Fiscal Year 2018
Feasibility study of the overseas dissemination of high-quality infrastructure
(Feasibility study on establishing LNG receiving terminal business in Indonesia)

Study Report

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Ministry of Economy, Trade and Industry

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Contents

Chapter 1. Purpose of study

Growing demand for infrastructures worldwide, particularly in emerging nations, due to rapid urbanization and economic growth, is expected to drive continued market expansion.

It is vital for Japan to capitalize on this huge worldwide demand to ensure the nation's sound economic growth. Japan must stimulate private investment and maximize its strengths in technology and expertise as part of a strategy to ensure sustained growth and international expansion.

The revised infrastructure system export strategy agreed on at the Ministerial Meeting on Strategy relating to Export and Economic Cooperation on May 29, 2017 emphasizes the importance of proposing solutions that address various issues comprehensively, based on a thorough understanding of conditions in the target country, in efforts to introduce infrastructure systems overseas. This approach seeks to ensure that the target country fully appreciates the superiority and reliability of the concepts and technologies proposed by Japan.

Against this backdrop, we undertook a study of the feasibility of submitting proposals to target countries to establish infrastructure projects that draw on Japan's advanced technologies and know-how and meet a wide range of global needs in potential growth fields.*

*Of the areas listed on pages 29 to 31 of the government-enacted "Infrastructure System Strategy" (May 17, 2013), fields such as energy, transportation (particularly railroads and next-generation automobiles), telecommunications, infrastructure (particularly industrial parks), living environments (particularly, water and recycling), and new fields (particularly healthcare and space).

Chapter 2. Description of study

2.1 Benefits of project for target nation

2.1.1 Project overview

JFE Engineering Corporation is examining a development and investment project ("this project" hereafter) in partnership with the Indonesian Company P to operate a LNG regasification plant and pipelines to supply gas consumers in Indonesia, including gas-fired thermal power plants in the region.

Company P, JFE Engineering's partner in this project, will subcontract business entity to handle LNG storage (FSU) operations and JFE Engineering to operate the LNG regasification facility and pipelines. Business planning will be undertaken jointly by JFE Engineering and Company P.

The following section describes the need for this project from natural gas supply and demand perspectives.

2.1.2 Background and need for project

The gas-fired power plant, a gas consumer in this project, is a vital regional power plant for the reasons described below.

First, according to forecast data in the RUPTL 2018-2027, the electricity supply business plan for the period from 2018 to 2027 published by the state-owned electricity company PLN, shortfalls relative to demand in power-generating capacity are expected by the early 2020s in the region. The power plant is positioned as an additional power plant to cover this capacity shortfall.

By applying Japanese electricity energy mix philosophy to the daily load curve, coal-fired and geothermal power plants will serve as base load, while gas- or oil-fired power plants serves as middle or peak load, to cover demand fluctuations for stable grid operations. However, gas-fired and oil-fired power plants in the region, which are preferable for peak and middle load due to positive load-following characteristics, comprise only small portion. In other words, capacity in the peak and middle load, required to cover fluctuations in the daily load curve for the region, appears inadequate.

This shows the importance of the power plants in ensuring the stable power supply to the region.

2.1.3 Benefits for Indonesia

If implemented, this project will provide the following benefits to Indonesia:

(1) Stable power supply

As described in section 2.1.2, the power plant is a vital power plant for the stable power supply to the region. It appears that this project to provide a stable supply of gas to the power plant in the face of impending gas supply shortages may contribute materially to the stable supply of power to the region and contribute to sustainable economic growth in Indonesia.

(2) Model case for small to medium scale LNG receiving terminal

While Indonesia is a gas-producing nation, the supply and demand of gas has grown increasingly tight, making the provision of LNG-related infrastructure a key issue in facilitating LNG imports. At the same time, Indonesia's status as a nation of islands has compelled it to promote LNG transportation using smaller-size LNG tankers to meet the energy demands of eastern regions, which have lagged economically. This means LNG receiving terminals must be of a smaller scale. However, there are numerous examples in which the receiving terminals of terrestrial bases have large CAPEX, making them unprofitable. This has increased the need for floating LNG receiving terminals, but the market for small and medium units targeted in this project is relatively new, with very few actual facilities in use anywhere in the world.

Given this background, the case we considered here involves using a secondhand standard-size LNG tanker as a floating LNG storage facility (FSU) and an LNG regasification plant on an offshore platform (described later in greater detail). This is an alternative for small and medium LNG receiving terminals that can also be used in other parts of Indonesia. Our goal is to build a model case for small and medium facilities through active involvement in problem-solving and by building experience through the EPC, project participation, and O&M aspects of the project.

If this model case can be applied to other locations in Indonesia, it will ensure the viability of small and medium LNG receiving terminals. This in turn will promote the construction of small and medium LNG receiving terminal in island regions and promote the expansion of electricity supply, leading to economic growth and sustainable growth for Indonesia.

2.2 Indonesian national and local government policy trends

Trends in the policies of the Indonesian national government and local governments are described below.

2.2.1 Promoting use of imported natural gas

Indonesia is an LNG-producing nation. From the time it began exporting LNG in 1977 until the mid-2000s, Indonesia was the world's largest LNG exporting nation.

Domestic demand has grown since the mid-2000s, making the balance between supply and demand ever tighter. From 2013, more than 50% of the natural gas produced by Indonesia was destined for domestic consumption. This percentage has risen annually and is predicted to reach 60% (3,926 BBTUD) in 2018. According to the Special Taskforce for Upstream Oil and Gas Business Activities (SKK Migas), this trend is expected to continue.

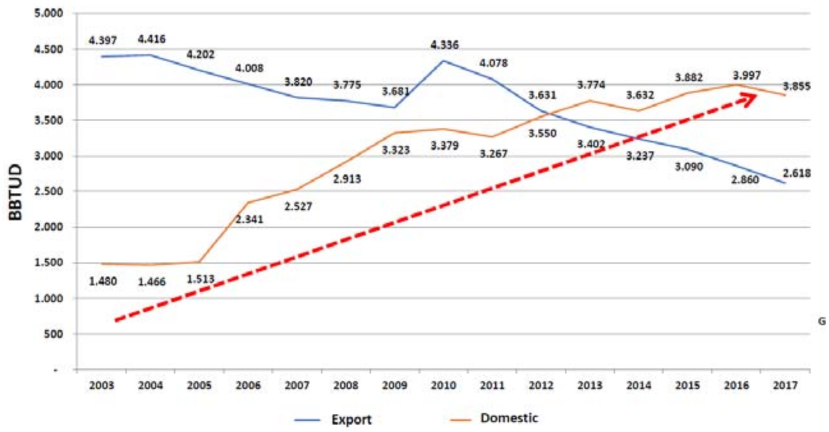


Figure 1 Breakdown of gas distribution (domestic and export)

Source: Excerpt from published documents[1]

More specifically, total gas demand is forecast to grow 5% annually between 2016 and 2030, driven, as in the past, by the need for electricity generation and industry.

1 Directorate General of Oil and Gas, Ministry of Energy and Mineral Resources) (2018): "Moving Ahead with Natural Gas and LNG Utilization for Indonesia" (Bali LNG Conference 2018)

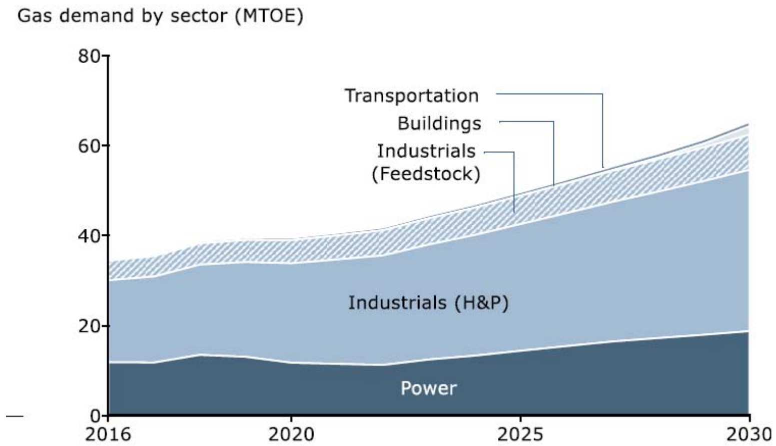


Figure 2 Major gas consumers
Source: Excerpt from published documents[2]

From 2025 on, the supply capacity (including LNG imports) will be unable to meet domestic gas demand.

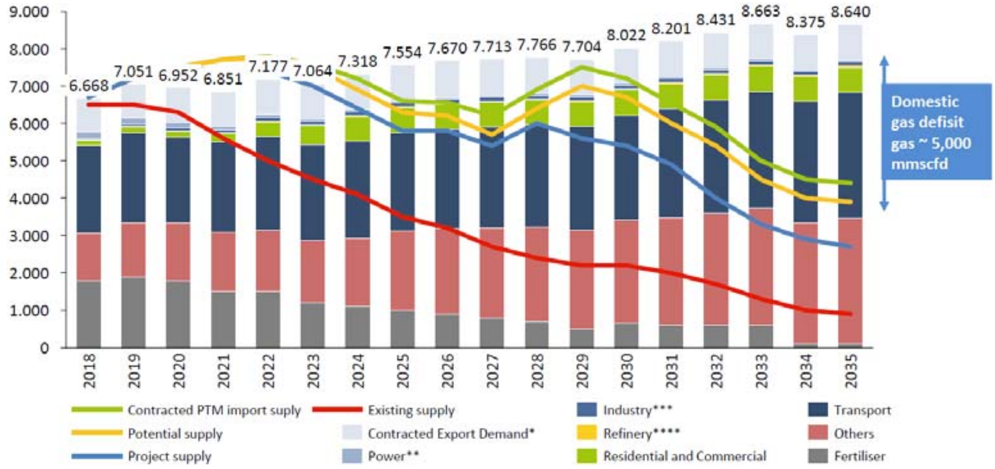


Figure 3 Natural gas supply and demand balance trends in Indonesia
Source: Excerpt from published documents[3]

This has created the need to promote use of imported LNG, which makes developing and strengthening the natural gas infrastructure essential. Specifically, this entails reinforcing infrastructures in the western parts of Indonesia and developing infrastructures in the eastern regions.

2 Pertamina (2018): “Pertamina Gas Roadmap” (Bali LNG Conference 2018)
3 Pertamina (2018): “Pertamina Gas Roadmap” (Bali LNG Conference 2018)

Spurred by the urgency of the natural gas supply and demand situation, efforts are underway in Indonesia to develop new gas fields and increase production. However, most of these efforts are planned for locations outside Java. Larger projects in particular are concentrated in the eastern regions of the country, like Tangguh and Abadi.

SKK Migas intends to allocate surplus from eastern regions to meet supply shortages in western regions, where Indonesia's economy is centered. This makes it necessary to further bolster LNG-related infrastructure (LNG transportation, LNG regasification and storage, and natural gas transportation).

The fact that natural gas production is centered on the eastern regions while more than half of the gas produced is allocated to western Indonesia or to exports is generating local resentment. The Joko Widodo government is seeking to promote the development of the country's outlying regions and developing areas and to reduce poverty and social disparities. These policies are expected to increase the need for LNG-related infrastructures in the eastern regions of the country.

2.2.2 Regulations on midstream and downstream costs

Enacted in 2017 in Indonesia, the Ministry of Energy and Mineral Resources Regulation No. 45 caps the plant gate price of natural gas at the power plant to ICP × 14.5% (USD/mmbtu) (ICP: Indonesian Crude Price). This regulation is a revision of Minister of Energy and Mineral Resources Regulation No. 11/2017, which capped the FOB price of LNG for domestic power generation use at ICP × 11.5% (USD/mmbtu).

Thus, costs related to LNG transportation, regasification, and storage and the cost of natural gas transportation are estimated to be 3%. For example, if the ICP is 70 USD/bbl, the midstream and downstream costs demanded by the Indonesian government are estimated to be 2.1 USD/mmbtu.

This regulation is currently expected to be rigorously enforced. In October 2017, the Indonesian and Qatar governments signed an agreement on the sale of LNG from Qatar to Indonesia. Under this agreement, the price of natural gas produced in Qatar is set to ICP × 14%. Ignasius Jonan, the Minister of Energy and Mineral Resources, commented as follows on this agreement:[4]

> "The Indonesian government will allow the procurement of LNG from Qatar in accordance with the 'Agreement on gas-fired power plant in northern Sumatra'[5] between PLN and Nebras Power. The plant gate gas price is expected to be less than ICP × 14%. We will use domestically produced gas and LNG if the cost is equal to or lower

4 TEMPO (October, 2017): "Govt to Finalize LNG Purchase from Qatar"
Media Monitoring Oil and Gas (October, 2017): "Nebras Guarantees Gas Supply"

5 PLN and Nebras Power (a subsidiary of Qatar's state-owned energy company QEWC, Qatar Electricity & Water Co.) are working jointly to build two 250 MW gas-fired power plants and an LNG receiving terminal in northern Sumatra.

than this figure. There is no problem if imported LNG is cheaper than domestically produced LNG."

This indicates that reducing midstream and downstream costs is vital, but according to PLN's analysis[6] of these costs, it will be difficult to stay within the upper limit of 14.5% if the ICP is assumed to be 70 USD/bbl, and the FOB price of LNG is ICP × 11.5%. Additional efforts will be required.

Specifically, this includes (1) use of FSRU (reducing CAPEX and OPEX) and (2) integration of gas demand and open access to the business model (in which FSRU is positioned as a hub to consolidate dispersed demand in western Indonesia). Offshore terminals make it possible to reduce CAPEX by up to 50 to 75% compared to onshore terminals, making them an ideal solution for Indonesia.

2.2.3 Energy mix policy

As described earlier, a major driving force behind future gas demand in Indonesia is electric power generation.

RUPTL 2018-2027 predicts a 6.86% annual growth in power generating capacity through 2027. The breakdown is as follows, with increasing dependency on renewable energy:

- Coal-fired: Approximately 5% decrease
- Gas-fired: Roughly constant in the low 20% range
- Renewable energy (hydroelectric, geothermal, etc.): Approximately 63% increase

As shown in Figure 4, looking further into the future, demand is expected to shift away from oil and coal toward gas and renewable energy in the years leading up to 2050. However, it will take time to develop renewable energy projects, and the resulting output obtained will not be stable.

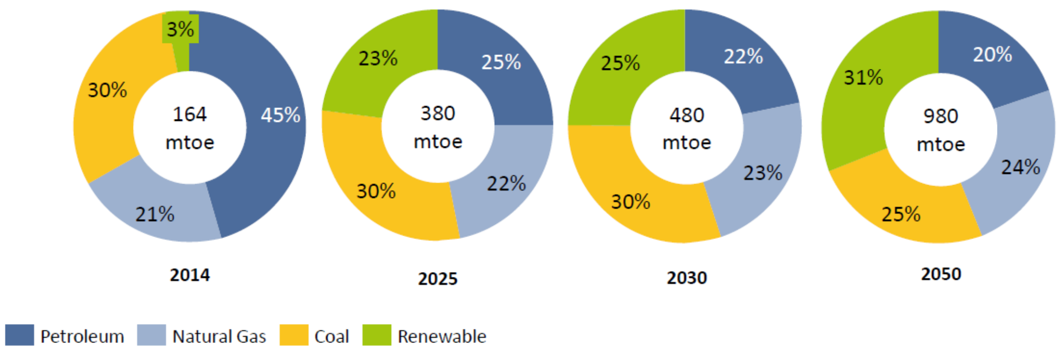


Figure 4 Energy mix trends

Source: Excerpt from published documents[7]

[6] PLN Gas & Geothermal (2018): "LNG for Electricity" (Bali LNG Conference)

[7] Pertamina (2018): "Pertamina Gas Roadmap" (Bali LNG Conference)

Based on these factors, Pertamina predicts natural gas will offer the greatest potential as a replacement energy source.

2.3 Basic infrastructure and system design

2.3.1 Infrastructure and systems required for this project

This project requires LNG regasification plant and gas pipelines, both to be newly constructed.

The LNG regasification plant will regasify LNG and output natural gas in response to demand from gas consumers. For this project, we examined a proposal wherein an LNG storage tanker (FSU) is permanently moored in a bay and an LNG regasification plant is situated on an offshore platform alongside. The proposal accounts for the location of gas consumers, business profitability, and ease of future business expansion. The gas pipelines would transport natural gas from the LNG regasification plant to gas consumers. The LNG regasification plant and gas pipelines are assumed to offer standard functionality and performance.

In addition, we examined the feasibility and effectiveness of the following initiatives to improve business profitability.

2.3.2 Adopting advanced technologies from Japanese firms

(1) AI to optimize LNG receiving scheduling

The LNG value chain, which includes LNG receiving terminals, is constantly subject to gaps between supply and demand, between the volumes supplied to the FSU and gas consumption rates for consumers such as power plants. While LNG is received at intervals of days or even weeks, gas consumption occurs daily. This gap is adjusted by the LNG tanks of the FSU, with LNG from the tanks regasified and output to meet daily gas demand during times when no LNG delivery occurs.

While this gap between supply and demand is unavoidable when handling LNG, it may be possible to minimize the costs for adjusting this supply and demand gap. The key to achieving this is optimizing LNG receiving scheduling. When receiving LNG, the available LNG tank capacity must exceed the volume to be received. If an LNG tanker arrives at a time when the tanks lack sufficient spare capacity, demurrage fees are incurred, adding to business costs. Conversely, if the LNG tanker's arrival is delayed, the LNG available in the FSU may be insufficient to meet sudden increases in demand.

The WinmuSe® artificial intelligence engine developed by JFE Engineering is capable of modeling cause and effect relationships using deep learning techniques that incorporate a wide range of natural conditions and social factors, including seasonal factors, weather, day of the week, and past data for daily fluctuations in electricity and gas demand. Providing WinmuSe® with information such as weather forecasts for several days into the future will allow more accurate predictions of electricity and gas demand over the next several days. These predictions, in turn, will allow the determination of optimal LNG receiving schedules.

This project will use WinmuSe® to predict demand volumes for the several days ahead for various natural gas consumers. This data will be fed back to the FSU to estimate the LNG volumes remaining several days into the future. Figures for remaining LNG volumes will be updated daily, making it possible to calculate when sufficient free capacity will become available in the LNG tanks and allowing scheduling of the subsequent LNG receiving date.

The benefits of using WinmuSe® include minimizing demurrage fees by optimizing the arrival times of LNG tankers at the receiving terminal, as described earlier. The demurrage fees are generally equivalent to charter fees (57,000 USd/day for a 130,000m3 class LNG tanker, as of October 2018, source: Shipping broker), which are extremely costly. Charter fees for LNG tankers have been rising since the middle of 2018 (35,000 USD/day) and may rise further. Taking this into account should be a significant indicator in the savings benefits.

(2) Use of pipeline simulator to optimize operations

Even now, gas pipelines in Indonesia are not operated efficiently, relying on operator experience and intuition. This incurs unnecessary OPEX (electricity costs and fuel costs).

In this project, we plan to apply the Win GAIA® pipeline simulator developed by JFE Engineering to prevent such waste. Win GAIA® simulates the unsteady gas flow inside the pipeline accurately and quickly, providing the operator with three benefits that are: (a) offline planning support; (b) real-time status monitoring; and (c) near-future operation support. (See the following table.)

Table 1 Win GAIA® system configuration

Source: Prepared by JFE Engineering

Operational information	Win GAIA main module	Operation support information
・Supply/demand planning ・Plant planning	(Offline planning support function) Pipeline model creation → Planning support simulation	・Basic operation, examining response for maintenance/emergencies ・Study plans for new demand ・Study future pipeline ・Operational training
SCADA system ・Pressure/flow rate/temperature ・Ancillary plant operation information	(Real-time status monitoring function) Measured data processing → Real-time simulation Real-time simulation → Leak detection Actual demand/ temperature	・Detailed monitoring of entire pipeline ・Accurate amount of line packed gas ・Creating criteria for leak detection ・Creating initial values for near-future prediction simulations ・Leak detection and location identification
Weather information system ・Temperature forecast	(Near-future operation support function) Demand prediction → Near-future prediction simulation	・Optimal operations scheduling to suit demand ・Reduced operational load and refinement ・Optimal margins management ・Creating emergency action plans

In this project, we assume that the LNG regasification plant and pipeline is operated by an operator based on an operational scenario created to minimize OPEX using (c) the near-future operation support function with gas demand predicted by the WinmuSe® AI engine described previously. Note that it is also possible to use (b) the real-time status monitoring function together to adjust and optimize the scenario, instantly and in real time, if the actual status departs from the conditions assumed in the scenario (e.g., gas demand). We will seek to minimize OPEX using this combination of functions.

One issue with using Win GAIA® is that it has yet to be deployed with an LNG regasification plant. However, the scenario which Win GAIA® will propose is the degree of opening of the pressure control valve at the outlet of the LNG pump in the LNG regasification plant. Whether the flow medium is liquid or gas, the pressure control valve typically used in a pipeline is almost same. Thus, we do not believe this would be a cerious issue which prevents Win GAIA® from being employed in the FSU. Moreover, the pipeline itself is extremely simple, posing no practical issues to applying Win GAIA®. Win GAIA® is capable of simulating the flow of gas inside a complex intersecting network of multiple pipelines — for example, the town gas pipe network in the Tokyo area. It should be easily capable of simulating a pipeline with a single inlet and single outlet as in this project.

(3) Next-generation electric resistance welded pipe

Electric resistance welded pipes are steel pipes fabricated by rolling hot-rolled steel plate into a circular arc, then welding the two edges together using high-frequency resistance welding. Compared to welded pipes (e.g., UOE), they are approximately 20% cheaper. Since steel pipes account for reasonable portions of pipeline construction costs, this will have a significant impact on business feasibility.

However, electric resistance welded pipes are typically not used for pipelines transporting hazardous substances like oil or natural gas for two reasons: (1) the weld tends to suffer significantly reduced toughness due to the effects of oxides formed during the welding process; (2) there are concerns related to groove corrosion caused by potential differences between the structure of the parent metal and the weld, depending on thermal history. The Mighty Seam™ next-generation electric resistance welded pipe developed by JFE Steel addresses these concerns by precisely controlling thermal input rates during welding. Additionally, JFE Steel’s proprietary ultrasonic inspection technology detects defects, ensuring high quality. These pipes have already beenused in seasea oil pipelines in the North Sea.

We do not foresee technical issues for using Mighty Seam™ pipes in this project, since the conditions are considerably more favorable than the North Sea, where the product has already been deployed. The pipes will transport the natural gas regasified from LNG which contains virtually no sulfur or moisture, factors that contribute to corrosion. Additionally, the seasea pipeline will be laid at relatively shallow depths. No significant stress will be imposed on the pipes during pipelaying. The sea conditions are extremely calm, with wind speed equivalents to a typhoon in Japan anticipated once in 100 years.

With respect to costs, while Indonesia has steel manufacturers that fabricate line pipes, they tend to be uncompetitive with respect to price. Thus, Mighty Seam™ appears competitive, even in the Indonesian market.

2.3.3 Partnering with third-country companies

The market for offshore LNG regasification modules is dominated by the Nordic conglomerate Wärtsilä. Prices are inflated due to the absence of competitors. Other companies within the field have attempted to compete against Wärtsilä, but with little success.

One company that is trying to compete with Wärtsilä is Company A of the Philippines. Company A is among the world's leading manufacturers of oil and gas plant modules. It has extensive experience in upstream facilities, including FPSO, but less experience with LNG regasification processes. In a joint effort to break the Wärtsilä's grip on the market, JFE Engineering has established a partnership with Company A in which it will contribute its own extensive experience with process design for onshore LNG receiving terminals.

In this project, JFE Engineering plans to work with Company A to build cheaper LNG regasification modules than those from Wärtsilä and to install these on an offshore platform.

2.3.4 Optimizing operations and maintenance to improve mid/long-term profitability

The project will be led by JFE Engineering. Accordingly, JFE Engineering will be responsible for operations and maintenance of the LNG regasification plant and gas pipeline over the mid to long term.

To improve project feasibility, we may ask Japanese utility companies (for example, power generating companies and gas utility companies) with extensive experience in operating and maintaining LNG receiving terminals participate in this project. Fortuitously, these companies are currently implementing cost-cutting methods at unprecedented levels following deregulation of the power and gas utility markets in Japan. They have accumulated knowledge on methods that are quite likely to prove especially relevant to the current project.

The following section discusses potential issues with applying the expertise of Japanese businesses to this project and the measures required to do so.

In Japan, the electricity required for an LNG receiving terminal would normally be purchased from a power company or, if built next to a gas-fired power plant, supplied from that plant. However, the electrical power infrastructure in Indonesia is less robust. Power outages occur frequently. Given the circumstances, if the electricity for an LNG receiving terminal were drawn from the PLN grid, measures account for and protect against frequent power outages would become necessary. This would complicate operations and maintenance, add to the instability of the gas supply, and ultimately impair project profitability.

Thus, plans to operate an LNG receiving terminal in Indonesia must consider the option of on-site power generation. In the case of a floating LNG regasification plant (FSRU), the tanker would almost certainly have its own power generating facility. Likewise, given the risks power outages pose for profitability, we will propose installing a power generating facility on the LNG storage facility (FSU) in this project which calls for a floating LNG storage facility (FSU) and an LNG regasification plant berthed offshore.

2.4 Information, investigations, and analysis needed to draft the proposal

2.4.1 Market size and demand forecasts

In January 2015, the Indonesian government announced a five-year infrastructure development plan totaling IDR 5,500 trillion (approximately JPY 50 trillion). The major infrastructure projects covered by this plan include power plants, transportation (new ports and new airports), roads, and water treatment plants, as well as LNG receiving terminals for power plants, the latter given a prominent position for reasons described above.

Table shows data extracted from the "Gas Infrastructure Roadmap 2016-2030" published by ESDM. Projections indicate a total of 80 receiving terminals will be needed by 2030.

Table 2 Plans to build LNG receiving terminals in Indonesia
Source: Prepared by JFE Engineering based on information provided by ESDM (Bali Conference 2016)

	Period I						Period II	Period III
	Existing	2016	2017	2018	2019	2020	2021-2025	2026-2030
Offshore [Units]	2	2	5	9	10	11	11	12
Onshore [Units]	1	17	24	46	62	64	66	68

In the plans shown above, plans call for five times as many onshore receiving terminals as offshore terminals. However, the number of offshore terminals currently operating significantly exceeds the number of onshore terminals (Table 3). (Only one facility in Aceh is an onshore facility. This was originally an LNG liquefaction facility, so all purpose-built facilities can be considered offshore facilities.) This is because locating facilities offshore sidesteps issues associated with land acquisition, allowing faster startup. Onshore facilities tend to be less profitable unless the site is sufficiently large (sufficient gas demand can be secured) due to large initial investment costs, in addition to problems associated with land acquisition.

Table 3 Summary of LNG receiving terminals currently operating in Indonesia

Source: Prepared by JFE Engineering based on information from Global Data

Site name	Operation start year	Capacity [mmscfd]
West Java	2012	400
Aceh	2015	400
Lampung	2014	240
Bali	2016	50

Since LNG receiving terminals pose an urgent issue, it is highly likely that the trend toward offshore facilities will continue. The current project involves using a secondhand LNG tanker as a floating LNG storage facility (FSU) and mounting an LNG regasification plant on an offshore platform. These plans are consistent with the preceding trend and may come to represent a model case for deployment to other regions, including the eastern parts of Indonesia.

Note that ESDM regulations set the priority for the distribution of gas produced in Indonesia. (See Table 4)

Table 4 Comparison of current and past regulations governing gas distribution

Former regulations (ESDM 2010 No.3)	Current regulations (ESDM 2016 No.6)
1. Increased oil/gas production 2. Fertilizer industry **3. Power generation businesses** 4. Other industries	1. Government plans (for transportation, households, small-scale users) 2. Increased oil/gas production 3. Fertilizer industry 4. Gas industry (use of gas raw material) **5. Power generation businesses** 6. Gas consuming industry (use of gas as fuel)

Major gas off-takers for the purposes of this project are assumed to be power generation businesses. Power generation businesses consistently are granted high priority for gas distribution.

As shown in Figure 5, Indonesia currently plans to build more than 70 LNG receiving terminals. The market is very likely to continue growing into the future.

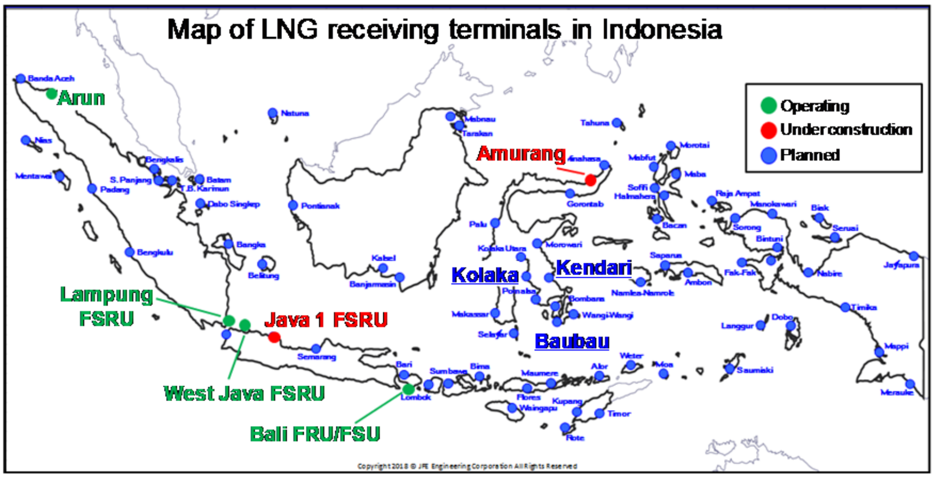


Figure 5 Map of LNG receiving terminals in Indonesia

Source: Prepared by JFE Engineering based on information from 8th Bali LNG Conference (held September 2018) provided by ESDM, state-owned oil company, state-owned gas company, and state-owned power generating company

2.4.2 Economic assessment

We assessed this project using a specially-created economic model together with preconditions.

(1) Assumptions

Table 5 lists the preconditions assumed for the economic assessment.

Table 5 Preconditions assumed for economic assessment (Prepared by JFE Engineering)

Project period	30 years
EPCC period	Approx. two years
Project cost	USD 39.3 million - CAPEX: USD 38 million - Working capital: USD 0.8 million - Construction interest: USD 0.5 million
Debt equity ratio	8/2
Operating and maintenance cost	USD 4 million/year
Corporate tax rate	25%
Value-added tax	10%
Land and building tax	0.2%
Interest rate	5.5%

For a detailed breakdown of CAPEX and OPEX, refer to Chapter 12.5 エラー！参照元が見つかりません。エラー！参照元が見つかりません。.

(2) Assessment results

The following table addresses project profitability.

Table 6 Project profitability (Prepared by JFE Engineering)

Project-IRR	15.6%
Payback period (after tax)	Nine years

Note that the estimates and preconditions make certain assumptions and incorporate uncertainties. More detailed studies will be needed in the future.

2.4.3 Risk analysis

Implementing this project entails a number of conceivable risks. The project should be implemented in accordance with the basic principles of risk control, whereby the party most suitably positioned to minimize risks bears the burden of taking on risks or the related parties strive to share risks to the extent reasonably possible.

Table 7 sets forth the main risks, the probability and severity of their occurrence, and the corresponding corrective actions.

Table 7 Major risks, risk probabilities/effects, and countermeasures (*: High/Medium/Low ; **: High/Medium/Low)

Major risk	Probability *	Impact**	After countermeasure (Risk probability/ degree of effect)	Countermeasure
Interface with FSU	M	H	M/L	・ Specify interface conditions in the terminal usage agreement with Company P. Stipulate PDG's responsibility to send LNG to BL in accordance with the conditions specified. ・ Take steps to ensure that a fixed amount is paid in accordance with the use-or-pay agreement, even if supply of LNG to a regasification facility falls behind schedule. ・ If SPC sustains lost profits due to an FSU accident and the loss cannot be fully offset by the fixed amount specified in the use-or-pay agreement, the difference should be made up through contingent business interruption insurance.
Interface with power plant	M	H	M/L	・ Designate an LD upper limit in the contract with Company P. ・ Specify interface conditions in the terminal usage agreement with Company P. Stipulate Company P's responsibility to receive gas at BL in accordance with the conditions specified. ・ Take steps to ensure that a fixed amount is paid in accordance with the use-or-pay agreement even if acceptance of gas falls behind schedule for reasons of the power plant. ・ If SPC sustains lost profits due to a power plant accident and the loss cannot be fully offset by the fixed amount specified in the use-or-pay agreement, the difference should be made up through contingent business interruption insurance.
COD delay attributable to JFE Engineering	M	H	M/M	・ Designate an LD upper limit (base usage fee × 90 days*) in the contract with Company P. * This condition was applied in the past to a similar project in Indonesia. ・ In addition, impose LD of at least equal amount on EPC contractors. ・ Consider taking out advance loss of profits insurance to cover portions not covered by LD for delays caused by accidents.

Major risk	Probability *	Impact**	After countermeasure (Risk probability/ degree of effect)	Countermeasure
COD delay attributable to Company P or other companies	M	H	M/M	・ Include the relevant provisions in the contract with Company P. ・ Collect from Company P the amount to be paid to contractors during the waiting period. ・ Clearly define COD and Final Acceptance conditions. ・ Consider taking out advance loss of profits insurance to cover portions not covered by LD for delays caused by accidents.
Power plant's inability to receive electricity/gas after operation commencement due to *force majeure* (natural disaster, extraordinary weather/climatic factors, fire, lightning strike, explosion, earthquake, other accidents)	L	H	L/L	・ Company P should assume responsibility for the fixed-amount portions (fixed expenses) after the 14-day grace period. ・ Obtain contingent business interruption insurance.
Lost profits due to operation shutdown or failure after operation commencement due to damage to SPC facility caused by *force majeure*	L	H	L/L	・ Obtain property damage insurance. ・ Obtain business interruption insurance.
COD delay due to damage to the power plant caused by *force majeure*	L	H	L/L	・ Deemed commissioning after the grace period if repairs of damage to the power plant cannot be completed on time. If COD is delayed by more than 180 days, the right to rescind the transaction shall arise. In such cases, have Company P make the purchase at the following amount: principal and interest + investment

Major risk	Probability *	Impact**	After countermeasure (Risk probability/ degree of effect)	Countermeasure
				cost + 15% of profit.
COD delay due to damage to SPC's facility caused by *force majeure*	L	H	L/L	・ Contractor's all risk insurance to cover CAPEX-equivalent value ・ Change the COD and extend the contract period. ・ If project completion is delayed for reasons that cannot be insured, negotiate to establish a new construction timeframe and toll fee. If an agreement cannot be reached, SPC has the right to rescind the transaction. ・ Impose LD of at least equal amount on EPC contractors. ・ Consider taking out advance loss of profits insurance to cover portions not covered by LD for delays caused by accidents.
COD delay due to governmental *force majeure* (for example, revised laws)	L	H	L/L	・ Change the COD and extend PPA periods. Deemed commissioning if SPC cannot perform the completion test. ・ If costs increase, raise the toll fee. ・ If COD is delayed by more than 180 days, SPC should withdraw from the contract. In such cases, have Company P make the purchase at the following amount: principal and interest + investment cost + 15% of profit.
Lost profits due to governmental *force majeure* (for example, revised laws)	M	H	M/M	・ If costs increase, raise the toll fee. ・ If electricity cannot be sold, use deemed dispatch to pay for the fixed expenses. If electricity cannot be sold for a period of 180 days or more, terminate the PPA and purchase the facility (principal and interest + investment cost + 15% of profit).
Payment in rupiah	H	M	H/L	・ Discuss with Company P regarding the currency of contract (US dollar) and the currency of payment (rupiah), and incorporate them in the terminal usage fee agreement. * In previous PPA between PLN and IPP, completely-dollar-linked rupiah was used for the payment of capital and transmission cable installation cost. ・ Exchange rupiah to US dollar immediately after receiving payment from

Major risk	Probability *	Impact**	After countermeasure (Risk probability/ degree of effect)	Countermeasure
				Company P (retain the amount of rupiah necessary for the payment of wages to local workers and others).
Decreased profitability due to inflation	H	M	M/L	・ Adjust the terminal usage fee in step with inflation.
OPEX reduction	M	H	L/L	・ Borrow accommodation from an FSU. ・ Minimize the number of operators. ・ Cut management personnel expenses (employment of Indonesians). ・ Install a BOG recondenser. ・ Use a seawater-type vaporizer. ・ Include consumables for a period of three years within the scope of EPC contractors.
Delay in acquisition of approvals/licenses	M	H	M/M	・ Include the acquisition of approvals and licenses within the scope of EPC contractors. ・ Include EIA in the scope of Company P.

2.5 Calculating business scale (including operating and maintenance expenses)

(1) Initial investment costs

The initial investment costs for a complete LNG regasification facility installed on a platform are approximately 12 million US dollars.

The total cost of constructing a platform and pipeline is 25 million USD.

The expenses incurred in the marine geological survey, marine topography survey, environment assessment, acquisition of approvals and licenses, and the meteorological/maritime meteorological survey total 0.7 million USD.

The total initial investment for the project is estimated to be 38 million USD, with tolerances in the range of +50% to −30% given the factor method used to estimate the cost of the main project equipment.

(2) Operating and maintenance expenses

The anticipated project operating and maintenance expenses (operators expenses, repair and maintenance expenses, insurance, electricity expenses, SPC expenses, Head office expenses, etc.) are approximataely 4 million US dollars.

2.6 Financing study and proposals

With regard to procuring the necessary funding for this project, we have presented the project business model and other information to a commercial bank, and confirmed loan conditions.

We concluded that corporate finance would be the appropriate funding scheme for this project.

Table 8 Confirmation of loan conditions for corporate financing

	Confirmation item	Result of confirmation
Loan eligibility	Loan eligibility for corporate financing	・ If the funding scale is between 30 million to 40 million USD, corporate financing is appropriate. ・ There are no credit enhancement issues in the case of sole funding by JFE Engineering (without the participation of Indonesian companies). ・ Clarifying the scope of responsibility on the FSU side and on the power plant side is essential.
Required steps	Steps to take	・ Unlike project financing, corporate financing requires no determination process and generally takes one to two weeks to sign the loan contract (actual times period can vary from project to project). ・ The typical steps are given below: ✓ Submit necessary documentation from JFE Engineering. ✓ Based on the above, internal adjustments are made and a proposal prepared (loan amount, loan period, interest rate, etc.). ✓ Upon receiving the proposal, JFE Engineering and the bank exchange views and adjust conditions.
Documentation	Information required for screening	・ The most important item examined for corporate financing is the credit standing of the guarantor (JFE Engineering or its parent company). ・ However, no loan is granted to a project that is expected to default. Thus, the following information is also carefully reviewed (including some information yet to be determined): ✓ Project business plan (project scheme, economic model, risks, etc.) ✓ Contract specifics (in particular, terminal usage agreement, EPC contract, shareholders' agreement) ✓ Partner and offtaker's credit risks ✓ Term sheet of shareholders' agreement and other factors

	Confirmation item	Result of confirmation
Key points of the assessment	High priority examination items	・ The most important item examined for corporate financing is the guarantor's credit. ・ In addition, since covenants (net debt/EBITDA, etc.) are also set for corporate financing, profitability is important.
Loan period	What is the loan period?	・ The loan period for corporate financing is typically three to five years but may exceed five years, depending on the specifics of the parent company's guarantee. ・ If the loan period exceeds five years, however, the loan is likely to be structured on the assumption of refinancing.
Repayment method	What are the repayment rules?	・ In the case of corporate financing, the standard repayment method is either principal and interest equal monthly payments or principal equal monthly payments, but, as in the case of project financing, debt sizing is also possible.

2.7 Potential use of Government supportive tool

The middle-class in Indonesia is growing, increasing the numbers of individuals receiving higher education. Although employment conditions are favorable in the country, workplaces are rarely equipped with advanced technologies. Because Indonesia has been an LNG exporting country, the country only recently began constructing, owning, and operating LNG receiving terminals. Thus, Indonesia does not possess the advanced technologies necessary to receive LNG, unlike Japan, which is a major LNG importing nation. In discussions with Indonesia's Coordinating Ministry for Maritime Affairs and ESDM regarding this project, we received many strong requests for the packaging small-scale LNG receiving terminals.

Based on the above, we evaluate what Japanese companies should do in near future and how governmental should assist them.

(1) Packaging a small-scale LNG receiving terminal design (regasification facility) and related issues

Large-scale receiving terminals are the mainstream in Japan, but Indonesia requires smaller terminals that can be constructed faster and use low-cost equipment. An LNG receiving terminal of this scale is generally considered as a satellite terminal or secondary terminal.

Packaged terminal facilities are preferred and JFE Engineering has received many related inquiries, however, we encountered the following issues:

① Standardization based on international standards

Satellite/secondary terminals in Japan are designed and constructed to comply with the JIS standard under the Electricity Business Act or Gas Business Act. For installation in Indonesia, we would need to ensure compliance with international standards (API, ASME, ANSI).

② Creating design procedures and manuals

Customization is performed based on standard package; however, intentions are not readily understood if no design guidelines, procedures, manuals are provided. There is a need for reference documents.

③ Developing human resources and transferring technologies

Even if the abovementioned documents are available, technologies cannot be transferred overnight. Design documents for a standard package are merely basic design documents. Creating drawings (detailed design documents) to build a facility in compliance with local laws and regulations requires supervision by engineers or specialists. Indonesian engineers can gain some basic knowledge through higher education, but they will need instruction and guidance to acquire the technologies required but not widely diffused in Indonesia.

④ Quality control/assurance

Design documents for facility construction created by local engineers must be reviewed. It will take some effort to enable Indonesian engineers to prepare design document. It is required to clarify the conformity of purchased equipment with specifications, including welding quality (so-called QA/QC).

⑤ Licensing

Such effort entails time and money. A company will not take a first step unless it expects to recover its investment. A solution to this issue is licensing.

(2) Pilot project

A pilot project is a potential way to resolve these issues systematically. The purpose of a pilot project is to benchmark CAPEX, OPEX, schedule, profitability, and other aspects. Since the availability of materials, levels of engineers, and applicable regulations and standards vary from country to country, equipment cannot be constructed in the same way as in Japan. From the standpoint of technology providers, we cannot simply hand over drawings and let local companies construct a facility on their own. We must provide instructions and manage the QC/QA; we must confirm that the design documents are understood and that construction is performed correctly. For this reason, when technologies are transferred from one country to another country, pilot projects are often initiated to custermize the standardized package in order to make the technology suitable for the country.

By giving this project a benchmarking function in addition to performing "packaging of small-scale LNG receiving terminal," the project will serve as a model for medium/small-size LNG receiving terminals, as described in the section 2.1.3 (2).

① Benefits for Japanese companies

In most of the cases, companies have to go through bidding process to participate in LNG receiving terminal business. However, a bidding process may not be necessary for a pilot project carried out in collaboration with a university for benchmarking purposes. We believe such pilot projects will provide advantages in participating such business to Japanese companies offering advanced technology advantages.

Japanese companies can utilize retired engineers as supervisors responsible for providing guidance and instruction to Indonesian engineers. In return for dispatching such personnel, companies can receive license fees when the pilot project leads to a full-scale project.

② Benefits for Indonesia

The Indonesian government and educational institutions can acquire technologies related to small-scale LNG terminals the country will need in the future; they can also develop valuable human resources capable of engaging in the construction of such terminals. The plant constructed in a pilot project through BOOT (Build, Own, Operate, and Transfer) contracts will ensure future ownership by Indonesian entities. The government can use the benchmarking values obtained from pilot projects for planning policies, regulations, and standards.

(3) The Association for Overseas Technical Cooperation and Sustainable Partnership (AOTS)

The cooperation of the government is essential to materialize the above. However, whether it is possible to incorporate this cooperation into an existing program depends on the outcome of further discussions with stakeholders. A potential mechanism available today is AOTS. Collaboration with a state-owned company, university, graduate school, or vocational training school will reduce the burdens on the company and help create systematic programs. ESDM is considering establishing a vocational training school in Bandung with the goal of promoting industrial development in the nation. This move would be welcome.

2.8 The competitive edge of Japanese companies (competitors' trends and competitive edge over competitors, if necessary) and forecasting benefits (economic consequences) for Japan

2.8.1 The competitive edge of Japanese companies

(1) Competitive edge of WinmuSe®

To find information on trends in other companies concerning the application of artificial intelligence technologies similar to WinmuSe® to the LNG value chain, we searched the Internet using keywords like "Artificial Intelligence" and "LNG." Although we found several articles that appeared to be academic abstracts describing concepts, only three websites posted information on practical applications or commercialization.

Table 9 Introducing artificial intelligence into the LNG value chain by other companies

Source: Corporate websites of each company

Company	Introduction period	Description
Chiyoda Corporation	Undecided	The company signed a memorandum of understanding with ADNOC LNG in U.A.E. to provide the most advanced digital technologies such as AI and big data analysis for ADNOC LNG's LNG liquefaction plant, with the goal of optimizing plant operations/maintenance and improving production efficiency. Announced on May 2, 2018
Chiyoda Corporation	Undecided	The company launched AI development of the Donggi-Senoro LNG liquefaction terminal in Indonesia for commercial purpose. AI is used to identify the most suitable operation parameters under continuously changing operating conditions at the terminal by analyzing past operations data, thereby improving production efficiency and increasing LNG production volumes. Announced on August 6, 2018
JGC Corporation	Undecided	The company agreed to collaborate with Petronas to improve the productivity of the air-cooled LNG liquefaction plant in Malaysia. The company plans to create a hot air recirculation (HAR) prediction system using AI and IoT. Announced on August 6, 2018

These projects, all of which were undertaken, incidentally, by Japanese companies, seek to apply artificial intelligence for LNG liquefaction plant operations. They do not compete with our project facility consisting of an LNG receiving terminal and pipeline. While the objectives of those three projects are to optimize the operations of LNG liquefaction plants, JFE Engineering's WinmuSe® is designed to achieve not just the optimization of operation of an LNG receiving terminal and pipeline themselves, but to enhance operations by forecasting natural gas consumption by end users (thermal power plants, city gas, industrial parks, etc.). Since JFE Engineering's technology differs from the above three technologies in terms of objective, it has no competition and provides benefits not offered by the others.

(2) Advantage of using Win GAIA®

Pipeline simulators potentially competitive with Win GAIA® include Pipeline Studio (ESI in the US) and Atmos SIM (Atmos in the UK). Both simulators are also used in pipeline operations outside Japan.

Since the technical information disclosed by the competitors is limited, we were unable to determine facts that attest to the advantage of Win GAIA® over the others. As for computational speed, however, we estimate that Win GAIA® is faster than the others due to the algorithm used. Moreover, only Win GAIA® is equipped with a demand forecast function. We believe Win GAIA® has an edge over the others, at least with respect to these two features.

2.8.2 Forecast of benefits (economic effect) for Japan

This project is a long-term project encompassing various processes and activities ranging from project development to investment in the LNG receiving business for which Japan boasts the world's most extensive track record. By participating from the project development stage, Japan can incorporate its extensive experience and knowhow into the project and look to medium-/long-term profits through terminal operations/maintenance and business management.

The project will contribute to the concretization of the infrastructure export strategy formulated by the Japanese government. However, employing the system and method commonly used in Japan for the project in Indonesia will result in high costs and potentially increase the cost of gas. Thus, we examined how we could maximize the benefits for Japan while meeting the needs of gas consumers and the Indonesian government.

(1) WinmuSe® and Win GAIA®

To protect technology rights, work related to software improvement and update will continue to be conducted in Japan. This is unlikely to hinder the acquisition of business opportunities.

The key to maximizing benefits for Japan is feedback from users in Indonesia. Factors that affect natural gas demand in Japan differ from those in Indonesia (see section 2.3.2 (1)). This means feedback from users in Indonesia may differ dramatically from the feedback received from customers in Japan. New opinions and comments from Indonesia may help us recognize areas requiring improvements and create opportunities to explore new customer bases inside and outside Indonesia.

We believe it is preferable to assign Indonesians to the task of receiving feedback from users in Indonesia. Since the same members will also be responsible for responding to troubleshooting requests, we need to establish a system that allows the prompt dispatch of technicians to sites in the event of problems. Communication using the Indonesian language will also result in more accurate feedback.

Indonesia currently has plans to build LNG receiving terminals at more than 70 locations (see section 2.4.3). Assuming that WinmuSe® and Win GAIA® are employed by 20 (approx. 30%) of these, the expected license fees will total a couple of billion yen. If they gain widespread deployment in other pipelines in Indonesia, licensing fees will increase beyond this.

(2) Mighty Seam™

As stated earlier, use of this next-generation electric resistance welded pipe is growing steadily around the world for applications such as submarine pipelines in the North Sea. We can think of no factors that would impede its dissemination in the Indonesian market.

At this point in time, we cannot foresee the benefits of manufacturing this line pipe in Indonesia for cost reduction purposes. This is due to the relatively weak cost competitiveness of steel makers in Indonesia as described in 2.3.2 (3). Furthermore, there is a risk of leakage of manufacturing technology, always a major concern with technology transfers.

We believe we can maximize benefits for Japanese companies by using Mighty Seam™ in this project and widely advertising its performance and quality to industrial sectors in Indonesia—for example, by introducing Mighty Seam™ and its application examples in industry magazines and other media published in Indonesia.

Plans in Indonesia call for LNG receiving terminals to be built at more than 70 locations (see section 2.4.3). Assuming that Mighty Seam™ are employed by 20 (approx. 30%) of these, Japanese companies may achieve sales of a couple of billion yen. Wider acceptance and expanded applications including non-LNG terminal pipelines would naturally lead to greater sales in this country.

(3) How to make Japan's LNG-related technologies penetrate in Indonesia

Indonesia has plan to build LNG receiving terminals at more than 70 locations (see Figure 5). The Indonesian market offers great business potential for Japanese companies offering outstanding LNG-related technologies.

The country needs LNG receiving terminals because Indonesia's economic development has boosted energy consumption. The growth in energy demand, coupled with the rise in crude oil prices, adverse situations for coal-fired power plants, and declining production from existing gas fields, has compelled Indonesia to allocate LNG to domestic consumption, rather than exports to Japan and other countries. The Indonesian government and state-owned companies (for example, Pertamina Gas, PLN, and PGN) have unanimously expressed the need to construct LNG receiving terminals at various opportunities.

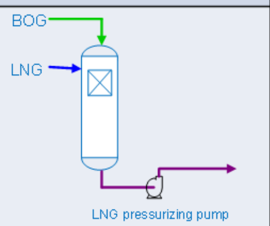
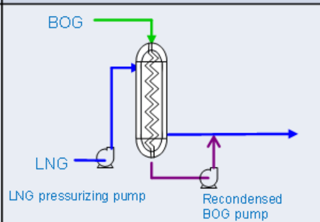
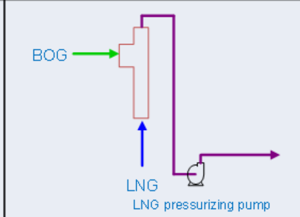
LNG/natural gas demand in Indonesia, however, differs significantly from that in Japan. We must appropriately take into account the following characteristics.

① Demand per one location is very small. (Large demand exists only in some large cities.)
② There are many sites of small-scale demand, scattered throughout the nation.
③ A majority of demand areas are far from LNG liquefaction terminals and separated by the sea.
④ Most demand is consumed for power generation. Petroleum is currently used as fuel. Generators can use either petroleum or gas for generation.

To promote their products in the Indonesian market, Japanese companies at the same time must make their equipment and devices smaller and reduce costs. As mentioned earlier, there are cases in which entire LNG receiving terminals were constructed as floating facilities to reduce costs. The equipment and devices used in those terminals must obtain type approval from classification societies.

An example of JFE Engineering's LNG-related technologies that achieve the above is the super-compact BOG recondenser (see the figure below). Although we do not plan to install this product in this project (to minimize the business operator's risks), it represents a technology that would help reduce the size and cost of LNG regasification facility and aptly meets the needs of Indonesia.

Figure 6 Super-compact BOG recondenser (comparison with conventional equipment)
Source: Prepared by JFE Engineering

	Conventional equipment		JFE Engineering's development (Lower cost, smaller installation area)
BOG recondensation system	Packed-bed type (Mainstream type in overseas markets)	Heat exchanger type (Mainstream type in Japan)	Super-compact type (Static mixer type)
System configuration			
Reference image			
BOG recondenser dimensions	Height: 5.2 m, Diameter: 1.6 m Weight: 7 tons	Length: 12 m, Diameter: 1 m Weight: 15 tons	**Length: 2.6 m, Diameter: 0.3 m** **Weight: 0.3 tons**

One can easily imagine that if other Japanese companies can achieve breakthroughs in their technologies, they will have better chances of achieving business success in Indonesian and stand to gain larger benefits.

2.9 Surveys necessary to enhance the value of the project proposal and responding to requests and comments from representatives of the host country during the project phase

We received the following two requests from stakeholders. We undertook the necessary surveys to provide thorough and rational explanations.

(1) CAPEX/OPEX reduction

Despite the rising cost of electricity generation in Indonesia, the government is refraining from increasing the electricity prices to consumers. Consequently, PLN's financial state has steadily declined. Against this backdrop, upper limits have been set on the price of gas for power generation applications in Indonesia, and PLN is making urgent requests for lower gas prices.

The project operator, on the other hand, wants to reduce CAPEX and OPEX to secure profitability without compromising the reliability of the technology. We undertook a thorough review of this aspect, the specifics of which are described in Sections 2.3 and 2.5.

(2) Reliability of the technology

Since the project terminal supplies gas to power plants, major elements of the social infrastructure, the reliability of the technology is critical. JFE Engineering possesses extensive knowledge in constructing LNG receiving terminals and pipelines, allowing it to identify and avoid potential issues during the planning stage.

For this project, we focused on process optimization and adaptability to gas demand at power plants and identified methods for improving reliability to ensure a stable gas supply.

Among the several maintenance-related analysis methods, RAM study is the most commonly used in the energy industry.

RAM (Reliability, Availability, Maintainability) studies are used to analyze risks associated with maintenance. This method involves analysis of maintenance and operations records/data and formulating plans for effective maintenance and operations (*1).

Indonesia currently has four LNG receiving terminal projects. Only one is a small-scale receiving terminal. For this terminal, no RAM study was implemented. In anticipation of growing numbers of small-scale LNG receiving terminals, we believe that introducing RAM study to this project will improve energy supply stability and contribute to the nation's sustainability.

RAM study assesses whether expected equipment/plant reliability can be maintained using evaluation indices, such as operating hours, maintenance efficiency, and production efficiency. The results are applied to plan and implement improvement measures (*1).

Reliability is assessed based on operating hours (mean time between failures). Maintainability indicates the level of maintenance difficulties determined based on equipment repair hours (mean time to repair).

Plant planning is enriched by using the results of a quantitative analysis such as Monte Carlo simulations. The method is to rank the impact of the reductions in availability of each plant component by analyzing the failure rate and average repair time. Highly critical components will be made redundant.

Plant availability has a major impact on business profitability. In making final investment decisions, if availability derops below a certain level, profitability worsens.

A RAM study is often performed at the basic design stage as well as immediately after project completion. We obtained partner agreements on cooperating with information collection efforts.

(*1): Plant Life Cycle Management (PLCM), JGC Information Systems (presently Fujitsu Engineering Technologies)

2.10 Potential for rolling out the technology to other countries/regions and roll-out promotion plan

2.10.1 Potential for technology dissemination to other countries/regions

Presently, the total amount of LNG imported into Asia is 185 MTPA maximum per year. This accounts for a 70% share in the global LNG market. Global LNG demand is forecast to reach 470 MTPA by 2035 (200 MTPA in 2010, 100 MTPA in 2000), and demand growth is largest in the Pan-Pacific region (increase by more than 100% during the period from 2015 to 2035).

Japan, China, and India are major LNG importing countries. As the use of coal declines, LNG demand is anticipated to increase significantly. (In addition, LNG is becoming increasingly important in Singapore, Thailand, Philippines, and Vietnam.)

Table 10 LNG supply-and-demand balance[8] in main regions

	Pacific	Atlantic	Middle East
Supply (MT)	220	215	105
Demand (MT)	400	110	30
Supply-and-demand balance (MT)	180	100	75

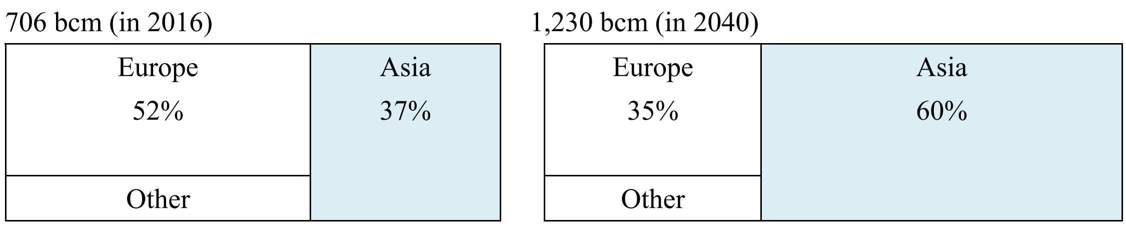


Figure 7 Summary breakdown of natural gas imports by region
Source: Excerpt from published documents[9]

Moreover, engineering innovations in recent years have reduced US shale gas production costs (currently less than break-even cost of $4/mmbtu) and increased production output (from 5 tcf in 2010 to 13.6 tcf in 2035). As a result, exports from the US to Pan-Pacific markets are expected to increase.

Against this backdrop, LNG receiving terminal projects totaling more than 260 MTPA are planned in the Pacific region by 2030. This creates a potential need for advanced technologies in various countries.

[8] Galway Group (2018): "FSRU outlook and Opportunities in South East Asia" (3rd FSRU and Small-Scale LNG Shipping Forum 2018)
[9] Nusantra Regas (2018): "FSRU as an effective LNG integrated system" (3rd FSRU & Small Scale LNG Shipping Forum 2018)

2.10.2 Planning the roll-out of technologies to other countries/regions

The need for LNG receiving terminals is growing in Asia, but the numbers of LNG receiving terminals are not actually increasing to meet the need. One reason is the high cost of LNG/natural gas.

One aspect shared among the aforementioned countries is a past reliance on domestically produced natural gas to meet domestic demand (mainly for fertilizer, electric power, and industrial sectors). Supplies can no longer meet growing demand, and the gas fields in their countries are nearly exhausted.

Importing LNG from other countries imposes additional costs, including LNG liquefaction, LNG transportation, and regasification/storage expenses. These costs raise the price of electricity and product/service prices, increasing financial burdens on citizens and on various industrial sectors. Since electricity prices are controlled by national governments, concepts like the fully distributed cost method used in Japan cannot be applied unchanged.

For instance, India has four inland LNG receiving terminals, with a total capacity of approximately 30 million MTPA. Natural gas is consumed mainly for fertilizer production and electricity generation. For electricity, gas-fired power plants are capable of producing a total of 23 GW. The amount of gas required is about 113 mmscfd. The amount consumed in 2015 to 2016 was 28 mmscfd. Electrical fees paid by one household in India are very low (2 to 8 cents/kWh); from time to time, local politicians apply pressure on regulatory authorities to deter attempts to raise these prices. Power companies, on the other hand, suffer from chronic deficits because prices remain unchanged while the cost of producing electricity increases. This prevents them from accepting natural gas. Illustrated below is the relationship between the quantity of imported LNG and LNG receiving capacity. The contracted volume is much lower than receiving capacity. This data clearly shows a situation in which LNG receiving terminals have been established, but are not in use due to high operating costs.

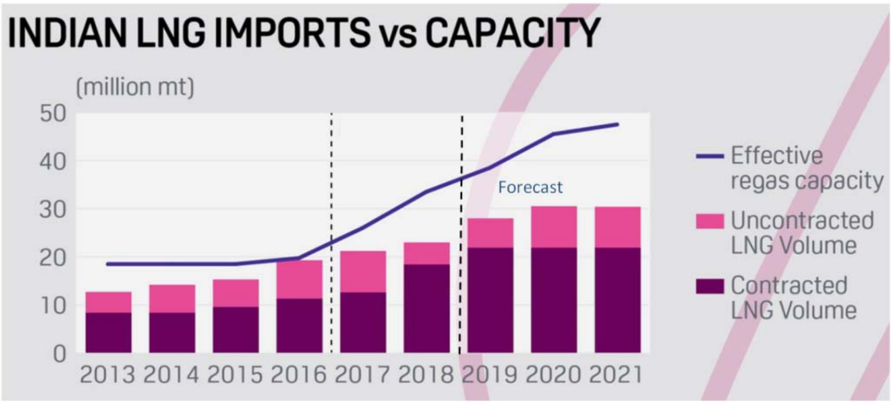


Figure 8 Quantity of imported LNG vs. LNG receiving terminal capacity in India
Source: Excerpt from published documents[10]

[10] H-Energy (2018): "Opportunities in small-scale LNG in India" (3rd FSRU and Small-Scale LNG Shipping Forum 2018)

Shown next are power generating costs. The cost of generating electricity using gas-fired power plants in the United States and Canada (AMER), Europe, Middle East, and Africa is lower than other countries. In the APAC (Asia-Pacific) region, the cost of gas-fired power generation is high (102 USD/MWh as of 2017), behind geothermal power generation and biomass power generation. It is twice the cost of coal-fire power generation (50 USD/MWh).

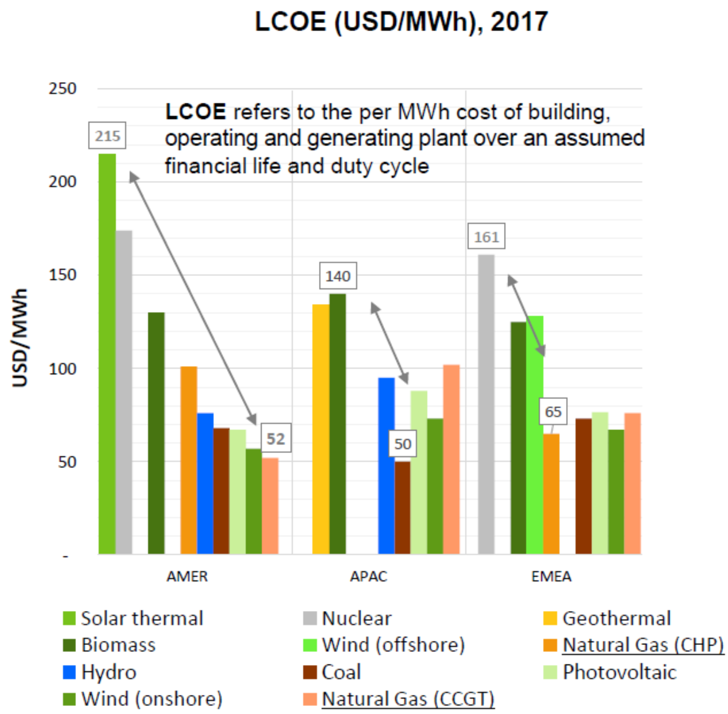


Figure 9 Levelized costs of electricity in major regions

Source: Excerpt from published documents[11]

Gas price reductions are essential to further promote imports of LNG to Asian countries. CAPEX and OPEX for LNG receiving terminals must be lowered. A global shift to floating receiving terminals has emerged in recent years; 60% of the projects (under construction/already proposed) scheduled for development from 2017 to 2030 are based on floating-type facilities.[12]

- Floating type 11 projects under construction, 57 projects already proposed
- Inland type 17 projects under construction, 28 projects already proposed

Around half of the floating-type facilities are being developed in Asia (some 30 floating terminals, some 20 inland terminals). Furthermore, 27 FSRU projects are currently in operation, and 70 new floating LNG receiving terminal projects are under construction or have been proposed.

[11] Galway Group (2018): "FSRU outlook and Opportunities in South East Asia" (3rd FSRU & Small Scale LNG Shipping Forum 2018)

[12] Galway Group (2018): "FSRU outlook and Opportunities in South East Asia" (3rd FSRU & Small Scale LNG Shipping Forum 2018)

The energetic adoption of floating facilities in Asia is due to the following benefits:

Project development period	Approvals/licenses related to land expropriation are less restrictive than for inland terminals, accelerating project timelines.
CAPEX/OPEX reductions	CAPEX/OPEX may be reduced compared to that for an inland terminal construction project.
Location Operational flexibility	Depending on specifications, an FSRU can be a movable asset. It can be moved to another location or used as a marine vessel.

Developing countries also have other issues to address, such as lack of regulations and rigid LNG contract systems (LNG price, LNG supply period, etc.). The most urgent need may be CAPEX and OPEX reductions from the standpoint of project operators.

2.11 Enhancing the cost competitiveness of Japanese companies participating in projects

When aforementioned Japanese technologies are incorporated into this project, technological advantages will be secured through the full-fledged introduction of the essence of our technologies while cost competitiveness must be ensured by reducing labor costs by employing Indonesian technicians.

As in the example of the LNG vaporizer given earlier, to reduce overall project costs, outsourcing the design, manufacturing, and construction of components to companies in third-party countries must be promoted, rather than relying on Japanese companies to complete everything in the project. However, leaving entire tasks to outsourced companies must be avoided. Appropriate systems must be established to allow Japanese companies to control important processes and achieve cost reductions while maintaining project quality and schedule.

In introducing the essence of technologies, it is important to conclude appropriate contracts (example: license agreements) with Indonesian companies. These contracts must include clauses that safeguard intellectual property and explicitly specify usage fees to prevent the illegal imitation of technologies developed by Japanese companies.

(1) WinmuSe® and Win GAIA®

We plan to rely as much as possible on the Indonesian people in introducing the WinmuSe® and Win GAIA® software to reduce costs. To this end, the language of the user interfaces and the manuals must be translated into the Indonesian language to prevent errors by Indonesian operators.

The personnel responsible for responding to troubleshooting needs should also be Indonesian. They will be stationed at the project site for several months after the start of commercial operations. This will establish the organization necessary to ensure the utmost performance of WinmuSe® and Win GAIA® in the project and to allow such personnel to be assigned to troubleshooting and feedback receiving tasks for other projects (see section 2.9.2 (1)) when the software is rolled out to other projects in Indonesia. Assigning Indonesians to these tasks will accomplish both tasks.

For technology protection, the license agreements signed with users (SPC) should allow use of the software only. The agreements must explicitly indicate that JFE Engineering retains ownership of the software. It must also prohibit copying of the software, transfer to other facilities, and sublicensing.

(2) LNG regasification system

If JFE Engineering joins hands with Company A to manufacture an LNG regasification system to compete with Wärtsilä, the most effective way to enhance cost competitiveness will be to package the design of the system and transfer it to Company A, then entrust system production to Company A, as described in section (1) of Section 2.8.

As mentioned earlier, Company A is a global leading manufacturer of modules for oil and gas production facilities and capable of developing detailed design plans (including modularization design plan) based on a design package prepared and provided by JFE Engineering. The company can handle all processes, ranging from material/equipment procurement to production. It is also possible to make effective use of Company A’s local high-quality, low-cost laborers (welders and others).

（様式２）

二次利用未承諾リスト

報告書の題名
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頁	図表番号	タイトル
8	Figure 1	Breakdown of gas distribution (domestic and export)
9	Figure 2	Major gas consumers
9	Figure 3	Natural gas supply and demand balance trends in Indonesia
11	Figure 4	Energy mix trends
14	Table 1	Win GAIA® system configuration
17	Table 2	Plans to build LNG receiving terminals in Indonesia
17	Table 3	Summary of LNG receiving terminals currently operating in Indonesia
18	Table 4	Comparison of current and past regulations governing gas distribution
19	Figure 5	Map of LNG receiving terminals in Indonesia
19	Table 5	Preconditions assumed for economic assessment
20	Table 6	Project profitability
21	Table 7	Major risks, risk probabilities/effects, and countermeasures
27	Table 8	Confirmation of loan conditions for corporate financing
32	Table 9	Introducing artificial intelligence into the LNG value chain by other companies
35	Figure 6	Super-compact BOG recondenser (comparison with conventional equipment)
38	Table 10	LNG supply-and-demand balance in main regions
38	Figure 7	Summary breakdown of natural gas imports by region
39	Figure 8	Quantity of imported LNG vs. LNG receiving terminal capacity in India
40	Figure 9	Levelized costs of electricity in major regions