INTERNATIONAL FORUM ON GLOBAL ENERGY LANDSCAPE: ELECTRICITY & GAS MARKET LIBERALIZATION AND IT'S IMPLICATION TO MALAYSIAN ECONOMY

PUTRAJAYA, MALAYSIA, 13 FEBRUARY 2018

Formulating Policy Options for Promoting Natural Gas Utilization in the EAS

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Outline

- Background and Motivation
- Analysis on the Demand Side
- Analysis on the Supply Side

Background and objective

- EAS Energy Ministers Meeting gives a rationale of the study. (Sep. 2016 in Myanmar)

> "To advance the EAS collaboration on natural gas, *the Ministers welcomed Japan's proposal* to facilitate collaboration and discussion among EAS countries with the support of the ASEAN Council on Petroleum (ASCOPE), the ASEAN Centre for Energy (ACE) and the Economic Research Institute for ASEAN and East Asia (ERIA), *on ways in which governments can spur the development of natural gas markets* that are open, transparent, competitive and resilient, and promote new technologies for the storage and efficient use of this clean energy resource. The Ministers noted that *Japan will endeavor to formulate pro market policy options to ensure that gas markets operate efficiently* for possible consideration of the next EAS ECTF meeting"

- The study will cover ASEAN and India to investigate;

Future gas demand

Necessary investment amount

→

Understanding size of the market

Clarify the challenges

→

Propose the policy options

Multiple advantage of natural gas

Power generation sector

- Environmental benefit
  - ✓ Gas-fired power plant (GPP) will become more attractive under the tougher environmental regulation condition.
  - ✓ **To address air pollution:** The least emitter of air pollutants (SOx, NOx, PM) among fossil fuels.
    Contribute to improve environment, hence standard of living.
    Gas fired power plant is easier to gain better acceptance than coal-fired and oil-fired.
  - ✓ **To address global warming:** The least CO_2 emitter among fossil fuels.
    If carbon pricing is introduced in the future, the economic advantage of GPP will increase.
- Operational benefit
  - ✓ GPPs are capable of quick start-up and power adjustment, hence it is optimal as a backup of a variable renewable power supply which is expected to flow more into the grid in the future.
- Supply security benefit
  - ✓ Many new natural gas liquefaction projects are planned. In addition, thanks to growing unconventional natural gas supply from the United States, sufficient amount of natural gas supply can be expected.

Other sectors

- Security benefit
  - ✓ The energy security risks are increasing in the region, such like decreasing crude oil self-sufficiency rate, increasing dependence on the Middle East. The industrial sector and transport sector are highly dependent on oil, hence the substitution by natural gas is one effective way to reduce the energy security risks.
  - ✓ There are gas producing and LNG exporting countries in ASEAN, such as Brunei, Indonesia and Malaysia. In addition, it is possible to import from less energy security risk countries, Australia and the United States.
- Economic benefit
  - ✓ Considering the trend to tighten environmental regulations, natural gas is expected to have more advantageous against oil and coal in terms of economical aspect (less environmental cost).

Analysis on the Potential of Future Demand for Natural Gas

Assumptions for demand analysis

Baseline of estimation	ERIA energy outlook 2015 • Up until 2030 • BAU scenario
Power generation	RE power generation: will not be replaced to gas. Existing plants: will be replaced to gas after 40 yrs. life. New addition: 3 scenarios (share of gas: 15%, 30%, and 60%)
Industry	Assume to increase share of gas depending on baseline estimation. • Share of gas in 2030: more than 33% in BAU >> 5% higher share • Share of gas in 2030: between 10 to 33% in BAU >> 1.5 times share • Share of gas in 2030: less than 10% in BAU >> 2 times share
Residential & commercial	Assume 25% of oil, including LPG, demand in BAU will be replaced to gas.
Road transportation	Assume 2 times higher gas demand increase than BAU.
Marine transportation	Assume 32.5% of high sulfur bunker fuel demand in BAU will be replaced to LNG.

Ref.) Detail of power generation sector

Basic assumptions

- Baseline:
  BAU scenario of ERIA Outlook 2015
- Renewable energy will not be replaced by gas.
- Nuclear power generation will not be operated within the projection period, and it will be supplemented by thermal power generation.

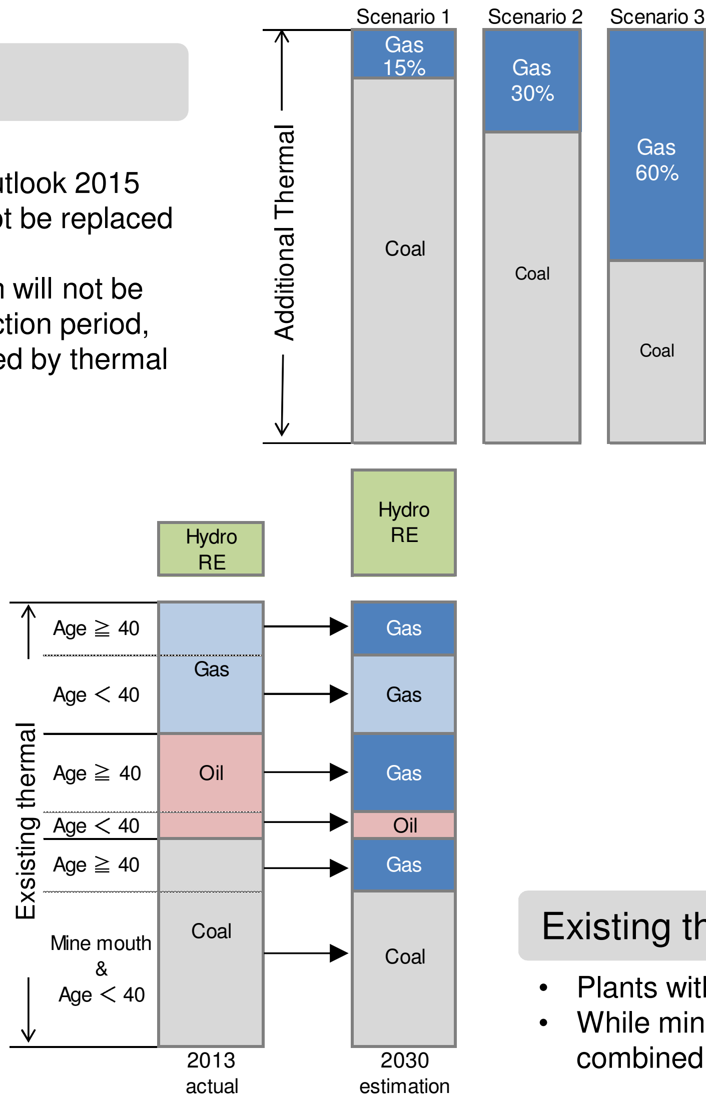


Image of scenarios
(Electricity generation mix)

* Scale is not accurate.

Additional thermal power plant

Three scenarios to assume the share of natural gas in additional thermal power generation

Scenario 1: 15% of natural gas share

- LNG prices will increase as crude oil prices goes up.
- Momentum of climate action will be relatively weak.
- Domestic coal industry and CPP development will be promoted due to domestic energy utilization policy and domestic industry protection policy.

Scenario 2: 30% of natural gas share

- LNG prices will be on the same level at present, or moderate increase.
- Strength of climate action will be same as present situation.
- The development ratio of CPP and GPP will be same as present situation.

Scenario 3: 60% of natural gas share

- LNG price will stay at low due to LNG glut under smooth start up of the new LNG project.
- Stronger climate action will take place to reduce CPP.

Existing thermal power plant

- Plants with operation years more than 40 will be replaced to GPP.
- While mine mouth CPPs are exceptional as their operation is combined with that of coal mine.

Ref.) Detail of industry sector

Scenario

From the following background, the use of natural gas will expand in the industrial sector.

- Subsidies will be eliminated to increase oil price for industrial use.
- In light of climate protection;
  - ✓ Energy efficiency standards will be established and strengthened.
  - ✓ Carbon emission amount will be limited.
- The new LNG projects will start steadily and sufficient LNG supply will be expected.

Assumption

- Small increase of natural gas is assumed for the countries where the natural gas utilization rate in 2030 in the BAU scenario is similar to or higher than the OECD average (33%).
- In other countries, it is assumed that natural gas utilization rate will increase by developing supply infrastructure and strengthening supply capacity such as LNG imports.
- It is assumed that countries with lower natural gas demand outlook in the BAU scenario will have higher demand growth.

Assumption of natural gas demand increase in industry sector

Share of natural gas in 2030 of BAU scenario *	Increase of share	Applicable country
33% or more	+ 5% share compare to BAU	Indonesia, Malaysia
10 – 33%	1.5 times share compare to BAU (max. 33%)	Myanmar, Singapore, Thailand, Viet Nam
10% or less	2 times share compare to BAU	Brunei, India, Philippines

* BAU scenario of ERIA energy outlook 2015

Ref.) Detail of residential and commercial sector

Scenario

From the following background, the use of natural gas in the residential and commercial sectors will expand.

- The current natural gas utilization rate is 5% for Brunei and 6% for Singapore, but almost zero for the other countries.
- From the viewpoint of improving convenience of life and reducing health damage, substitution from traditional biomass to commercial energy, from coal and oil to natural gas will be promoted.
- Subsidies will be eliminated, and the price of oil (including LPG) for residential and commercial use will increase.
- The tightening of electricity supply/ demand balance will lead to promote the use of natural gas (city gas).
  (e.g. cooking, water heating, and autonomous power and heat generation.)
- The new LNG projects will start steadily and an sufficient LNG supply will be expected.
- The development of natural gas supply infrastructure (e.g. pipeline) for industrial use will help cultivate city gas demand in urban areas.

Assumption

- It is assumed that 25% of the 2030 oil (mainly LPG) consumption in the BAU scenario will be replaced by city gas.

Ref.) Detail of road transportation sector

Scenario

From the following background, the use of natural gas vehicles (NGVs) will expand.

- Subsidies for oil will be eliminated, hence the oil prices for transport use will increase.
- Air pollution in urban areas will deteriorate further and stronger measures will be required.
  - ✓ Restriction on the use of outdated vehicles
  - ✓ Strengthen emission standards for new vehicles
- The new LNG projects will start steadily and sufficient LNG supply will be expected.
- The development of natural gas supply infrastructure (e.g. pipeline) for industrial use will help expand pipeline distribution network in urban areas.

Assumption

- Estimate the potential by doubling the annual average growth rate in the BAU scenario from 2013 to 2030.
- In the BAU scenario, the country with zero natural gas demand for vehicles as of 2030 assumes that 1% of oil demand for transportation will be replaced by natural gas.

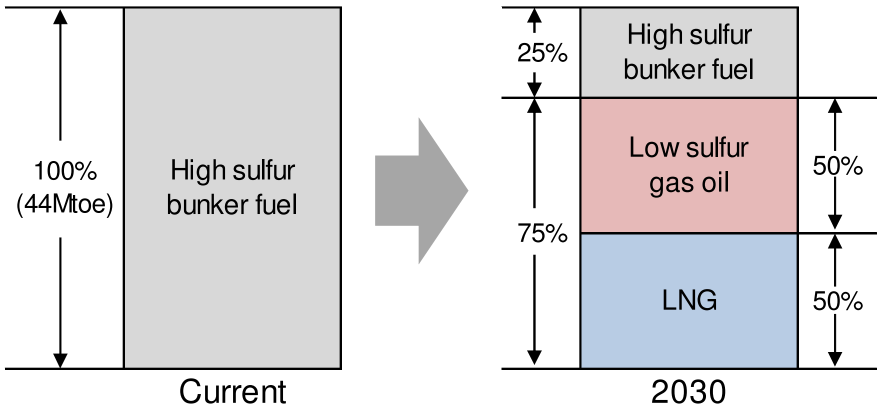
Country	Actual 2013/2000 (annual growth rate)	BAU scenario 2030/2013 (annual growth rate)	Potential 2030/2013 (annual growth rate)
Brunei	-	-	1% of oil demand
India	28%	8%	16%
Indonesia	2%	7%	14%
Malaysia	-	1%	2%
Myanmar	41%	3%	6%
Philippines	-	21%	42%
Singapore	-	2%	4%
Thailand	73%	2%	4%
Viet Nam	-	-	1% of oil demand

Assumption of annual average growth rate of natural gas demand for vehicle

Ref.) Detail of marine transportation sector

International marine bunker

- The total bunker fuel demand in 2030 is assumed to be almost the same as the current situation.
- LNG demand to fuel ship is assume to increase as IMO regulation for SOx emissions from ocean vessels will be strengthened from 2020.
- Along with strengthening regulations, it is assumed that one is chosen from below three options.
  - ✓ Continue to use high sulfur bunker fuel and install exhaust gas desulfurization equipment. (25% of demand)
  - ✓ Replace by low sulfur diesel. (32.5% of demand)
  - ✓ Replace by LNG. (32.5% of demand)



Assumption of change of international marine bunker fuel

Domestic marine bunker

- It is assumed that domestic marine bunker fuel will also be replaced by LNG at ports where LNG bunkering facilities for international marine use are to be in place.
- By considering limited number of LNG bunkering facility equipped port, the replacement by LNG for domestic marine bunker fuel is assumed to be 10%.

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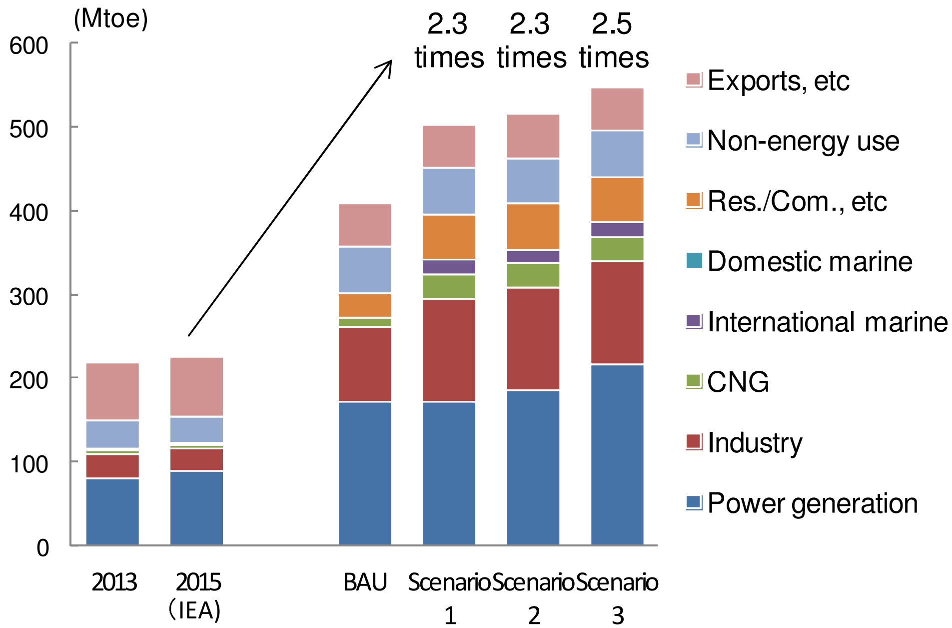
Overview of gas demand potential (ASEAN + India)

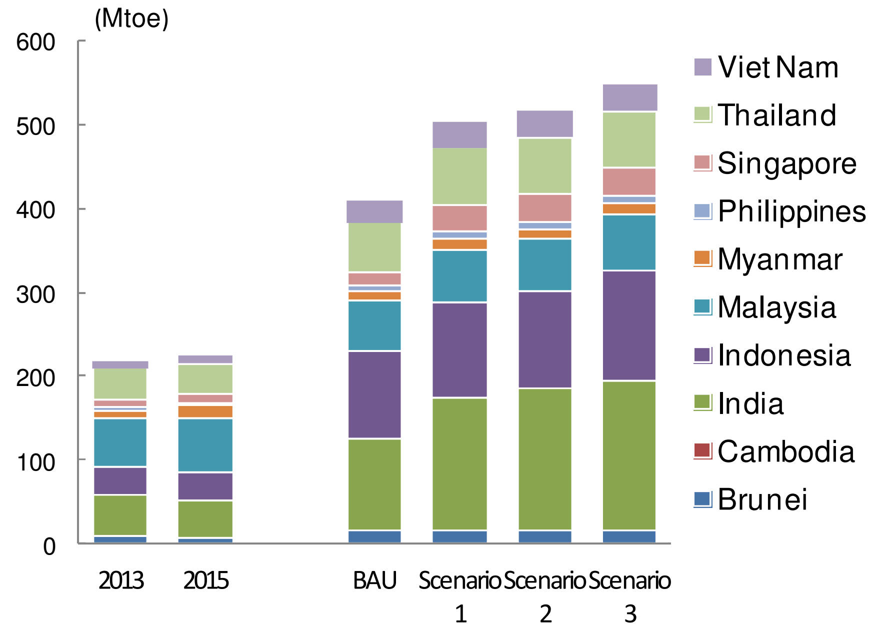
Large potential of gas demand has identified.

- Natural gas demand for ASEAN + India may expand to;
  - ✓ 2.3 to 2.5 times larger than 2015 (Approx. +293 to +339Bcm @ 40 MJ/ m^3)
  - ✓ 1.2 to 1.3 times larger than BAU scenario
- By sector, the power generation sector has the largest potential, followed by the industrial sector.
- By country, India has the largest potential, followed by Indonesia.
- In order to realize the natural gas demand potential, various policy supports will be required.

Natural gas demand potential by sector (2030)



Natural gas demand potential by country (2030)



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Expected economical and environmental benefit

Natural gas can bring economical and environmental benefit.

- In power generation sector, part of fuel cost increase will be offset by reduction of construction cost. There are scenario where reduction of CO_2 emissions can be expected.
- In other sectors, both fuel and CO_2 emissions can be reduced by substituting oil.

Power generation

Case	Fuel import cost LNG: USD 11.9/MMBtu (Billion USD)	Fuel import cost LNG: USD 9/MMBtu (Billion USD)	Fuel import cost LNG: USD 6/Mbtu (Billion USD)	Construction cost (Billion USD)	CO_2 emission (Million tons-CO2)
Scenario 1	**+0.7**	**+0.5**	**+0.4**	* **+0.1**	* **+6.4 (+0%)**
Scenario 2	**+7.5**	**+4.9**	**+2.2**	**-0.5**	**-55.8 (-2%)**
Scenario 3	**+20.7**	**+13.3**	**+5.6**	**-1.7**	**-176.5 (-6%)**

Other sectors total

Fuel import cost LNG: USD 11.9/Mbtu (Billion USD)	Fuel import cost LNG: USD 9/Mbtu (Billion USD)	Fuel import cost LNG: USD 6/Mbtu (Billion USD)	CO_2 emission (Million tons-CO2)
-23.2	**-33.7**	**-44.6**	**-0.047 (-2%)**

* Effect of assumption that Vietnam's nuclear power generation after 2028 in BAU scenario will be substituted by coal and natural gas fired power.

Assumptions

- International fossil fuel cost

Coal	Crude oil	LNG		
77 USD/ton **(125)** USD/toe	**111** USD/bbl **(820)** USD/toe	**11.9** USD/MMbtu **(472)** USD/toe	**9** USD/MMbtu **(357)** USD/toe	**6** USD/MMbtu **(238)** USD/toe

Source: IEA, World Energy Outlook 2016, New Policy Scenario
USD6/MMBtu : Assume current LNG market condition will remain.
USD9/MMBtu : Middle of IEA assumption and USD6/MMBtu.

- Unit power plant construction cost

	Construction cost	Life time
Coal (SC)	USD 1,600/kW	30 years
Natural gas (CCGT)	USD 700/kW	25 years

Source: IEA, Southeast Asia Energy Outlook 2015

- Unit CO2 emission: Utilize definition in IEA

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Policy recommendation to increase natural gas demand

1. Clear policy indication for promoting natural gas use.
   - ✓ Energy / electricity mix target.
   - ✓ Climate and environmental regulation. (promote lower carbon energy)

2. Enhance economical competitiveness of natural gas.
   - ✓ Eliminate energy subsidies.
   - ✓ Mechanism to internalize environmental value of natural gas. (e.g. carbon pricing)

3. Support for developing supply infrastructures (LNG receiving terminal, pipeline, etc.).
   - ✓ Support securing residential and commercial demand.
   - ✓ Dialogue with stakeholder to gain acceptance.
   - ✓ Present clear regulatory framework.
   - ✓ Financial support. (e.g. low interest rate loan, tax benefit)

4. Human capacity building.
   - ✓ Development of law and regulation.
   - ✓ Development of safety (technical) standard.
   - ✓ Controlling and monitoring of market. (i.e. enforcement of regulations, change of price)
   - ✓ Gas business operation. (commercial and technical operation)
   - ✓ Gas utilization technology.

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Ref.) Challenges to increase natural gas demand

	Political factor	Economical factor	Social factor	Technological factor
Cross sectoral	• Insufficient policy to promote natural gas use (e.g. energy mix policy, air/GHG emission regulation). • Insufficient regulatory framework for commercial and technical operation of gas business. • Insufficient human capability to develop necessary policies and regulations.	• Competition with other energy • Existing of energy price subsidies. - Hide true cost of energies - Uneven competition environment • No mechanism to internalize environmental value • Large upfront cost of supply infrastructure	• Insufficient knowledge for natural gas • Local acceptance for natural gas related infrastructure (including land acquisition, landscape problems of ground installations)	• Lack of technologies, know-how, engineers • No technical/safety standard for natural gas use
Power gen.	• Contradiction with policy to protect domestic coal industry • Contradiction with policies for other power sources	• Price competitiveness against coal • Price competitiveness against cost reducing renewable energy	-	• Lack of technology and industry for O&M of GPP
Industry	• Less incentive for replacing old equipment due to lax EE&C policy	• Secure critical minimum demand to make gas business feasible • Too far from primary supply location to be economically feasible. • Less capability of small & medium size enterprises and people for investment • Competition with electricity	• Awareness for benefits of natural gas use	• Lack of technology, know-how, and engineers for city gas business • Lack of supply and appeal of natural gas utilization equipments
Residential & commercial	• Insufficient regulatory framework for city gas business		• Awareness for benefits of natural gas use • Remove concern about gas safety	
Road transportation	• Absent of promotion policy • Absent of regulations	• Small number of natural gas fueling station • Competition with EV, biofuel	• Awareness for benefits of natural gas use among freight operators.	• Insufficient supply of natural gas/LNG driven fleet • Absent of technical standards
Marine transportation		• Small number of bunkering port • Competition with low sulfur oil		

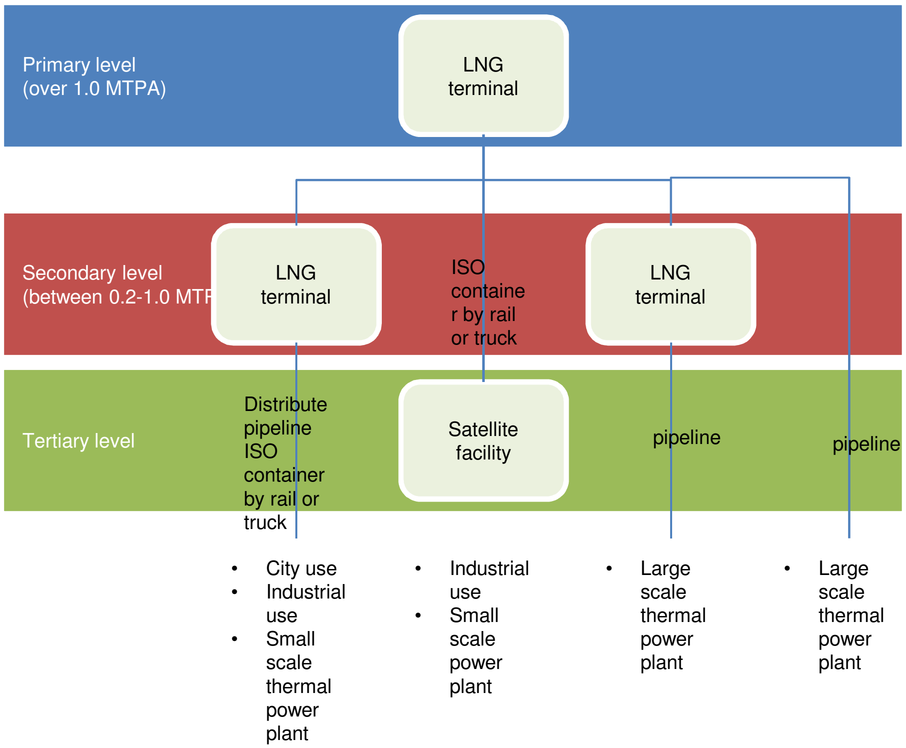
Analysis on the Necessary Investment in Infrastructure

Methodology

Scope of LNG supply chain infrastructure and allocation methodology

☐ Scope of LNG supply chain infrastructure

- Three level hierarchy system is assumed
- Upto demand type, the transport methods are decided
- Pipeline, Land transport (Truck and Railway) and Sea transport are assumed.



☐ Allocation methodology

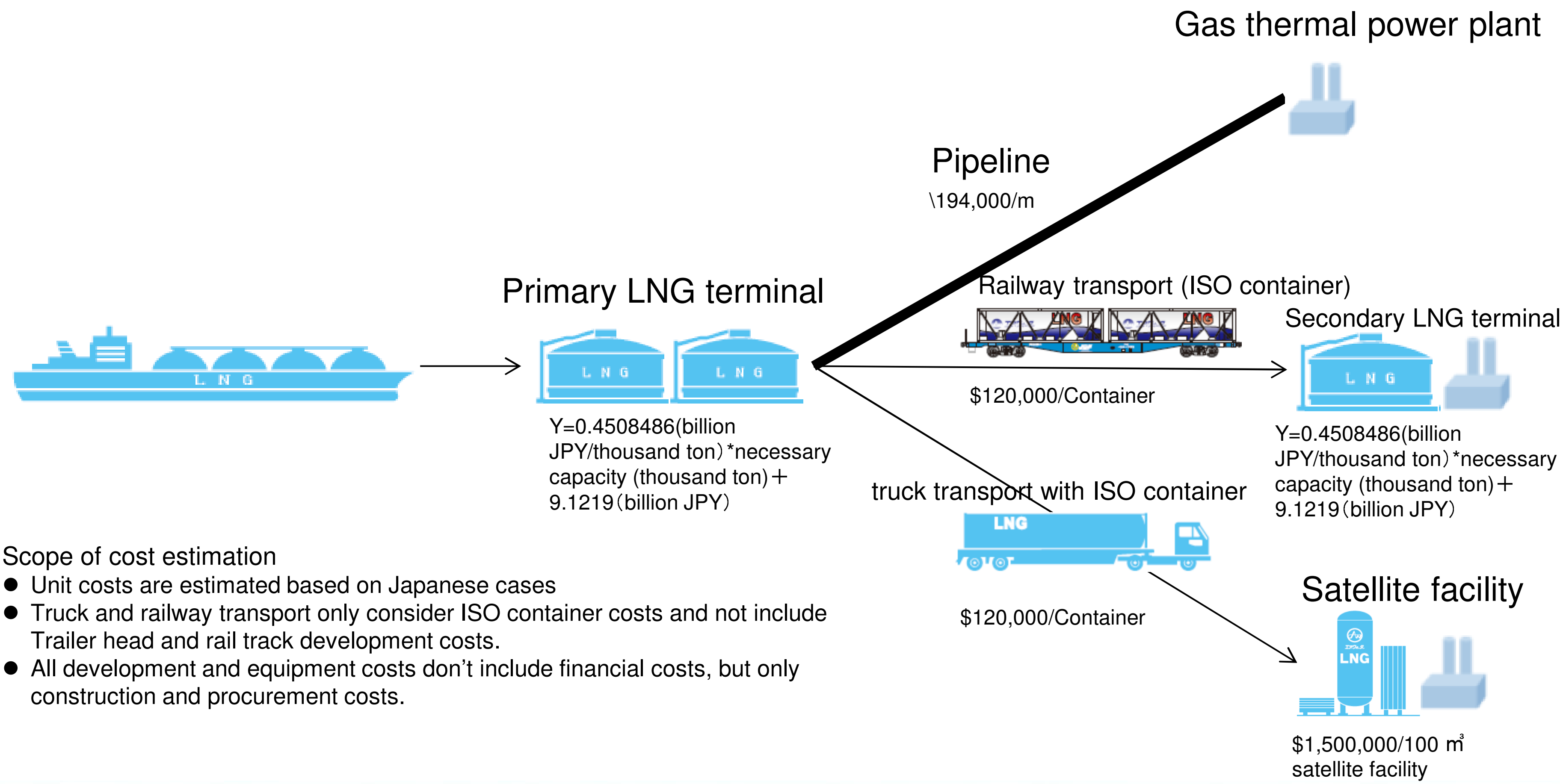
- When ISO containers are used, the pipeline transport is prioritized in case of the distance from port to thermal power plans are close as within 32.5 km because transshipment works need time and efforts.
- In case that both neighbor ports and thermal power plants have rail connectivity and distance between them is over 32.5 km, the railway transport is assumed.
- In case of impossibility to use pipeline and railway, the conditions to use truck transport can be satisfied, the truck will be used for the transport.
- Other cases but the above-mentioned case are discussed as case by case.

Transport mode from neighbor ports		Rules
Transmission pipeline		According to the case in Japan (Tokyo Elec. Corp.: distance from Futtsu LNG terminal to Chiba gas thermal power plant is 32.5 km), so that the transmission pipeline is assumed as transport mode with 32.5 km from port to thermal power plant.
Rail	At port	Based on acknowledge port-rail connectivity case, if the distance between railway and port is within 15km, it is judged as connectivity.
	At demand points (e.g. thermal power plant)	Based on acknowledge thermal power plant-rail connectivity case, if the distance between railway and thermal power plant is within 15km, it is judged as connectivity.
trucks	Distance	Normally, port has road connectivity, so that if the demand points are within 700km from ports, it is judged as transportable.
	Frequency	Upper limit is set as 24 times of 40ft ISO container (13.5 ton eq.)

Methodology

Unit costs of supply chain facilities

- Facility capacity is decided by dividing total LNG demands (MTPA) by 52 weeks
- Estimated investment is calculated by capacity multiplying unit price of construction or equipment.

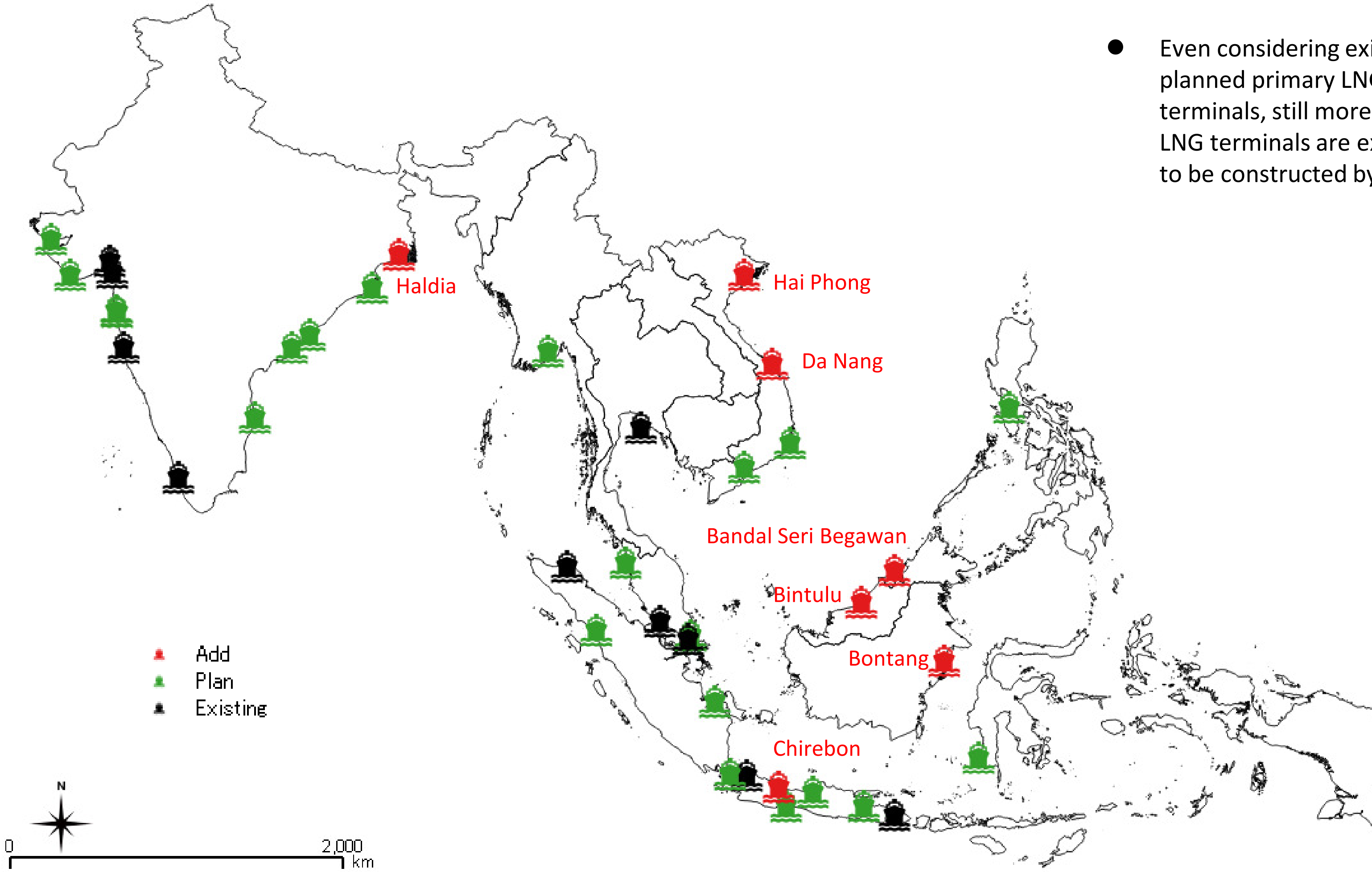


Scope of cost estimation

- Unit costs are estimated based on Japanese cases
- Truck and railway transport only consider ISO container costs and not include Trailer head and rail track development costs.
- All development and equipment costs don't include financial costs, but only construction and procurement costs.

Key results

LNG primary terminal location (existing, planned and added)



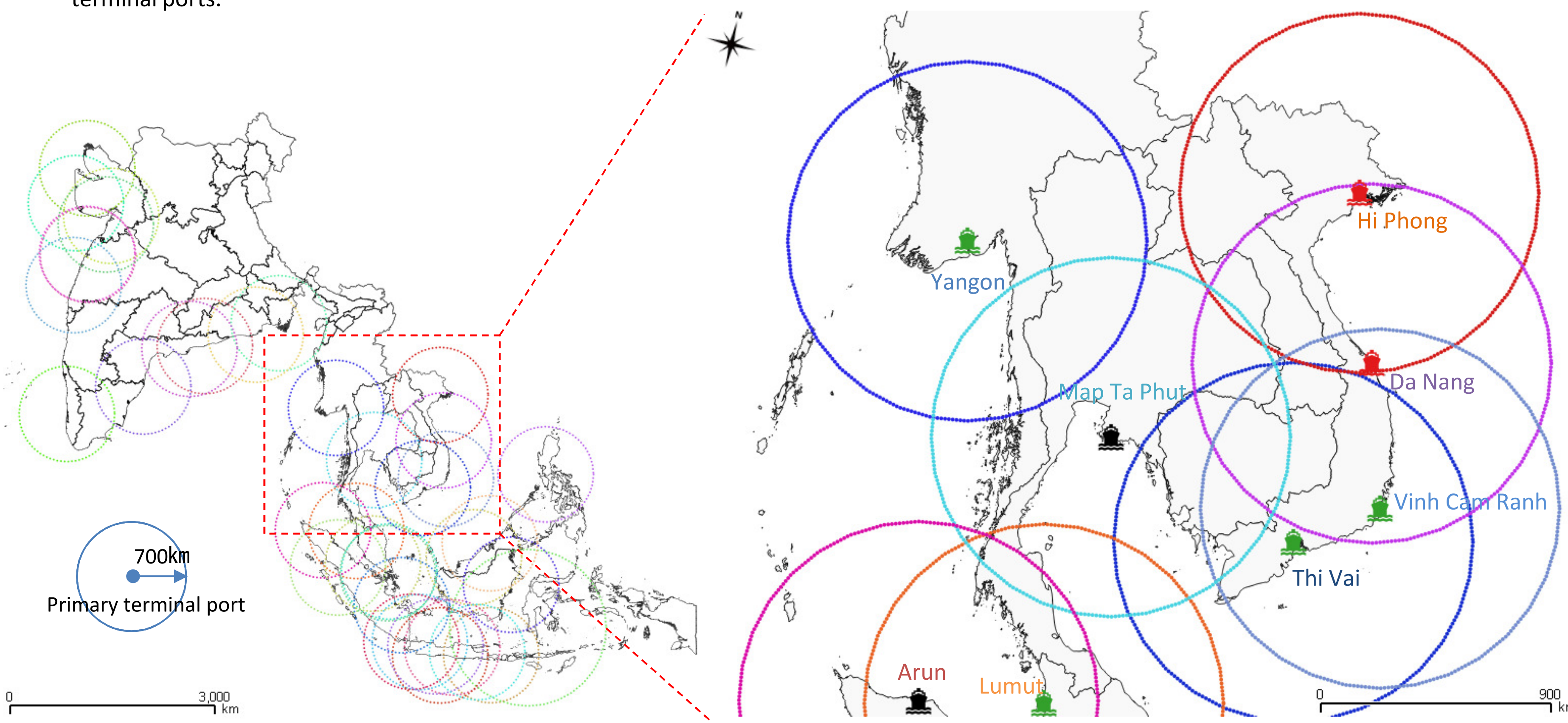
- Even considering existing and planned primary LNG terminals, still more primary LNG terminals are expected to be constructed by 2030.

Note: Some of LNG existing and planned terminals are used as acknowledged name, but port name.

Key results

Cover area of each primary LNG terminal in 2030.

- Except for the Northern India, Karnataka, and northern Myanmar, almost all areas in ASEAN and India can be covered by existing, planned and added primary LNG terminal ports.
- Primary LNG terminal in ASEAN can cover other countries' area. For example, in Indo Sina peninsula, Map Ta Phut can cover southern Thailand, Cambodia and southern Myanmar.



List of Downstream Infrastructure Projects for Natural Gas

- List of new gas thermal power plants × Pipeline
- List of new gas thermal power plants × Railway
- List of new gas thermal power plants × truck transport with ISO container
- List of fuel conversion thermal power plant × Pipeline
- List of fuel conversion thermal power plant × Railway
- List of fuel conversion thermal power plants × truck transport with ISO container
- List of additional demand points × Pipeline
- List of additional demand points × Railway
- List of additional demand points × truck transport with ISO container

Key Outputs

Estimated investment for Additional LNG supply chain until 2030 is 81 billion USD altogether.

- The unit price based on Japanese case, the investments for LNG supply chain infrastructure till 2030 are estimated (110 JPY=1.00 USD)

(Billion USD)	Primary terminal	Secondary terminal	Pipeline	Satellite facilities	ISO containers	Total by countries
Brunei	0.340		0.019	0.086		**0.445**
Cambodia			0.008	0.034	0.001	**0.043**
India	14.768	4.207	0.666	11.390	0.435	**31.467**
Indonesia	7.456	1.511	0.261	9.296	0.322	**18.846**
Laos						**0.000**
Malaysia	1.655	2.750	0.205	3.532	0.137	**8.279**
Myanmar	0.261	0.621	0.006	0.670	0.027	**1.584**
Philippines	0.427	0.444	0.078	1.853	0.052	**2.854**
Singapore	2.712	1.208	0.025			**3.945**
Thailand	1.824	1.876	1.155	1.025	0.038	**5.919**
Vietnam	2.473	0.635	0.542	4.171	0.164	**7.985**
ASEAN + India	**31.916**	**13.253**	**2.965**	**32.058**	**1.177**	**81.369**

Policy Implication for LNG supply infrastructure development

Implication from the study results

- LNG supply chain development beyond the national boarders will bring investment saving and achieve efficient LNG supply chain development for member countries of ASEAN + India.
  - To realize cross-border LNG supply chain network using sea route, ASEAN countries may have to relax Cabotage regulation.
- Railway and sea transport are another solution for LNG supply in ASEAN and India
  - They can utilize existing infrastructure like national railway system and ports.
- When hinterland LNG demand development are prioritized, either on-shore LNG storage facilities or on-shore mooring FSRU could be applied, depending on cost considerations.
  - Some of LNG storage and regasification facilities are assumed as FSRU, but FSRU needs pipeline transport system for hinterland LNG demand. It may need more money and time to develop LNG supply infrastructure.