Chapter 2

Methodology Part II

February 2018

This chapter should be cited as

ERIA (2018), 'Methodology Part II', in Uemura T. and K. Ishigami (eds.), *Formulating Policy Options for Promoting Natural Gas Utilization in the East Asia Summit Region Volume II: Supply Side Analysis*. ERIA Research Project Report 2016-07b, Jakarta: ERIA, pp.2-8.

Chapter 2

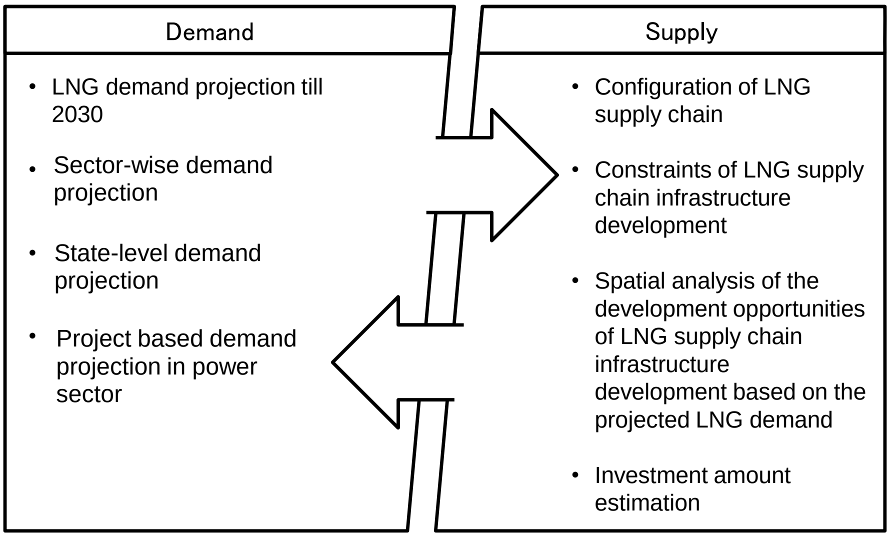
Methodology of Part II

2.1 Framework of Part II

Part II presents the results of the supply side study as well as the results of the legal framework study.

The supply side study consists of four sub-items, namely: configuration of the LNG supply chain, constraints of the LNG supply chain infrastructure development, spatial analysis of the development opportunity of LNG supply chain infrastructure, and investment amount estimation as shown in Figure 1.

Figure 1. Study Framework and Study Items



LNG = liquefied natural gas.

Source: Authors.

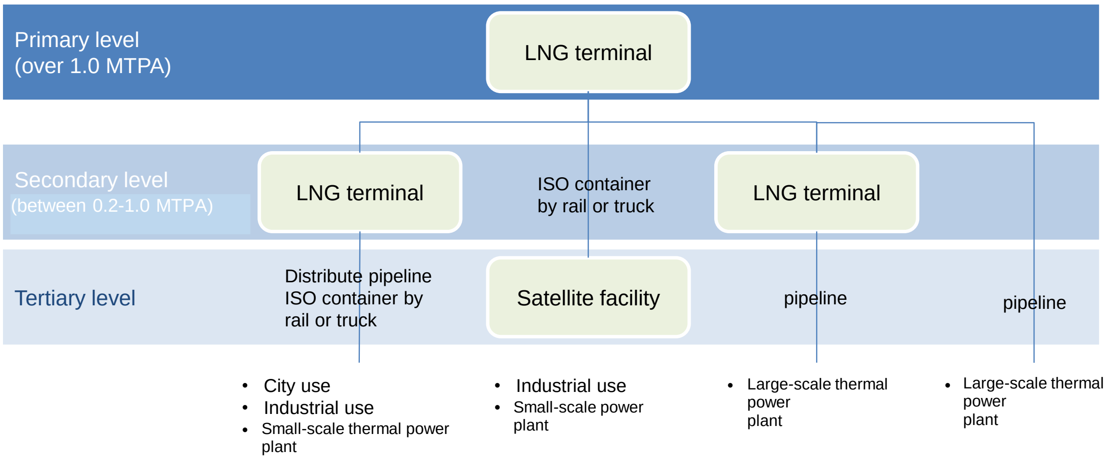
2.2 Scope of LNG supply chain infrastructure analysis

This study assumes a three-level hierarchy system of LNG supply chain infrastructure. The primary level has more than 1.0 million tonnes per annum (MTPA) facility capacity, the secondary level has 0.2–1.0 MTPA facility capacity, and the tertiary level has less than 0.2 MTPA facility capacity. These are based on the Japanese case study results. The evidence of this classification will be presented in Chapter 3.

The transport modes between the different levels in the hierarchy to the final consumption points are assumed to be small-scale LNG (SSLNG) vessels, pipelines, lorries, and International Organization for Standardization (ISO) containers by either lorry or rail. The geographical conditions between neighbour

LNG terminals and the demand size of final consumption points will determine the transport mode. There are few chances to reflect economic analysis in the selection of the best transport mode because, in most cases, physical constraints were faced such as lack of railway connectivity, bigger amount of LNG demand against transportable amount of LNG by lorries, and so on. In Chapter 5, the constraints analysis on the transportation mode of LNG will be conducted and the results will be presented for each LNG transport mode.

Figure 2. Three-Level Hierarchy System of LNG Supply Chain Infrastructure



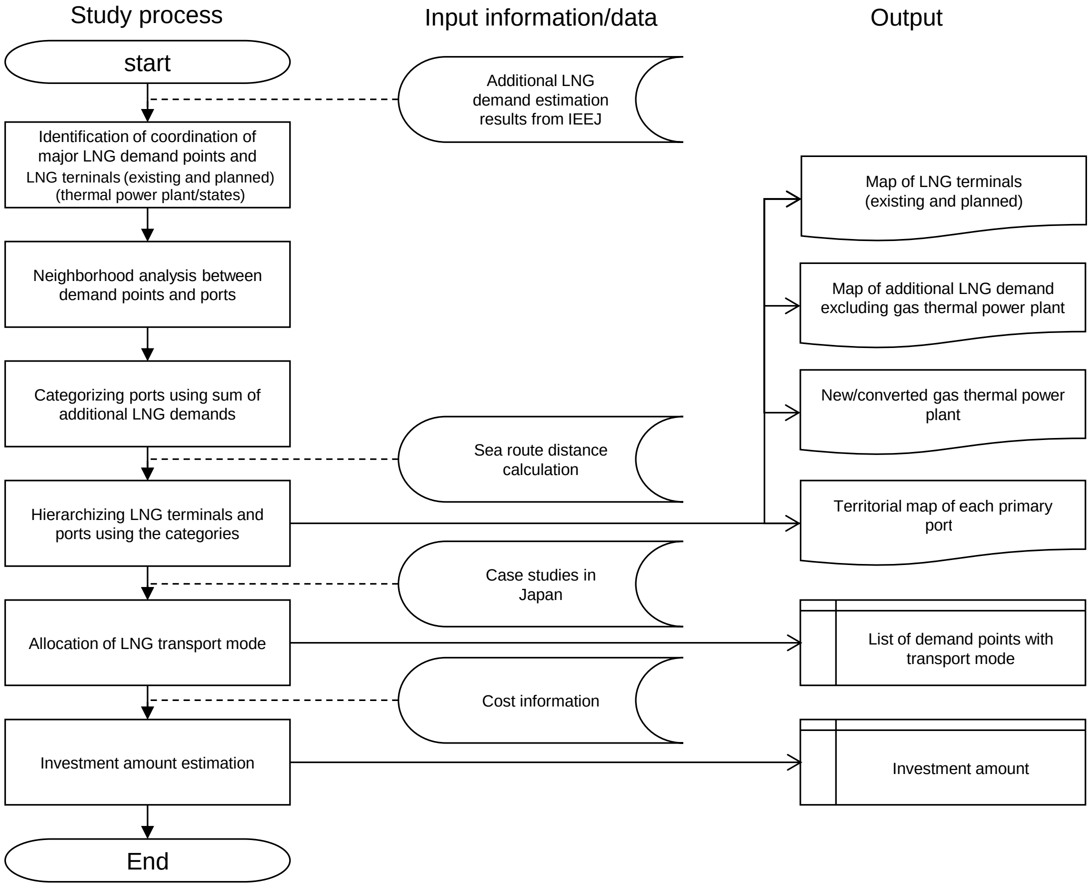
ISO = International Organization for Standardization, LNG = liquefied natural gas, MPTA = million tonnes per annum.
Source: Authors.

2.3 Flow of LNG supply chain infrastructure development investment estimation

Figure 3 shows the flow of LNG supply chain infrastructure development investment estimation. The demand data were presented in Part I, and the necessary unit cost of investment data and information on transport mode selection conditions from case studies in Japan were used. The unit cost of investment on LNG supply chain infrastructure development in Japan might be higher than the actual unit investment level in ASEAN and India, but a higher number will suggest less risk of investment cost escalation for the future due to inflation and other reasons. Of course, to improve the accuracy of the investment amount, more detailed cost studies are required, but this is for future research tasks.

Major outputs of the study include map of LNG terminals (existing and planned); map of additional LNG demand, excluding gas thermal power plant; new/converted gas thermal power plant; map of coverage by each primary port; list of demand points with transport mode; and the required amount of investment.

Figure 3. Flow of LNG Supply Chain Infrastructure Development Investment Estimation



IEEJ = The Institute of Energy Economics, Japan, LNG = liquefied natural gas.

Source: Authors.

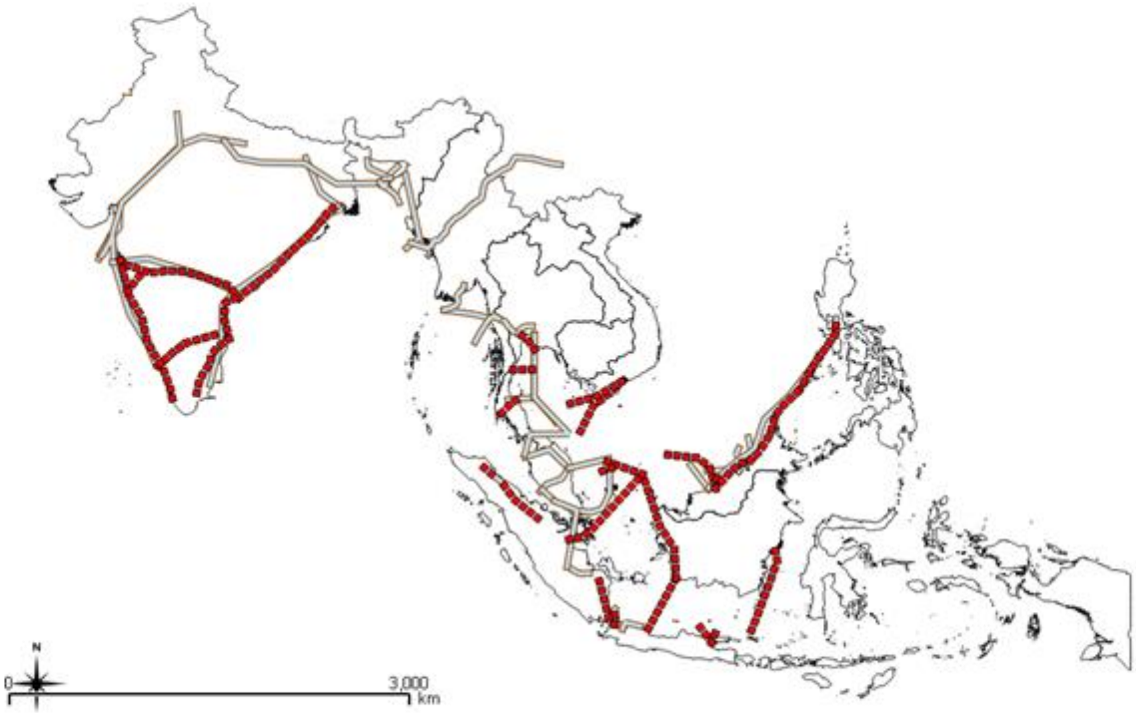
2.4 Constraints and conditions

2.4.1 Constraints

When this study was conducted, not all necessary information was collected. Therefore, this study has some data availability constraints.

First, it is difficult to collect reliable natural gas pipeline information. Figure 4 shows a Geographical Information System (GIS) map of existing natural gas pipelines in ASEAN and India but the data is old and not necessarily accurate from a spatial analysis perspective. Using inaccurate and old information will mislead the analysis. Thus, during the study, the research team and the Economic Research Institute for ASEAN and East Asia (ERIA) requested ASEAN members and India to provide their latest GIS information on natural gas pipelines. However, no responses were received during the study. Therefore, this study does not reflect the latest natural gas pipeline information in these countries. The study results can be updated in the future once the latest pipeline GIS information with location, capacity, and pressure have been provided.

Figure 4. Map of Natural Gas Pipelines in ASEAN and India



NG = natural gas.

Source: Authors. Available at: http://worldmap.harvard.edu/geoserver/wfs?outputFormat=SHAPE-ZIP&service=WFS&request=GetFeature&format_options=charset%3AUTF-8&typename=geonode%3Agas_proposed_nsp&version=1.0.0

Second, some domestic regulations on road structure do not allow the use of ISO containers because of its width, length, and axial weights, but these regulations were not taken into consideration because of the lack of information on road category. This study also did not consider the capacity and standard of railway lines which will be used for freight service of LNG transport. Accordingly, the estimated investment does not also include road and railway infrastructure improvement costs.

Third, some LNG terminal ports are not registered in the marine transport distance table. In these cases, the nearest neighbour port was used as a proxy because this difference will not influence the results critically.

Fourth, the location of industrial and household consumption of natural gas was assumed to occur in the centre of the province. This means that this study did not consider the population distribution within the province. Moreover, the industrial and household demands cannot be identified geographically. Small- and medium-sized island demands were also not identified. Therefore, ISO-container transport by truck was assumed as the average transport. This ISO-container transport can become the typical transport mode for small- and medium-sized islands because ISO containers can be transported by normal barges and ferries in those islands.

2.4.2 Conditions

This study has three major conditions.

First, when the nearest neighbour points between LNG terminals and LNG terminal and demand points, road networks, and railway networks were analysed, it was difficult to identify the exact location of the LNG supply chain infrastructure because, in some cases, the spatial resolution of the railway network was not enough and the port aspect information like the connectivity of railway supplied by World Port Index did not reflect the actual situation. Therefore, the distance between the additional LNG demand points and ports were calculated as direct distance using coordinates information. On the other hand, the distance between ports (primary and secondary LNG terminals on the ports) is calculated using aquaplot service (https://www.aquaplot.com/). This service calculates the distance between ports following shipping routes. If not, the direct distance between ports calculated by coordination information will give misleading estimation of the distance of of ports.

Second, only the 40-feet ISO container for LNG transport was assumed to be used for simplification instead of the usual 20-, 30-, and 40-feet containers. This is because the 30-feet ISO container is the special size for Japanese railway transport and it is difficult to be found in ASEAN and Indian markets. The 20-feet containers can be found in the market, but this needs more frequent distribution service than the 40-feet ones. When considering the operation of LNG supply, operational costs will increase if the 20-feet containers will be used. Of course, if the demand points are in rural areas, the demand size is small enough, and the transport infrastructure constraints are strong, the 20-feet containers will be used. It is, however, difficult to identify those situations one by one. Therefore, the 40-feet container was used as a model case to estimate the investment amount in this study.

Third, the investment amount on LNG supply infrastructure to satisfy the additional LNG demand is estimated as the accumulated value of investment until 2030. This is because the estimated additional demand only provided discrete data points about the future and there is no information when the estimated additional demand will be realized. None of the countries in ASEAN or India provided detailed plans to implement LNG supply chain and further discussions are needed to develop a detailed roadmap of LNG supply chain infrastructure implementation.

2.5 Methodology to decide transport modes

In this study, various modes of transport for LNG/natural gas transportation are assumed. They include: small LNG tankers for secondary transport, pipelines, and 40-feet ISO containers for truck/rail transport. If the 40-feet ISO container will be used, satellite LNG tanks and evaporators are assumed to be installed. The outline of transport mode application rules are shown in Table 1.

Small LNG tankers were not included in the investment estimation but they are necessary tools to transport LNG to islands and middle-sized demand areas near primary LNG terminals. The water draft of small LNG tankers is normally 4–5 metres (m) and it will not become a critical constraint for the small LNG tankers to enter the port with secondary LNG terminal.

Pipeline is assumed to be used for natural gas transport between primary LNG terminals and gas thermal power plants. This is because gas thermal power plants consume huge amounts of natural gas and it is difficult to transport such a huge amount of natural gas through other means. Japan has the longest natural gas transport from the primary LNG terminal to the inland thermal power plant at 32.5 kilometres (km). Therefore, this 32.5 km is regarded as the threshold to check the possibility of transmission pipeline usage for gas transport for natural gas thermal power plants.

For rail transport, the threshold distance for LNG transport must be shorter than 15 km between either port or demand point. This is because the distance from the acknowledged ports and demand points – like thermal power plants to the railway service – is less than 15 km when the authors checked them manually. Even though there is no railway connectivity or poor railway connectivity, new connectivity construction or improvement of rail tracks is not significantly costly for such a short distance. Therefore, those cases will not influence the final results. In addition, when railway transport is considered as the transport mode, the availability of railway connectivity on both the port side and the demand point side is essential. If one side does not satisfy the condition on railway connectivity, railway transport mode will not be assigned. Furthermore, when discussing the possibility of railway transport, the volume of natural gas consumption is also considered. This is because unloading LNG also needs some time and frequency of freight train service is also consequently limited. For example, in Japan, the maximum load capacity for transport by electric locomotive is 1,300 tonnes, which is the maximum capacity in the railway freight service. This time, there is no information on such constraints for freight railway transport. Thus, the Japanese capacity limitation was applied for the railway transport mode.

In terms of the ISO container transport by trucks, the maximum distance that road transport can economically reach ASEAN and India is 700 km. Considering the loading and unloading times, the frequency of the truck transport faces some limitations. This time, the maximum frequency of truck transport to one demand point is set at 24 times/day. If the LNG demand goes beyond this upper cap, the other transport mode will be assigned.

Other cases that do not satisfy the above-mentioned conditions are discussed case by case, but in some demand points near mega cities in countries with natural gas distribution pipelines like Jakarta and Delhi, the pipeline transport is assumed without any additional pipeline infrastructure expansion.

Table 1 summarizes how to decide on which transport mode to use.

Table 1. Transport Mode Assignment Rules

<table>
<tr><th colspan="2">Transport Mode from Neighbour Ports</th><th>Transport Mode Assignment Rules</th></tr>
<tr><td colspan="2">Transmission pipeline</td><td>Based on Japan's experience (Tokyo Electric Corporation), distance from Futtsu LNG terminal to Chiba gas thermal power plant is 32.5 km. So, the transmission pipeline is assumed as the transport mode, with 32.5 km from the port to the thermal power plant.</td></tr>
<tr><td rowspan="2">Rail</td><td>At port</td><td>Based on existing port-rail connectivity, a 15 km distance between railway and port is judged as connectivity.</td></tr>
<tr><td>At demand points (e.g. thermal power plant)</td><td>Based on existing thermal power plant-rail connectivity, a 15 km distance between railway and thermal power plant is judged as connectivity.</td></tr>
<tr><td rowspan="2">Trucks</td><td>Distance</td><td>Normally, ports have road connectivity. So, if the demand points are within 700 km from ports, they are judged as transportable.</td></tr>
<tr><td>Frequency</td><td>Upper limit is set at 24 times/day of 40 ft ISO containers (equivalent to 13.5 tonnes).</td></tr>
</table>

ft = feet, km = kilometre, ISO = International Organization for Standardization, LNG = liquefied natural gas.
Source: Authors.

2.6 Other methodologies

This study also used other methods like literature review. In addition, it consists of several sub-study items, and methods to collect and analyse necessary information are introduced in the beginning of each chapter to help readers understand them.