A Consideration of Approximate C.I.F. Cost of Imported LPG*

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Summary: The share of imported LPG in the total energy consumption in Japan has been increasingly encouraged by the future possibilities of larger volume consumption — as in the case of LNG — for power generation and other industrial uses. LPG is a liquefied gas similar to LNG in many aspects but differing markedly in composition, which consists of C_3 and C_4 fractions, and in cost factors. Since the operating temperature of LPG under atmospheric pressure is not lower than -40°C as opposed to about -160°C for LNG, operating and material costs, in turn the construction costs, particularly, of tanks and tankers, will be substantially less. This paper introduces a practical cost estimation method together with an example of conceptual planning of an LPG project based on experimental data and experience.

1 Introduction

The history of the past 15 years, since the first import of LPG into Japan from Middle East, is the history of the transition of household fuel from solid or liquid to the more convenient gas fuel in the areas where city gas is not available. With the emergence and increase in requirements of energy during this period for production of chemicals, including ammonia, methanol etc.; for automobile fuel and industrial fuel and for the needs of the iron and steel industry etc., demand for LPG has sharply increased resulting in the larger share of the total energy dependent on imported LPG.

The amount of LPG imported in 1973 exceeded the domestic production and it was about 7,000,000 ton in 1975. Large quantities of unrecovered associated gas from oil fields, mainly in Middle East countries, are still available, and an increasing number of LPG production projects are constantly being proposed.

In the future, imported LPG, supported by such expanding demand and supply structure, will be used in large quantities as fuel for power generation as LNG is now being used. Therefore, the costs of production and others, such as ocean transportation of LPG, will be a matter of great interest. Though LPG is a liquefied gas like LNG, it differs from LNG in composition, which consists of C_3 and C_4 fractions, and in its operating temperature range under atmospheric pressure which

is $-40^\circ\text{C}\sim 0^\circ\text{C}$. In this paper we will introduce a cost estimation method based on the experiential data and an example as to how to develop a conceptual plan of an LPG project.

2 Concept of Imported LPG System

LPG passes through the following stages from production to import:

- Production of feed gas (usually associated with crude oil production)
- Extraction of crude NGL
- Fractionation into C_1 — C_2 , C_3 , C_4 , C_{5+} fractions
- Refrigeration of C_3 and C_4 fractions
- Storage, Shipment
- Ocean transportation
- Receiving, Storage

For extraction of crude NGL, three systems are normally used such as compression and refrigeration system, absorption system and adsorption system, and the final selection is made by contents of C_3 and C_4 in the feed gas and yield requirements. The first two systems are usually adopted for large projects. Recently, the system most generally adopted is that in which refrigeration temperature is lowered and yields are raised by incorporating an expansion turbine in the system.

In case the source of feed gas is remotely located from the shipping site, the most common practice is to carry on the NGL extraction at the source of feed gas, and the crude NGL extracted is piped to the site on the coast where it will be fractionated, refrigerated, stored and shipped. For LPG production, essentially three processes i. e., extraction, fractionation and refrigeration are involved as shown in **Fig. 1**.

* Received December 14, 1976.

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Table 2 Example of Cost Estimate for LPG with Marine Transportation

Stage	Capacity	Investment (\$ million)	Annual Cost (\$ million)	
			Total	Shared by LPG
NGL Extraction	2,300 10 ⁶ ft ³ /day of Feed Gas	105	24.2	14.5
Fractionation & Refrigeration	58,000 bbl/day of NGL (35,000 bbl/day of LPG)	18	4.1	3.3
Storage & Loading System (Sub-total)	70,000 m ³ × 2	15 (138)	2.7 (31.0)	2.7 (20.5)
Transportation by Gas Tankers (Total)	70,000 m ³ × 3	138 (276)	29.0 (60.0)	29.0 (49.5)

(Reference date; 1975)

Fig. 4 Construction Cost of Gas Tanker

pending on the conditions of the tank site. Also the construction cost of shipping facilities, including that of berth, is influenced not only by soil conditions, but by geographical conditions, including marine conditions and depth of water, etc. However, based on our experience, the total cost of storage and shipping facilities is roughly 300–400% times the construction cost of storage tanks.

Storage tank capacity is determined mainly by the cargo tank volume of a gas tanker. Usually it is sufficient to provide with twice the tanker's cargo tank volume. Presently, the cargo tank capacity of gas tankers is standardized around 70,000 m³ based on the depth of water and other factors, but even when the capacity is raised to 140,000 m³—70,000 m³ for propane and 70,000 m³ for butane — and even when the shipment volume exceeds this level, facilities for storage and shipment will not be altered markedly.

4 Example of Cost Estimation

When the construction cost of LPG plant ob-

tained from above calculation is available, we can immediately determine the capital cost to which we must add adequate operating costs to arrive at the total cost. Thus, we can get production cost of LPG by allocating its various costs to LPG item by item. **Table 2** is an example of such calculation in which ocean transportation cost was added. We shall assume in our cost estimation that gas source is in the Middle East adjacent to the shipping site and the imported amount is 1,000,000 t/yr. (**Fig. 4**)

In this example, LPG production cost (including costs of storage and loading) comes to \$ 20.50/t and transportation cost to \$ 29.00/t, resulting in \$ 49.50/t in total, which in terms of cost per calorific value for comparing with other fuels are as follows:

Production cost;	0.43 \$/10 ⁶ B.t.u.
Transportation cost;	0.61 \$/10 ⁶ B.t.u.
Total;	1.04 \$/10 ⁶ B.t.u.

5 Conclusion

We have introduced our concept together with illustrative calculation of CIF cost of LPG produced from natural gas or gas condensates supplied at oil field. In our example the CIF cost is about \$ 1.00/10⁶ B.t.u. however not including the production cost of feed gas.

As the current market prices based on CIF Japan of various fuels including crude oil and LPG are around \$ 2.50/10⁶ B.t.u. LPG can allocate more than half of its total price to the price of feed gas and it still can be competitive with other fuels.

Acknowledgment is due to the Bridgestone Liquefied Gas Co. for permission to publish this paper.