / Department of natural Resource and Environment, Soc Trang Province
October 4th, 2022	Tue	Visit to CJ Company
October 5th, 2022	Wed	Visit to MTV Company, 28General Public Company
October 17th, 2022	Mon	Visit to Company A
October 24th, 2022	Sat	Visit to An Cu Company

4.2. Technologies / products proposed

(1) Grind Mill (TRM-200CR)

Tromso's Grind Mill (rice husk briquette machine) is the machine to be proposed. In the Grind Mill - specifically designed to produce briquette (TRM-120F/120JPF) - of Tromso, the rice husk extruded by the rotor screw passes through a nozzle heated to 310°C by an electric heater, where it is compressed and molded, and the surface is baked to form a bar-shaped briquette (solid fuel)(Figure15).

Figure15 Grind Mill

The Grind Mill is a device that grinds rice husks and solidifies them through compression molding and heating processes and can convert 120 kg of rice husks into solid fuel per hour (120 kg of rice husks ≒ 120 kg of rice husk solid fuel). The solid fuel produced is 100% derived from rice husks, and no adhesives need to be added when solidifying the fuel.

The rice husk has a water-repellent cuticular layer (waxy) on its surface, and silica is accumulated in this layer, making it very solid. Therefore, the processing of rice husks causes metal parts to wear quickly, but the main parts of the Grind Mill have a special surface treatment that greatly improves wear resistance.

In addition, the volume of the solid fuel is reduced to about 1/10 (when compared with the volume of raw rice husk) because it is manufactured through a compression molding process. The calorie content of rice husk solid fuel is about 4,000 kcal/kg, and when ignited, it burns with a flame for about 30 minutes and then continues to burn for about one hour.

The main parts of the Grind Mill for the rice husk grinding compression molding and heating processes are shown in the Figure below.

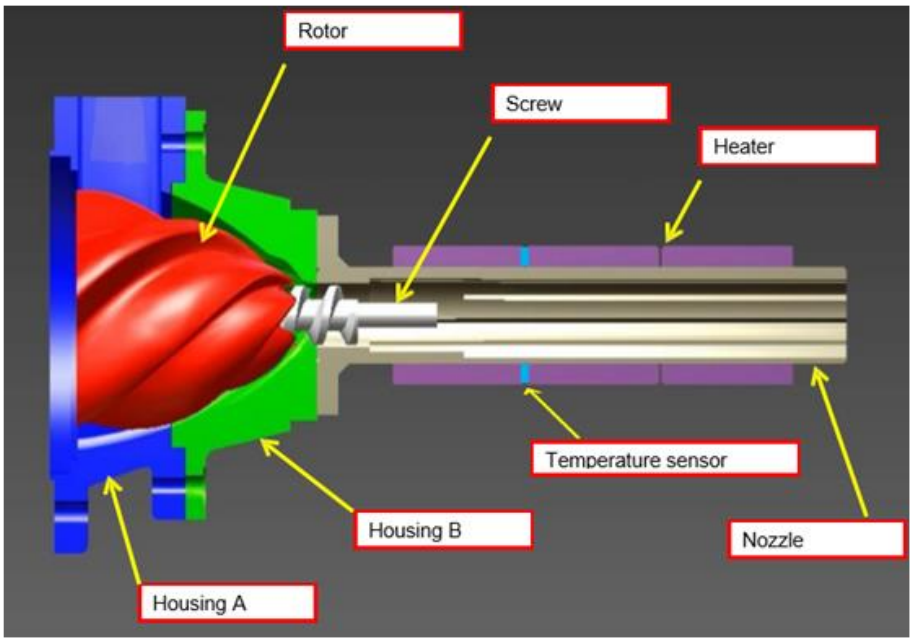


Figure16 The core parts of Grind Mill

When rice husks are fed into the material hopper, they are ground by the rotation of the rotor and the engagement of housings A and B. The ground rice husks are pushed out toward the nozzle by the rotation of the rotor and screw. The ground rice husks are heated by the heater attached to the outer circumference of the nozzle and are pushed out toward the nozzle exit. The heating causes the husks to adhere to each other and solidify due to the action of lignin contained in the husks. When the rice

husks are pushed out of the nozzle, they are discharged as solid fuel in the form of sticks. About 37 cm of solid fuel is equivalent to about 1 kg.

On the other hand, the proposed Grind Mill (a special machine for curl chips) can produce curl chips made of coiled rice husks without an electric heater. The lignin in the rice husk is softened by frictional heat and pushed into the nozzle, which is specially designed for making curl chip, by a screw. The pressed husk is formed into a coiled solid fuel that follows the shape of the screw. The curl chip has a slightly lower heat value of about 3,700 kcal compared to the briquette (approx. 4,000 kcal). When ignited, it burns with a flame for about 15 minutes and then continues to burn for about an hour. In addition, because of the compression molding process, the volume of the curl chip is reduced to about 1/8 to 1/9 (relative to rice husk).

Figure17 Grind Mill for curl chip Production (TRM-200CR)

The curl chip machine, when operated with the nozzle removed, can produce ground rice husks with a size of 1 to 3 mm. Since the ground rice husks are produced by applying pressure to the husks and rubbing them together, frictional heat of about 90°C is applied inside the machine. As a result, the ground rice husk is sterilized to some extent and has excellent water absorption and retention properties. The ground rice husk can be used as gardening soil or livestock bedding.

The characteristics of briquettes, curl chips, and ground rice husks that can be made by the Grind Mill are shown in the tableTable10 below.

Table10 Comparison of briquette, curl chip, and ground rice husk

Item	Briquette	Curl chip	Ground rice husk
Machine Type	Briquette Machine	Curl Chip Machine	Briquette/ Curl Chip
Size	Diameter 55mm, hole diameter 15mm, length 350mm	Width 20 mm, thickness 17 mm	1～3 ㎜
Shape	Hollow Bar	Coil Shaped	Powder
Heater	Yes	No	No
Main Application	Fuel	Fuel	Soil medium, bedding material, fertilizer material
Heat Generation	3,970kcal/kg	3,700kcal/kg	—
Image			

The table below shows a comparison of Grind Mills (machines dedicated to briquetting and curl chips).

Table11 Comparison of Grind Mills (machines dedicated to briquetting and curl chips)

Item	Briquette	Curl chip
Capacity	Approx.120kg/h	Approx.240kg/h
Dimensions	Approx. width 2,500 x depth 990 x height 1,500 (mm)	Approx. width 2,250 x depth 1,100 x height 1,550 (mm)
Weight	Approx.850kg	Approx.985kg
Drive power	AC200-400V 3φ50/60Hz 4P Reduction ratio 1/15	AC200-400V 3φ 50/60Hz 4P Reduction ratio 1/7.12
Power Consumption	20kW	30kW
Price (JPN)	5.5 million Yen(+tax)	5.5 million Yen(+tax)

(2) Sales and introduction record of the machine and similar models

Domestic and overseas sales and introduction results for ① above (year of sales launch, sales volume, sales amount, market share, etc.)

Sales started June 2008/ Grind Mill is launched in Japan – domestic market.

Domestic sales Approx.150 unit (as of January 2023)

Overseas sales 36 units (see TableTable12)

Most recent sales 55million Yen (annual domestic/overseas sales of Grind Mills)

Table12 Overseas deliveries of Grind Mills (dedicated to briquetting and curl chips)

year	country	Number of units	Model name	Remarks
2014	China	1	TRM-120F	
2014	Tanzania	4	TRM-120F	Introduced through JICA dissemination and demonstration project
2015	Tanzania	4	TRM-120JPF	Introduced through JICA dissemination and demonstration project
2015	Tanzania	1	TRM-120TA	
2015	Nigeria	1	TRM-120TA	
2015	Vietnam	1	TRM-120TA	
2016	Vietnam	3	TRM-120JP	
2018	Madagascar	3	TRM-120JPF	
2019	Nigeria	7	TRM-120JPF	Grant Aid, Ministry of Foreign Affairs
2019	Tanzania	3	TRM-120JPF	Assembled by local partner
2020	Senegal	2	TRM-200CR	
2023 (tentative)	Nigeria	2	TRM-120DD	Being assembled at a factory of Tromso
2023 (tentative)	Senegal	4	TRM-200CR	Being assembled at a factory of Tromso

Tromso has already sold Grind Mills (specialized for curl chip machines) to the Republic of Senegal in 2020 and introduced them as part of a project by JICA to improve the organizational capacity of vocational training centers in Senegal. One Grind Mill will be installed in the training building of the Center for Japanese Vocational Training (CFPT) in Dakar, Senegal, and one in the premises of a private company in Saint-Louis, which is linked to the CFPT. One Grind Mill will be installed in the premises of a private company in the state of Saint-Louis, with the aim of procuring equipment and conducting training that will strengthen CFPT's human resource development function to demonstrate and prove the feasibility of promoting Grind Mills in the region through the sale of solid fuel operation and maintenance of the equipment. At the same time, a Grind Mill will be installed at the CFPT and maintenance skills will be taught to the CFPT instructors. The trained instructors will then teach the same skills to trainees and graduates, enabling CFPT graduates to take up jobs in Grind Mill maintenance and manufacturing. Therefore, it is contributing to various fields such as human resource development, job creation, and effective utilization of waste, not only for commercial use but also to promote environmental protection by replacing the fuel for daily cooking in households, and to create employment opportunities for local workers engaged in machine manufacturing.

(3) Dimensions

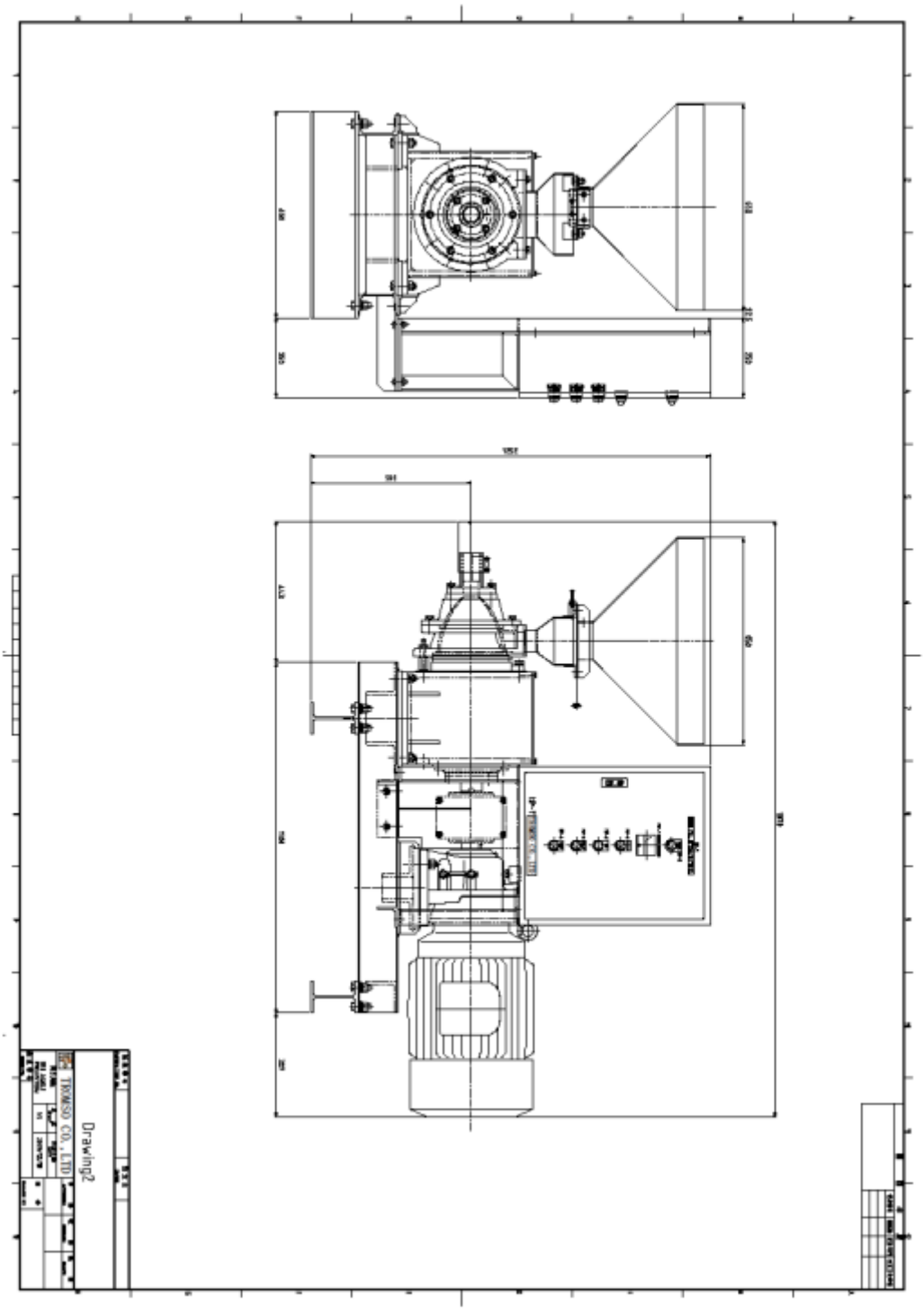


Figure18 Grind Mill（TRM-200CR） dimensions

4.3. Visit to Soc Trang Province Department of Natural Resource and Environment

We visited the Soc Trang Province branch of the Department of Natural Resource and Environment to report on our research on this project up to the last fiscal year and to request cooperation for future research. We met with the five individuals – Nguyen Thi Thuy Nhi (deputy director, Department of Natural Resource and Environment), Pham Van Tung (Director of Environmental Protection Department, Department of Natural Resource and Environment), Huynh Van Nhung (Deputy Director of Financial Planning Department, Department of Agriculture and Rural Development), Mong Van (Energy Management Department Expert, Department of Industry and Trade), Pham Thi Doan Duy (Environmental Impact Assessment and Evaluation Division Expert, Ministry of Natural Resources and Environmental) – to discuss disclosure of information related to rice cultivation in Soc Trang Province, possible collaborative projects, and cooperation on this project.

Figure19 Building of DONRE, Soc Trang Province

(1) Rice Cultivation in Soc Trang Province

Soc Trang Province has about 327,825 ha of rice cultivation area and produces more than 2,000,000 tons of paddy per year, however, about 80% of the paddy produced is sold to neighboring provinces (An Giang, Tien Giang, Can Tho City, and Dong Thap Province) in its unhulled state for hulling and processing. Therefore, although rice is actively cultivated in Soc Trang Province, the amount of rice husks generated as raw material for the grind mill is small compared to the amount of rice produced, and the amount of rice husks generated from approximately 20% of the rice consumed in the province is the potential amount that could be converted into solid fuel. Based on the calculation method of rice husk emissions in Japan, the potential amount of rice husk emissions that could be utilized in Soc Trang Province is estimated to be about 80,000 tons. In addition, Soc Trang Province is considering reducing rice production and expanding aquaculture industries such as shrimp farming due to problems related to salt damage to farmland caused by the rising sea level and is expected to continue to purchase and sell rice milled in other provinces.

(2) Explanation about this project and TRM-200CR

Basic information on TRM-200CR and rice husk solid fuel was presented to Soc Trang Province Department of Natural Resource and Environment officials regarding the fuel time, combustion temperature, and processing capacity of the equipment for rice husk solid fuel. The discussion then evolved into a detailed discussion of the components of the combustion gases when the rice husk solid fuel is used as fuel, and possible problems when combustion is conducted using an existing coal boiler. In addition, explanation was given regarding the Joint Crediting Mechanism (JCM), and the officials offered to provide a list of rice mills in Soc Trang Province that could be considered for installation of the equipment.

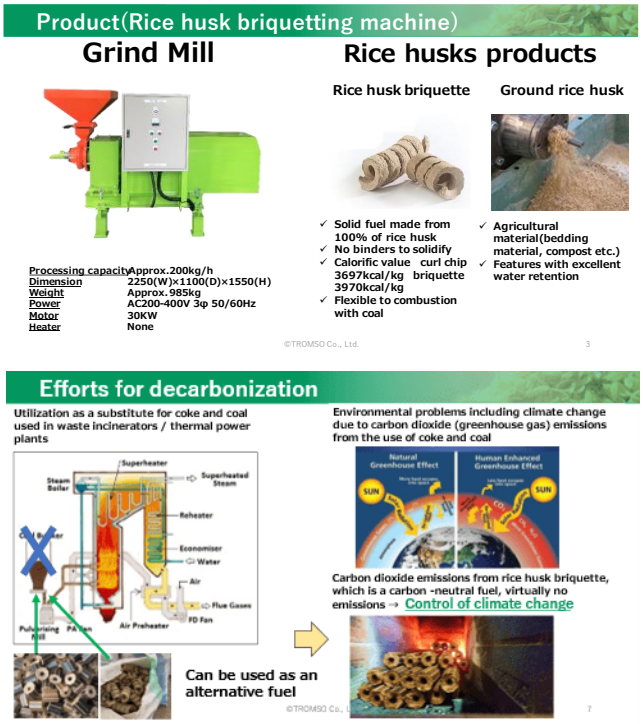


Figure20 Excerpts from explanatory materials for DONRE

(3) Ongoing projects for potential collaboration

The World Bank is funding the Vietnam Sustainable Agriculture Transformation Project (VnSAT), which aims to improve the productivity of nine cooperatives in the project area. In the project, 9 warehouses with paddy dryers (about 30-40 tons/batch) have been constructed, and charcoal is used as fuel for the dryers, which has potential to replace rice husk solid fuel.

Table13 A list of temporary storage warehouses for rice in the VnSAT project Soc Trang Province

NO	Name	Establishment year	Address	Number of farmers	Total area (ha)	Investment scale
1	Hợp tác xã Nông nghiệp **Tín Phát**	2005	Thanh Tan hamlet - Ke Thanh commune - Ke Sach district	306	527	Warehouse for temporary storage and cover of drying kiln, capacity of 1000 tons; Horizontal static drying equipment 40 tons/batch
2	Hợp tác xã Nông sản **Mỹ Hương**	2017	Tra Coi A hamlet - My Huong commune - My Tu district	306	545	Warehouse for temporary storage and cover of drying kiln, capacity of 1000 tons; Horizontal static drying equipment 20 tons/batch

3	Hợp tác xã Nông nghiệp **Phước An**	2016	Phuoc An hamlet - Phu Tan commune - Chau Thanh district	295	523	Warehouse for temporary storage and cover of drying kiln, capacity of 1000 tons; Horizontal static drying equipment 40 tons/batch
4	Hợp tác xã Nông nghiệp **Đoàn Kết**	2012	Tra Do hamlet - Lam Kiet commune - Thanh Tri district	235	569	Warehouse for temporary storage and cover of drying kiln, capacity of 1000 tons; Horizontal static drying equipment 20 tons/batch
5	Hợp tác xã Nông nghiệp **Kiết Lập B**	2012	Kiet Lap B hamlet - Lam Tan commune - Thanh Tri district	296	503.1	Warehouse for temporary storage and cover of drying kiln, capacity of 1000 tons; Horizontal static drying equipment 20 tons/batch
6	Hợp tác xã Nông nghiệp **Thọ Hòa Đông A**	2004	Tho Hoa Dong A hamlet - Phu Tam commune - Chau Thanh district	386	693	Warehouse for temporary storage and cover of drying kiln, capacity of 1000 tons; Horizontal static drying equipment 40 tons/batch
7	Hợp tác xã Dịch vụ Nông nghiệp **Tân Tiến**	2017	Xay Da B hamlet - Ho Dac Kien commune - Chau Thanh district	413	581	Warehouse for temporary storage and cover of drying kiln, capacity of 1000 tons; Horizontal static drying equipment 20 tons/batch
8	Hợp tác xã Dịch vụ Nông nghiệp **Hưng Lợi**	2017	Hoa Hung Hamlet - Long Duc Commune - Long Phu District	538	608.23	Warehouse for temporary storage and cover of drying kiln, capacity of 1000 tons; Horizontal static drying equipment 40 tons/batch
9	Hợp tác xã Nông nghiệp **Thạnh Trị**	2016	Truong Hien Hamlet - Thanh Tri Commune - Thanh Tri District	432	451	Warehouse for temporary storage and cover of drying kiln, capacity of 1000 tons; Horizontal static drying equipment 20 tons/batch

Source: Soc Trang Province

Figure21 Meeing with DONRE,Soc Trang Province

4.4. Survey on rice mills

This fiscal year's survey was conducted with the cooperation of two rice milling companies in Soc Trang Province, which had continued from the previous year, as well as with the cooperation of one new rice milling company. Of the two companies surveyed, Thanh Tin Rice Mills has been purchasing brown rice from other provinces and milling it in-house and selling it from this fiscal year, resulting in no rice husk was being discharged. Therefore, when the grind mill was introduced to the company, it was found that the company could not utilize the large amount of rice husks it had been generating, and that it would need to procure rice husks from nearby or other provinces. Until last year, both companies had been producing rice husk solid fuel, but Thanh Thin Rice Mill had stopped producing solid fuel because it no longer generates its own rice husks. The Chau Hung rice mill continued to consume its own rice husk solid fuel, mainly as fuel for its own dryers. We also found that the use of rice husks as biomass fuel is gradually becoming more common in Vietnam, and that the price of rice husks is on the rise.

Table14 Results of hearings with Rice Millers

Company name	Chau Hung	An Cu	Thanh Tin
Location (Province)	Soc Trang Province	Soc Trang Province	Soc Trang Province
Factory type	Rice mill	Rice mill	Rice mill
Number of Employees	20	30	250
Site area	5,000m2	8,500m2	70,000m2
Rice production output Rice husk production	Rice Milling：2,000 t /year Rice husk Production：400 t /year	Rice Milling：10,000 t/year Rice husk Production：2,000 t/year	Rice Milling：180,000 t /year -
Selling price	Rice husk: 2.0 yen/kg	Rice husk: 11.7 yen/kg	Rice husk: -
	After solidification: 11.7 yen/kg	After crashed: 14.1 yen/kg	After solidification: -
Boiler	Yes(dryer)	Yes(dryer)	No
Grind Mill introduction	△ Currently owns 4 briquetting machines (currently 2 out of 4 is operational/need maintenance) Production Capacity: 150-200kg/h Approx. 1/4 million yen/machine	△ Currently owns 1 briquetting machine (non-operational/need maintenance) Motor ps 60hp Approx. 0.12 million yen(second hand)/machine	△ Currently owns 15 briquetting machine (however, none is used)
Transportability (curl	The river is narrow and requires transportation by	Located by a river	river transport

chip)	small boat. Large ship is 20km away	Large ship can be used	The factory is on riverside
Curl chip storage space	No site or building available, acquisition required	Approx. 3,500m2of empty land is available	site and building are available
Business Plan	No plan for more production	Planning to 4-5 times the production	—
Interest in using rice husks	Yes, if the product selling price is increased.	Yes, if the profit margin is high.	—
Transportation costs and volume	Currently, paddy is transported by river, but with large vessels Impossible to operate, capacity is limited	Paddy is transported by waterway and rice by land. Procurement of paddy rice is via trading companies	Currently, paddy is transported by river or sea Curl chips can also be transported

1JPY=173.03VND (as of December 19th , 2022)

(1)Chau Hung rice milling plant

Chau Hung Rice rice milling plant has a briquette production unit that solidifies rice husks that can be used as fuel for the boiler. Excess rice husks that are not used for briquette production are sold to other companies or used as fuel for the company's own rice drying equipment. Of the rice husk sales, 70% of the total sales are in the form of raw rice husks, with the remainder being briquette sales. The whole briquette-making equipment is the device shown in Figure23, and the equipment for processing rice husks into briquettes has the shape shown in Figure22. The supplied rice husks are fed into a funnel-shaped receptacle from the top of the machine, and then transported to the rotor in the lower processing section, where they are processed into a cylindrical shape by the rotation of the rotor, and briquettes are manufactured as solid fuel (cylindrical). Until last fiscal year, briquettes were piled and stored in the plant. However, only two of the four pieces of equipment are currently in operation, with the other two requiring maintenance and repair. The equipment is purchased at a cost of 46,000,000VND/unit in 2012 and has a production capacity of 2 t/day.

Specifications of the Briquette Machine.

Production capacity	2 t/day
Price	46,000,000VND (approx.230,000 yen)/unit
Manufacturing temperature	300°C
Motor	30HP
Consumables	① Nozzle, ② Screw, ③ Heater

The following are the current response to each consumable item.

① Nozzle

The company orders nearby machining companies to manufacture the products with available materials. The price is 2,000,000VND (approx. 10,000 yen)/unit and the materials are not specified and built with the materials that are in stock at the time of order.

② Screw

It is replaced about every five years, and since they are worn out after about 12 hours of normal operation, they are soldered and repaired as they are used. Since the repair work is very complicated, there is only one 1person in the factory who can handle it.

2000,000VND (about 10,000 yen)/unit, made of iron.

Although they approach a university professor they knew and tried to develop a screw with high wear resistance material, the development has been stalled due to lack of cost-effectiveness.

③ Heater

They use Vietnamese commercial heaters, which are replaced once a month. The price is 200,000VND (approx. 1,200 yen)/unit.

Figure23 Local briquette machine

Figure22 Local briquette machine with a hopper (Rice husks are fed from the top)

Figure25 Nozzle of a briquette machine

Figure24 Manufactured tubular briquettes

Figure27 Screw of current briquette processing

Figure26 Site of briquette sales

Figure28 Storage of rice

Figure29 Maintenance status of briquetting equipment

Although the rice husks were stored indoors, it was observed that trash (fine plastic strings, pebbles, etc.) was mixed in with the husks. Due to the design of the company's existing briquetting equipment, rice husks are poured into the machine from the top feed and solidified while being compressed in the screw section, so it was assumed that the contamination of dust caused cracks and damage to consumable parts, forcing early replacement or repair. In addition, Figure 31 was taken from the top of the raw material inlet of the briquette processing equipment and shows rice husks sticking to the sides, suggesting that the cleaning and maintenance frequency inside the parts is low. If a grind mill is to be introduced to the company, we believe that training on the handling of rice husks and maintenance of the equipment is essential.

At the time of last year's survey, an average of 250 tons/month of rice delivered to rice mills was milled, generating approximately 50 tons/month of rice husks, one half of which were processed into briquettes and sold and used as fuel for boilers. This year, an average of approximately 170

tons/month of paddy rice was delivered and approximately 35 tons/month of rice husks were generated, indicating that the scale of handling is shrinking compared to the previous year. As a sales channel for unprocessed rice husks, the company has approached to brick makers, liquor makers, etc., and is selling unprocessed rice husks at 300-400VND/kg (200-250VND/kg (when the 2021 survey was conducted)). Because of the penetration of new sales channels since last year, the proportion of unprocessed rice husks still accounts for 70% of the total. At present, only about 5 tons/month are processed as briquettes, and two of the four briquette-making machines installed are in operation. Briquettes were sold primarily to the general public, but the increase in gas penetration among nearby households has led to an increase in sales of unprocessed rice husks and a decrease in briquette production.

Chau Hung Rice Milling Plant is built beside on the riverside, and the unhulled rice is transported by waterway. Since it is a small river, it is difficult for large ships to pass through, so the ships dock at places where large ships can dock, and when transporting the unhulled rice, small ships of about 10 tons are used to transport the rice over a distance of about 20 km to and from the places where large ships are docked.

Figure30 Rice husk storage

Figure31 Rice husk transport boat

The company wishes to expand its facilities in the future, giving priority to business expansion of existing businesses. In addition, at present, unprocessed rice husks are transported to the facility for sale, but a business plan is being formulated so that sales can be started around the rice field where the rice husks are generated. Concerns regarding the introduction of grind mills are the price, the availability of sales channels, and the company's maintenance system for the equipment.

The following is an installation plan for installing a Grind Mill in an existing building (inside a factory).

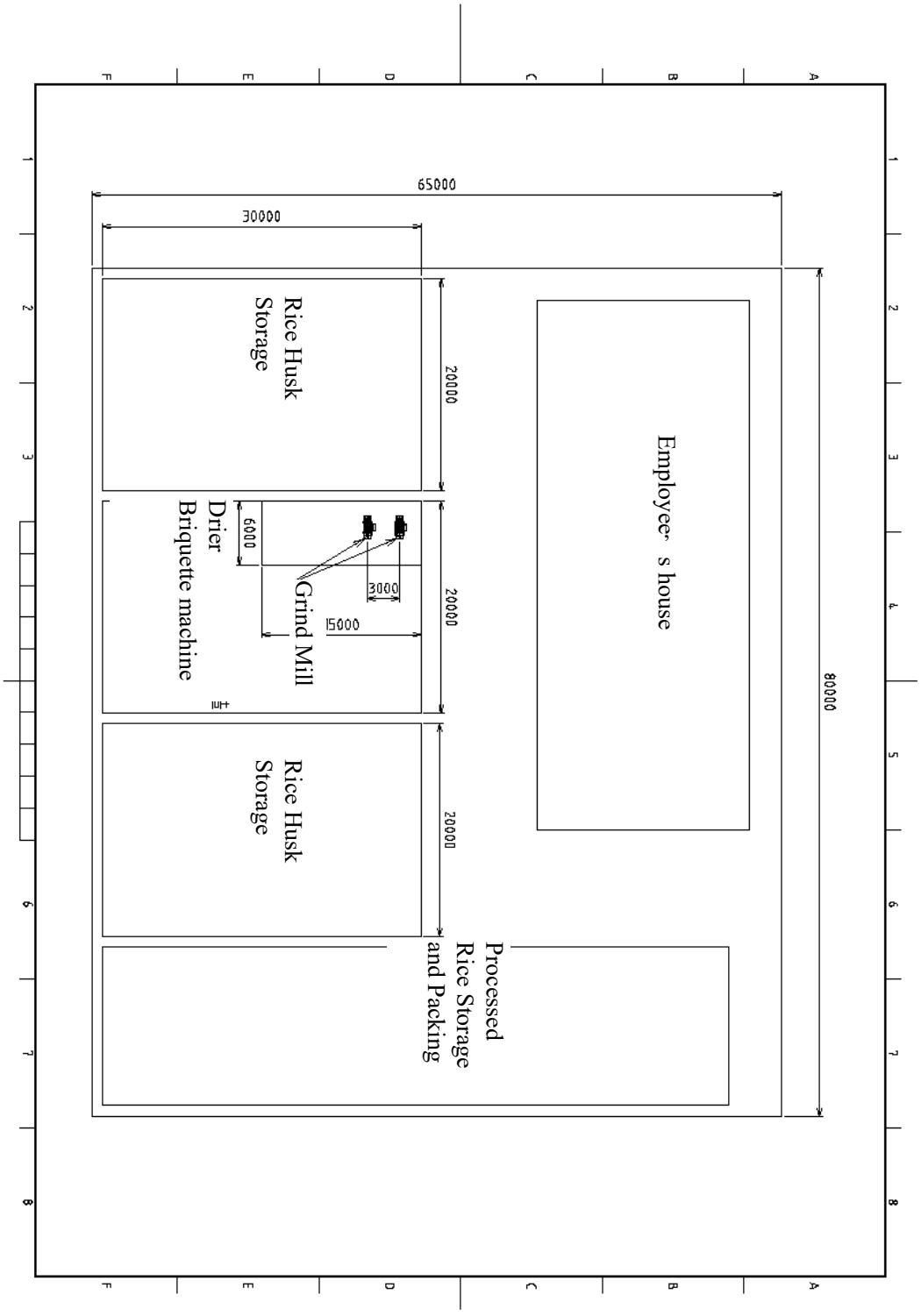


Figure32 Proposed installation of Grind Mills (Chau Hung rice milling plant)

(2)An Cu rice milling plant

This rice mill was added to the survey this year. The company started its rice milling business on a small scale in 2000 with a milling capacity of approximately 100-200 kg/hour, and has now expanded its milling capacity to approximately 5 tons/hour, generating approximately 2,000 tons of rice husks per year. Half of the products (rice) are sold to exporters located in Hanoi, and the other half to companies in Long An and other provinces (southwestern part of Vietnam). In addition, approximately 80% of the rice husks generated are sold to two brick burning companies after being crushed to a size of 1.8 mm or smaller using a crusher equipped by the company. The remaining 20% is reused as a heat source for its own drying equipment. Although unprocessed rice husks are used as fuel for the dryer, briquette production equipment has also been installed due to interest in the combustion efficiency of briquettes. However, they are not produced on a regular basis and have problems such as ① frequent machine breakdowns, ② high repair costs, ③ smoke emissions during production, and ④ briquette quality issues.

Figure33 Rice husk crusher

Figure34 Crushed rice husk

Figure35 An Cu Company

Figure36 Drying process of paddy

Figure38 Rice husk storage warehouse

Figure37 Existing briquette making machine

As shown in Figure38, the rice husks are stored in a rice husk storage warehouse (W30m x D16m x H8m) in a condition that protects them from rain and wind, and the maximum storage volume is 3,000 t. In addition, almost no dust (such as fine plastic strings and small stones) was found mixed in, confirming that the storage conditions are good from the perspective of briquette production. The company has built a factory along a river, which can accommodate 200-ton vessels, and uses waterways to bring in paddy. The company owns five 15-ton vessels as its own equipment, but they are almost never used. In addition, the rice is moved on land, and as shown in, Figure39, the road adjacent to the site is passable for trucks under 10 tons, but for trucks over 10 tons (container trucks, etc.), a small truck is required to take the rice out to the road approximately 100 meters away for refilling.

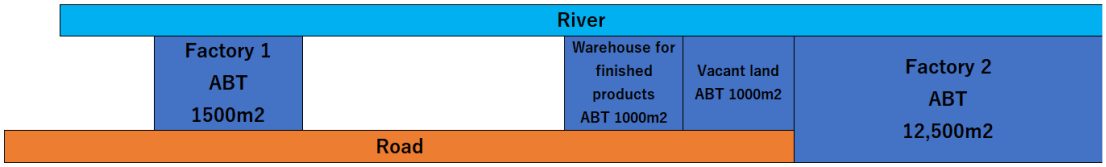


Figure39 Layout of An Cu Company

Figure40 Vacant Land of An Cu Company

Figure41 An Cu Company's second plant

If a grind mill were to be installed at the company, as shown in Figure40, there is an underutilized vacant lot, and the percentage of materials and equipment installed at Plant 2 (12,500 m^2) is less than 50%, which could be used as an installation site. Figure42 shows the proposed installation of a grind mill.

The proposed installation of a grind mill to the company is as follows.

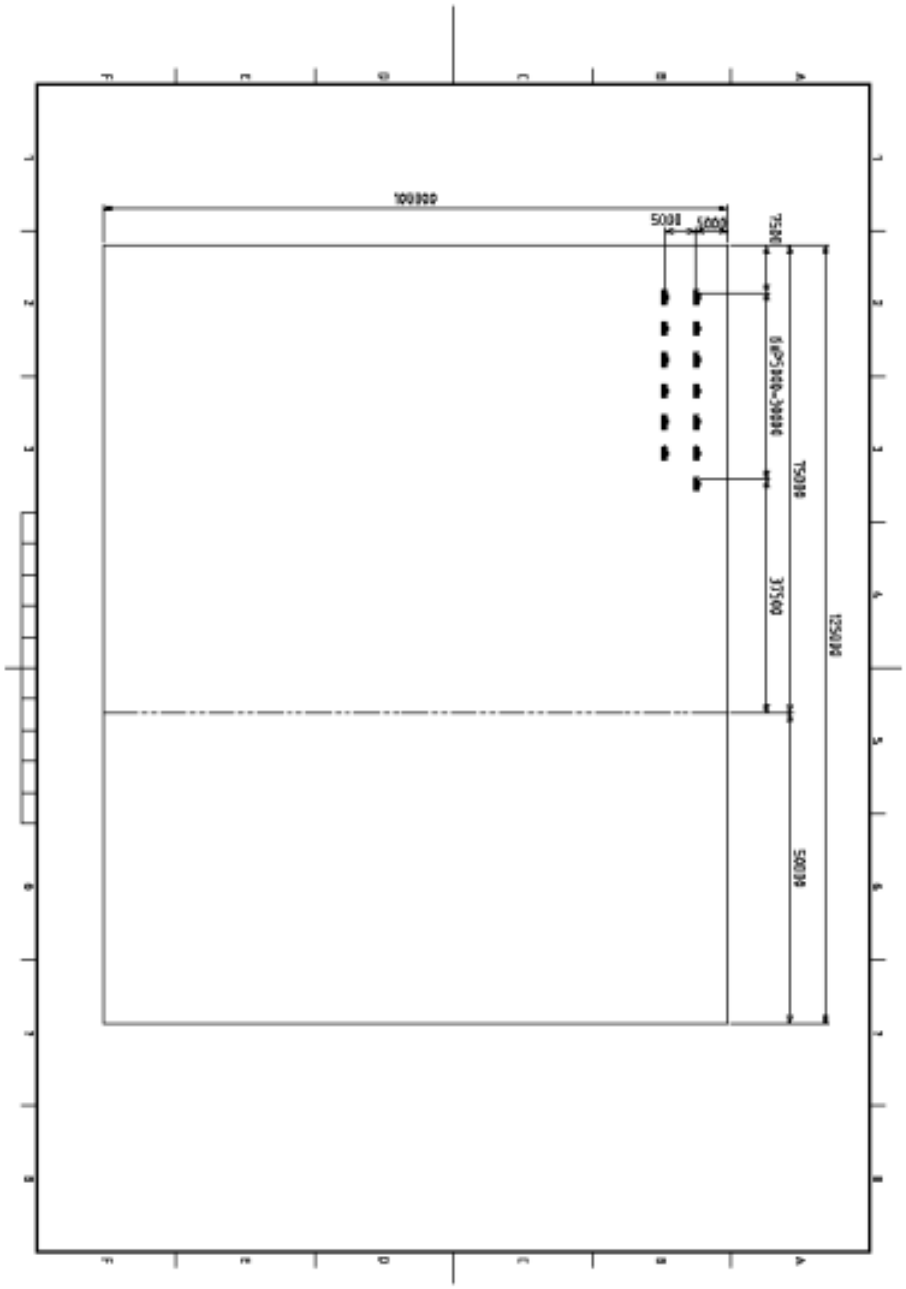


Figure42 Proposed installation of Grind Mills (An Cu Company)

At present, only about 50% of the company's customer needs can be met by the size of its business, and the company is expanding the scale of its business every year, increasing its sales by about 30% in 2022 compared to 2021. The company plans to expand the scale of its operations by approximately five times by 2023. The capital investment is scheduled to be completed in February 2023, and the milling capacity is expected to be improved to 25 t/h, with a corresponding increase in the amount of rice husks generated by approximately five times. Taking into account the rapid increase in the amount of rice husks generated due to capital investment in 2023 and calculating the number of grind mills to be installed based on the increased amount of rice husk discharge, the introduction of 15 units will enable processing of rice husks generated during hulling without delay. Against the background of the expected increase in rice husk generation, there is a high interest in introducing grind mills, taking profit margins into consideration.

(3)Thanh Tin rice milling plant

Until last fiscal year, the Thanh Tin Rice Mill had been milling rice delivered to the mill using large equipment and processing the resulting rice husks into cylindrical solid fuel using automated manufacturing equipment, but since the in-house hulling process was discontinued, no rice husks were generated as raw material and all of this equipment was not in operation. The current milled rice production at the mill is 180,000 tons/year (220,000 tons/year in 2021), which is a decrease from the previous year, but it is still the largest rice mill in Soc Trang Province. The company procures brown rice from An Giang Province, a neighboring province.

Until the previous year, about 70% of the rice husks generated in-house were processed into briquettes and sold to companies producing livestock feed, but the company began purchasing unhulled brown rice.

Until the previous fiscal year, 15 units of briquetting equipment made in Vietnam had been installed, capable of producing approximately 1.6 tons of briquettes per day, and although the equipment was less expensive than grind mills, the consumable parts were consumed fast, and the company's maintenance team was operating the equipment while performing repairs. Currently, due to changes in the company's rice procurement methods, all equipment has been shut down.

Figure44 Existing briquette machine

Figure43 Conveyer belt that feeds briquette

In the project to introduce a grind mill (a machine exclusively for curl chips), there is no handling of rice husks at this time and plans to procure brown rice in the future, so there is a need to procure rice husks, which is an obstacle to the introduction of the machine.

The number of grind mills required to procure the same amount of rice husk emissions as last year and process the entire amount would require the installation of 79 grind mills. However, the space (Figure45and Figure46) that could be utilized when introducing a grind mill to the existing building (inside the plant) was checked during the survey, it is necessary to rearrange the existing equipment or secure new space for installation. Figure45 shows a proposed installation in which the existing equipment in the space available for installation is removed and a grind mill is installed.

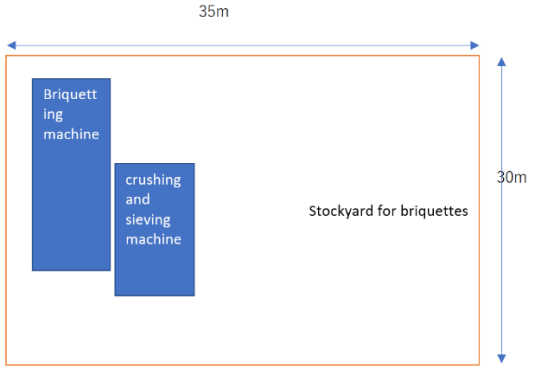


Figure45 Installation of existing equipment in space available for grind mill installation

Figure46 Space available for grind mill installation

4.5. Survey on use of coal in Vietnam

(1) Characteristics of coal in Vietnam

The quality of coal in Vietnam was surveyed in order to provide basic data for the feasibility study on fuel conversion of coal boilers in this study. Vietnam is one of the leading coal-producing countries in the ASEAN region, producing more than 40 million tons per year domestically. However, the supply of domestic coal cannot keep up with the demand for electricity that supports the country's economic growth, and imports have been increasing rapidly in recent years.

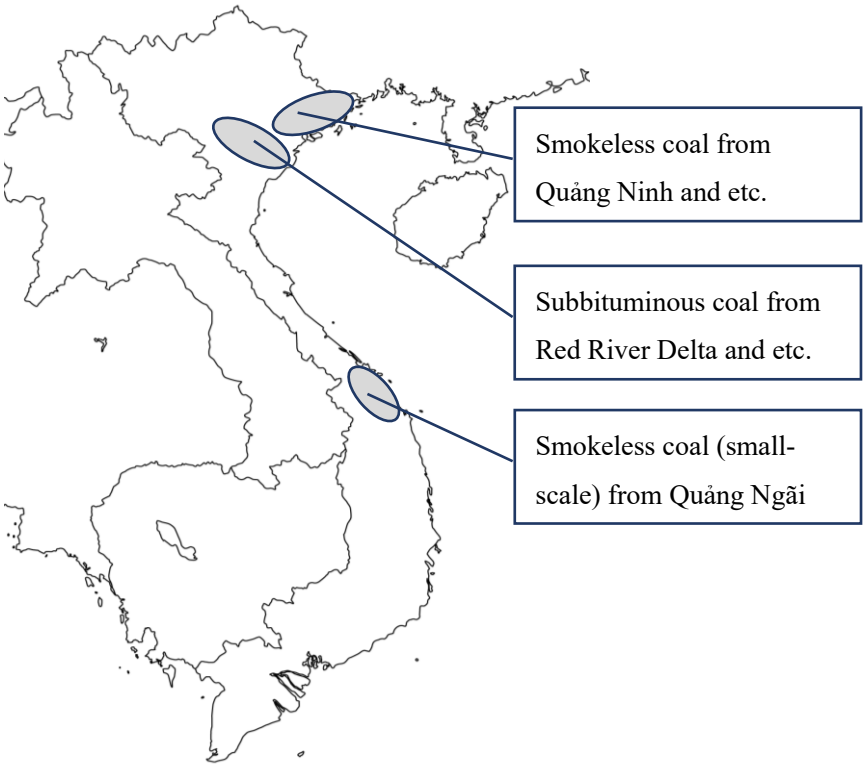


Figure47 Major coal mines in Vietnam
Source: Compiled by JCOAL

The major coal fields are shown in the Figure47. The age of coal formation in Vietnam is Paleozoic to Cenozoic, and it is mainly found in the northeast of the country. It is also distributed in the central and southern parts of the country, but except for a small amount of anthracite coal around Quang Ngai in the central part, it is peat, lignite, or sub-bituminous coal. In the north, anthracite coal from the Quang Ninh coalfield and sub-bituminous coal from the Red River Delta coalfield in southern Hanoi are representative.

Since the coal-producing areas are mainly located in the northern part of the country, the central and southern parts of the country are transported by rail and coastal vessels. As a result, southern coal users must pay a premium for transportation. Some major power companies also import coal from Indonesia for their own power plants.

The following table shows the specifications and quality of domestic charcoal in Vietnam. Vietnamese charcoal produces a lot of anthracite coal, which is enriched with carbonaceous matter and high-quality anthracite coal is exported to such countries as Japan and China for steal processing as a source of foreign currency. In recent years, the government has adopted a policy of prioritizing the domestic market, and exports have frequently been unilaterally suspended. On the other hand, grades with high ash content and relatively low calorific value are distributed to coal-fired power plants and small domestic users.

Table15 Grades of domestic coal in Vietnam

	Grade		Size	Ash content (%)	
	Domestic	World	(mm)	Average	Scope
Lump	2a	02A	35-100	8.00	6.00-10.00
Lump coal	2a	02B	25-100	12.50	10.01-15.00
	3	03A	25-50	4.50	3.00-6.00
	4a	04A	15-35	5.50	4.00-7.00
	4a	04B	15-35	9.50	7.01-12.00
	4a	04C	15-35	14.00	12.01-16.00
	5a	05A	6-18	6.50	5.00-8.00
	5b	05B	6-18	10.00	8.01-12.00
Fine	1	06	<15	6.50	5.00-8.00
(Powdered coal)	2a	07	<15	9.00	8.01-10.00
	3a	08A	<15	11.50	10.01-13.00
	3a	08B	<15	14.50	13.01-16.00
	3a	08C	<15	17.50	16.01-19.00
	4a	09A	<15	21.00	19.01-23.00
	4a	09B	<15	25.00	23.01-27.00
	5a	10A	<15	29.00	27.01-31.00
	5b	10B	<15	33.00	31.01-35.00
	6a	11A	<15	37.50	35.01-40.00
	6b	11B	<15	42.50	40.01-45.00
Sludge	1a	12A	<0.5	29.00	27.01-31.00
(Sludge)	1b	12B	<0.5	33.00	31.01-35.00

Source: Compiled by JCOAL from VINAVCON data

Table16 Quality of domestic coal in Vietnam

	Grade	ash content (%)	moisture (%)	volatile component (%)	Sulfur content (%)	Calorific value (kcal/kg)
		Average	Average	Average		
Lump	2a	8.00	4.00	6.00	0.65	7,600
(Lump coal)	2a	12.50	4.00	6.00	0.65	7,100
	3	4.50	4.00	6.00	0.65	7,950
	4a	5.50	4.50	6.00	0.65	7,900
	4a	9.50	4.50	6.00	0.65	7,400
	4a	14.00	4.50	6.00	0.65	7,050
	5a	6.50	4.50	6.00	0.65	7,850
	5b	10.00	4.50	6.00	0.65	7,400
Fine	1	6.50	8.00	6.50	0.65	7,800
(Powdered coal)	2a	9.00	8.00	6.50	0.65	7,600
	3a	11.50	8.00	6.50	0.65	7,300
	3a	14.50	8.00	6.50	0.65	7,000

	3a	17.50	8.00	6.50	0.65	6,750
	4a	21.00	8.00	6.50	0.65	6,400
	4a	25.00	8.00	6.50	0.65	5,950
	5a	29.00	8.00	6.50	0.65	5,600
	5b	33.00	8.00	6.50	0.65	5,250
	6a	37.50	8.00	6.50	0.65	4,800
	6b	42.50	8.00	6.50	0.65	4,350
Sludge	1a	29.00	20.00	7.00	0.65	5500
(Sludge)	1b	33.00	20.00	7.00	0.65	5200

Source: Compiled by JCOAL from VINAVCON data

Compiled by JCOAL from VINAVCON data

Table16, the moisture, volatile matter, and sulfur content of Vietnamese coals are the same regardless of the grade, indicating typical anthracite properties. The difference in calorific value is inversely proportional to the amount of ash contained, and since the price is set based on calorific value, the higher the grade, the higher the price. However, depending on the volume of trade and transportation costs, selected coal[5] may be used.

The Table18 shows the projected demand for coal in Vietnam. Most of the demand is for coal-fired power generation to meet the increasing demand for electricity, while the demand from other industries is increasing slightly.

Figure 24

①Wood
②Cellulose
③Lignin
④Peat
⑤Lignite
⑥Low Level Bituminous Charcoal
⑦Bituminous Charcoal
⑧Highly Bituminous Charcoal
⑨Semi-anhydrous Coal
⑩Anthracite Coal

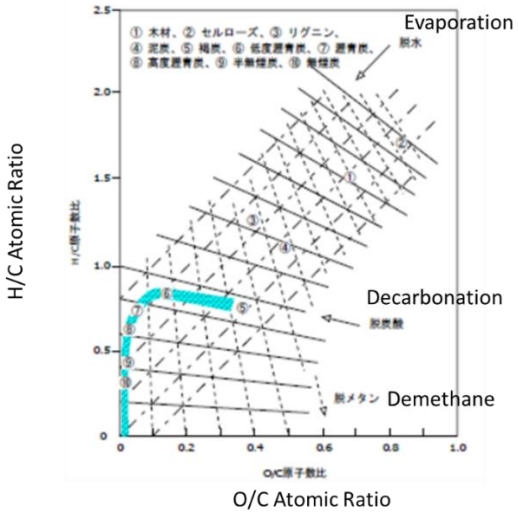


Figure48 Coal type, coal band

Source: JCOAL Call Note 2011 (original source: Van Krevelen, "Coal")

[5] Method of continuous sedimentation separation under water flow by utilizing the difference in specific gravity between rock and coal

Table17 Types and characteristics of coal

Types of coal	Features
lignite	It is the youngest coal in terms of coalification reaction and contains a large amount of volatile matter and moisture. Therefore, it is not suitable for long-distance transportation because of its tendency to spontaneously combust during long-term storage and is often used in coal-producing areas. Figure48⑤
bituminous coal	It has properties intermediate between those of lignite and bituminous coal. It is less expensive than bituminous coal on the international market, and its use as a fuel for power generation in blends with bituminous coal has been increasing in Japan in recent years. Figure48⑥
bituminous coal	The coal commonly used in Japan for power generation. High in calorie content and low moisture, ash, and sulfur content is expensive, but Japan procures it under long-term contracts. Some of it is also used for steel production. Figure48⑦,⑧
smokeless coal	It is a bituminous coal that has undergone further coalification reactions. It is high in calories, but takes a long time to burn. Good quality anthracite is used as a raw material for steel coke. Figure48⑨,⑩

Table18 Projected coal demand in Vietnam

(Unit: million tons))

No.	Coal demand	2016	2020	2025	2030
1	Thermal Power Generation	33.2	64.1	96.5	131.1
2	Fertilizers and Chemicals	2.4	5.0	5.0	5.0
3	Cement	4.7	6.2	6.7	6.9
4	Metallurgy	2.0	5.3	7.2	7.2
5	Others	5.2	5.8	6.1	6.4
Total		47.5	86.4	121.5	156.6

Source: Compiled by JCOAL from CDP, Ministry of Industry and Trade, Vietnam

(2) The position of coal power in Vietnam

Vietnam's power operations were governed by Power Development Plan 7 (PDP7), the country's most recent power generation capacity plan, which was revised in March 2016 and revised to significantly increase the share of renewable energy toward 2030, as shown in Figure 57.

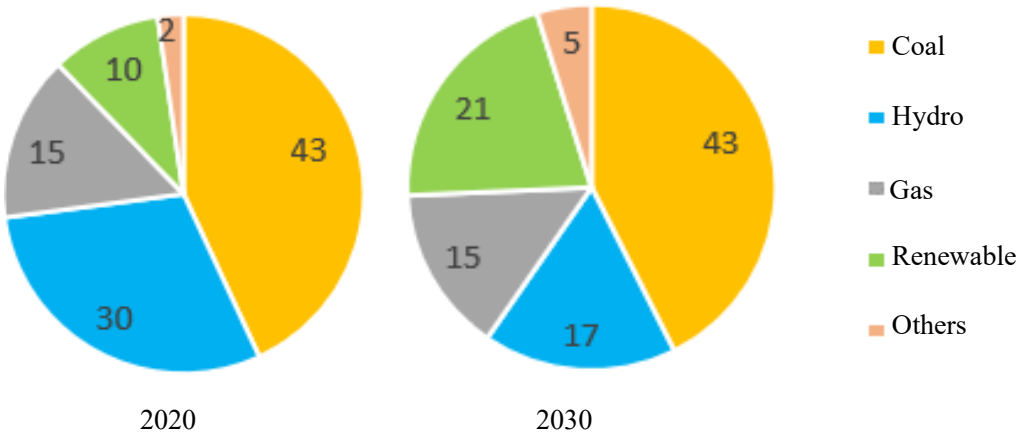


Figure49 Share of installed capacity and share of electricity generation by power generation plan in Vietnam

Source: Compiled by JCOAL from the revised PDP7 of the Vietnamese Ministry of Industry and Trade

As a result, the share of renewable energy is expected to increase substantially, not only in electricity, but also in projected demand for primary energy from agriculture, forestry, and fisheries, industry and construction, and consumer-related industries. Among the renewable energies, the use of biomass for power generation and heat supply is expected to increase substantially. As coal-fired power generation is expected to continue, the increased use of biomass in renewable energies is expected; therefore, the use of biomass in coal boiler is desirable.

(3) The energy policy in PDP8 draft version

In the draft version of Vietnam Power Development Plan (PDP8), "Vision to 2045 and National Power Development Master Plan for 2021-2030 (PDP8)," was released in March 2021. Due to the impact of COP26 in 2021, the government has yet to approve the draft version of PDP8, and is expected to review the introduction of renewable energy in the near future. This section outlines the coal policy in the draft version of PDP8.

The Ministry of Industry and Trade of Vietnam has released the first draft of the "National Electricity Development Master Plan for Vision to 2045 and 2021-2030 (PDP8)" to obtain the opinions of relevant ministries and agencies. Vietnam's GDP growth rate is 6.6%/year on average in the phase of 2021-2030 and 5.7%/year on average in the phase of 2021-2045. Electricity forecast to maintain high growth rate is expected to be 491 TWh in 2030 and 877 TWh in 2045.

By 2030, Vietnam's total installed capacity will reach 137.2 GW (coal-fired: 27%; gas-fired: 21%; hydro: 18%; wind, solar and other renewable energy: 29%; imports: less than 4%; pumped storage and other energy storage: less than 1%). By 2045, the total installed capacity, including nuclear power, will reach 276.7 GW (of which coal-fired power: 18%; gas-fired power: 24%; hydro: 9%; wind, solar and other renewable energy: more than 44%; imports: less than about 2%; pumped

storage and other energy storage: about 3%).

The Vietnamese government is encouraging the development of renewable energy, excluding hydropower, and the capacity ratio in 2020 is about 13%, while it is expected to increase to just under 30% in 2030 and 44% in 2045. On the other hand, the coal-fired power development plan has made it a policy not to develop new coal-fired power plant projects except for those under construction or under construction investment promotion that can be put into operation between 2021 and 2025 in the 2021-2030 phase. Therefore, the power supply mix of coal-fired power generation will decrease from 34% in 2020 to 27% in 2030, which is a 16% decrease compared to the revised PDP7 plan. Furthermore, if this plan is implemented, the share of coal-fired power generation will decrease 17-18% in 2045. Only advanced technologies above the ultra-supercritical (USC) power generation system are to be introduced in coal-fired plants after 2025 to reduce CO2 emissions from coal-fired power generation by thus achieving higher efficiency of generating electricity. Looking at this trend in terms of power generation, the composition of coal-fired power generation is expected to decrease from about 40% in 2030 to 28-30% in 2045.

As for coal-fired power generation, the production and supply of domestic coal has already reached a ceiling of 45-50 million tons, and the country – mainly for coal-fired power plants in the south – is dependent on imported coal from Indonesia and other countries. Coal imports for power generation are expected to be 47-52 million tons as of 2030 and 75-96 million tons as of 2045, depending on the scenario.

(4) Position of biomass in Vietnam's energy policy

In 2015, the government published its first national development strategy on renewable energy, which aims to increase the share of renewable energy in primary supply and overall electricity generation to about 32% by 2030.

As shown in Table19, Table20, the latest version of the PDP8 draft shows that biomass combustion/co-firing, which is not so prevalent that it cannot be counted as installed capacity at the end of 2020, is scheduled to reach 1,230 MW in 2030 and 5,210 MW in 2045, indicating that biomass is playing an important role in the introduction of renewable energy in Vietnam.

Table19 Estimated installed capacity by each generation method in 2030

Year / Item	2020	2030		
	Installed capacity			
	End of 2020	Proposal No. 1682(March 2021) Base-scenario	After review (October 2021) Base-scenario	After review (Apr 2022) High-scenario
Coal-fired thermal power	21,838	37,573	40,649	37,467
Combined cycle gas turbine + domestic		14,783	14,783	14,930

gas – fired thermal power + domestic gas-fired thermal				
Gas turbine utilizing new LNG	9,025	12,550	12,550	23,900
Flexible source running on LNG(ICE+SCGT)		1,400	0	150
Thermal power + Oil and Gas Turbine		138	138	0
Hydropower (including small-scale hydropower)	20,993	24,872	25,484	28,946
Wind power	538	16,010	11,820	16,121
Offshore wind power		2,000	0	7,000
Solar power (including rooftop solar power)	16,506	18,640	18,640	16,491
Biomass power and other renew Ables		3,150	1,170	1,230
Pumped – Storage hydropower + battery energy storage, Others	325	1,200	1,200	2,450
Import	572	5,743	3,937	5,000
Total installed capacity (MW)	69,797	138,059	130,371	153,685

Source: Baker & McKenzie

Table20 Estimated installed capacity by each generation method in 2045

Year / Item	2045		
	Installed capacity		
	Proposal No. 1682(March 2021) Base-scenario	After review (October 2021) Base-scenario	After review (Apr 2022) High-scenario
Coal-fired thermal power	50,168	50,699	37,467
Combined cycle gas turbine + domestic gas – fired thermal power + domestic gas-fired thermal	12,754	14,783	14,930
Gas turbine utilizing new LNG	38,150	39,050	31,400
Flexible source running on LNG(ICE+SCGT)	15,600	8,100	28,200
Thermal power + Oil and Gas Turbine	0	0	0
Hydropower (including small-	25,772	29,077	35,139

scale hydropower)			
Wind power	39610	27,110	55,950
Offshore wind power	21,000	21,000	66,500
Solar power (including rooftop solar power)	55,090	51,540	96,666
Biomass power and other renew Ables	5,310	5,250	5,210
Pumped – Storage hydropower + battery energy storage, Others	7,800	6,600	29,250
Import	5,743	8,743	11,042
Total installed capacity (MW)	276,997	261,952	411,754

Source: Baker & McKenzie

The latest version of the PDP8 draft does not mention in detail whether biomass utilization should be co-firing or dedicated burning, however, according to estimates by eREX Co.,Ltd., which is developing biomass fuels in Vietnam, it is estimated that in 2030, 1.0 GW of coal-fired co-firing and 1.2 GW of dedicated burning; in 2035, 2.3 GW of coal-fired co-firing and 2.0 GW of dedicated burning; and in 2040, 4.6 GW of coal-fired co-firing and 3.4 GW of dedicated burning.

4.6. Survey on coal boiler users

In addition to continuing the survey of the three companies that cooperated in the survey last year, we requested the cooperation of one new coal boiler user to conduct this year's survey.

(1) List of coal boiler user survey results

Table21and Table22 list the results of the survey of coal boiler users and other users in the Mekong Delta region.

Table21 Results of interview survey of coal boiler users

Company name	MTV (dried produce)	AGTEX28 (cloth dyeing)	Company A (food processing)	CJ Agri (feed manufacturing)
Location (Province)	Dong Nai	Ho Chi Minh	Ho Chi Minh	Long An
Factory type	Drying of agricultural products (paddy, sorghum)	Fabric and clothing manufacturing	Instant Noodle Production	Feed manufacturing (livestock and fisheries)
Number of employees	5	1,800	1,000-2,000	400
site	1,000 ㎡	90,000 ㎡ (1,500 m^2 is boiler	30,000 ㎡	53,000 ㎡

		operation site)		
production output			1billion meals/year	27,000t/month
boiler	○(4 units 2 are in operation)	○(4 units, added 1 on August 2022)	○	○
fuel	Coal:75t/year	Coal; 12,000t/year	Coal; 20,000t/year	Coal; 50,000ｔ/year
coal properties	6,200kcal/kg	5,500kcal/kg	4,200kcal/kg	3,600kcal/kg
Coal purchase price	47.0Yen(8,000VND)/kg	Pulverized coal 14.7 yen (2,500VND)/kg Coal 17.0 yen (2,900VND)/kg	Not disclosed	14.1 Yen (2,400VND)/kg
Coal transportation method	Truck	Truck	Not disclosed	Truck
Boiler equipment (coal use)	Drying furnaces (2 furnaces: 4x8m)	4 steam boilers (made in Taiwan×1, made in Vietnam×3)	Steam boiler×1	Steam boiler×2 (made in Vietnam×2)
	Manufactured by local drying oven manufacturer	Purchased from the Southern Branch of Vietnam Boiler Co.		Purchased from Vietnam Boiler Co.
Crusher	No	No	No	No
coal mining equipment	No	Transported by a bulldozer		Transported by a forklift
Coal storage.	No (15m2 of storage space next to the furnace)	Covered warehouse of about 300 ㎡	Using existing coal yard	Transported by a forklift
ash disposal	Backfilling the pond Dumped on factory grounds	Entrusted to a contractor for processing at about 3 yen/kg	Outsourced to professional companies	Warehouse with room of about200m2 (almost no inventory as coal is delivered by order.).
Dust removal equipment	No	Waste gas is passed through water and then discharged.	Processed appropriately	Disposed of as general waste

Table22 Results of interview survey of coal boiler users (continued)

Company name	MTV (dried produce)	AGTEX28 (cloth dyeing)	Company A (food processing)	CJ Agri (feed manufacturing)
Possibility of using curl chips	△	△	○	○
	No place to store, requires more labor, Questionable in terms of cost	Possible, however, curl chip may clog. If clogging occurs, additional grinding steps are required	Have an experience of using it in the past	Can be used as is

Transportability of curl chip	90km, Purchased from a rice mill in Soc Trang Province, About 250 km by sea, then 90 km by truck.	Purchased from a rice mill in Soc Trang Province. About 250 km by sea, then 25 km by truck.	Purchased from a rice mill in Soc Trang Province.	Purchased from a rice mill in Soc Trang Province. About 200 km by sea, then 7 km by truck
How to procure coal	Coal delivers coal by truck (30km-40km away)	Contractors bring in and unload containers at late night	Not disclosed	Nearby coal distributor trucks in (within 2 km)
Curl chip storage space	Only 15 m^2 coal storage area next to furnace	Can be stored in existing coal storage facility more space is available for additional construction	Can be stored in existing coal storage	Possible to store in a coal storage building of approx. 200 m^2 Plenty of room on the site to build an addition
Business development (interest or not)	Yes, if profitable by maintaining drying capacity Yes, if profitable after all costs are deducted	If smoke generation and economic problems can be solved, consider installing		Consider introduction if cheaper than coal operation cost and stable supply is possible

1JPY=170.03VND (as of Dec 19th, 2022)

(2) MTV produce drying plant

While we observed an increase in coal prices during last year's survey, this year's survey also found that prices have increased further, although the size of the coal being purchased has not changed. The specifications of the drying oven have not changed since the previous year's survey; agricultural products are placed on the grid floor at the top of the drying room, coal is fed into the combustion furnace through the coal inlet, and air heated by coal combustion is blown by a fan, thereby drying agricultural products (rice, corn, tobacco, etc.) (see figure below); this system seems to be substitutable for curl chips as it is, however, as in the previous year, the demand for agricultural products has dropped due to the impact of COVID-19, and about 10 tons of corn is being dried per day, therefore, compared to the amount of coal used in the previous year, the amount of coal used this year is less than half and has continued to decrease for three consecutive years since the year

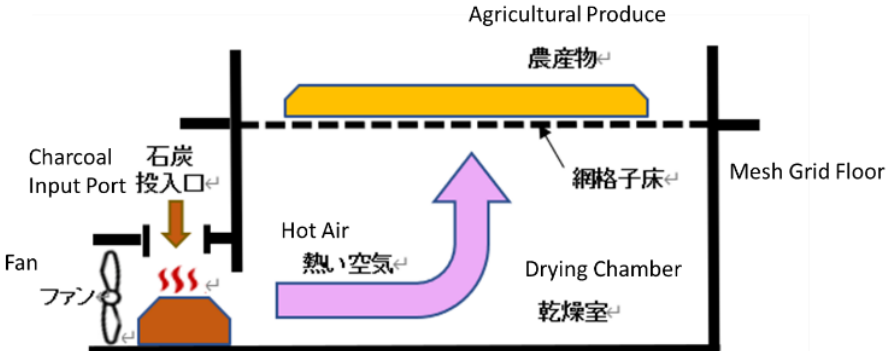


Figure 50 Structure of the agricultural product drying plant

before last when this project started its investigation.

Source: Compiled by JCOAL based on the survey results.

Figure51 Coal feed port to the combustion furnace (left), coal placed in the coal combustion furnace (right)

Figure52 Coal inlet to the combustion furnace (Combustion gases enter the lower part of the drying chamber.)

Figure53 Agricultural produce dryer (upper part of the drying chamber)

The coal is priced at 8,000VND/kg and the annual consumption is about 75 tons. The company purchases the coal from a coal distributor located in Bien Hoa province, about 30-40 km away from the company. Solid coal is purchased, and ash and soot emitted after coal combustion is disposed of in-house by using it to fill ponds or dumping it on the plant site, rather than asking a contractor to take it away. Until 2 years ago, the company used its own trucks to procure the coal, but starting this year, it is entrusting deliveries from coal dealers. There is an existing 15 m^2 space capable of storing about 10 tons of coal, but it is not suitable for storing rice husk solid fuel because it has no roof and is temporarily stored and kept out of the rain. On the other hand, it was confirmed that there is space

for additional storage warehouse near the drying oven; this space should be utilized when using curled chips.

Figure54 Dried crops

Figure55 Coal storage

Figure56 Disposed status of ash and soot

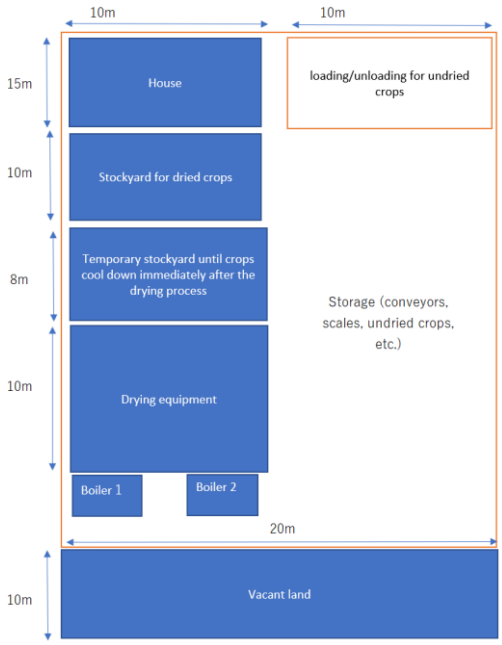


Figure57 Layout of MTV Company

As for the replacement of coal with rice husk solid fuel, the existing coal boiler drying equipment can be used and it is an advantage, however, if the company were to substitute rice husk solid fuel, it would require twice the amount of coal it currently uses; therefore, the company would need to hire new workers and build a covered yard for the solid rice husk fuel. If the company can expect to make a certain amount of profit on these initial investments, they would like to consider introducing the system.

(3) AGTEX28

AGTEX 28 is a state-owned enterprise under the jurisdiction of the Ministry of National Defense, located in Ho Chi Minh City, established in 1975, with offices throughout the country, expanding its business from the main business of cloth and clothing manufacturing to real estate and fuel business, and using coal boilers in its cloth and clothing manufacturing plants. It had signed a contract with an external party to manage boiler operation in 1999, however, in 2010, it founded another company (THANH DAT TIEN Co., Ltd.) that AGTEX28 owns the boiler, land, and building, and THANH DAT TIEN Co., Ltd. is responsible for boiler operation. AGTEX28 has 90,000 ㎡ of land and 1,800 employees, while THANH DAT TIEN has 1,500 ㎡ of controlled land (only the boiler operation site) and 20 employees.

Coal prices have not been stable since last year, fluctuating between about 930 and 1,700 VND/kg, and this year the price fluctuated to 2,900 VND/kg. One of the reasons for the lower price compared to the average coal market price may be that the company is a state-owned enterprise and can cooperate with THANH DAT TIEN of which main business is coal trade. AGTEX28 company uses coal from India, and in August 2022, a new coal (powdered coal) boiler was installed to replace the boiler made by the Southern Branch of Vietnam Boiler Co. The new boiler is designed to be able to use biomass (coffee husks, coconut shells, wood chips, rice husks, etc.), which means rice husk solid fuel can also be used, although the size needs to be adjusted. The exhaust gas is filtered through water and then discharged outside.

The annual consumption of about 12,000 tons and a calorific value of 5,5000 kcal (the composition list of the coal used is confidential and could not be obtained). However, the coal used by AGTEX28 has an ash content of 40-45%, compared to 20-25% for a coal standard with the same calorific value. In addition, the coal used appears to be wet, suggesting the use of low-quality coal with high moisture content. The coal is transported by the supplier to AGTEX28 every night by truck in containers and then unloaded.

Figure58 Newly installed powdered boiler

Figure59 Powdered coal storage

Regarding the substitution of coal for rice husk solid fuel, they say it is possible to consider if the price is equal to or lower than the price of coal currently used. Therefore, in the case of substituting curl chips, 5,500 kcal ÷ 3,700 kcal (heat value per kg of curl chips used) = about 1.48 kg (amount of curl chips required (calorific value basis)). Therefore, if the overall cost, including the cost of purchasing 1.48 kg of curl chips and using them in the boiler, is superior to the company's cost of purchasing coal and disposing of the ash, the project is considered to be profitable.

i Boiler Specifications and Technology of AGTEX28

The plant is equipped with one thermal oil boiler and three coal boilers (one newly installed).

① Thermal Oil Boiler

Summary: Made in Taiwan, purchased in 2012.

Specification: Use liquid oil as heat medium, circulating oil temperature: 275℃, returning oil temperature: 265℃.

Figure60 Thermal oil boiler

The heat transfer medium circulating in the coiled heat transfer tubes inside the drum-shaped high-

temperature, low-pressure heating furnace is heated in the furnace, sent to the dyeing equipment in the factory, and then returned to the boiler for circulation. The special arrangement of the heat transfer tubes in the furnace allows for high thermal efficiency and fuel savings. During operation, the furnace is under negative pressure and the high-temperature combustion gas does not leak outside the furnace.

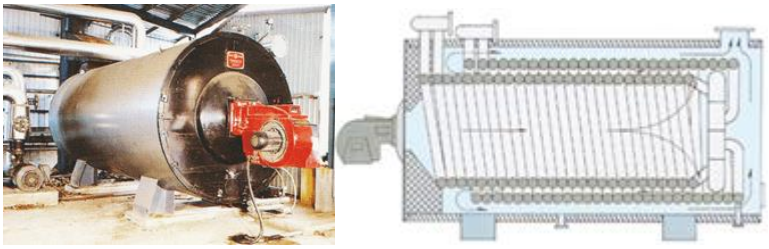


Figure61 Example of thermal oil boiler

② Coal boiler

Summary: Out of three boilers, first two boilers were originally Taiwanese thermal oil boilers, but one of them was replaced by a Taiwanese boiler (manufacturer and model number unknown) and the other by a coal boiler manufactured by Vietnam Boiler Company in 2011 and 2019, respectively. The third boiler, which was originally a Taiwanese boiler and used large lump coal as fuel, was replaced in August 2022 with a Vietnamese coal-fired boiler (made by Thai Duong) that can burn small-diameter coal. The Thai Duong boiler (model number: TD - 15.0/11 TS) is currently in operation.

<Specifications of Vietnam Boiler manufactured by Southern Branch of Vietnam Boiler Co.>

Specification (made in Vietnam): Southern Branch of Vietnam Boiler Co.

Model: LH10/10.GX Evaporation rate: 10t/h

Steam condition: 10kg/㎠ x 184℃ (Max. allowable pressure: 15kg/㎠)

Model: Single-body natural circulation boiler with moving floor stoker

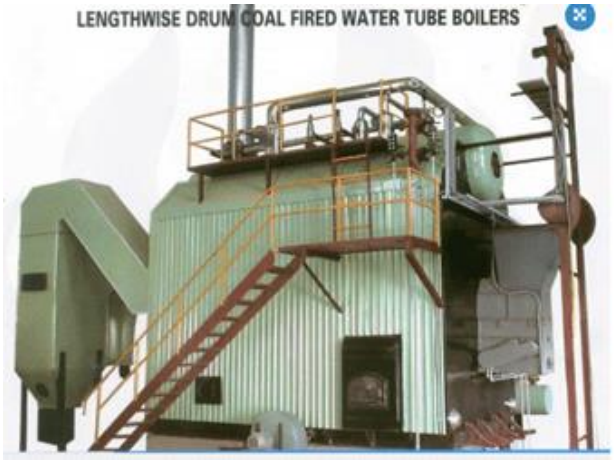


Figure62 Standard type single-body natural circulation boiler manufactured by Vietnam Boiler Co.

<Specification of boiler made by Thai Duong Co.>

Specification (made in Vietnam): Thai Duong Co.

Model: TD - 15.0/11 TS Steam rate: 15t/h

Steam condition: 10kg/㎠ x 179℃ Evaporation rate: (Max. allowable pressure:11kg/㎠)

Model: Coal-fired drum type boiler

The boiler consists of a combustion chamber with a chain grate stoker combustor and a rear heat transfer section. This type of boiler can handle evaporation capacities from 2 to 25 t/h. It can burn not only coal, but also sawdust pellets, wood chips, and finely chopped rice husks.

Figure63 Example of Thai Duong Co.'s boiler

Figure64 Model plate of Thai Duong Co.'s boiler

Figure65 Control panel of Thai Duong Co.'s boiler

ii Operation condition

- Boiler status

Figure66 Vietnam made single-body natural circulation boiler (moving floor stoker-fired), AGTEX28

The coal is from India, arranged by Thanh Dat Tien, and is installed together with the boiler in the building as shown in the picture below. In order to burn curl chips, it is necessary to secure a place to store them. The boiler on the left in the lower left figure is made by Vietnam Boiler Company and the one on the right is made by Taiwan Boiler Company. The coal storage area is on the right (lower right figure), with coal stored in the back and ash in the front, and a new boiler made by Thai Duong was installed in the space between the Taiwan made Boiler and the coal storage area.

Figure67 Boiler and coal storage area

The coal is handled with a bulldozer, and as mentioned earlier, in the Taiwanese boiler shown in the center figure, workers use shovels to feed the coal into the boiler's fuel feed hole. The boiler manufactured by Thai Duong Co. is equipped with an automatic coal feeding conveyor to the feeder hopper of the incinerator, and its operation can be controlled on the control panel. The automatic coal feed conveyor is installed in the coal powder storage tank, and the coal is transported to the tank by bulldozer just like coal.

Figure68 Coal feeding

The boilers are all stoker-fired, and the main fuel is Indian coal, but the particle size of the delivered coal is less than about 3 mm, and no grinding is required.（See Figure69） The ash after coal combustion is disposed of by a waste disposal company.

Figure69 Particle size of delivered coal

Figure70 Discharge system for furnace bottom slag

(4) CJ Agri

CJ is a member of the foreign-funded CJ Group in Korea, and built a factory in Long An Province in 1999, where it is building a feed production line for livestock, poultry, and fisheries, with a coal

boiler installed. CJ's coal consumption is 50,000 t/year – showing significant increase from last year (29,500t/year). On the other hand, the calorific value of coal used is approximately 3,600 kcal/kg. Considering that the calorific value was approximately 4,500 kcal/kg in the previous year's survey, and assuming an equivalent heat supply, approximately 36,000 tons of curl chips, or 22% more coal than was used, would have been required. However, based on the results of this year's survey, it was found that approximately 48,500 tons of curled chips, or 3% less than the amount of coal used, would be required. There is no need to build a new storage facility because there is enough space for storage as there is a 200m^2 covered coal storage warehouse and the coal distributor brings in only what is needed.

i Boiler Specifications and Technology of CJ Agri

CJ Agri's plant has one oil boiler and two coal boilers. One of the two coal boilers was installed in 2005. A new boiler of the same type is being installed in 2022.

① Oil boiler (purchased in 2005): Purchased as a back-up, but rarely used.
Specification (made in Vietnam): unknown
Steam condition: 7Pa
Fuel type: DO、FO

② Coal boiler (purchased in 2005)
Specification (made in Vietnam): made by Vietnam Boiler Co.
Model number: LT8/10X Steam rate: 8t/h (max)
Steam condition; 8.5Pa x 180℃
Model: External combustion chamber water tube boiler Moving floor stoker-fired

③ Coal boiler (purchased in 2022)
Specification (made in Vietnam): made by Vietnam Boiler Co.
Model number: LT8/10X Steam rate: 8t/h (max)
Steam condition; 8.5Pa x 180℃
Model: External combustion chamber water tube boiler Moving floor stoker-fired

The structure of this boiler is a natural circulation type boiler combined with an external combustion chamber and a water tube boiler, and the standard system diagram and external view are shown below. As shown in the system diagram, the coal boiler is a natural circulation type boiler that uses the gas generated by burning coal in a moving bed stoker furnace to generate saturated steam in a water tube boiler.

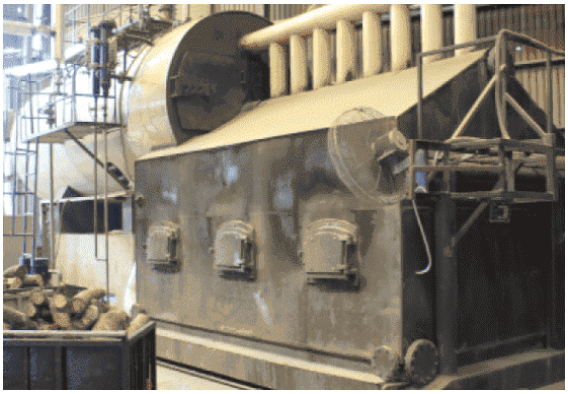


Figure71 Exterior view of a standard coal boiler

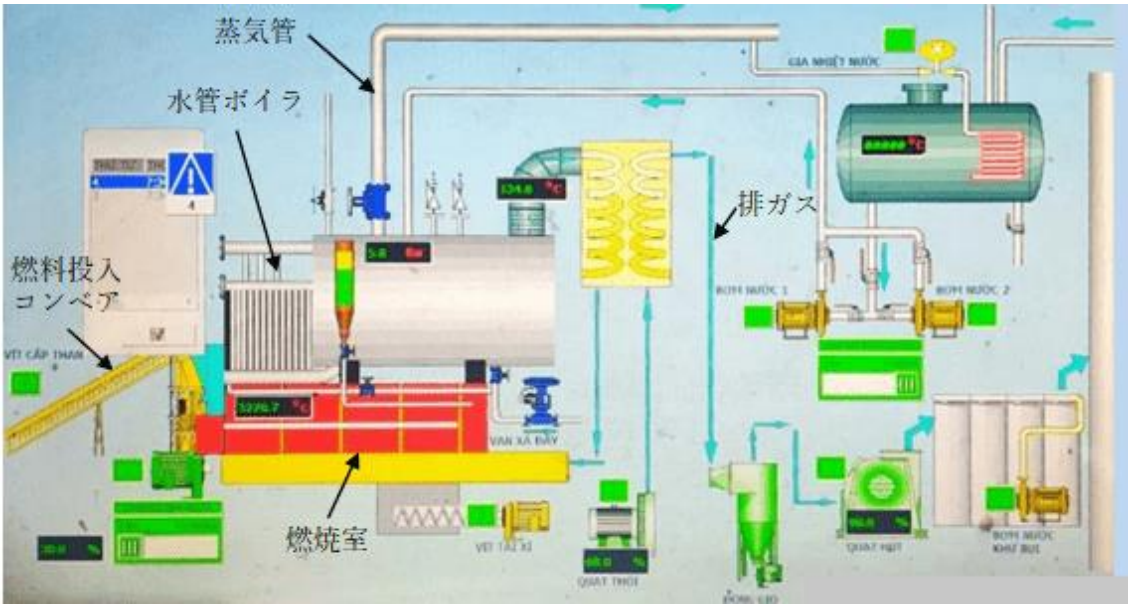


Figure72 Standard system diagram

Figure74 Coal is being fed to furnace for combustion

Figure73 Coal used by CJ Agri

ii Operation Status

Boiler operation

The company uses Indian coal as its main fuel, but for the last three years, when the fuel price has gone up, it has been using solidified rice husk fuel (in the form of small pellets). The company has already been using rice husk pellets, so they have responded that they have no resistance to the use of curl chips.

Figure75 Vietnam made natural circulation boiler (moving floor stoker-fired) at CJ Agri

The company has a policy of not having coal in stock, and asks a contractor to bring in only the necessary amount (enough for one 10-ton truck) each time from a 5,000 ㎡ warehouse of a coal sales company located about 2 km away. Rice husk pellets are brought in by truck from the neighboring province of Tien Giang and placed in the coal warehouse.

The ash from the coal used is disposed of as general garbage. When the existing rice husk pellets are used, a considerable amount of ash is discharged, but some people use it as fertilizer, and it is taken away for free of charge. The boiler exhaust gas is passed through water in front of the chimney to remove only the dust, and then discharged from the chimney.

Figure76 Combustion chamber and the section of water tube boiler

Figure77 Slag Discharge System at the bottom of furnace (right), Conveyor to feed Rice Husk Pellet (left)

At present, CJ is operating one factory each in Vinh Long, Long An, Dong Nai, Binh Duong, Binh Dinh, Hung Yen, and Ha Nam provinces, all of which use coal. The average coal consumption at each plant is about 20 tons/day, and the company requested to have a system in place to supply all plants with rice husk solid fuel when it is introduced. In addition, the company said that it would positively consider introducing rice husk solid fuel if the determined price of rice husk solid fuel is lower than that of coal, and it can be considered as a large-scale supplier of rice husk solid fuel.

(5) Company A

Company A is a major food manufacturer in Vietnam. The company owns factories in Ho Chi Minh City and Vinh Long Province, where coal boilers are used in the food product manufacturing process. The company has already used rice husk solid fuel in the past in the coal boiler of its factory in Vinh Long Province, and there is a high possibility that rice husk solid fuel can be used without any new capital investment. The site area is 30,000 m^2 and the number of employees ranges from 1,000 to 2,000.

i Boiler Specifications and Technology of Company A

One coal boiler is installed at each of the two factories. Originally, both plants used boilers from MAC TICH (MARTECH), but the plant in Vinh Long Province uses boilers from HAMADA. Company.

① Coal Boiler

Specification

Steam rate: 16 t/h

Steam condition: 1.1 MPa × Approx.190 ℃

Model

・Ho Chi Minh Plant:

MAC TICH（MARTECH）

Boiler:

Stoker boiler with chain grates

Figure78 Existing coal-fired boiler at Ho Chi Minh City plant

・Plant in Vinh Long Province

HAMADA Boiler (COALMAC): Stoker Cylindrical Boiler

Figure80 Cylindrical boiler

Figure79 Inside the Stalker (Chain Grate)

Figure81 Existing coal-fired boilers and coal storage sites at a plant in Vinh Long

The company's coal consumption is 20,000 tons/year, and the calorific value of coal used is approximately 4,200 kcal/kg. Similar to CJ company, estimated amount of rice husk solid fuel required based on the survey results shows that approximately 22,600 tons of curl chips, 13% more than coal consumption, are required. The storage site has a coal storage warehouse with roof, and the existing storage space can be used to store rice husk solid fuel, so there is no need to construct a new warehouse or other facilities.

Table23 Specification of coal used by Company A

No.	Item	ASTM	Parameter
1	Moisuture (%)	As Received	34 - 36
2	Ash content (%)	Dry	Max 10
3	Volatile component (%)	Dry	38 - 43
4	Sulfur content (%)	Dry	Max 0.5
5	Calorific value at arrival (Kcal/kg)	As received	4100 - 4200
6	Dry base calorific value(Kcal/kg)	Dry	Min 5900
7	Particle size （mm）	mm	4 – 30 (＜4mm; 20%)

The company compares the market price of combustion materials in a regular manner and selects inexpensive combustion materials. Based on the past market prices of combustion materials, the company responded that it could consider introducing rice husk solid fuel as long as the selling price was less than 2,500VND/kg. In addition, the company said that in considering the introduction of the system, it would be necessary to conduct a test using about 5 to 10 tons of rice husk solid fuel, taking into consideration the boiler capacity.

(6) Coal usage at each company

Among the results of the coal boiler user survey for each company, the results of the survey on coal usage are summarized in Table24. However, at the time of the survey of Company A, the unit price of coal was not answered. Therefore, since Company A's plant is located in Ho Chi Minh City, we tentatively set the unit price at the same level as that of the 28 AGTEX companies that also operate plants in Ho Chi Minh City.

Table24 Summary of coal use by each company

	MTV (dried produce)	AGTEX28 (cloth dyeing)	Company A (food processing)	CJ Agri (feed manufacturing)
Coal consumption t /year	75	12,000	20,000	50,000
Coal calorific value Kcal/kg	6200	5,500	4,200	3,600
Coal	47.0	17.0	17.0	14.1

Yen/kg				
Coal price VND/kg	8,000	2,900	2,900	2,400
Coal calorific value equivalent per kg of rice husk solid fuel requirement (kg)	1.68	1.49	1.14	0.97
Required Rice husk solid fuel (t/year)	126	17,838	22,703	48,649

1JPY=170.03VND(as of December 19th , 2022)

Curl chips calorific value=3,700kcal/kg

4.7. Potential of adopting the project

(1) Production cost of rice husk solid fuel

Amongst the three companies surveyed in this project – Chau Hung Rice Mill, Thanh Tin Rice Mill, and An Cu Rice Mill – and considering the amount of rice husk emissions and the feasibility of the installation, we will assume the installation of a grind mill (TRM-200CR) at An Cu Rice Mill. The calculations are based on the assumption that one TRM-200CR will be installed and operated 24 days a month for 12 hours a day to produce approximately 691 tons of curl chips in 12 months, and that the rice husks will be free of charge.

i Scenario of free rice husk

1. Prerequisites.

Item		Quantity	Unit	Remarks
1)	Purchase of TRM-200CR Grind Mill	295	10,000 yen	CR model 2.75 million yen + 200,000yen transportation fee included(The grind mill is priced in accordance with the applicable JCM capital investment project)
2)	Building electrical installation cost	0	10,000 yen	Assumed to be installed in an existing building.
	Total cost of equipment installation (2,750,000 yen + 200,000 yen)	295	10,000 yen	
3)	Depreciation and amortization (2.95 million yen / 7)	42	10,000 yen	Equal amortization over 7 years.
4)	Months of curl chip production	12	Month	
5)	Consumable parts (per 3,456 hours)	145.7	10,000 yen /3,456hs	12h x 24days x 12months=3,456h
6)	Labor cost for production (12-month operation)	94.8	10,000 yen /12months	25,000yen/month*2person , refer to Thanh Tin Rice Mill labor cost
7)	Amount of electricity used (12 months)	103,680	kwh/12months	30kw×3456h=103,680kwh

8)	Electricity Bill (12 months)	73.6	10,000 yen / months	7.1 yen/kWh Referred from electricity rates for Thanh Thin Rice Mill (normal unit price is applied)
9)	Curl chip production rate (1 hour operation)	200	kg/h	Assumed 200 kg/h.
10)	Curl chip production (12 months 3,456 hours operation)	691.2	t/3,456h	12-month production volume

2. Production Cost Estimate

Item	Cost	Unit	Remarks
Hull Husk Procurement cost	0.0	10,000 yen	Assumed to procure rice husks at 0 yen/kg/use own emissions
Depreciation of Grind Mill equipment	42	10,000 yen	295 million ÷ 7
Labor cost (12 months)	94.8	10,000 yen	39,500yen per month x 12 months x 2 persons
Electricity charges (for 12 months)	73.6	10,000 yen	7.1 円/kWh Referred from Thanh Thin Rice Mill's electricity rates (normal unit price is applied)
Cost of consumables	145.7	10,000 yen	Parts unit price x 3,456h
Total	321.4	10,000 yen	

3. Production Cost per Ton of Briquette

Item	Quantity	Unit
Curl chip production volume	691.2	t
Production cost of 460.8 tons of curl chip	356.2	10,000 yen
Production cost of 1 ton of curl chip	0.52	10,000 yen/ton
Production cost of 1 kg of curl chip	5.2	yen/kg

1JPY=170.03VND(as of December 19th, 2022)

ii Scenario of Rice Husk is paid for (assumed to buy from external sources)

1. Prerequisites.

Item		Quantity	Unit	Remarks
1)	Purchase of TRM-200CR Grind Mill	295	10,000 yen	CR model 2.75 million yen + 200,000yen transportation fee included(The grind mill is priced in accordance with the applicable JCM capital investment project)
2)	Building electrical installation cost	0	10,000 yen	Assumed to be installed in an existing building.
	Total cost of equipment installation (2,750,000 yen + 200,000 yen)	295	10,000 yen	

3)	Depreciation and amortization (2.95 million yen / 7)	42	10,000 yen	Equal amortization over 7 years.
4)	Months of curl chip production	12	Month	
5)	Consumable parts (per 3,456 hours)	145.7	10,000 yen /3,456hs	12h x 24days x 12months=3,456h
6)	Labor cost for production (12-month operation)	94.8	10,000 yen /12months	39,500yen/person/month referred An Cu rice mill labor cost unit price/day (280,000VND/day)
7)	Amount of electricity used (12 months)	103,680	kwh/12months	30kw×3456h=103,680kwh
8)	Electricity Bill (12 months)	73.6	10,000 yen / months	7.1 yen/kWh Referred from electricity rates for Thanh Thin Rice Mill (normal unit price is applied)
9)	Curl chip production rate (1 hour operation)	200	kg/h	Assumed 200 kg/h.
10)	Curl chip production (12 months 3,456 hours operation)	691.2	t/3,456h	12-month production volume

2. Production cost estimate

Item	Cost	Unit	Remarks
Rice Husk procurement cost	812.9	10,000 yen	Assumed to procure rice husks at 11.76yen/kg
Depreciation of Grind Mill equipment	42	10,000 yen	295 million ÷ 7
Labor cost (for 12 months)	94.8	10,000 yen	39,500yen per month x 12 months x 2 persons
Electricity charges (for 12 months)	73.6	10,000 yen	7.1yen/kWh Referred from Thanh Thin Rice Mill's electricity rates (normal unit price is applied)
Cost of consumables	145.7	10,000 yen	Parts unit price x 3,456h
Total	1,134.3	10,000 yen	

3. Production Cost per Ton of Briquette

Item	Quantity	Unit
Curl chip production volume	691.2	t
Production cost of 691.2 tons of curl chip	1,169.1	10,000 yen
Production cost of 1 ton of curl chip	1.69	10,000 yen/ton
Production cost of 1 kg of curl chip	16.9	yen/kg

1JPY=170.03VND(as of December 19th 2022)

If An Cu were to install one unit of TRM-200CR, the cost would be 4.7 yen/kg when using rice husks generated in-house. On the other hand, if rice husks are procured from other companies, the production cost would be 16.4 yen/kg. When rice husks are procured from other companies, the unit

price is far higher than the unit price at the time of last year's calculations, affected by the recent sharp rise in rice husk prices in Vietnam. Therefore, it is assumed that the entire amount of rice husks generated by An Cu Company will be used, and rice husks will be treated as free of charge.

(2) Transportation cost of rice husk solid fuel

If rice husk solid fuel (curl chips) is used as a substitute for coal by coal boiler users, the transportation cost from An Cu to each company should be included. The cost of transportation to each coal boiler user company is as follows based on the results of the field interview survey.

Table25 Cost of transporting curl chips to coal boiler uses

	MTV (dried produce)	AGTEX28 (cloth dyeing)	Company A (food processing)	CJ Agri (feed manufacturing)
Transportation cost VND(JPY)/kg	435(2.55)	337.5(1.98)	337.5(1.98)	287.5(1.69)
Mode of transportation by land or canal	land + canal	land + canal	land + canal	land + canal
Distance km	340	250	250	275
Maximum coal replacement capacity (t/year)	75	10,000	10,000	10,000

1JPY=170.03VND(as of December 19th 2022)

(3) Cost calculation when rice husk solid fuel is used instead of coal

The table below shows a simulation of when companies replaced coal with rice husk solid fuel (curl chips).

Table26 Simulation of substituting coal for curl chip

Item	Unit	MTV (dried produce)	AGTEX28 (cloth dyeing)	Company A (food processing)	CJ Agri (feed manufacturing)
Curl Tip Purchase Price	VND/kg	4,250	1,870	2,465	2,227
	Yen/kg	25.0	11.0	14.5	13.1
Maximum amount of curl tips that can be provided	t/Year	126	10,000	10,000	10,000
Annual curl chip purchase cost	VND/Year	535,500,000	18,700,000,000	24,650,000,000	22,270,000,000
	t/Year	3,150,000	110,000,000	145,000,000	131,000,000

※ 1 JPY=170.03VND(as of December 19th 2022)

Coal users can replace their current coal use with curled chips at a cost of 11.0 yen (1,870VND) to 25.0 yen (4,250VND)/kg.

(4) Calories of coal used by coal boiler users

According to the survey results obtained in this study, the calorie (calorific value) of coal used is 6,200 kcal/kg for MTV, 5,500 kcal/kg for AGTEX28, and 3,600 kcal/kg for CJ Agri, respectively, so from Table27, it is inferred that powdered coal 4a, powdered coal 5a, and powdered coal 6a are used respectively. Company A also uses imported coal (bituminous or sub-bituminous coal) from Indonesia and India.

Table27 Coal quality used (estimated from grades of the coal)

Business	Grade	Ash content (%)	Moisture (%)	Volatile matter (%)	Sulfur content (%)	Calorific value (kcal/kg)
MTV	4a	21.00	8.00	6.50	0.65	6,400
AGTEX28	5a	29.00	8.00	6.50	0.65	5,600
Company A	Bituminous/sub-bituminous coal	Max 10	34 - 36	38 - 43	Max 0.5	4,100 - 4,200
CJ Agri	6a	37.5	8.00	6.50	0.65	4,800

AGTEX28 and CJ Agri are storing coal in roofed warehouses and have already established a system to accept curl chips on a regular basis when they replace coal with curl chips. In addition, AGTEX28 disposes of combustion ash for a fee of 2,500 yen/t, but curl chips have less than half the ash content of coal, so the disposal cost is expected to be reduced.

(5) Possibility of using rice husk solid fuel with coal boilers

The MTV's Produce-drying plant can use it as is, but the impact of fuel conversion would be small due to its low usage. The boilers of AGTEX28 are all stoker-fired and use coal with a particle size of about 3 mm or less, which can be used in the same way as coal without the need for pre-processing, including the shredding of curl chips. The boiler structure used by CJ Agri is a natural circulation boiler that combines an external combustion chamber and a water tube boiler, and the coal boiler uses the gas generated by burning coal in a moving bed stoker furnace to generate water tube boiler saturated steam. Recently, rice husk solidified fuel (in the form of small pellets) is fed into the furnace using a rice husk pellet feed conveyor only when the price of coal, the main fuel, rises, so there is no need to introduce new equipment to replace curly chips. However, since rice husk contain a large amount of silicic acid, which is essential for the healthy growth of rice, when they are burned in a boiler, a mass of crystalline silica called clinker is formed in the combustion furnace of the boiler, and this must be taken into consideration. In the case of a stoker type boiler, it is necessary to take care of the high temperature inside the furnace due to excessive combustion, to protect the walls

of the combustion furnace with refractory materials or linings, and to prevent blowing through the grate or, conversely, blockage.

(6) Possibility of fuel replacement by rice husk solid fuel

Based on the results of the survey on actual coal use, all surveyed companies can use existing facilities as they are and use curled chips, so there are few technical obstacles to coal substitution, since no new capital investment is involved. Therefore, we estimate the costs incurred when coal is used and the costs incurred when curled chips are used for all surveyed coal users. See the section "Periods of Availability of Provision" in Table28 for the applicable period for each company.

Table28 Cost estimate of introducing curl chips to coal users

			MTV (dried produce)	AGTEX28 (cloth dyeing)	Company A (food processing)	CJ Agri (feed manufacturing)	Remarks
Coal	Coal consumption	t/year	75	12,000	20,000	50,000	
	Coal consumption	t/month	6	1,000	1,667	4,167	
	Coal calorific value	kcal/kg	6,200	5,500	4,200	3,600	
	coal price	VND/kg	8,000	2,900	2,900	2,400	
		JPY/kg	47.1	17.1	17.1	14.1	
	Annual coal purchase cost	VND/year	600,000,000	34,800,000,000	58,000,000,000	120,000,000,000	
		JPY/year	3,528,789	204,669,764	341,116,274	705,757,807	
	Annual coal purchase cost	VND/year	50,000,000	2,900,000,000	4,833,333,333	10,000,000,000	2months
		JPY/year	294,066	17,055,814	28,426,356	58,813,151	
	Boiler maintenance costs	VND/year	0	495,000,000	0	0	
		JPY/year	0	2,911,251	0	0	
	Annual running costs when using coal	VND/year	50,000,000	3,395,000,000	4,833,333,333	10,000,000,000	
		JPY/year	294,066	19,967,065	28,426,356	58,813,151	
Curl Chips	Maximum possible supply of	t/year	126	10,000	10,000	10,000	

	curl chips						
	Monthly substituted coal amount necessary	t/month	10	1,486	1,892	4,054	
	Supply Period	Month	12	6.7	5.3	2.5	
	Necessary amount of complete replacement	t/year	126	17,838	22,703	48,649	
	Curl chips calorific value	kcal/kg	3,700	3,700	3,700	3,700	
	Curl chip unit price	VND/kg	4,250	1,870	2,465	2,227	free rice husks
		JPY/kg	25.0	11.0	14.5	13.1	
	Annual curl chip purchase fee	VND/year	534,121,622	33,356,756,757	55,962,162,162	108,340,540,541	
		JPY/year	3,141,892	196,216,216	329,189,189	637,297,297	
	Cost of purchasing curl tips in applicable period	VND/year	44,510,135	2,779,729,730	4,663,513,514	9,028,378,378	free rice husks
		JPY/year	261,824	16,351,351	27,432,432	53,108,108	
	Boiler maintenance costs during the applicable period	VND/year	0	41,250,000※	0	0	
		JPY/year	0	242,604	0	0	
	Annual running costs when using curl chips	VND/year	44,510,135	2,820,979,730	4,663,513,514	9,028,378,378	free rice husks
		JPY/year	261,824	16,593,956	27,432,432	53,108,108	

*As ash content is halved, estimated at 50% of coal boiler maintenance costs

In addition, the following table shows the cost savings if the users were to replace all coal use with

curl chips.

Table29 Fuel cost reductions due to the introduction of curl chips

			MTV (dried produce)	AGTEX28 (cloth dyeing)	Company A (food processing)	CJ Agri (feed manufacturing)	Remarks
Comparison	Cost savings compared to coal use	VND/year	5,489,865	574,020,270	169,819,820	971,621,622	free rice husks
		JPY/year	32,241	3,373,109	993,924	5,705,043	
	Cost savings compared to coal use	%	11.0%	16.9%	3.5%	9.7%	free rice husks

Therefore, compared to the use of coal, MTV can expect to save about 32,241 yen (5,489,865 VND) per year, which is 11.0% of the cost of using coal. In addition, CJ Agri expects to save 5,705,043 yen (971,621,622 VND) during the applicable period, which is up to 9.7% of the cost of coal use. For the 28 AGTEX companies, replacing coal with curled chips could save up to 16.9% of costs compared to the costs incurred during the applicable period when coal is used. Furthermore, Company A, which was newly surveyed this year, is expected to similarly reduce costs by up to 3.5% compared to the costs incurred during the applicable period when coal is used. However, since Company A's coal prices were undisclosed, the coal purchase prices of coal boiler users in the area were set as tentative, and further survey is needed in the future. The feasibility of this project will be further imporved if it is possible to ① ensure the profitability of the rice mills while securing expected profits of rice mills from which the curl chips will be sold and ② ensure the economic advantage of the users to whom the chips will be purchased compared to the use of coal.

(7) The business feasibility of selling rice husk solid fuel at An Cu rice mill

In order to show (1) the revenue security of the rice mill and (2) the economic advantage of the user over coal use, as shown in the previous section, we estimated the business revenue for three years with a set sales price from An Cu Rice Mill to the coal boiler user (CJ Company). An Assumed maximum solid fuel production based on the upper limit of rice husks generated by the An Cu rice mill, and assumed that all the rice husks are sold to CJ Company; on estimate, if all solid fuel is

provided by the An Cu rice mill, CJ company can exclusively burn curl chips as a substitute for coal for 2 months. If An Cu rice mill sells curl chips to CJ for two months, the anticipated monthly sales are approximately 53,000,000 yen and the anticipated monthly profit is approximately 24,000,000 yen (Table 30).

Table 30 Profit and loss estimation for An Cu rice mill

[Sales]

Item	Price
Rice husks briquette(curl chip)	¥13.1

[Cost]

Item	Price
Rice husks briquette(curl chip)	¥7.1

Year	1st year												Total
Month	4	5	6	7	8	9	10	11	12	1	2	3	12 months
Amount of sales											53,107,400	53,107,400	106,214,800
Cst of sales											28,919,345	28,919,345	57,838,689
Gross profit	0	0	0	0	0	0	0	0	0	0	24,188,055	24,188,055	48,376,111

Year	2nd year												Total	Cumulative
Month	4	5	6	7	8	9	10	11	12	1	2	3	12 months	24 months
Amount of sales											53,107,400	53,107,400	106,214,800	212,429,600
Cst of sales											28,919,345	28,919,345	57,838,689	115,677,379
Gross profit	0	0	0	0	0	0	0	0	0	0	24,188,055	24,188,055	48,376,111	96,752,221

Year	3rd year												Total	Cumulative
Month	4	5	6	7	8	9	10	11	12	1	2	3	12 months	36 months
Amount of sales											53,107,400	53,107,400	106,214,800	318,644,400
Cst of sales											28,919,345	28,919,345	57,838,689	173,516,068
Gross profit	0	0	0	0	0	0	0	0	0	0	24,188,055	24,188,055	48,376,111	145,128,332

In addition, we also estimated the reduction effect if CJ substituted coal with curled chips during the applicable period. Based on this estimate, a reduction of approximately 5,700,000 yen per month is expected.

Table 31 Profit and loss estimation for CJ

[Purchase price]

Item	Price
Coal	¥14.1
Rice husk briquette (curl chips)	¥13.1

Year	1st year												Total
Month	1	2	3	4	5	6	7	8	9	10	11	12	12か月計
Coal	0	0	0	0	0	0	0	0	0	0	58,813,151	58,813,151	117,626,301
Rice husk briquette	0	0	0	0	0	0	0	0	0	0	53,108,108	53,108,108	106,216,216
Cost saving	0	0	0	0	0	0	0	0	0	0	5,705,043	5,705,043	11,410,085

Year	2nd year												Total	Cumulative
Month	4	5	6	7	8	9	10	11	12	1	2	3	12 months	24 months
Coal	0	0	0	0	0	0	0	0	0	0	58,813,151	58,813,151	117,626,301	235,252,602
Rice husk briquette	0	0	0	0	0	0	0	0	0	0	53,108,108	53,108,108	106,216,216	212,432,432
Cost saving	0	0	0	0	0	0	0	0	0	0	5,705,043	5,705,043	11,410,085	22,820,170

Year	3rd year												Total	Cumulative
Month	4	5	6	7	8	9	10	11	12	1	2	3	12 months	36 months
Coal	0	0	0	0	0	0	0	0	0	0	58,813,151	58,813,151	117,626,301	352,878,904
Rice husk briquette	0	0	0	0	0	0	0	0	0	0	53,108,108	53,108,108	106,216,216	318,648,649
Cost saving	0	0	0	0	0	0	0	0	0	0	5,705,043	5,705,043	11,410,085	34,230,255

The profitability of the coal curl chip replacement business depends largely on the price of

competing coal and the price of rice husks, making it difficult to foresee concrete introduction, but Tromso plans to approach An Cu to introduce a grind mill during FY2023 and to sell curl chips from the company to CJ and other coal boiler users.

(8) CO2 reduction and cost effectiveness

i Overview

The GHG emission reductions associated with fuel switching at existing manufacturers (non-energy applications) were evaluated. The project focused on the fuel switching from coal to rice husk-derived curl chips. As a result of the study on the "potential of curl chips as an alternative fuel" in Soc Trang Province, it was suggested that producing curl chips at An Cu Rice Mill or Chau Hung Rice Mill and utilizing the curl chips as an alternative fuel for boiler at four corporations, namely, CJ Agri, MTV, AGTEX28 and Company A was suggested to be feasible. In this section, GHG emission reduction potentials and Cost-effectiveness were evaluated for the following four cases:

1) All coal used at CJ Agri is switched to curl chips supplied by a Rice Mill
2) All coal used at MTV is switched to curl chips supplied by a Rice Mill
3) All coal used at AGTEX28 is switched to curl chips supplied by a Rice Mill
4) All coal used at Company A is switched to curl chips supplied by a Rice Mill

As both rice mills are located in Soc Trang province, it is assumed that the starting point of the transport distance required for the calculation of CO_2 emissions from the transport of biomass fuel, which is considered in the MRV assessment, is almost the same, and is simply referred to as 'a rice mill' here.

ii MRV methodology

The CDM methodology “AMS-III.AS.: Switch from fossil fuel to biomass in existing manufacturing facilities for non-energy applications (Version 2.0)” was referred to as an MRV methodology. The methodology is applicable to complete or partial fuel switching projects (Figure 82).

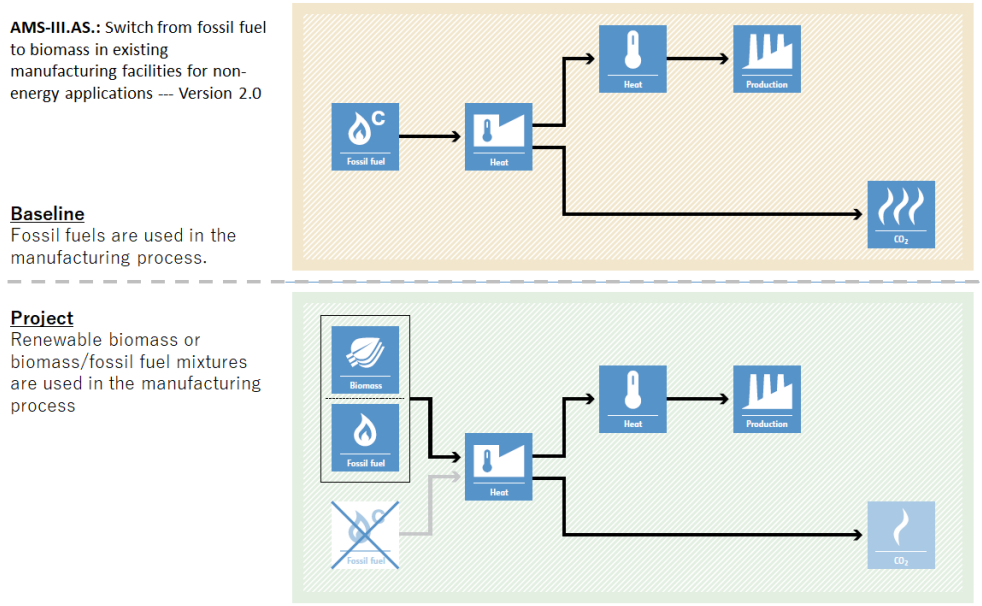


Figure 82 Image of a fuel switching project subject to CDM methodology AMS-III.AS.

Source: UNFCCC "CDM Methodology Booklet - Eleventh edition", Nov. 2019.

The eligibility requirements (applicability) of the project is as follows. The project under consideration was assumed to meet all the requirements.

<Applicability>

(a) The baseline fossil fuel and the project biomass are consumed in thermal energy conversion equipment (e.g. furnaces, kilns, dryers) that are used in the manufacture of products (e.g. steel, ceramics, aluminium, lime, clinker). This is referred to as an element process in this methodology;

(b) It shall be demonstrated, with historical data, that at least for the immediate prior three years to the start date of project, only fossil fuels (no renewable biomass) were used in the production systems, which are being modified, retrofitted or replaced. In cases where small quantities of biomass were used for experimental purposes then this can be excluded;

(c) Regulations do not restrict the use of the baseline fossil fuel or require the use of project biomass and low carbon energy sources unless widespread noncompliance (less than 50 per cent of manufacturing production activities comply in the country) of the local regulation is evidenced;

(d) The production process where the fuel switch takes place shall have a distinct energy input (i.e. specific fuels) and distinct output (i.e. intermediate or finished product). The output of each element process shall be an output for which an appropriate international/national standard or industrial norm exists;

(e) This methodology is not applicable to project activities where primary output of the processes is energy (e.g. heat, electricity) that can be directly measured;

(f) The product(s) (e.g. ceramic insulators, tiles, steel ingots, lime, aluminium cookware) produced

in the industrial facility throughout the crediting period shall be equivalent to the product(s) produced in the baseline. For the purposes of this methodology, equivalent products are defined as products having the same use, the same general physical properties, and which function in a similar manner. In addition, products produced in the industrial facility throughout the crediting period shall provide the same level of service, or better, and be of the same level of quality, or better than the product(s) produced in the baseline. When national or international product standards apply to the product(s), product quality shall be as defined in such standards, otherwise the relevant industrial norms are to be followed;

(g) The type of input materials used in the project shall be homogeneous and similar to the input material that was used in the baseline and any deviation during the crediting period of input material type, composition, or amount used per unit of product output shall be within the range of ±15 per cent of the baseline characteristics and values;

(h) The facilities involving modification, retrofit and/or replacement shall not influence the production capacity beyond ±15 per cent of the baseline capacity.

iii Project boundary

The project boundary is generally assumed to be a physical, geographical site where the switching of energy sources takes place. It includes all installations, processes or equipment affected by the fuel switching.

In the project under consideration, CO_2 emissions from electricity consumption for curl chip production from rice husks and fuel consumption for transporting curl chips in a project scenario were the subject of estimation; while, in the reference scenario, CO_2 emissions from electricity consumption for briquette production from rice husks and fuel consumption for transporting briquettes were not accounted for in order to ensure conservativeness.

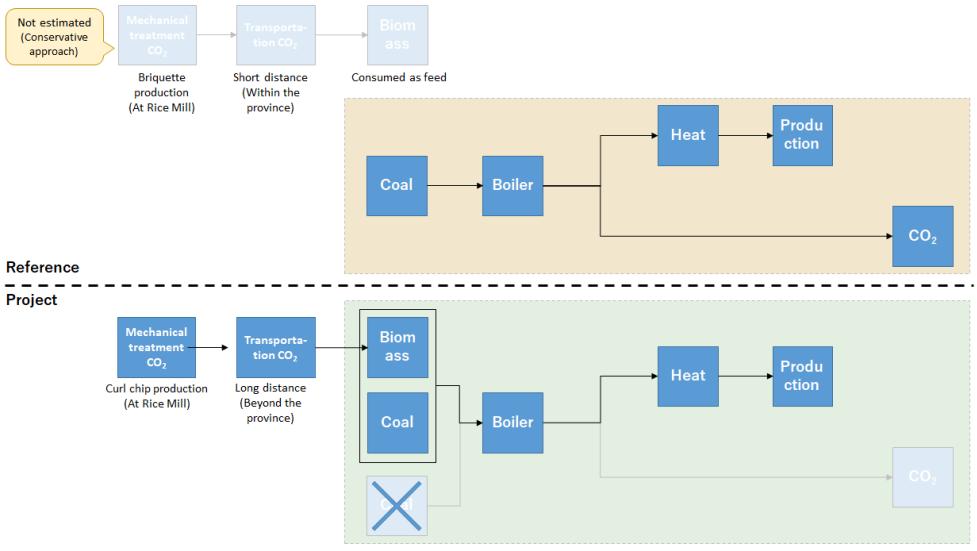


Figure 83 Boundary of the project

Table 32 GHGs and emission sources subject to estimation

Reference	Coal consumption at boiler	CO_2	Yes	Emission source
		CH_4,N_2O	No	Negligible. Excluded for the sake of conservativeness.
	Electricity consumption for boiler	CO_2	No	Excluded for the sake of conservativeness, assuming that it is consumed only by limited equipment.
	Electricity consumption for biomass production	CO_2	No	Excluded for the sake of conservativeness
	Fuel consumption for biomass transportation	CO_2,CH_4,N_2O	No	Excluded for the sake of conservativeness
	Decomposition by biomass dumping	CO_2,CH_4,N_2O	No	Consumed as animal feed. Not applicable.
Project	Coal consumption at boiler	CO_2	Yes	Emission source
		CH_4,N_2O	No	Negligible. Excluded for the sake of simplicity.
	Biomass consumption at boiler	CO_2	No	Carbon neutral
		CH_4, N_2O	No	Negligible. Excluded for the sake of simplicity.
	Electricity consumption for boiler	CO_2	No	Excluded for the sake of simplicity, assuming that it is consumed only by limited equipment.
	Electricity consumption for biomass production	CO_2	Yes	Emission source
	Fuel consumption for biomass transportation	CO_2	Yes	Emission source
		CH_4,N_2O	No	Negligible. Excluded for the sake of simplicity.
	Biomass storage	CO_2	No	Carbon neutral
		CH_4,N_2O	No	Excluded for the sake of simplicity, assuming that it is not stored for more than one year and that the amount generated is small.

iv Formula for estimating GHG emission reduction amount and the results

GHG emission reductions at the aforementioned four companies were calculated using the following formula.

Assuming that all four companies switched all of their coal with curl chips, annual CO_2 emission reduction amounts were estimated as: 65,400 tonnes for CJ Agri, 130 tonnes for MTV, 24,000 tonnes for AGTEX28 and 30,500 tonnes for Company A, respectively.

$ER = E_{Reference} - E_{Project}$

ER:	GHG emission reduction amount (t CO_2 eq./y)
$E_{Reference}$:	GHG emissions for the reference scenario (t CO_2 eq./y)
$E_{Project}$:	GHG emissions for the project scenario (t CO_2 eq./y)

GHG emissions for the reference scenario

$E_{Reference} = M_{Coal} * NCV_{Coal} * EF_{Coal}$

$E_{Reference}$:	GHG emissions for the reference scenario (t CO_2 eq./y)	
M_{Coal}:	Consumption amount of coal (t/y)	Measured value
NCV_{Coal}:	Calorific value for coal (GJ/t)	Measured value
EF_{Coal}:	Emission factor for coal (t CO_2/GJ)	IPCC default value for coal: 94.6 $kgCO_2$/GJ

GHG emissions for the project scenario

$E_{Project} = (M_{Coal} * NCV_{Coal} * EF_{Coal}) + (M_{Electricity} * EF_{Electricity}) + (M_{Transport} * EF_{Transport})$

$E_{Project}$:	GHG emissions for the project scenario (t CO_2 eq./y)	
M_{Coal}:	Consumption amount of coal (t/y)	Subject of monitoring Note: Zero if fully substituted.
NCV_{Coal}:	Calorific value for coal (GJ/t)	Same as for the reference scenario
EF_{Coal}:	Emission factor for coal (t CO_2/GJ)	Same as for the reference scenario
$M_{Electricity}$:	Electricity consumption for curl chip production (kWh/y)	Subject of monitoring
$EF_{Electricity}$:	Emission factor for electricity ($kgCO_2$/kWh)	Data for Viet Nam: 0.9130 $kgCO_2$/kWh
$M_{Transport}$:	Fuel consumption for biomass transportation (L/y)	Subject of monitoring (It can be estimated based on transportation distance, maximum loading capacity of trucks, and fuel consumption. In this case, the transportation distance is the subject of monitoring.)
ρ	Fuel density (kg/L)	Diesel: 0.85 kg/L (source: Science Direct)
$EF_{Transport}$:	Emission factor for fuel ($kgCO_2$/GJ)	IPCC default value for diesel: 74.1 $kgCO_2$/GJ

v Cost-effectiveness

The estimation results of cost-effectiveness for the case where the entire amount of coal used at the aforementioned four companies were replaced by curl chips are shown in Table 33. According to the guidelines for submitting proposals of JCM Model Project, it states that the Cost-effectiveness of financial support necessary to reduce 1 tonne of GHG emissions should be 4,000 JPY/tCO_2eq or lower. It was confirmed that if the minimum subsidy rate (30%) was applied, the Cost-effectiveness would be 190-890 yen/tCO_2, which is far less than 4,000 yen/tCO_2.

Table 33 Cost-effectiveness

Item	CJ Agri	MTV	AGTEX28	Company A	Note
Number of equipment installed	106	1	39	50	Curl chip producing equipment

Initial cost (Yen) (1)	286.2 Million	2.7 Million	105.3 Million	135.0 Million	2.7 Million Yen/Equipment
Product lifetime (y)	7	7	7	7	For "Agricultural Equipment" in the Ministerial Ordinance concerning the Useful Life, etc. of Depreciable Assets
GHG emission reduction amount (tCO_2) (2)	458,000	914	168,000	214,000	Performance for the entire period of product lifetime
Cost-effectiveness (Yen/tCO_2)	625	3,000	627	632	(1)/(2) Note: No subsidy is considered.
Cost-effectiveness (Yen/tCO_2)	188	890	188	190	Subsidy/(2) Note: Formula for the JCM Model Project is used. Subsidy rate at 30% is assumed.

vi Implementation system for monitoring

The parameters shown in Table 34 needs to be monitored when implementing the project. The monitoring implementers are also indicated in the table. When applying for the JCM Model Project, MRV reporting is required for the period of legal product lifetime for the installed equipment, so the implementation system for MRV needs to be established. A possible implementation system is shown in Figure 84. Although most of the data can be obtained at the rice mill factory, the data related to fuel consumption for biomass transportation in the project scenario needs to be obtained from the transporters. In order to do so, it is necessary to coordinate with other parties involved in the project, such as by signing cooperation agreements in advance.

In this report, it was assumed that all coal would be replaced by curl chips; however, in the case of partial switching (mixed firing), coal consumption amount should also be a subject to monitoring. In this case, it would be necessary to obtain cooperation from boiler user companies.

Table 34 Monitoring parameters

Parameter	Monitoring implementer
Amount of coal consumed (t/y)	Recorded by the curl chip manufacturer (CJ Agri, MTV, AGTEX28, Company A). Note: Monitoring is not required if the entire amount of coal is replaced.
Amount of curl chip supplied (t/y)	Recorded by the curl chip manufacturer (An Cu Rice Mill, Chau Hung Rice Mill).
Electricity consumption for curl chip production (kWh/y)	Recorded by the curl chip manufacturer (An Cu Rice Mill, Chau Hung Rice Mill)..
Fuel consumption for transportation (L/y), or transportation distance (km/y)	Recorded by the curl chip manufacturer (An Cu Rice Mill, Chau Hung Rice Mill). Data needs to be obtained by transporters.

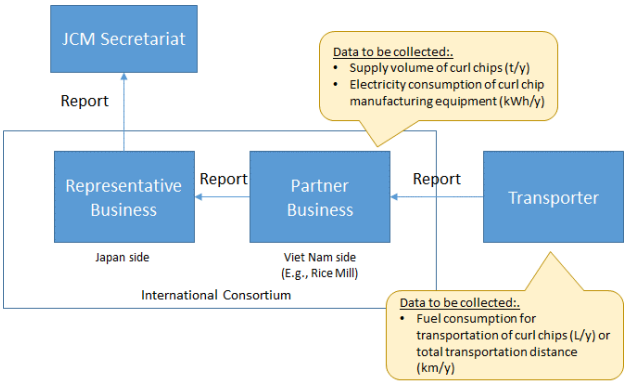


Figure 84 Draft implementation system for monitoring

vii Further considerations

Data needs to be updated as necessary when there are changes in the project content.

5. Study on waste power generation, etc.

Ogawa Econos Inc., a company in Hiroshima Prefecture, conducted a study on the feasibility of a project to reduce greenhouse gas emissions through waste power generation and other means.

5.1. Field survey schedule

In FY2021, the survey was conducted remotely due to COVID-19, but this year the field survey was conducted twice.

1st field survey schedule (October 10 to 14, 2022)

Date		Activity
Oct 10	Mon	Meeting with SPWC
		Visit to the existing waste treatment facility in Soc Trang Province and the planned new construction site
		Visit to a private incineration facility in Soc Trang Province
		Meeting with the People's Committee of Soc Trang Province
Oct 11	Tue	Meeting with SPWC
		Meeting with DONRE of Soc Trang Province
		Meeting with the People's Committee of Can Tho City
Oct 12	Wed	Visit to SPWC facility
		Visit to a private incineration and landfill facility
Oct 13	Thu	Meeting with Vina Kraft Paper
		Meeting with a local logistics company
Oct 14	Fri	Meeting with Vinayusen
		Meeting with CITTENCO
		Meeting with a private waste collection and transportation company

2nd field survey schedule (January 10 to 13, 2023)

Date		Activity
Jan 10	Tue	Meeting with DECOS
Jan 11	Wed	Meeting with the People's Committee of Can Tho City
		Meeting with DONRE of Can Tho City
		Meeting with Can Tho Urban Joint Company

Jan 12	Thu	Meeting with Can Tho Beer
Jan 13	Fri	Meeting with DONRE of Binh Duong Province
		Meeting with Vina Kraft Paper

5.2. Technologies and products to be introduced

(1)Solidified waste fuel (RPF)

Ogawa Econos is engaged in the production of solidified waste fuel (hereafter referred to as PRF), which is a popular alternative fuel to coal in Japan. RPF and related technologies are described in the FY2021 City-to-City Collaboration Project Report.

(2)Waste power generation

There are several methods of waste power generation. As an example, the following is an overview of the incineration and power generation facilities operated by Ogawa Econos in Japan. The incinerator installed by Ogawa Econos is called a vertical incinerator. The vertical furnace is surrounded by a water jacket for cooling, and the waste heat from the cooling is used to produce hot water, which is eventually used to generate electricity through a turbine. The feature of this small generator, called a binary generator, is that it uses CFC gas as the circulating heat medium and can be used as long as the hot water is 90°C or higher. This makes it possible to generate a certain amount of power even with a small amount of waste and a low calorific value. However, the facility being considered for installation in Soc Trang Province is expected to burn 600 tons of waste per day, and the income/expense forecast assumes the use of a large turbine rather than binary power generation.

5.3. National policy and master plan for Waste to Energy

(1)National Strategies related to waste power generation in Vietnam

The table below summarizes the policy direction of Waste to Energy in Vietnam.

Table 35 Policy direction of Waste to Energy in Vietnam

Related perspective	Direction viewpoints
Development of waste to energy	• Generating synchronized growth with the priority of utilization of renewable energy, new and clean energy, including waste to energy (WtE) • Encouraging waste treatment combined with energy recovery in such a way that it can save the land and is suitable for local conditions
Technology	• Developing renewable energy technology, including WtE's technology: o Combining using short-term technology and developing long-term technology o Focusing on using the technology that has been appraised and verified • Investing in a synchronous solid waste management system on the basis of appropriate technology

Related perspective	Direction viewpoints
	• By 2050: all types of generated solid waste will be treated with appropriate technologies in such a way that minimizes landfill
Planning	• Regarding solid waste management (SWM) in general and the planning of the activities of waste treatment with energy recovery in particular: o Implementing in an interregional and interdisciplinary way o Ensuring the optimization in terms of the economy, technique, and social and environmental safety o Ensuring compliance with local conditions and associated with the national planning • Regarding the planning of the energy recovery from waste treatment: o Distributing reasonably by regions and territories o Focusing on the optimal allocation of all fields based on comparative advantages of each region and locality
Others principles	• Using the energy economically and efficiently in such a way that protects the environment • Ensuring sustainable energy development • Developing the energy industry towards fair and transparent competition • Combining incentive and assistance policies with market mechanisms to promote the development and use of renewable energy, including WtE

(2)National Strategies related to the development of waste power generation in Vietnam

i Strategies related to the energy sector

With the view of prioritizing the exhaustive and efficient exploitation and use of renewable, new and clean energy sources, including energy recovered from waste treatment, Vietnam has come up with the following strategies.

Table 36 Energy-related strategies

Strategy/Plan	Issued year	Description
The development strategy of renewable energy of vietnam by 2030, with a vision to 2050	2016	The strategy is issued on the basis of: • The potential of Vietnam's renewable energy development • Vietnam's strategy for national energy development by 2020, with a vision to 2050 (2007) • The revised version of the PDP VII (2016)
The strategy for national energy development by 2030, with a vision to 2045 (The energy strategy 2020)	2020	The strategy is issued on the basis of: • Assessment of the situation after 15 years of implementing Vietnam's strategy for national energy development by 2020, with a vision to 2050 • Objectives: o Overcoming existing limitations in the energy industry and addressing challenges o Seting out development goals and orientations for the energy industry in the coming time

Strategy/Plan	Issued year	Description
The draft of the national power development plan VIII (PDP VIII)	Upcoming	The PDP VIII issues specific objectives and implementation roadmap for the national power master plan on the basis of the objectives set out in Vietnam's strategy for national energy development by 2030, with a vision to 2045

After 15 years of implementing Vietnam's strategy for national energy development by 2020, with a vision to 2050, there are still some limitations such as many target indicators that fluctuated in an unfavorable direction, many projects behind schedule, etc. Therefore, The strategy for national energy development by 2030, with a vision to 2045 is the latest strategy with adjusted objectives. On that basis, the national power development Plan VIII has been drafted and is in the process of being approved. Specific goals are systemized as follows:

Table 37 Targets of PDP8

Supply source	Policy & Year / Objectives	Energy strategy 2020	PDP VIII (Draft)	Energy strategy 2020	PDP VIII (Draft)
		2030		2045	2050
Primary	The total primary energy source (Mil. TOE)	75-195	Not mentioned	320-350	Not mentioned
	The ratio of renewable energy source/ the total primary energy source (%)	15-20		25-30	
	The total renewable energy source (Mil. TOE)	11.25-39		80-105	
Secondary	Total Capacity of electricity sources (MW)	125,000	121,757 - 145,989	-	201,836 - 295,638
	The ratio total capacity of renewable energy/ total capacity of electricity sources (%)	-	18-27	-	54.9-58.9

ii **Vietnam's Strategy related to waste management and treatment**

Since the input source of waste power generation is waste, this field is also related to waste management. Hence, the policy directions of waste power generation are also mentioned in "The National Strategy For General Management Of Solid Waste To 2025, With vision towards 2050" (the revised version - Decision 491/QD-TTg).

In terms of general objectives related to energy recovery from solid waste, Vietnam identifies:

- Increasing the capacity of the general management of solid waste, concurrently adopting solutions for promoting the storing, collecting, transporting, reusing, recycling and treatment of solid waste

- Promoting private sector involvement and attracting investments from private or foreign organizations in daily-life solid waste management
- Applying advanced and environmentally-friendly technologies for treating solid waste; selecting solid waste treatment technologies that are safe, combined with energy recovery, the reduction of greenhouse gas emissions, etc.

Specific objectives related to waste treatment with energy recovery are illustrated as follow:

Table 38 Targets for waste treatment with energy recovery

Objectives	Rate (%)	Type of waste
Collecting transporting and treating satisfying the environmental protection requirement	100	• Hazardous solid waste is discharged from production, business, service, medical facilities, and trade villages • Ordinarily industrial solid waste discharged from production, trading service facilities, and trade villages • Medical solid waste is discharged from medical facilities or hospitals
	90-<100	• Daily-life municipal waste discharged is treated in general, which enhances the treatment method with energy recovery • Construction solid waste discharged from urban centers
	80-89	• Hazardous solid waste discharged from households or individuals • Daily-life rural solid waste • Other solid waste discharged from cattle and poultry farming
Closing, rehabilating, reuse landfills	100	• Spontaneous landfills of Daily-life rural solid waste which is not included in the planning meeting the environmental protection requirement
	90-<100	• Daily-life municipal solid waste landfills • Daily-life rural solid waste landfills in rural areas
The rate of landfills	<30	• Collected Daily-life municipal solid waste that is disposed by burial
	<20	• After treating of Daily-life municipal/rural treatment facilities that are invested and constructed in the local

iii Solutions to promote the development of waste power generation

a Strategic solutions[6]:

To fulfill the above strategic objectives related to the waste power generation field, Vietnam has advocated solutions to promote the development of renewable energy, including energy recovered from waste as follows:

Table 39 Solutions to facilitate the development of Waste to Energy

Aspect	Solution
Renewable energy	• Enhancing the capacity for large-scale integration of renewable energy sources

[6] Synthesized from the National Energy Strategy 2020 and National Strategy For General Management Of Solid Waste To 2025, With vision towards 2050

	• Ensuring suitable power purchase agreement mechanisms; energy auction/bidding mechanisms for renewable energy projects • Ensuring transparency of electricity price • Encouraging the development and use of renewable energy sources in rural areas
Energy using biomass energy/ solid waste	• Maximizing the use of energy from biomass co-generation • Coal power plants need to study combined power generation using biomass energy; as well as improving technology to switch to using biomass fuel • Strengthening the development of electricity sources from solid waste and biomass energy • Strengthening and perfecting the related mechanism and policies to encourage investment; exemption and reduction of procedures for grid connection and sale of grid electricity for power plants using biomass energy/solid waste
Techonology	• Prioritizing the development of power generation technology from solid waste treatment • Researching and applying criteria and standards in technology selection as well as in the design, construction and operation of solid waste treatment facilities
Planning	• Forming and developing renewable energy centers in advantageous areas • Encouraging investment in the construction of power plants using solid waste and biomass along with environmental protection and circular economy development • Reviewing, adjusting and making investment and development plans for solid waste treatment facilities according to the approved planning • Identifying prioritized investment projects and tasks for each stage according to the approved plan of each locality
Capital/ Finance	• Encouraging public-private partnership mechanism (PPP) • Implementing credit policies towards creating favorable conditions for energy enterprises to access capital sources, especially enterprises with green energy projects • Establishing a Fund for Sustainable Development of Energy and using it in the field of renewable energy
Awareness enhancement	• Implementing research and development programs for renewable energy technologies • Strengthening information sharing and communication, raising awareness of people and communities about the development and use of renewable energy as well as solid waste management

iv Incentive and assistance policies for the development of WtE

Incentives and support policies for the development of waste-to-energy (WTE) are summarized in the table below.

Table 40 Incentive and assistance policies for the development of WtE

Incentive	Content	Conditions[7]
Investment capital	**From VEPF and provincial environment protection funds:** • Being entitled to a loan at a preferential interest rate: no more than 4.275%/year • The total loan: within 70-80% of the total investment in construction (Depending on the type of entities) • Being prioritized post-investment assistance covered by the difference between annual revenue and expenditure[8]	Entities that fall under one of the following conditions: • Solid waste treatment projects that apply a waste treatment technology with less than 30% of waste to be buried after treatment compared to the total volume of collected waste • Enterprises producing renewable energy; or providing the technology of waste treatment with energy recovery, etc.
Investment capital	**From the VDP:** • The total loan: within 70% of the total investment in construction (not including working capital) and must be: o Within 15% of all the bank's capital for 01 customer o Within 25% of all the bank's capital for 01 customer and affiliated person[9] • Interest rate of the investment credit loans: 8.55%/year • Duration: within 12-15 years	Investment projects that fully statisfy the following conditions: • Projects on building waste treatment facilities in urban centers, industrial parks, economic zones, export processing zones, hi-tech parks, hospitals, industrial clusters and craft villages (Group A, B)[10] • Must be appraised and evaluated by the VDB as being efficient and capable of repaying the loan • Having an equity capital for the project implementation equal to at least 20% of the total project investment capital • Providing loan security • Having no non-performing loan owed to any credit institutions by the time of the provision and disbursement of a loan • Having no non-performing loan owed to any credit institutions by the time of the provision and disbursement of a loan • Having purchased property insurance for the loan security property • Observing the regulations on accounting, annual financial statements and audit of annual financial statements
	For post-investment support: The difference of the interest rate given post-investment support: 2.4%/year (applied to every single time of repayment by the investor to the credit institution)	

[7] All projects specified in "the condition box" must belong to the development planning of grid-connected energy production from solid waste/biomass energy and the power planning approved by the competent authority
[8] In case the difference of annual revenue and expenditure is positive (+), the Fund shall deduct 20% of the remaining money after paying other amounts under the responsibility of the Fund into its additional capital to perform sponsor and assistance, etc.
[9] Regulations on "affiliated persons"are specified at Clause 28, Article 4 of the Law on Credit Institutions.
[10] Classification of projects belongs to Groups A and Group B are specified at Articles 8, 9, Law 39/2019/QH14 on Public investment

Incentive	Content	Conditions[7]
Land assistance	• The State prioritizes the allocation of land associated with available works and technical infrastructural construction items such as roads, electricity, etc. outside the scope of the projects connected to the common technical infrastructure system of the area without holding an auction of land use rights • If the State fails to meet the above article, the project owners are entitled to receive assistance in construction of infrastructural constructions in accordance with regulations of law on investment	Entities that fall under one of the following conditions: • Solid waste treatment projects • Not belongs to business/investment activities: technological innovation, renovation and the upgrade of waste treatment works
Land assistance	Exemption and reduction of land levy and land rents: • Exemption from non-agricultural land use tax[11] • Exemption of land rent during the fundamental construction period: no more than 3 years • Exemption from land rent for 11-15 years after being exempted during the capital construction period (Depending on the conditions of areas where the project is implemented)	• Investment projects [12] in the field of renewable energy production from waste treatment in areas with difficult or extremely difficult socio-economic conditions
Corporate income tax	Regarding tax rate: • Incentive applied tax rate: 10% of the total income • Duration: 15-30 year (depending on size or applied technology or investment attraction needs) Regarding tax exemption/ reduction mechanism: • The first 4 years: exempt tax at the above tax rate • In the next 9 years: reduce 50% of the payable tax amount at the above tax rate	Enterprises that fully statisfy the following conditions: • Implement the new investment project in the field of renewable energy production from waste treatment in areas with extremely difficult socio-economic conditions • Have Investment License or Investment Certificate or the enterprise registration certificate (in case of the domestic investment project which has the investment capital less than 15 bil VNĐ & is not in the List of fields of conditional investment but associated with the establishment of new enterprise)

[11] According to Clause 1, Article 9 Law on non-agricultural land use tax; There is no time limit.
[12] Belongs to the List of business lines eligible for investment incentives at Appendix II, Part A, Decree 31/2021/NĐ-CP

Incentive	Content	Conditions[7]
Corporate income tax	Regarding tax rate: • Applied tax rate : 20% of the total income • Duration: 10 year Regarding tax exemption/ reduction mechanism: • The first 02 years: exempt tax at the above tax rate • In the next 04 years: reduce 50% of the payable tax amount at the above tax rate	• Enterprises implement the new investment project in areas with difficult socio-economic conditions
Corporate income tax	• Reduce 50% of the payable tax of the income gained from technology transfer	Enterprises performing the technology transfer in the priority fields of transfer for organizations and individuals in the areas with difficult socio-economic conditions
Exemption from import duties	• Exemption duties on imported fixed assets, including: o Machinery and equipment; separate parts, spare parts for ynchronous assembly; loose parts and spare parts of machines and equipment, etc. o Specialized means of transport o Construction materials that cannot be produced domestically o Duration[13]: within 50-70 years depending on the location of the projects • Exemption from import duties on raw materials, supplies and components that cannot be domestically manufactured and are imported to serve manufacturing activities of investment projects o Duration: 05 year from the manufacture commencement date	• The investment project in the field of renewable energy production from waste treatment (in areas with extremely difficult or difficult socio-economic conditions)
For projects with technology transfer	1. Being entitled to investment incentives which are provided for investment projects in the field of renewable energy production from waste treatment (mentioned above) 2. For the loans used for transferring technology shall	Enterprises that fully statisfy the following conditions: • Having investment project in the field of renewable energy production from waste treatment • Having the technology transfer which is under the project mentioned above

[13] The investment project can exempt duties on imported fixed assets until the end of the duration of the investment project, which regulated at Article 44, Law on Investment

Incentive	Content	Conditions[7]
	• Have an interest subsidy of up to 2%/ year by the National Technology Innovation Fund or Science and Technology Development Fund • Receive loans with preferential interest rates as prescribed in the regulations of the funds or credit institutions which provide concessional loans	

5.4. Legal Framework related to waste power generation

(1)Regulations related to the process of waste treatment with energy recovery

Depending on the type of solid waste, Vietnam will have specific corresponding regulations of the waste treatment process, which also includes waste treatment with energy recovery. However, because waste power generation is still new and the related legal framework is continuing to improve, Vietnam has no regulations that directly specify this field.

Given that in the current Waste power generation of Vietnam, Daily-life solid waste and hazardous waste (less common but already has one implemented facility[14]) are encouraged to apply the technology of waste treatment with energy recovery. Hence, the report will analyze related regulations focusing on 2 types of waste: Daily-life solid waste and hazardous waste.

i Regulations on solid waste treatment facilities

Regulations on solid waste treatment facilities, including treatment with energy recovery methods, are specified in the Law on Environmental Protection 2020:

Table 41 Regulations regarding waste treatment facilities

Type of waste	Regulations on facility
Daily-life waste	• Encourage co-processing method • Meeting the environmental protection requirements • People's Committees at all levels shall select treatment facilities through one of the following methods: (i) Bidding; (ii) Order placement or (iii) Task assignment o In case of failure to make a selection through bidding, the method of order placement or task assignment shall be adopted as prescribed by law.
Hazardous waste	• **Planning:** The national environmental protection planning or planning containing contents regarding hazardous waste treatment is conformed to, except for the case of hazardous waste co-processing; Safe environmental distance is maintained • **Human resource:** majoring in environment or suitable field

[14] Facility in Soc Son district, Hanoi City which treat hazardous waste for Vinh Phuc Province, Bac Ninh province, Hung Yen province by combustion with energy recovery technology

	• **Operation:** must have process for safe operation; an environmental management plan; The environmental license; and must pay deposits on environmental protection (in case the waste burial is carried out) • **Technology:** must be appraised and given opinions in accordance with the law on technology transfer; in which, treatment combined with energy recovery technology is recommended

Note: Depending on the type of waste treatment facility, the investor needs to check relevant national technical regulations/standards (if any). For example, for the projects of waste treatment with energy recovery using the incineration combined with power generation, facility owners need to ensure that the incinerator complies with the following standards:

Industrial solid waste: QCVN 30:2012/BTNMT

Daily-life solid waste: QCVN 61-MT:2016/BTNMT

ii Regulations on the criteria for technology selection

Currently, there are 03 groups of criteria for selecting technologies applied in waste treatment in general, and waste treatment with energy recovery in particular in Vietnam, which include:

① **Technology:** suitability with conditions of enterprises and production facilities reflecting through the volume, composition, nature of solid waste, market demand, etc.

② **Environment and society:** the extent of solving environmental sanitation tasks and the social impact of technology

③ **Economy:** significance for the national and local economy

Particularly, technology selection criteria for projects/the facilities of Daily-life/hazardous waste treatments with energy recovery are specified in Circular 02/2022/TT-BTNMT:

Table 42 Technology selection criteria for domestic and hazardous waste treatment projects and facilities with energy recovery

Criteria	Content
Technology	• Origin of the technology • Degree of mechanization and automation; Capability to expand and increase capacity; Advanced degree of processing technology • Degree of conformity of standards and regulations on the production of technological lines with national technical standards and regulations, Vietnam standards or standards of G7 countries and Korea in safety, energy saving and environmental protection • The technology of waste treatment with energy recovery is encouraged • The uniformity of equipment in the technological lines, the ability to use and replace domestic components and spare parts • Localization rate of technology system, equipment

	<u>As for the Daily-life waste treatment technology:</u> • Capacity of receiving and classifying waste, flexibly treating odors, sewage, exhaust gas in combination with other technology for the purpose of treating different types of solid waste • Capacity energy recovery, secondary waste treatment • Appropriate level of treatment scale • Treatment, reuse, recycling and burial rate
Environment and society	• Comply with environmental technical standards and regulations. E.g. QCVN 19:2009/BTNMT; QCVN 20:2009/BTNMT; QCVN 40:2011/BTNMT, etc. • Save land use area • Save energy, be capable of energy recovery/ valuable components (of hazardous waste) throughout treatment process; • Capacity of training local resources participating in equipment management, operation, maintenance. **<u>As for hazardous waste treatment technology:</u>** • Criteria for identification of technology for the purpose of assessment: belongs to the list of transfer restriction; or technology that can cause adverse impacts on the environment, such as: incineration, etc. • Level of impact of treatment technology and products after treatment on: the environment, ecosystems and people • Level of risks to the environment and capacity to prevent and overcome technical problems
Economy	• Market potential of the products collected from waste treatent activities of project • Potential and economic value brought from the reuse energy after treatment • Market demand; product quality standard applied after treatment; • The appropriateness in the cost of construction and installation of equipment; operating cost; maintenance and repair costs.

iii **Regulations on the support mechanism for the selling price of electricity generation from waste**

For grid-connected waste power generation projects: Vietnam has a regulation on a support mechanism for the selling price of electricity generation from waste, whereby the electricity buyers has the obligation to buy all the electricity from the grid-connected generation projects using biomass energy/solid waste in the area under its management. Details are regulated at Decision 24/2014/QĐ-CP; Decision 08/2020/QĐ-CP; Decision 31/2014/QĐ-CP:

Table 43 Definition of sellers and buyers of Waste to Energy

Subject	Content	Reference
Buyers	Buyer refers to one of the following entities: • Vietnam Electricity • Its authorized member company	

	• An organization that receives rights and obligations from the former mentioned above	- Decision 24/2014/QĐ-CP - Decision 08/2020/QĐ-CP - Decision 31/2014/QĐ-CP
Sellers	Seller refers to one of the following entities: • An organization or individual engaging in power generation projects using biomass energy/solid waste • The one receiving rights and obligations from the former as regulated in law Conditions of the above projects must be subject to: • Planning for the development of power generation from the use of biomass energy/solid waste The development power planning approved by competent state agencies	

The sales price applied to solid waste/biomass energy generation projects can be illustrated as follows:

Table 44 Selling price applied to power generation projects using solid waste/biomass energy

Type of electricity	Type of power generation project	Selling price		Reference
		VND/kWh	UScents/kWh	
Biomass (Agricultural waste)	Co-generation (CHP)	1,634	7.03	Decision 08/2020/QĐ-TTg
	Other than CHP	1,968	8.47	
Using solid waste	Direct combustion	2,114	10.05	Circular 32/2015/TT-BCT
	Combustion of gases recovered from the landfill	1,532	7.28	

As can be seen:

- The selling price of electricity from all projects mentioned above is higher than the price of electricity generation from hydropower plants, which is 1,110 VND/kWh.
- The selling price of electricity from "other than CHP" of biomass electricy and from direct solid waste combustion projects are higher than that of electricity from coal power plants: 1,773.76 VND/kWh.
- **For an independent power system using an independent power source produced from renewable energy sources**: The investor shall develop an electricity price scheme and determine the total amount of support from the state budget and submit it to the Ministry of Industry and Trade to be appraised and reported to the Prime Minister for approval.

(2)**Regulations on project implementation/investment**

i **Procedures for setting up a business**

On the basis of survey, study of local needs and reference to the national electricity development planning, the investor shall formulate an investment project in accordance with the provisions of the

Investment Law, the Electricity Law and other relevant legal documents then send the application to the investment registration agency (Department of Planning and Investment) for consideration, appraisal and opinion.

Table 45 Procedures for establishing a company in Vietnam

Procedure		Competent authority	Duration[15]	Reference
Approval for investment guidelines*		National Assembly/Prime Minister/Provincial People's Committee	For the National Assembly and Prime Minister: no specific time For provincial People's Committee: within 50 days	The Law on Investment 2020
Investment Registration Certificate		Provincial Department of Planning and Investment	Within 15 days	
Enterprise registration	Certificate of Enterprise Registration	Provincial Department of Planning and Investment	Within 3 days	The Law on Enterprises 2020
	Publishing of enterprise registration information	Enterprise	Within 30 days	

Note: During this process, hazardous waste treatment projects must be appraised or commented on technology by a competent authority according to Chapter II of the Law on Technology Transfer 2017. For a project using the transferred technology, it is compulsory to carry out the technology transfer procedure, detailed in the section below.

ii Technology transfer procedures

Many waste power generation projects in Vietnam currently use technology transferred from other countries in the world such as Japan, China, European countries, etc. Technology transfer procedures for this type of investment project are as follows:

a. Conditions

- One or some of the following technologies are transferable:
  - Technical know-how and technological know-how;
  - Technology plans or processes; engineering solutions, parameters, drawings or diagrams; formula, computer software and database;
  - Solutions for rationalization of production and technology innovation;

[15] From the receipt of a sufficient and valid application

- Accompanying machinery and/or equipment of 3 transferable technologies mentioned above.

- According to Decree 76/2018/ND-CP, power generation technology using biomass/waste energy belongs to the list of technologies encouraged for transfer.

b. Procedures

The technology transfer may be implemented under contracts or terms or provisions or appendixes of contract or dossier of the investment project which are later signed between the parties. After that, for technology transferred from abroad to Vietnam, it is compulsory to register for technology transfer under the Law on Technology Transfer 2017:

Table 46 Technology transfer registration procedure under the Technology Transfer Act 2017

Step	Procedure	Performer	Duration
1	Submit an application for a Certificate of registration of technology transfer	The transferee	Within 90 days from the conclusion of the technology transfer agreement
2	Issue the Certificate of registration of technology transfer	Ministry of Science and Technology/Provincial Department of Science and Technology[16]	Within 5 days from the receipt of a sufficient and valid application

Note: The technology transfer agreement shall become effective as from the issued date of Certificate of registration of technology transfer.

iii **Types of permits required for waste treatment facilities including energy development**

a **Environmental license**

1. Entity

Table 47 Environmental licenses

Type of project	Entity	Level of compulsion	Reference
New	Hazardous waste treatment projects	Mandatory	Article 39 of the Law on Environmental Protection 2020
	Daily-life waste/common industrial waste treatment projects	Depending on project classification	
Old (been put into official operation before 01/01/2022)	Projects that already hold the component environmental license(s)	Optional, allowed to continue using the component license until it expires[17]	Point d, Clause 2, Article 42 of the Law on Environmenta
	Projects that does not hold the component environmental	Mandatory (must obtain the environmental	

[16] Depending on the type of investment project
[17] Or within 05 years from 01/01/2022 if it is an indefinite-term component environmental license

	license(s), but are required to have environmental license according to new regulations	license within 36 months from 01/01/2022)	l Protection 2020

2. Conditions

For projects that are subject to environmental impact assessment[18], it is required to obtain the decision on approval of EIAR appraisal result before applying for issuance of an environmental license. Pursuant to Article 30, Section 3 of the Law on Environmental Protection, projects providing hazardous waste treatment services are required to carry out an environmental impact assessment.

- Depending on the type of investment project
- Or within 05 years from 01/01/2022 if it is an indefinite-term component environmental license
- Based on the classification to determine whether the project is subject to environmental impact assessment (Articles 28, 30 of the Law on Environmental Protection 2020)
- Conducted concurrently with the preparation of the feasibility study report

3. Procedures

- **Environmental impact assessment[19]**

Table 48 Environmental impact assessment procedures

Step	Procedure	Performer	Duration
1	Preparing an EIAR	Project owner/Qualified consultancy	-
2	Appraisal of EIAR	Ministry of Natural Resources and Environment/Provincial People's Committee	Within 45 days
3	Issuing the decision on approval of EIAR appraisal result		

· **Environmental license**

Table 49 Environmental license issuance procedures

Step	Procedure	Performer	Duration
1	Submitting the application	Project owner	Within 45 days
2	Issuing environmental license	Ministry of Natural Resources and Environment/Provincial People's Committee/District People's Committee	

b Electricity business license

1. Entity

Organizations and individuals conduct electricity activities in one or many forms.

2. Conditions

According to Clause 2, Article 32 of the Electricity Law 2004 (amended 2012), organizations,

[18] Based on the classification to determine whether the project is subject to environmental impact assessment (Articles 28, 30 of the Law on Environmental Protection 2020)
[19] Conducted concurrently with the preparation of the feasibility study report

individuals shall be granted electricity activity licenses fully satisfying the following conditions:

- Having feasible projects or schemes for electricity activities;
- Having valid dossiers of application for the grant, amendment or supplementation of electricity activity licenses;
- The administrators or managers have the managerial capability and professional qualifications suitable to the fields of electricity activities.

3. Procedure

The Ministry of Industry and Trade has the authority to grant electricity activity licenses to projects generating electricity from waste. The time limit for this process is 30 working days from the date of receipt of a complete and valid dossier.

iv Public Private Partnership investment (PPP) procedures

According to Ms. Vu Quynh Le, Deputy Director of the Procurement Management Department under the Ministry of Planning and Investment, most of the current waste power generation projects in Vietnam are implemented in the form of public-private partnerships (2022). Based on the Law on PPP Investment 2020, the investment process of this method is as follows:

Table 50 Public-Private Partnership investment (PPP) procedures

Step	Procedure	Details
1	Making and assessing pre-feasibility study reports, decisions on investment guidelines and project announcement	The project preparation unit prepares a pre-feasibility study report for appraisal, then completes the application and submits it to the respective competent authority for consideration and decision[20]
2	Making, assessing feasibility study reports, and approving projects	The project preparation unit prepares a feasibility study report for appraisal (as above) then completes and submits the application for project approval[21]
3	Selecting investors	• Drawing up the shortlist (if any) • Making preparations • Selecting investors • Evaluating bidding documents • Submitting, assessing, approving and publishing results • Negotiating, finalizing and concluding a PPP contract, and publishing contract information
4	Establishing PPP project enterprises and concluding PPP contracts	After the decision to approve the selection results is issued, the investor shall establish a PPP project enterprise in a form of a limited liability company or a

[20] The authority to decide on investment guidelines for PPP projects (in the energy sector) belongs to the National Assembly, the Prime Minister, the Minister of Industry and Trade or the provincial People's Council depending on the project classification
[21] The authority to approve PPP projects belongs to the Prime Minister, Minister or Chairman of the Provincial People's Committee depending on the project classification

Step	Procedure	Details
		joint stock company that is not a public company with the sole purpose of signing and implementing PPP contracts[22]
5	Implementing PPP contracts	• Building constructions and infrastructure systems • Managing and operating • Transfering and discharging PPP contracts

(The time to complete procedures for PPP projects is not fixed. In fact, many PPP projects to the stage of contracting can take several years.)

5.5. Practices of waste power generation in Vietnam

(1)Examples of waste power generation projects

In general, a lot of waste power generation projects in Vietnam are still on paper or under construction. Regarding Daily-life and industrial waste, only 2 commercial projects in Hanoi (No. 2, Table 51) and Can Tho (No. 3, Table 51) have been put into operation. Meanwhile, biomass power plants from agricultural waste are mainly invested in and built by manufacturing enterprises (e.g. sugar cane) in combination with their main factories. Many biomass power projects in the Mekong Delta region (An Giang, Tien Giang, Dong Thap, Kien Giang, Can Tho,...) even though they were planned to be invested many years ago, had to be stopped due to various reasons such as farmers change their crops, prices of agricultural input waste increase, waste can be used to create by-products with higher value than electricity[23], etc. Depending on the plan of each locality, waste-generated power projects in Vietnam will be proposed by the state or private enterprises. Many projects are built, deployed and expanded phase-by-phase in order to save time so that projects can be put into operation as soon as possible. Daily-life and industrial waste power projects are usually located in the provinces' existing/soon-to-be waste treatment areas. The following table summarizes some typical waste-based power generation projects in Vietnam. Most of the energy recovery projects from waste in Vietnam currently only use the incineration method.

[22] Follow the same process as item 1, except for the step of approving the investment guidelines
[23] E.g. Sugar production waste can be used to produce molasses and organic fertilizer

Table 51 Operating projects of waste power generation

No.	Name	Construction site	Company	Waste disposal capacity (ton/day)	Type of waste	Capacity (MW)	Assumed power generation (thou. MWh/year)	Commencement of operation (planned)	Investment amount (mil. USD)	Site areas (ha)	WTA (if any)
=1	NEDO Industrial Waste Treatment Power Plant[24]	Hanoi City	JV between New Energy and Industrial Technology Development Organization (Japan), Hitachi Zosen Corporation (Japan), Urban Environment Limited Company (Vietnam)	75	Industrial waste	1.93	-	Operation started in April 2017	27[25]	1.7	Nam Son Waste Treatment Complex, Soc Son District
2	Soc Son Waste Power Plant	Hanoi City	Ha Noi Thien Y Environmental Energy JSC (belongs to China Tianying Group)	Phase 1: Plant No. 3: 800; Phase 2: Plant No. 2& No. 4: 800/plant Phase 3: Plant No.1 and No.5: 800/plant → After 3	Daily-life waste and industrial waste	Phase 1: 15 of plant 2 Phase 2: 45 of plant 1 and 2 Phase 3: 75 of plant 1,2,3	-	Operation started on July 25th, 2022	295	17.51	

[24] Just a pilot project so the capacity is low
[25] 20 mil. USD is non-refundable aid from NEDO and 7 mil. USD is reciprocal capital from Hanoi City budget

No.	Name	Construction site	Company	Waste disposal capacity (ton/day)	Type of waste	Capacity (MW)	Assumed power generation (thou. MWh/year)	Commencement of operation (planned)	Investment amount (mil. USD)	Site areas (ha)	WTA (if any)
				phases: 5000							
3	Thoi Lai Waste Power Plant	Can Tho City	China Everbright International Limited (Hong Kong)	400	Daily-life waste	7.5	60	Operation started in October 2018	47	5.3	Solid WTA in Thoi Lai District
4	KCP - Phu Yen Biomass Power Plant	Phu Yen Province	KCP Vietnam Industries Limited (India)	-[26]	Agriculture waste (bagasse)	Phase 1: 30 Phase 2: 60	70 (Phase 1)	Operation of phase 1 started in April 2017	54	-	
5	Lasuco Co-generation Plant from Bagasse	Thanh Hoa Province	Lam Son Sugar JSC (Vietnam)	-	Agriculture waste (bagasse)	33.5	69.57	Operation started in 2012	-	-	
6	NASU Co-generation Plant from Bagasse	Nghe An Province	Nghe An Sugar Limited Liability Company (Vietnam)	1,800	Agriculture waste (bagasse)	10	15[27]	Operation started in 2016	-	-	
7	An Khe Biomass Power Plant	Gia Lai Province	Quang Ngai Sugar JSC (Vietnam)	1,370	Agriculture waste (bagasse)	95	95 – 120[28]	Operation started in 2018	80	-	

[26] The main sugar processing factory has a capacity of pressing 11,000 tons of sugarcane per day
[27] During the sugarcane pressing season in 2020 – 2021
[28] The plant generated 110.7 thousand MWh and 97 thousand MWh in 2018 and 2019 respectively

Table 52 Constructing projects waste power generation

No.	Name	Construction site	Company	Waste disposal capacity (ton/day)	Type of waste	Capacity (MW)	Assumed power generation (thou. MWh/year)	Commencement of operation (planned)	Investment amount (mil. USD)	Site areas (ha)	WTA (if any)
1	Seraphin Waste Power Plant	Hanoi City	Amacao Group (Vietnam)	1,500	Daily-life waste and common industrial waste	37	2.4	Scheduled for completion by the end of 2023	162	5	Xuan Son WTA, Son Tay Town
2	Que Vo District Waste Power Plant	Bac Ninh Province	Thang Long Energy Environment JSC (Vietnam)	500	Daily-life waste	11.7	-	Scheduled for completion in October 2023	69	4.8	Centralized WTA of the province in Phu Lang Commune, Que Vo District
3	Luong Tai District Waste Power Plant	Bac Ninh Province	Bac Ninh EU - Conch Venture New Energy Co., Ltd - a joint venture between EU Energy & Waste Disposal JSC (Vietnam) and Conch Venture (China)	300	Daily-life waste	6	-	Scheduled for completion in December 2022	0.04	8.7	Centralized WTA of the province in An Thinh Commune, Luong Tai District

No.	Name	Construction site	Company	Waste disposal capacity (ton/day)	Type of waste	Capacity (MW)	Assumed power generation (thou. MWh/year)	Commencement of operation (planned)	Investment amount (mil. USD)	Site areas (ha)	WTA (if any)
4	Thuan Thanh District Waste Power Plant	Bac Ninh Province	T&J Green Energy – a joint venture between JFE Engineering (Japan) and Tuan Thanh Environment (Vietnam)	500	Daily-life waste and industrial waste	11.6	91.872	Scheduled for completion in January 2024	58[29]	4.8	Centralized WTA of the province in Ngu Thai Commune, Thuan Thanh District
5	Vietstar Waste Power Plant	HCMC	Vietstar JSC (Vietnam)	Phase 1: 2000 Phase 2: 4000	Daily-life waste	Phase 1:20 Phase 2:40	-	No specific completion date has been determined (old schedule for completion: end of 2020/beginning of 2021)	400	30	Northwest Solid Waste Treatment Complex, Cu Chi District
6	Tam Sinh Nghia Waste Power Plant	HCMC	Tam Sinh Nghia Investment Development JSC (Vietnam)	Phase 1: 2000 Phase 2: 5000	Daily-life waste	40	-	No specific completion date has been determined (old schedule for completion: end of 2020/beginning of	210	8	

[29] 18 mil. USD is from Japan's Ministry of Environment, 30 mil. USD is from International Finance Corporation and the rest is from the investor

No.	Name	Construction site	Company	Waste disposal capacity (ton/day)	Type of waste	Capacity (MW)	Assumed power generation (thou. MWh/year)	Commencement of operation (planned)	Investment amount (mil. USD)	Site areas (ha)	WTA (if any)
								2021)			
7	Tasco Waste Power Plant	HCMC	Tasco Joint Stock Company (Vietnam)	3000	Daily-life waste	-	-	No specific completion date has been determined (old schedule for completion: end of 2020/beginning of 2021)	42	-	
8	Waste-to-Energy Plant in Tram Than commune	Phu Tho Province	Phu Tho Tianyu Environmental Energy Co., Ltd (China)	Phase 1: 500 Phase 2: 1000	Daily-life waste and common industrial waste	9	-	No specific completion date has been determined (old schedule for completion: end of 2022)	90	14	
9	Hau Giang Waste Power Plant	Hau Giang Province	Greenity Hau Giang Co., Ltd (Vietnam)	Phase 1: 300 Phase 2: 600	Daily-life waste	Phase 1: 6 Phase 2: 12	-	Scheduled to start operation in 2024	56	23	
10	Hau Giang Biomass Power Plant	Hau Giang Province	Hau Giang Bioenergy JSC (Vietnam)	330	Agriculture waste (rice hulls)	20	125	Scheduled to start operation in 4th quarter of 2024	37	10	

Table 53 Planning projects waste power generation

No.	Name	Construction site	Company	Waste disposal capacity (ton/day)	Type of waste	Capacity (MW)	Assumed power generation (thou. MWh/year)	Commencement of operation (planned)	Investment amount (mil. USD)	Site areas (ha)	WTA (if any)
1	Khe Giang Disposal Plant: Incineration Power Generation of Medical Waste and General Waste	Quang Ninh Province	JV between Viet Long Investment and Construction JSC (Vietnam); Chodai Co. Ltd. (Japan); and Maeda Corporation (Japan)	350	Medical waste and Daily-life waste	10	-	Scheduled for completion in 2026	-	-	Khe Giang Solid WTA, Thuong Yen Cong Commune, Uong Bi City
2	Waste-to-Energy Plant in Vinh Tan commune	Dong Nai Province	JV between Ecotech Vietnam Technology Investment & Trading JSC (Vietnam) and Le Delta JSC (Vietnam)	Phase 1: 800 Phase 2: 1200	Daily-life waste	Phase 1: 20 Phase 2: 30	Phase 1: 160	Starts in 2023, and takes 3 years to build	96	12	Solid WTA in Vinh Tan Commune, Vinh Cuu District
3	Waste-to-Energy Plant in Quang Trung commune	Dong Nai Province	Sonadezi Services JSC (Vietnam)	Phase 1: 150 Phase 2 & 3: will be decided based on the economic	Daily-life waste	Phase 1: 3.4 Phase 2 & 3: will be decided	-	Pending approval, will start construction as soon as it is approved	27[30]	3	Solid WTA in Quang Trung Commune, Thong Nhat District

[30] Of which 30% is from the investor, the rest is loan capital

No.	Name	Construction site	Company	Waste disposal capacity (ton/day)	Type of waste	Capacity (MW)	Assumed power generation (thou. MWh/year)	Commencement of operation (planned)	Investment amount (mil. USD)	Site areas (ha)	WTA (if any)
				efficiency of phase 1		based on the economic efficiency of phase 1					
4	DIVI Biomass Power Plant	Binh Phuoc Province	Dinh Viet Energy Co., Ltd (Vietnam)	-	Agriculture waste	10	-	Applying for an addition to the electricity master plan	-	-	
5	Waste Treatment Plant Using Waste Incineration Technology	Ba Ria - Vung Tau Province	-	Phase 1: 500 Phase 2: 1000	Daily-life waste	-	-	In process of participating in project selection	55	5	Toc Tien Centralized WTA, Phu My Town
6	Waste-to-Energy Plant No.1 in Dinh Vu Waste Treatment Area	Hai Phong City	-	Phase 1: 1000 Phase 2: 2000	Daily-life waste	Phase 1: 20 Phase 2: 40	-	Scheduled to start operation in 12/2025	105	9	Dinh Vu Solid WTA, Hai An District
7	Waste-to-Energy Plant No.2 in Tran Duong Commune	Hai Phong City	-	Phase 1: 1000 Phase 2: 2000	Daily-life waste	Phase 1: 20 Phase 2: 40	-	Scheduled to start operation in 2027	106	10 - 20	
8	Khanh Hoa Waste Power Plant	Khanh Hoa Province	KH New City JSC (Vietnam)	1,300	Daily-life waste	32	-	Pending approval	137	-	

(2)Related Issues

i Delays in project implementation

- **The process of adding projects to the power generation planning is difficult:** A reportage by the National Assembly Television of Vietnam made in August 2022 said that according to regulations, power generation must be in the Power Development Plan to be allowed to connect to the grid, but because there are no specific guidelines for adding the projects to the PDP, this process is usually prolonged. Besides, according to the National Assembly's Economic Committee, the PDP VIII has not been approved, leading to the fact that many power development projects have been added but have not yet been implemented. Mr. Ngo Nhu Hung Viet, General Director of Vietstar JSC (the project owner of Vietstar Waste Power Plant), said that the company has completed the installation and operation of 3 garbage sorting lines, making a 27-meter wide road leading to the plant, leveling 45,000 square meters, signing contracts and paying deposit for main equipment imported from abroad, etc but everything is currently on hold because of the late promulgation of PDP VIII.
- **Many projects have been started for a long time but have not been completed/put into operation,** for example the group of 3 WtE projects at the Northwest Solid Waste Treatment Complex, Cu Chi district, HCMC has long exceeded the expected completion date (late 2020 early 2021) but still it has not been able to come into operation, **due to problems with procedures**. Some of the detailed reasons for these cases are:
  - **Long investment process:** Enterprises pointed out that the investment procedure for waste treatment projects is complicated because it requires approval from many different ministries, branches and agencies. For investment in the form of public-private partnership (PPP), the selection of investors alone usually takes 1-2 years.
  - **Localities' difficulty in calling and selecting bids for investors in the form of PPP:** Mr. Vu Van Dinh, Deputy General Director of Ha Noi Thien Y Environmental Energy JSC (the project owner of Soc Son Waste Power Plant) said that currently, some big cities such as HCMC and Da Nang have prepared to invite bids, but so far there have been no bidding documents issued for investors to check.
  - **Some other reasons:** Slow site clearance, waiting for loan approval or purchase order, the project owner's proposal to increase capacity scale, struggle in finding suitable locations for waste collection point as well as the construction site of the plant due to the opposition of local people, etc.

- **Construction progress is affected due to weak investor capacity:** According to Mr. Nguyen Dinh Trong, Chairman of Vietnam T-TECH Technology Corporation[31], besides the above objective reasons, the progress of the project , especially in the construction phase, largely depends on the investor's capacity. Investors may have weak financial/technological capacity or do not have much experience in organizing the construction of waste power plants so they tend to rely heavily on contractors. All of these lead to delays.

ii Challenges in operating the project

- **Sorting waste before it is treated is fraught with difficulties:** The reason is, as analyzed by Dr. Nguyen Xuan Quang of the School of Heat Engineering and Refrigeration (Hanoi University of Science and Technology), that Daily-life waste in Vietnam is mixed but not sorted at its source. On the other hand, regarding modern WtE technologies that do not need input classification, investment costs are often high and good technical capacity from investors is also required.
- **While incinerating waste, it is challenging to keep air pollution under control:** Dr. Nguyen Xuan Quang also made the point that only large-scale waste treatment plants can afford the significant investment costs required to treat and monitor gases and dust emitted into the environment. It will be burdensome for small businesses to equip these facilities.
- **The amount of input waste is not enough for the needs of plant operation:** To operate efficiently, the plant's waste collecting and incineration needs to have a large scale (should be >500 tons/day). Therefore, WtE is only appropriate for specific regions with a high amount of trash and reliable collection and transportation capability. This is the opinion of Mr. Nguyen Huu Tien - General Director of URENCO, Vice President of the Vietnam Association of Urban Environment and Industrial Parks.

iii Issues related to costs and capital recovery

- **WtE projects have significant investment costs and high risks which make it hard to get loans from banks:** WtE projects frequently require significant investment resources since they call for cutting-edge technology and methods. When the investor makes a request for a loan (e.g about 50% of the project value) and mortgages from the off-plan property (here is a waste power plant), it is not easy for the bank to accept this offer. The reason is that WtE project is considered to be risky and likely to not be completed on schedule due to many subjective and objective reasons above. In addition, a majority of investors complained that

[31] A company that owns the T-TECH incinerator technology and has invested in intensive research in the field of waste incineration to generate electricity

the actual project investment was much higher than estimated because of the unexpected rise in material costs during the two years of the Covid-19 pandemic.

- **The payback period is quite long:** Despite the large investment costs, the efficiency of waste power plants is only about 20-25%, much lower than that of thermal power plants which are 40-42%. The amount of electricity transmitted to the national grid is small. In addition, the purchase price of electricity for power generation projects from waste and biomass in Vietnam is still low compared to other countries in the world.

5.6. Status of household and industrial waste discharged and collected in Soc Trang Province

In Soc Trang Province, the Waste Management Corporation (SPWC) collects waste for 6 of the 11 zones, while the private sector collects waste for the remaining 5 zones. About 40% of the entire Soc Trang Province has not collected waste. It is estimated that only about 600 tons/day are collected, and that about 1,000 tons/day of waste is generated in Soc Trang Province as a whole if uncollected areas are included.

SPWC's processing plant processes a total of 215 tons/day of the six areas collected by SPWC, including 125 tons/day for the four categories in Soc Trang City and 100 tons/day outside of Soc Trang City. After composting food waste and collecting plastic bags, etc., the remaining materials are landfilled.

5.7. Consultation with the government for project implementation

(1)Hearing with the People's Committee of Soc Trang Province

Last fiscal year, the main method of information gathering was through web conferencing, but this fiscal year, we visited the site and exchanged opinions directly with the people's committee officials of Soc Trang Province, and were also able to hear the opinions of the vice chairman of the Soc Trang Provincial People's Committee, who is actually the top official on the ground.

Figure 86 Hearing with the People's Committee of Soc Trang Province

Figure 85 Coverage by a local TV station

The vice-chairman spoke of the desire to improve environmental issues, including waste, by introducing foreign technology. Regarding waste, the committee also requested proposals for equipment and operations related to waste power generation, as the committee has already budgeted for waste power generation. In other environmental policies, the committee also expressed the view that although some aspects of environmental programs are improving, such as the increasing use of wind and solar power generation, land subsidence, waste storage, and groundwater pollution are still problems.

In addition, the RPF, which may help with waste management issues, was explained, and the People's Committee responded that it would cooperate if it had the necessary data.

<< Supplement: Subsidence >>

In exploring future possibilities, we visited Can Tho City, which is a well-developed city with infrastructure in the vicinity of Soc Trang Province. In doing so, we had to walk on roads flooded by water from rivers and were also interviewed by a local newspaper, which gave us a firsthand look at the effects of land subsidence. We were told that the rain from a typhoon that had passed a few days earlier had reached Vietnam after passing through Thailand and other countries and flooded the country. Although the rivers in the Mekong Delta are slow and gentle, and floating markets are popular, they seem to be more prone to flooding due to the influence of subsidence.

Figure 87 Coverage by a local newspaper

This is a problem not only in Can Tho City, but in the entire Mekong Delta area, where excessive use of groundwater, sea level rise, and low-level drainage systems have been cited as the main causes of land subsidence. In some places, the land has sunk 80 cm in the past 10 years.

Figure 88 Garbage collection in Soc Trang Province

Figure 89 Garbage dumpster in the city of Soc Trang Province

When considering waste collection, there are also possible problems such as vehicles being unable to pass through when roads are flooded, making it impossible to collect the waste at the appropriate time, and the waste itself becoming wet with water. Overall infrastructure reinforcement is desirable.

(2)Waste-related investment budget

According to Soc Trang Province, the waste investment budget includes VND70 billion (approx. JPY420 million) for domestic waste and another VND110 billion (approx. JPY656 million) that is awaiting approval from the People's Committee in the future.

These budgets include waste power generation. However, assuming waste power generation, the budget is not sufficient depending on the amount of waste to be processed, so the company believes that it will be necessary to propose other processing methods as well.

(3)Meeting with Soc Trang Public Works Joint Stock Company (SPWC)

Figure 90 Meeting with SPWC

Soc Trang Public Works Joint Stock Company (SPWC) collects waste from targeted areas in the city, sorts it in its own facilities, and sells it after sorting some plastics as valuable resources. In the past, SPWC even converted waste into pellets, but due to many issues such as equipment management, SPWC now only conducts sorting.

Figure 91 Plastic pelletizing equipment

There are two main landfill sites, but the unused landfill site is in a rainy season and practically unusable due to rain accumulation. The company employs 400 people and has five main businesses: domestic waste collection and disposal, industrial waste collection and disposal, wastewater sludge management, lighting projects, and park management Since 2018, the company has been a joint stock company, 38% of which is owned by the government.

The President of Soc Trang Public Works Joint Stock Company (SPWC) expressed the view that waste power generation is not easy and that the waste power generation they are starting in Can Tho City is aware that there are problems with emissions and power generation, and that the waste they handle may not generate enough power They indicated that the waste they handle may not be sufficient for power generation. He also expressed the view that it would be better to have less material going to landfills than waste-to-energy generation.

(4)Issues at SPWC and private incineration facilities in Soc Trang Province, etc.
i Waste treatment facility of SPWC
The equipment was made in Belgium (by MENART), introduced as Norwegian ODA, and was used to process food scraps and other waste. The total investment was 10,322,584 USD. First, food scraps in plastic bags are put into a bag breaker conveyor, and after the bags are broken, they are put through a trommel (rotary sorting machine: sieve size 90 mmφ). Some workers re-break bags that were not fully broken in the middle of the input conveyor.
On the sorting line, valuable plastics are extracted as colored and uncolored. A sorting line with a maximum of 20 workers. Food scraps are not neatly separated, but are sent to the composting facility with plastics and other materials mixed in.

Figure 92 Collected garbage

Figure 93 Trommel

The biggest problem is the reality that hazardous wastes such as fluorescent bulbs are also disposed of together. Naturally, composted materials may also contain toxic substances.

The composted food scraps, which contain plastic, are matured using a special heavy machine that mixes the plastic with water and agitates it. The maturation period is about one month. The ripened material is again put through a trommel (sieve size 15 mmφ) to separate it into plastic and compost.

Figure 94 Sorting line

Figure 95 Plastic for value after sorting

Figure 96 Colored plastic for value after sorting

Figure 97 Matured compost mixed with plastic

Figure 98 Compost after removal of plastic

Figure 99 Compost mixer

Figure 100 Trommel for compost

The compost is mixed with water while being stirred in the device shown in Figure 99, and the compost is allowed to mature for about a month.

The remainder after the compost is removed is landfilled. Mostly plastic, but since much of the food waste is composted, there seems to be less of a foul odor. In terms of appearance alone, many of the materials are fully usable as raw materials for FPF.

Figure 101 Distant view of landfill site

Figure 102 Close view of landfill site

ii Private incineration facility in Soc Trang Province

Waste in the suburbs of Soc Trang Province is handled by a private treatment plant (incineration, landfill). However, waste was being incinerated despite the fact that the plant was malfunctioning. There is not enough space for landfill, and a drastic solution is needed.

Figure 103 Private incineration facility

Figure 104 Private landfill site

(5)Meeting with DONRE of Soc Trang Province

Figure 105 Meeting with DONRE of Soc Trang Province

The Department of Natural Resources and Environment (DONRE) of Soc Trang Province will start three types of household waste separation from 2024, but they are instructing contractors and others because it is meaningless if they get mixed up during collection and subsequent disposal.

Regarding the disposal of waste in Soc Trang Province, it was stated that if two or more companies apply for the project, it will be put out to bid, but even if only one company submits a proposal, if the proposal is good, that one company will be selected and proceed with the project. At this point, although some companies are investigating, no concrete proposals have been submitted to the Soc Trang Province yet. The next FIT price (8th price) for waste power generation has not yet been set, but Soc Trang Province has included it in its plan, so basically they would like to proceed with the project.

The Ministry of Soc Trang will also consider the content of the project, which is specific to industrial waste only. The current disposal cost of the Waste Management Corporation is VND359,000/ton (about 2,100 yen/ton), which is considerably cheaper than the average disposal unit cost of 20,000 yen/ton for general waste in Japan.

(6)Proposals and directions for waste management in Soc Trang Province
Soc Trang Province intends to give priority to waste power generation, which has already been budgeted and decided upon. Although some private companies have joined the project to collect and dispose of waste (incineration, landfill, etc.), incineration facilities are in an environmentally problematic state, and it is desirable to use incineration facilities that can comply with environmental standards, while sorting and recycling what can be recycled. It is also appropriate to use what cannot be materially recycled as thermally recycled fuel for waste power generation, fluff, RPF, etc.

However, hazardous wastes such as fluorescent tubes are currently disposed of together with combustible wastes, and further investigation and study are needed to promote thermal recycling of such wastes. At this point, it is difficult to make a proposal that includes waste power generation because the details of waste separation have not yet been clarified. We plan to make proposals to Soc Trang Province as appropriate, while gathering information from other municipalities on the issue of profitability of waste power generation.

Assuming that the contamination of hazardous wastes could be improved in the future, the possibility of waste power generation from dusty wastes is examined[32]. Generally, combustion of waste by its own calorific value without using auxiliary fuels is called "self-combustion," and the lower limit of self-combustion is said to be about 3,350 kJ/kg (about 800 kcal/kg) for lower heating value. The lower limit of self-combustion is said to be approximately 6,300 kJ/kg (about 1,500 kcal/kg), which can be used to generate electricity by recovering part of the calorific value of the waste itself during the incineration process. Table 54 shows the waste composition in HCMC. The weighted average lower heating value by composition ratio is 4,947 kJ/kg, which meets the 3,500 kJ/kg required for self-combustion, but is lower than the lower limit of 6,300 kJ/kg for power generation.

[32] For a discussion of waste-to-energy and the composition of municipal solid waste, the online magazine of the National Institute for Environmental Studies' Resource Recycling and Waste Research Center was referenced.

Table 54 Garbage composition of Ho Chi Minh City

	Weight	Water	Combustible	Ash	Hydrogen content	HHV	LHV
Unit	%	%	%	%	%	kJ/kg	kJ/kg
Kitchen waste (degradable)	69.0	73.4	20.4	6.2	1.6	3,707	1,509
Kitchen waste (persistent)	0.8	17.4	0.0	82.6	0.0	0	-434
Papers	3.0	50.1	40.1	9.8	3.1	8,849	6,899
Disposable diaper	3.0	76.1	19.7	4.2	1.1	5,837	3,686
Plastics	15.9	37.8	54.5	7.7	6.8	21,670	19,190
Metals	0.2	4.6	0.0	95.4	0.0	0	-115
Other inorganic materials	1.9	4.6	0.0	95.4	0.0	0	-115
Wood	0.7	33.3	60.4	6.2	4.0	11,224	9,485
Rubber and leather	0.7	30.9	54.3	14.8	3.2	14,394	12,904
Fibers	5.0	48.1	45.7	6.2	3.4	9,885	7,917

Table 55 Garbage composition of Soc Trang Province（Estimate）

	Weight	Water	Combustible	Ash	Hydrogen content	HHV	LHV
Unit	%	%	%	%	%	kJ/kg	kJ/kg
Kitchen waste (degradable)	73.0	73.4	20.4	6.2	1.6	3,707	1,509
Kitchen waste (persistent)	0.8	17.4	0.0	82.6	0.0	0	-434
Papers	3.0	50.1	40.1	9.8	3.1	8,849	6,899
Disposable diaper	3.0	76.1	19.7	4.2	1.1	5,837	3,686
Plastics	11.9	37.8	54.5	7.7	6.8	21,670	19,190
Metals	0.2	4.6	0.0	95.4	0.0	0	-115
Other inorganic materials	1.9	4.6	0.0	95.4	0.0	0	-115
Wood	1.5	33.3	60.4	6.2	4.0	11,224	9,485
Rubber and leather	0.7	30.9	54.3	14.8	3.2	14,394	12,904
Fibers	4.0	48.1	45.7	6.2	3.4	9,885	7,917

Based on data from Ho Chi Minh City, Soc Trang Province is estimated to produce 4,246 kJ/kg of organic waste (Table 55), assuming slightly more kitchen waste and less plastic than in Ho Chi Minh City, and although the waste is self-burning, it is estimated to be less than the 6,300 kJ/kg that can be generated. However, Soc Trang Province believes that the composting process described below will significantly reduce the moisture content of kitchen waste, and if the waste is extracted in a subsequent process, the calorific value will increase and power generation will be possible. If the moisture content of kitchen waste is reduced to 1/3, the calorific value would be 6,841 kJ/kg, which is higher than the 6,300 kJ/kg that can be generated.

This method is similar to the thermal recycling method in Japan using tunnel composting conducted by Mitoyo City in Kagawa Prefecture (Ecomaster Co., Ltd.). Mitoyo City accepts combustible general waste such as raw garbage, and after shredding, it is fermented and dried. This process is called tunnel composting, which uses microorganisms to decompose food waste and the heat from the fermentation process to remove moisture. The remaining plastic and paper are converted into RPF and used as fuel. Reducing water content by fermentation is considered to be one of the most effective methods of pretreatment for waste power generation from dusty wastes.

5.8. Collection of information on other municipalities and RPF

(1)Hearing with DECOS

i Hearing on RPF utilization

We visited DECOS (DAI DONG ENVIRONMENT SOLUTIONS CO, LTD) to learn about the procedures for RPF production and utilization. URENCO11, a subsidiary of Hanoi's waste management company. The company was established in May 2016 and is engaged in RPF production and sales in Vietnam.

Figure 106 Meeting with DECOS

DECOS said that the regulations for burning RPF are left to the users, and they are aware that there

are no special regulations for RPF in Vietnam because it is not recognized in the country. However, they need to apply for it as a manufacturing industry and have it registered as a product with the General Directorate of Standards, Metrology, and Quality.
DECOS believes that it is necessary to communicate and raise awareness of RPF, and that it will make efforts to promote RPF throughout Vietnam.

ii Production of RPF at DECONOS
RPF production at DECOS uses about 90% plastic-based material, which has an ash content of about 5%. In the past, raw materials with high moisture content, such as pulper dregs from paper mills, were used, but currently, more materials with low moisture content, such as rolls of plastic film, are being used. Disposal of the ash burned at the destination is the responsibility of the user, but the company is also proposing to bring the ash to URENCO11 to be incinerated and landfilled again.

Figure 107 Raw materials of RPF

Figure 108 Briquetted RPF

The RPF is used by brick makers, feed makers, paper companies, pharmaceutical companies, textile companies, food and beverage manufacturers, etc., and the transport distance is within 100 km. value.

Since equipment maintenance is almost the same as that for wood pellet production equipment, it seems that equipment maintenance companies in Vietnam can handle this task. The company has its workers undergo training in Japan to perform welding and repair work on the equipment.

Figure 109 Crusher made in Vietnam

In the early stages, equipment from Japan and China was used, but due to the high cost of installation and problems with repairs, crushers and other equipment were now switched to Vietnamese equipment.

(2)Hearings with relevant organizations in Can Tho City

i Overview of Can Tho City

Can Tho City is one of the municipalities in the Mekong Delta with a population of approximately 1.2 million, and is located about 3.5 hours south of Ho Chi Minh City by car. Can Tho City has long been a strategic point in the Mekong Delta, and its airport and other infrastructure are top class. The city has a thriving floating market, as waterways used to be a means of transporting goods. Can Tho City is more industrialized than Soc Trang Province, and the city is considering material recycling and thermal recycling of industrial wastes with well-defined compositions.

ii Hearing with Can Tho City and the Department of Natural Resources and Environment (DONRE)

Can Tho City generates 700 tons/day of domestic waste, 350 tons/day of industrial waste, and several tons/day of medical waste, and the incineration facility installed by ODA is not operating well, which seems to have affected the medical waste treatment. In addition, the city has been sending industrial waste out for disposal outside the city, and there is a desire to set up an industrial waste treatment plant within the city. Composting is being done, but the quality is not good, so it is necessary to adjust the ingredients, etc., and it appears that the compost cannot be used as is.

Figure 110 Meeting with Can Tho City

Other issues include the lack of a set garbage separation method and citizens not putting out their garbage in designated areas. The city is divided into nine zones, and these zones are collected by four collection companies, but there is a difference in the level of collection. Three of the collection companies are private companies, and the remaining one is funded by the government but operates as a joint-stock company.

Of the 9 areas, 3 areas are treated by Minton Co., and 6 areas are treated by waste power generation. 4 of the 6 areas are designated as exclusive waste power generation areas. Mr. Cantho asked for suggestions for efficient waste disposal, including collection and transportation. Can Tho City also had many incineration facilities, but it appears that those facilities that do not meet environmental standards are gradually being taken out of operation.

When we asked DONRE about the use (combustion) of RPF, they recognized that there would be no problem as long as exhaust gas standards are met, and that there would be no problem for companies licensed for waste treatment to manufacture RPF. However, they were of the opinion that a license for waste treatment is required if the waste from the company's own plant is to be converted into fuel and sold.

iii Private incineration facility (Minton Co.)

The purpose of the visit was to investigate the actual status of a private incineration facility in Can Tho City. As a private incineration facility in Can Tho City, Minton Inc. processes 100 tons of garbage per day by incineration and composting. Workers were separating plastics and compostable materials, such as food scraps, by sorting them on an earthen floor. Although the incineration is privately operated with a business license, it does not meet the latest emission standards. There are five incineration facilities of various sizes that appear to have inadequate dioxin control measures.

The DONRE side of Can Tho City said that they do not dare to give instructions on the standards at this point because it will not be viable if the regulations are tightened, but this facility could be closed in 2026.

Figure 111 Work at Minton Co.

Figure 112 Hearing with CEO of Minton Co.

iv Canto Urban Joint Company

The possibility of intermediate treatment methods was explained, and issues related to waste treatment, including collection and transportation, were also interviewed.

Figure 113 Meeting with CUJC

Canto Urban Joint Company (CUJC) used to be publicly owned as a waste management corporation, but is now a joint stock company. It is also funded by the national government. The company's main business is refuse collection, but it also handles street trees, parks, and lighting management. The company has about 80 collection vehicles.

The company collects and transports waste in 8 of the 9 areas. The company collects about 600 tons per day, of which 500 tons are delivered to Waste Power Generation and 100 tons to Minh Thong. Currently, there is no contractor in Can Tho City that handles industrial and hazardous waste, so the waste is transported to Ho Chi Minh City, which is recognized as a problem.

Can Tho City is also working to improve waste treatment, and is conducting a demonstration experiment on waste separation with the support of JICA, and river waste collection with the support of the Netherlands. Insufficient relay points and the lack of intermediate treatment facilities make it impossible to handle the subsequent processing of the sorted materials, and it is hoped that relay points and intermediate treatment facilities will be established.

(3)Hearing with Binh Duong Province

i Binh Duong Province Department of Natural Resources and Environment (DONRE)

We conducted an interview with DONRE in Binh Duong Province, where Vina Kraft Paper (see below) is located, regarding regulations on RPF production and utilization. Binh Duong Province seems to have been slower to develop economically than other areas, but is now one of the most investment-friendly areas in Vietnam, and is rated the fourth best investment environment in the country, consisting of 12 zones for general housing and 20 zones for industrial parks. In Binh Duong Province, industrial waste is processed by eight companies that hold licenses. Currently, there is a 100 ha treatment plant, but additional plants of 200 ha and 400 ha are being prepared to handle domestic, industrial, and hazardous wastes.

Currently, six domestic ministries, together with Japan (METI Kansai and others) and the Vietnamese Ministry of Natural Resources and Environment (MONRE), are participating in the project to review standards for incineration and landfill, collection and transportation, and power generation.

In Binh Duong Province, we have learned that a paper company is already manufacturing and using RPF made from plastic and paper. It seems that Binh Duong Province also considers RPF production and utilization to be effective. However, Binh Kraft Paper has obtained a license to import waste materials, and since MONRE has jurisdiction over all such imports, the company requested that application for the RPF introduction procedure be made to MONRE.

In order for Vina Kraft Paper to engage in the RPF business, a business plan to manufacture RPF must be included in the product registration license. If the license is not renewed, the waste must be disposed of at a designated waste disposal site in Binh Duong Province.

Basically, the key point is whether the waste can meet the QCVN30 of the Air Pollution Control Law regarding the combustion of waste. However, a review is currently underway and is expected to be issued by the end of 2023, with application beginning in 2025. Binh Duong Province seems to recognize RPF raw materials as waste.

(4)Hearing with waste management companies in Ho Chi Minh City

i Vinausen

A private waste management company in Ho Chi Minh City that handles collection, transportation, incineration, recycling, and oil reclamation. It also performs infectious incineration. The company is owned by Australian and Vietnamese capital. Although this visit was only a tour of the facility, as a private waste treatment company in Ho Chi Minh City, information will be exchanged with the company as it will continue to play a central role in waste treatment in Vietnam in the future.

Figure 115 Hazardous wastes

Figure 114 Waste treatment facility of Vinausen

ii CITENCO

CITENCO is the Ho Chi Minh City Environmental Corporation, a contractor that handles the collection and disposal of both general and industrial waste. The company also owns a wastewater treatment and incineration facility with a capacity of 42 tons per day (for industrial waste), and has a fleet of over 300 collection vehicles. In parts of Ho Chi Minh City, the company has begun offering a service that converts recyclable waste into cash and gifts. The company is a waste handler (public corporation) in Ho Chi Minh City, the most economically developed city in Vietnam, and has received various proposals (including waste-to-energy) from all over the world.

Like Vinayusen, information will continue to be exchanged in order to keep abreast of trends in waste management in Vietnam.

5.9. Hearing with potential RPF users

Considering RPF delivery destinations with reference to examples in Japan, paper mills and cement plants are possible candidates for RPF users. In addition to the paper mill (Hau Giang City) and

cement factory (An Giang Province) surveyed in FY2021, we visited Can Tho Beer (Can Tho City) and Vina Kraft Paper (Binh Duong Province) as potential users in the vicinity of Soc Trang Province.

(1)Can Tho Beer

Figure 117 Meeting with Can Tho Beer

Figure 116 Products of Can Tho Beer

The company used to produce beer, but has now stopped producing beer and instead produces juice and mineral water. Juice production used to be 10 million liters/year, but since Corona, it has dropped to about 3 million liters/year. There is only one factory, with about 100 employees.

They used to use coal, but no longer do, and have been using rice husk fuel (briquettes) for more than ten years. The amount used is 30 to 50 tons/month, at a price of 2,000 to 3,000 VND/kg, and the freight cost is about 5 yen/kg. Most of the industrial waste generated by the business is recycled as valuable resources, except for a small amount of organic waste such as food scraps.
When switching from coal to rice husk fuel, the company conducted and submitted an analysis of the exhaust gas, and also submitted the results of the analysis every three months. The company was exempted from the requirement to install a system to perform continuous monitoring and measurement and to automatically submit the data.
Regarding the size of RPF manufactured by Ogawa Econos (35 mmφ in diameter and 50 mm to 100 mm in length), we confirmed that there were no problems in feeding it into the boiler. When conducting a combustion test, we were told that it would take about 2 tons/day to analyze and confirm the fluctuation. The analysis cost was approximately 5 million VND. In the future, consideration will be given to conducting tests using locally manufactured RPF or RPF exported from Japan.

(2)Vina Kraft Paper

This is a company that we have visited before regarding the possibility of using RPF, and we visited this time to conduct another investigation of its potential. Vina Kraft Paper is a company that manufactures and sells containerboard base paper, in which the Siam Cement Group of Thailand and Japan's Rengo Co. The company has an annual production capacity of 500,000 tons and owns two paper machines.

Currently, the company outsources the processing of 3,000 tons of plastic waste per month. The main waste is pulper dregs with a moisture content of approximately 50%. Before being sent outside, the waste is crushed and metal such as guard wires is removed in the company's own plant. There is a molding machine for RPF that squeezes out the water content, and OGAWA ECONOS Co. They are of the opinion that if there is a cost advantage over the use of coal and the external treatment of waste, they would like to consider it.

Figure 118 Meeting with Vina Kraft Paper

Figure 119 Boiler of Vina Kraft Paper

5.10. The way forward

The waste handled by the Soc Trang Province Waste Management Corporation (SPWC) differs from other areas in that food waste is composted and separated from other plastics and other materials before landfill disposal, which considerably reduces odor problems at the landfill site. However, since hazardous wastes such as fluorescent tubes were collected together with the original wastes at the time of collection, investigation and thorough study are needed before thermal recycling. We plan to continue our proposals and discussions while confirming the content of sorting.

First, we would like to consider material recycling and thermal recycling using stable raw materials such as industrial waste, etc. Since industrial industries are not flourishing in Soc Trang Province, we would like to propose a review of possible collection and treatment in Soc Trang Province, while

investigating neighboring municipalities. We also plan to communicate our views on power generation based on our research.
Can Tho City, which is relatively close to Soc Trang Province, is another candidate as a municipality, and as with Soc Trang Province, we need to watch how the application of the three waste types for general waste in the municipality will be operated in 2024, but there is a possibility of companies that can become industrial thermal recycling raw materials or RPF users. However, we will continue to investigate and discuss with Can Tho City because of its high potential as a user of industrial thermal recycling materials and RPF.
As for the production and use of RPF at Vina Kraft Paper (paper mill) as an individual case, we will continue to discuss with the company after making a cost estimation, and work toward the demonstration while obtaining confirmation from MONRE.

5.11. Feasibility of introducing the project

(1)Projected income and expenditures for waste generation projects
Based on the survey, estimates were made for the projected income and expenditures for waste-to-energy generation under the assumption that Japanese facilities would be installed. The estimates are based on the same assumptions as those for a general waste-to-energy facility operated in Japan, but some costs, such as labor and consumables, are assumed to be priced for Vietnam. Civil engineering and construction was set at 3.5 billion yen, plant facilities at 9 billion yen (three units), and heavy machinery and other equipment at 150 million yen.

Table 56 shows our calculations based on the assumption that the unit disposal cost is 3,000 yen/ton for general waste and 10,000 yen/ton for industrial waste. The current treatment cost is considerably lower than the general waste treatment unit cost of 20,000 yen/ton in Japan, and the results do not fully cover the running costs of LNG and other resources used when starting up the furnace. Other major assumptions made include the amount of waste: 450 tons/day of general waste and 150 tons/day of industrial waste, for a total of 600 tons/day. Three combustion reactors are used, with a power generation efficiency of 13%, and although the latest FIT price has not been provided, a revenue of 10.05 cents/kWh (13.266 yen/kWh) was used as an assumption.

Table 56 Revenue and cost projections for waste-to-energy project (Normal case)

Unit: Million Yen

Profit and loss		Year	1	2	3	4	5	6	7	8	9	10
Revenue	Revenue from FIT	57.5%	1,155	1,155	1,155	1,155	1,155	1,155	1,155	1,155	1,155	1,155
	Revenue from waste disposal (general waste)	20.1%	405	405	405	405	405	405	405	405	405	405
	Revenue from waste disposal (industrial waste)	22.4%	113	225	338	450	450	450	450	450	450	450
	Total sales	**100.0%**	**1,673**	**1,785**	**1,898**	**2,010**	**2,010**	**2,010**	**2,010**	**2,010**	**2,010**	**2,010**
Cost	Outsourcing expenses	1.0%	30	30	30	30	30	30	30	30	30	30
	Disposal fees	1.2%	39	39	39	39	39	39	39	39	39	39
	Labor cost	3.1%	94	95	96	97	98	99	100	101	102	103
	Depreciation (plant)	16.8%	529	529	529	529	529	529	529	529	529	529
	Depreciation (construction)	2.9%	92	92	92	92	92	92	92	92	92	92
	Depreciation (equipment)	1.0%	30	30	30	30	30	30	30	30	30	30
	Fuel, water, etc.	35.4%	1,082	1,093	1,104	1,115	1,126	1,137	1,149	1,160	1,172	1,184
	Consumables	17.4%	533	538	544	549	555	560	566	572	577	583
	Maintenance	11.9%	375	375	375	375	375	375	375	375	375	375
	Insurance	0.8%	25	25	25	25	25	25	25	25	25	25
	Asset retirement obligations	1.0%	31	31	31	31	31	31	31	31	31	31
	Property tax	5.8%	215	204	193	182	171	162	151	140	129	118
	Others	1.9%	60	60	60	60	60	60	60	60	60	60
	Total cost	**100.0%**	**3,136**	**3,142**	**3,148**	**3,154**	**3,161**	**3,170**	**3,177**	**3,184**	**3,191**	**3,199**
Gross profit		**-56.9%**	**-1,463**	**-1,356**	**-1,250**	**-1,144**	**-1,150**	**-1,160**	**-1,166**	**-1,174**	**-1,181**	**-1,188**

Table 57 Revenue and cost projections for waste-to-energy project (Trial calculation)

Unit: Million Yen

Profit and loss		Year	1	2	3	4	5	6	7	8	9	10
Revenue	Revenue from FIT	26.3%	1,155	1,155	1,155	1,155	1,155	1,155	1,155	1,155	1,155	1,155
	Revenue from waste disposal (general waste)	55.3%	2,430	2,430	2,430	2,430	2,430	2,430	2,430	2,430	2,430	2,430
	Revenue from waste disposal (industrial waste)	18.4%	203	405	608	810	810	810	810	810	810	810
	Total sales	**100.0%**	**3,788**	**3,990**	**4,193**	**4,395**	**4,395**	**4,395**	**4,395**	**4,395**	**4,395**	**4,395**
Cost	Outsourcing expenses	1.0%	30	30	30	30	30	30	30	30	30	30
	Disposal fees	1.2%	39	39	39	39	39	39	39	39	39	39
	Labor cost	3.1%	94	95	96	97	98	99	100	101	102	103
	Depreciation (plant)	16.9%	529	529	529	529	529	529	529	529	529	529
	Depreciation (construction)	2.9%	92	92	92	92	92	92	92	92	92	92
	Depreciation (equipment)	1.0%	30	30	30	30	30	30	30	30	30	30
	Fuel, water, etc.	35.7%	1,082	1,093	1,104	1,115	1,126	1,137	1,149	1,160	1,172	1,184
	Consumables	17.6%	533	538	544	549	555	560	566	572	577	583
	Maintenance	12.0%	375	375	375	375	375	375	375	375	375	375
	Insurance	0.4%	13	13	13	13	13	13	13	13	13	13
	Asset retirement obligations	0.5%	16	16	16	16	16	16	16	16	16	16
	Property tax	5.8%	215	204	193	182	171	162	151	140	129	118
	Others	1.9%	60	60	60	60	60	60	60	60	60	60
	Total cost	100.0%	3,107	3,114	3,120	3,126	3,133	3,142	3,149	3,156	3,163	3,170
Gross profit			**680**	**877**	**1,073**	**1,269**	**1,263**	**1,254**	**1,247**	**1,240**	**1,232**	**1,225**

The latter table shows a trial calculation of how to deal with the situation. Assuming that half of the initial investment for plant construction can be covered by subsidies, we assumed that a total of 12.5 billion yen (3.5 billion yen for civil engineering and construction and 9 billion yen for the plant (three units)) can be handled for 6.25 billion yen. Furthermore, if the company were to operate at a unit disposal cost of 18,000 yen/ton, which is close to the cost of general waste disposal in Japan, it would be possible to secure a gross profit margin of about 28.9%. However, the unit price of 18,000 yen/ton is not considered realistic in Vietnam at this time. On the other hand, we believe that there is room for improvement by combining sorting and composting, which is being implemented in Soc Trang Province, and by operating waste for waste-to-energy generation with reduced moisture content.

There are already some municipalities in Vietnam that have implemented waste-to-energy operations, and we believe that there is a need to continue to investigate realistic operational methods.

(2)CO2 reduction and cost effectiveness

i Overview

The GHG emission reductions through the avoidance of CH_4 emissions from landfill sites by using all of the general waste generated in Soc Trang Province as a fuel for waste-to-energy were evaluated.

ii MRV methodology

The MRV methodology was based on the JCM methodology 'JCM_MM_AM001_ver01.0'33, which was used for the JCM subsidy project 'Introduction of Waste to Energy Plant in Yangon City'.

The eligibility criteria are as follows. It was assumed that the project under consideration met all eligibility criteria.

< Eligibility criteria >

(a) The project newly installs an incinerator, waste heat recovery boiler, exhaust gas treatment equipment and turbine generator.

(b) The project incinerates municipal solid waste (MSW) which has been disposed at a SWDS (solid waste disposal site or landfills) where the generated landfill gas is not recovered, and generates electricity from steam produced in waste heat recovery boiler.

(c) There is a plan to operate the project facility for more than 5 years.

[33] JCM_MM_AM001_ver01.0 (https://www.jcm.go.jp/mm-jp/methodologies/75/approved_pdf_file)

iii Project boundary

The GHGs covered and their sources are listed in Table 58.

Table 58 GHGs and emission sources subject to estimation

	Emission source	GHG
Reference	Decomposition of waste at a SWDS	CH_4
	Electricity generation	CO_2
Project	Combustion of fossil carbon contained in waste	CO_2
	Incineration of waste	N_2O
	Electricity use by the project facility	CO_2
	Consumption of auxiliary fossil fuels needed to be added into incinerator	CO_2

iv Formula for estimating GHG emission reduction amount and the results

The formula for calculating greenhouse gas emissions is shown below. The calculation tool (Excel) provided in Chapter 3 of Volume 5 of the IPCC 2006 Guidelines was used to estimate methane emissions from landfill sites, while the data on general waste generation and compositional analysis reflected the results of the survey.

As a result, methane emissions from landfill sites were estimated at 83,000 tonnes CO_2 equivalent/year and project emissions at 3,300 tonnes CO_2 equivalent/year, resulting in estimated greenhouse gas reductions of 79,000 tonnes CO_2 equivalent/year.

$ER_p = RE_p - PE_p$

ER_p:	GHG emission reduction amount in the project period p (tCO_2/p)
RE_p:	GHG emissions in the project period p for the reference scenario (tCO_2/p)
PE_p:	GHG emissions in the project period p for the project scenario (tCO_2/p)

GHG emissions for the reference scenario

$RE_p = RE_{CH4,p} + RE_{elec,p}$

RE_p:	Reference emissions during the period p [tCO_2e/p]	
$RE_{CH4,p}$:	Reference emissions from decomposition of MSW at a SWDS during the period p [tCO_2e/p]	
$RE_{elec,p}$:	Reference emissions from electricity generation during the period p [tCO_2e/p]	

$$RE_{CH4,p} = \sum_{y=p,start}^{p\_end}[\varphi \times (1 - f) \times GWP_{CH4} \times (1 - OX) \times \frac{16}{12} \times f \times DOC_f \times MCF \times \sum_{i=1}^{y-1}\sum_{j}\{W_i \times p_j \times DOC_j \times e^{-kj(y-1-i)} \times (1 - e^{-kj})\}]$$

$RE_{CH4,p}$:	Reference emissions from decomposition of MSW at a SWDS	

	during the period p [tCO_2e/p]	
y:	The Nth year from the first disposal (or incineration), extending from the first year of the period p (y=p_start) to the last year of the period p (y=p_end). If y is equal to 1, methane generation cannot be accounted.	
p_start:	The Nth year from the first disposal (or incineration), which is the first year of the period p	
p_end:	The Nth year from the first disposal (or incineration), which is the last year of the period p	
φ:	Model correction factor to account for model uncertainties	Default value: 0.80
f:	Fraction of methane captured at a SWDS and flared, combusted or used in another manner that prevents the emissions of methane to the atmosphere	Default value: 0
GWP_{CH4}:	Global Warming Potential of methane [tCO_2e/tCH_4]	Default value: 25
OX:	Oxidation factor	Default value: 0.1
16/12:	Conversion factor [tCH_4/tC]	
F:	Fraction of methane in the SWDS gas [volume fraction]	Default value: 0.5
DOC_f:	Fraction of degradable organic carbon (DOC) that decomposes under the specific conditions occurring in a SWDS [weight fraction]	Default value: 0.5
MCF:	Methane correction factor	Varies according to conditions. See methodology for details.
i:	The Nth year from the first disposal (or incineration), extending from the first year in the time period in which MSW is disposed at a SWDS (i = 1) to year y (i = y)	
W_i:	Quantity of MSW fed into incinerator in the year i (wet basis) [t]	Subject f monitoring
p_j:	Fraction of the waste type j [weight fraction]	Measured value
DOC_j:	Fraction of degradable organic carbon in the waste type j [weight fraction]	Default values
k_j:	Decay rate for the waste type j [1/yr]	Default values
j:	Type of waste	

$R_{Eelec,p} = EG_{elec,p} \times EF_{elec}$

$R_{Eelec,p}$	Reference emissions from electricity generation during the period p [tCO_2e/p]	
$EG_{elec,p}$	Quantity of electricity generated by the project facility during the period p [MWh/p]	Subject of monitoring
EF_{elec}	Emission factor for electricity generation [$t_{CO2}e/MWh$]	Data for Viet Nam: 0.9130 $kgCO_2/kWh$

GHG emissions for the project scenario

$PE_P = PE_{COM\_CO2,p} + PE_{COM,N2O,p} + PE_{EC,p} + PE_{FC,p}$

PE_P	Project emissions during the period p [tCO_2e/p]	
$PE_{COM\_CO2,p}$	Project emissions of CO_2 from combustion of fossil carbon contained in waste associated with incineration during the period p [tCO_2e/p]	
$PE_{COM,N2O,p}$	Project emissions of N2O from combustion of waste associated with incineration during the period p [tCO_2e/p]	

$PE_{EC,p}$	Project emissions from electricity consumption by the project facility during the period p [tCO_2e/p]	
$PE_{FC,p}$	Project emissions from auxiliary fossil fuel consumption associated with incineration during the period p [tCO_2e/p]	

$$PE_{COM\_CO2,p} = EFF_{COM} \times 44/12 \times \sum_j(\sum_{i=p,start}^{p\_end} W_i \times p_j \times \frac{DC}{100} \times FCC_j \times FFC_j)$$

$PE_{COM\_CO2,p}$:	Project emissions of CO_2 from combustion of fossil carbon contained in waste associated with incineration during the period p [tCO_2e/p]	
EFF_{COM}:	Combustion efficiency of incinerator [fraction]	Default value: 1
44/12:	Conversion factor [tCO_2/tC]	
i:	The Nth year from the first incineration	
W_i:	Quantity of MSW fed into incinerator in the year i (wet basis) [t]	Subject of monitoring
p_j:	Fraction of the waste type j [weight fraction]	Measured value
DC:	Dry matter content of MSW [%]	Measured value
FCCj:	Fraction of total carbon content in waste type j [tC/t]	Default values
FFCj:	Fraction of fossil carbon in total carbon content of waste type j [weight fraction]	Default values
j:	Type of waste	

$$PE_{COM,N2O,p} = \sum_{i=p,start}^{p\_end} W_i \times EF_{N2O} \times GWP_{N2O}$$

$PE_{COM,N2O,p}$	= Project emissions of N_2O from combustion of waste associated with incineration during the period p [tCO_2e/p]	
W_i:	Quantity of MSW fed into incinerator in the year i (wet basis) [t]	Subject of monitoring
EF_{N2O}:	Emission factor for N_2O associated with incineration [t_{N2O}/t_{waste}]	Default values
GWP_{N2O}:	Global Warming Potential of nitrous oxide [tCO_2e/tN_2O]	Default value: 298

$$PE_{EC,p} = EC_p \times EF_{elec}$$

$PE_{EC,p}$	Project emissions from electricity consumption by the project facility during the period p [tCO_2e/p]	
EC_p:	Quantity of electricity consumed by the project facility during the period p [MWh/p]	Subject of monitoring
EF_{elec}:	Emission factor for electricity generation [tCO_2e/MWh]	Varies according to conditions. See methodology for details.

$$PE_{FC,p} = \sum_{fuel}(FC_{fuel,p} \times NCV_{fuel} \times EF_{CO2,fuel})$$

$PE_{FC,p}$	Project emissions from auxiliary fossil fuel consumption associated with incineration during the period p [tCO_2e/p]	
EF_{fuel}:	Quantity of auxiliary fossil fuel consumed during the period p [kL or m^3 /p]	Subject of monitoring

NCV_{fuel}:	Net calorific value of fuel [GJ/kL or m^3]	Measured value/ country-specific data (expert judgement)/ IPCC default value
$EF_{CO2,fuel}$	CO_2 emission factor of fuel [tCO_2/GJ]	Default values
fuel:	Type of fuel	

v Cost-effectiveness

The estimation results of cost-effectiveness for the project are shown in Table 59. According to the guidelines for submitting proposals of JCM Model Project, it states that the Cost-effectiveness of financial support necessary to reduce 1 tonne of GHG emissions should be 4,000 JPY/t CO_2eq or lower. It was confirmed that if the minimum subsidy rate (30%) was applied, the cost-effectiveness would be 3,200 yen/tCO_2, which is far less than 4,000 yen/tCO_2.

Table 59 Cost-effectiveness

Item	Value	Note
Initial cost (Yen) (1)	12.5 Billion	Civil engineering and construction, plant, heavy machinery, etc.
Product lifetime (y)	15	Published: Material cycles and waste management research, Vol. 31, No. 1, pp. 16 -19, 2020
GHG emission reduction amount (tCO_2) (2)	1,188,000	Performance for the entire period of product lifetime
Cost-effectiveness (Yen/tCO_2)	10,500	(1)/(2) Note: No subsidy is considered.
Cost-effectiveness (Yen/tCO_2)	3,200	Subsidy/(2) Note: Formula for the JCM Model Project is used. Subsidy rate at 30% is assumed.

vi Implementation system for monitoring

The parameters listed in Table 60 need to be monitored during project implementation. All needs to be measured by the project implementer. The roles and responsibilities need to be clarified in advance within the international consortium members.

Table 60 Monitoring parameters

Parameter	Monitoring implementer
Quantity of MSW fed into incinerator in the year i (wet basis) [t]	Project implementer
Quantity of electricity consumed by the project facility during the period p [MWh/p]	
Quantity of auxiliary fossil fuel consumed during the period p [kL or m^3/p]	

vii Further considerations

The data used for the estimation needs further scrutiny, including information on initial invest