Structural Changes in City Gas Production in Japan:
Diversification of Gas Production as a Result of Gas Family Integration by IGF21

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Keywords: 1. LNG-chain; 2. Terminal; 3. Diversification; 4.Change; 5. Integration

1 Introduction

In the Japanese city gas sector, there were formerly thirteen gas families due to differences in their calorific value and combustibility. Recently, the IGF21 (Integrated Gas Family 21) Program has triggered drastic structural changes in city gas production so that only high calorific gas will be used as city gas by 2010.

This paper reports the background for the transition to the high calorific gasification promoted by the IGF21 Program, the high calorific gas production structure where LNG is used as feedstock, and the plan for the production of city gas.

2 Background for Transition to High Calorific Gasification of City Gas

(1) Background for introduction of LNG

In Japan, low calorific gases made from coals and petroleum have been mainly used as feedstock for production of city gas. In 1959, indigenous natural gas deposits were found in Niigata Prefecture and the natural gas extracted from these deposits has been used as feedstock for city gas in suburban areas since 1962.

However, Japan's exploitable natural gas reserves are limited, and it is unavoidable to import the gas resources from foreign countries to cover the future demand forecast. (See Table 2-1.)

Since there are more than 200 private and municipal city gas utilities in Japan and these gas utilities have established their own supply networks, the infrastructures for the utilization of natural gas have evidently lagged behind those of the Western countries in which national pipelines had been established at an early stage.

Technologies that transport and store LNG at the very low temperature of about -160℃ were developed in addition to the natural gas liquefaction technologies that allow efficient transportation. With establishment of these technologies, LNG was first introduced as feedstock for city gas in 1969.

Table 2-1 Exploitable natural gas reserves in Japan

	Production (million m^3)	Reserves (million m^3)	Reserves-to-production ratio
Land	2500	47300	19
Marine	400	1400	4
Total	2900	48700	17

Note on Japan's Petroleum and Natural Gas (Japan Natural Gas Association (January 2009))

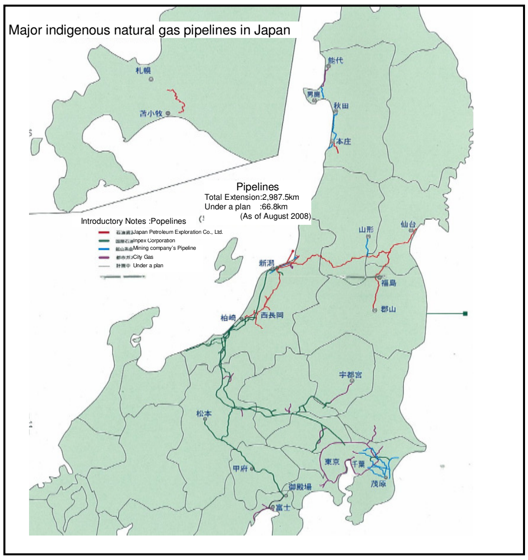


Fig. 2-1 Major indigenous natural gas pipelines in Japan

Fig. 2-2 First acceptance of LNG in Japan (Negishi terminal of Tokyo Gas (November, 1969)

(2) Transition to high calorific gas by IGF21 Plan

Natural gas earlier attracted considerable attention as feedstock for city gas because it is an environment-friendly material and provides high calorific value. Gas supplies have promoted the production of high calorific gas based on LNG, with major gas utilities acting as key players, since it is effective to purchase large volumes of LNG under long-term contracts to increase the economic performance of LNG-based city gas production.

Due to such a situation, small and medium gas suppliers are behind major utilities with respect to introduction of LNG to produce city gas, and a resultantly large difference was generated between major, small, and medium gas utilities in terms of calorific value and combustibility of their products. This was the major problem for gas utilities, gas appliance manufacturers, and customers. (See Table 2-2.)

Table2-2 Problems to respective industrial sectors

Sector	Problem
Customer	The quality of service is insufficient when compared to that for the customers to which the high calorific gas is supplied.
Gas appliance manufacturer	The manufacturing system and distribution network cannot be rationalized.
Gas utilities	It is difficult to efficiently rationalize and use the gas utilities' systems and meet customer needs.

The Ministry of International Trade and Industry (former organization of the present Ministry of Economy, Trade and Industry) judged that, considering the present status and future prospect of the low calorific gas with increasing penetration of natural gas in the market, gas families must be integrated from the standpoint of customers, gas appliance manufacturers, and gas utilities. It consequently proposed the program called, "Integrated Gas Family 21 (IGF21) Plan." In response to this proposal, The Japan Gas Associaiton and Japan Industrial Association of Gas and Kerosene Appliances drew up concrete action strategies for the IGF21 Program toward the final objective of completely replacing low calorific gas with high calorific gas to eliminate the problems with the low calorific gas. The organizations have promoted several activities to only use the high calorific gas as feedstock for city gas, according to the two steps shown in Fig. 2-3.

As of the end of March 2009, 94 % of gas utilities have completed the high calorific gasification program. (See Fig. 2-4 for change in breakdown of feedstock for city gas and Table 2-3 for change in consumption of feedstock.)

To smoothly promote the IGF21 Plan, we took the following actions.

1) Support by government (example: introduction of a tax break for the gas utilities that have not yet implemented high calorific gasification)
2) Establishment of joint calorific value change promotion system structured by the gas utilities that have not yet implemented the high calorific gasification
3) Development of simplified calorific value change gas appliances
4) Structuring of backup system for change of calorific value by establishment of IGF21 Plan Promoting Dept.

For the gas utilities that cannot receive the natural gas under the high calorific gasification program, the propane-air system or substitute natural gas (SNG) system has been employed to utilize high calorific gas.

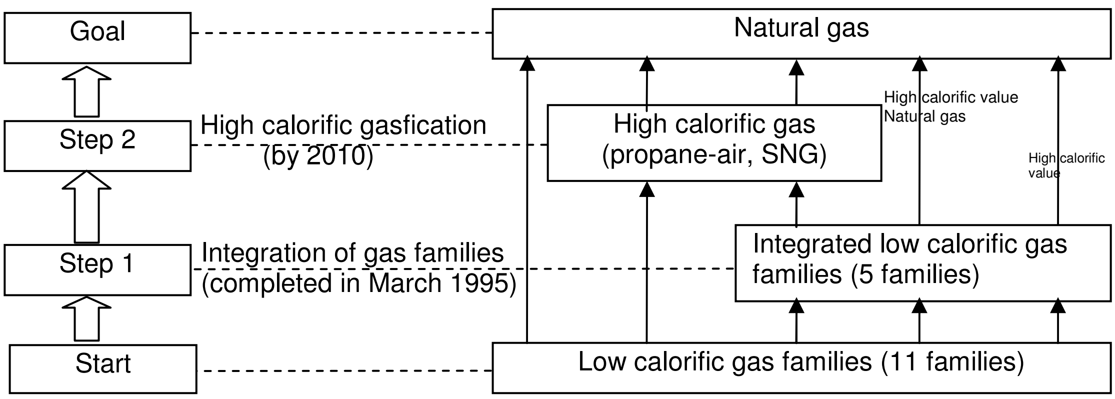


Fig. 2-3 Integration of gas families (step-by-step schematic diagram)

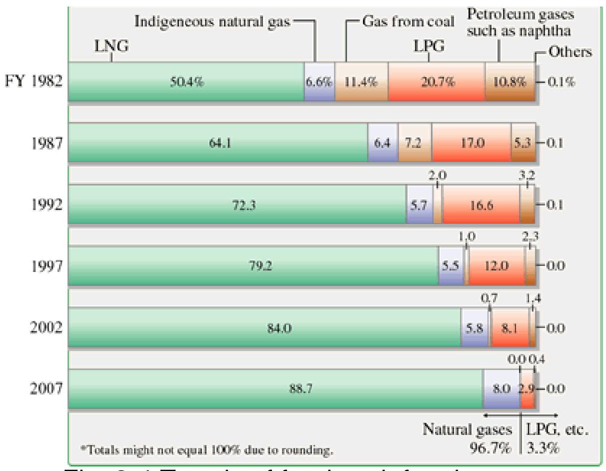


Fig. 2-4 Trends of feedstock for city gas

Table 2-3 Consumption of feedstock

	LNG (thousand t)	Indigeneous natural gas (million m³)	Coal (thousand t)	Coke (thousand t)	LPG (thousand t)	Naphtha (thousand kl)
FY 1982	3,967	702	4,401	61	1,829	891
1987	6,386	863	3,691	26	1,922	502
1992	9,502	1,047	1,440	0	2,511	333
1997	12,878	1,245	91	0	2,253	249
2002	16,647	1,619	0	0	1,827	67
2007	22,498	2,951	0	0	818	0

3 Structural Changes in Production and Supply of City Gas

With the development of the IGF21 Plan, the city gas production structure has been drastically changed. Japan has promoted high calorific gasification with LNG defined as its main feedstock and, therefore, structuring of the domestic LNG chain that covers transportation, reception, regasification, supply, and consumption has been playing a key role in this strategy.

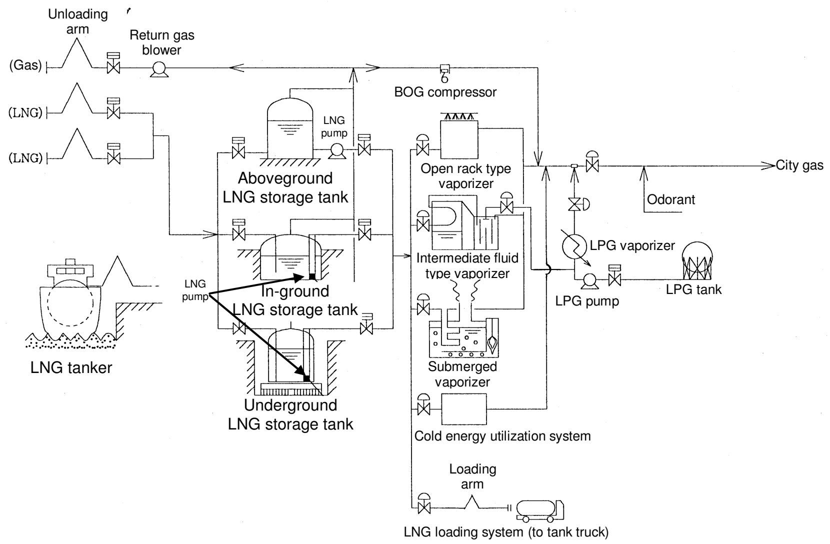
Presently, four types of LNG/gas transportation systems and associated city gas production terminal systems have been established, as shown in Table 3-1. The optimal type is selected and employed according to decision parameters such as the number of customers and geographical conditions.

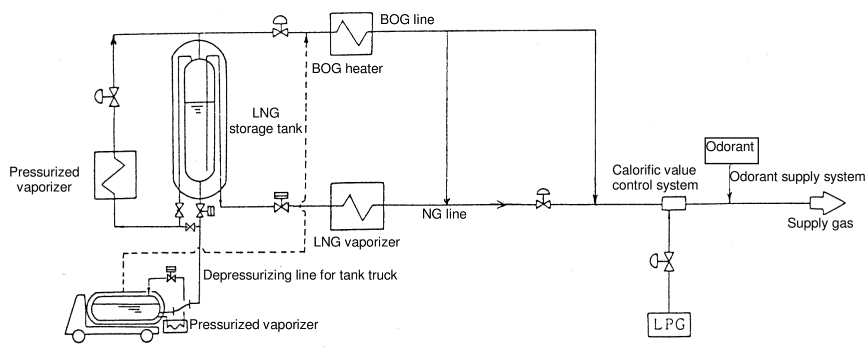
Table 3-1 City gas production terminal systems associated with LNG/gas transportation systems

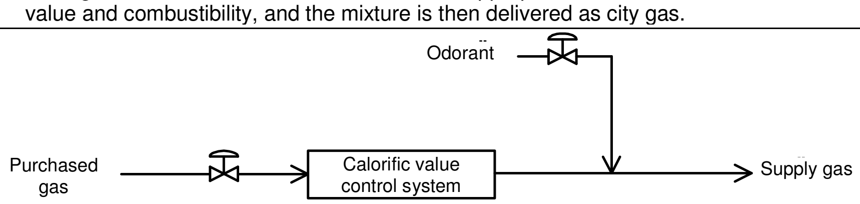
No	LNG/gas transportation system	City gas production terminal system
(1)	Marine transportation of LNG from foreign countries by means of large or medium LNG tankers (international marine transportation)	International LNG tanker terminal Coastal primary terminal that receives the LNG carried by international tankers and that produces the city gas.
(2)	Domestic marine transportation of LNG by means of small LNG tankers (national marine transportation)	National LNG tanker terminal Coastal secondary terminal that receives the LNG carried by national tankers and that produces the city gas.
(3)	Domestic land transportation of LNG by means of LNG tank trucks (tank truck transportation)	LNG satellite terminal Inland secondary terminal that receives the LNG carried by tank trucks and that produces the city gas.
(4)	Transportation of LNG regasified by other city gas utilities by means of gas pipelines	Purchased gas plant Plant that is installed near the pipelines to receive the LNG and produce the city gas.

Table 3-2 shows an example of process flow per city gas production terminal described in Table 3-1. Fig. 3-1 outlines the city gas production and supply network.

Table 3-2 Process flow of each city gas production terminal system (example)

<table>
<tr><th>No</th><th>City gas production terminal</th><th>Process flow</th></tr>
<tr><td>(1)</td><td>International LNG tanker terminal</td><td rowspan="2">

The LNG is received from the LNG tanker via LNG pump and unloading arm. In this process, the LNG is vaporized by an external heat input and as a result, the boil-off gas (BOG) is generated in the LNG storage tank. As the LNG is delivered from the LNG tanker, the gas phase space in the storage chamber of the tanker is increased to decrease the pressure in the chamber. To prevent this depressurization, the return gas blower sends a part of the BOG to the LNG tanker. The LNG received from the tanker is preserved in the LNG storage tank. After the LNG is pressurized with the LNG pump, the heat exchange process is executed between the LNG and seawater in the LNG vaporizer to evaporate the LNG. The vaporized LNG is mixed with LPG or other appropriate material to control the calorific value and combustibility. The odorant is then added to the mixture and delivered as city gas. As of the end of FY 2008, 32 LNG receiving terminals are under operation as shown in Fig. 3-2.</td></tr>
<tr><td>(2)</td><td>National LNG tanker terminal</td></tr>
<tr><td>(3)</td><td>LNG satellite terminal</td><td>

For the city gas utilities that locate in remote districts and thus hesitate installing new pipelines for economical reasons, satellite terminals are installed near the areas that need the city gas and the LNG is transported to these terminals by means of LNG tank trucks. The terminals that receive and store the LNG carried by tank trucks, and regasify the feedstock to produce and supply the city gas are generally called LNG satellite terminals. In most cases, the regasified LNG is mixed with LPG or other appropriate material to control the calorific value and combustibility, and the mixture is then delivered as city gas.</td></tr>
<tr><td>(4)</td><td>Purchased gas plant</td><td>

The gas utilities purchases the gas (e.g., natural gas, off gas, or biogas) from other gas utilities(s) through gas pipelines and controls the calorific value and combustibility on an as-necessary basis. The gas utility delivers the mixture as city gas after odorizing gas</td></tr>
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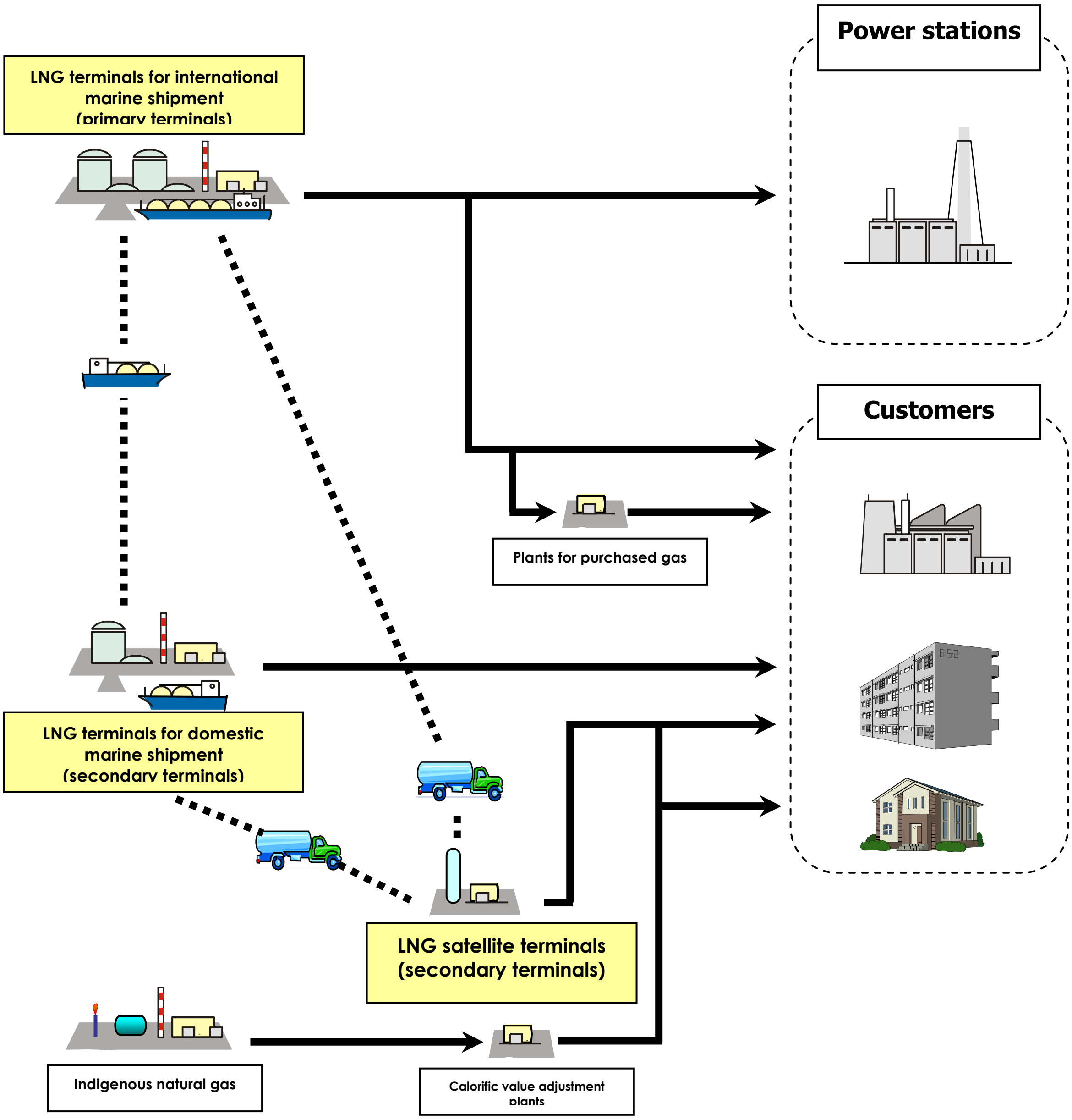

Fig. 3-1 Natural gas-based city gas production in Japan

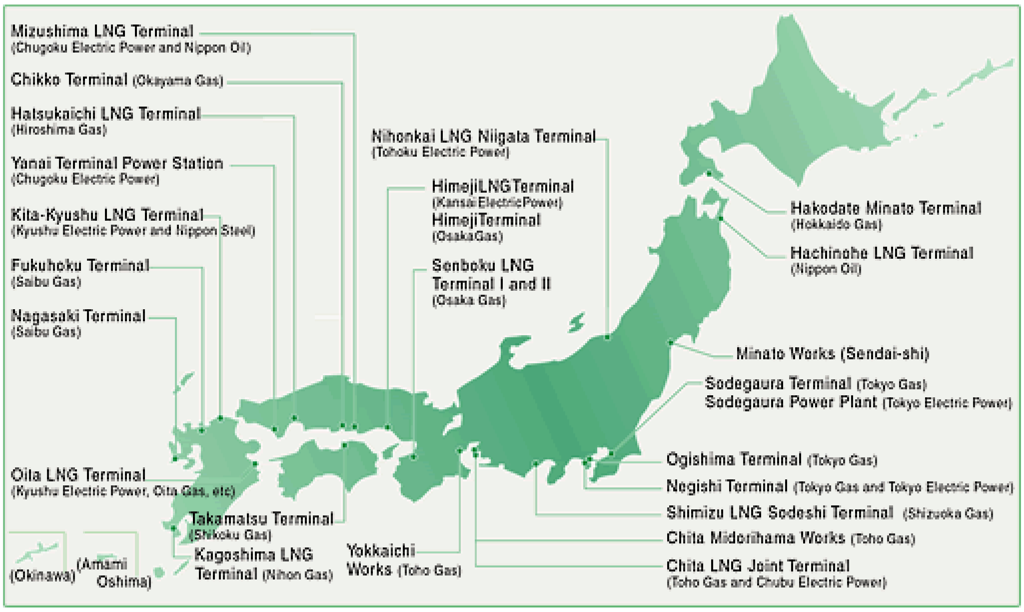

Fig. 3-2 LNG receiving terminals for gas distribution business (as of July 2008)

4 Future Prospect for City Gas Production in Japan

In Japan, similar to the worldwide trend, natural gas will play a leading role as feedstock for city gas in the future, and the demand is forecast to increase. The domestic LNG chain must be strengthened toward the fulfillment of the IGF21 Plan to transport the LNG stably and efficiently so that individual production facilities can produce the city gas to meet the demand.

In order to continuously and stably supply the city gas, it is also important to properly operate, maintain, and manage the production facilities that handle the liquefied natural gas at about -160℃.

References

[1] Note on Japan's Petroleum and Natural Gas (Japan Natural Gas Association (January 2009))