STRATEGIC DESIGN FOR IMPORTED LIQUEFIED PETROLEUM GAS DISTRIBUTION SYSTEMS IN EAST CHINA

by

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Submitted to the Department of Civil and Environmental Engineering
on January 18, 2002 in partial fulfillment of the requirements
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ABSTRACT

Numerous foreign investors are entering the Chinese energy markets. In China more than 50% of energy is consumed in the form of coal. In order to improve the environment, the Chinese government encourages the usage of natural gas and liquefied petroleum gas. It takes long time and lots of money for China to build up its natural gas grids. However, liquefied petroleum gas has been widely applied to China in recently years. With so many over-invested facilities, the existing distribution systems are not efficient.

The theme of this thesis emphasizes on building up a compact, simple, and powerful distribution system. The key principle is to minimize the total cost of a distribution system. This includes raising the efficiencies of the facilities, locating facilities on necessary spots, and make the system flexible. These principles represent the pillars that make a LPG company competitive.

It was concluded that an effective logistic system as well as good risk management help a LPG company success in China. China has become a formal member of the World Trade Organization but China is still a communist country. An enterprise has to handle the situation. On the other hand, the price risk is huge for LPG. To hedge at least part of the purchase costs can help a LPG company stabilize its financial operation.

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CHAPTER 1. INTRODUCTION

§1.1 BACKGROUND

China, an emerging economy, is increasing its energy consumption. Two thirds of the energy consumed in China is in the form of coal that heavily burdens the environment. The reliance on coal combustion has caused more than 60% of the Chinese cities exceed residential area sulfur dioxide air pollution standards. In order to solve the Chinese environmental problem, it is essential for the Chinese people to find a cleaner alternative to coal. Natural Gas (NG), with no dust and ash pollution after burning, is considered as the best solution. NG is the dominant energy consumed in most developed countries.

China's West-East Gas Pipeline Project is under construction. Costing 14.5 billion US dollars, the project is to build pipe systems to connect the far western province of Xinjiang with the eastern city of Shanghai and other cities in the coastal region. In 2003, the project will make Shanghai residents be able to consume natural gas that travel 4,200 kilometers.

The first imported liquefied natural gas (LNG) project will be launched in 2002. Costing over 3.6 billion US dollars, the project will supply four cities in Guangdong Province in 2005 and the whole Pearl River region in 2010.

It takes long time to establish costly infrastructures that are necessary to distribute NG. The State Development and Planning Commission plans to lift NG's share of current energy consumption from 2% to 6% by 2010.

Without costly infrastructures, liquefied petroleum gas (LPG), as clean as NG, has recently been widely applied to the Chinese market. Compared to NG, LPG is more expensive but more portable. Even in well-developed countries, LPG is used in rural areas far and wide. In Japan, 20 million tons of LPG as well as 40 million tons of NG are annually consumed. In China LPG is now used as a

temporary alternative to NG; however, the LPG, in the long run, will be used as an accessorial energy in the area without NG pipes. NG and LPG will simultaneously flourish for several decades.

The rapid growth of China's LPG demand has outstripped domestic sources of supply for more than 10 years. More and more LPG is exported to China to fill the gap between the production and consumption of LPG.

The Middle East, the Far East, and Australia are the main sources of the LPG exported to China. Most of China's imported LPG is transported to China's coastal import terminals by water-borne shipping. Import terminals then ship LPG to distribution plants and retail plants by tank lorry, cylinder truck, or barge. Primary transportation between distribution plants and retail plants is by cylinder truck. From distribution plants and retail plants, end users buy cylindered imported LPG by cylinder truck, by bicycle, or by motorcycle. (Fig 1.1)

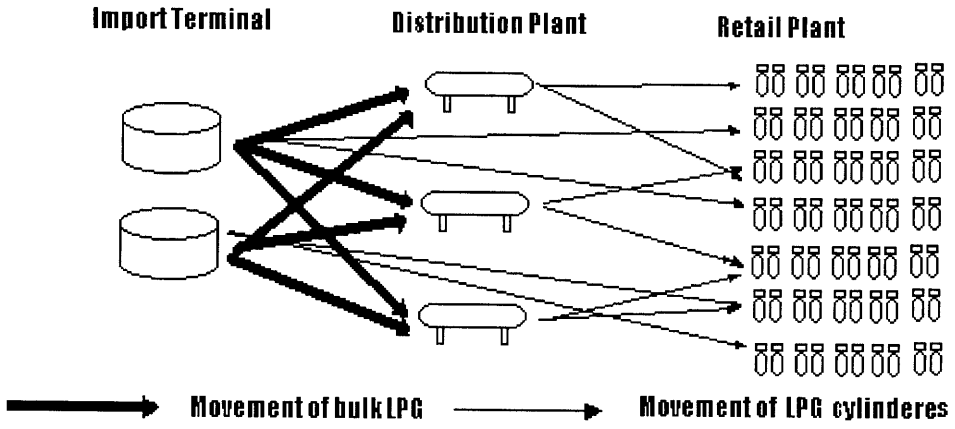


Fig 1.1 The distribution system of the East Chinese imported LPG market

South China and East China are the most important markets of imported LPG. South Chins imports about 70% of imported LPG and East China imports about 30%.

The Pearl River Delta is the essence of South China. The economic center of the Pearl River Delta is Guangzhou, the third largest city in China. The Pearl River Delta taking advantage of adjacent connection to Hong Kong and Macau, economical grow most rapidly in China.

The Yangtze River Delta is the essence of East China. Shanghai City is the economical center of the Yangtze River Delta, which has the most developed infrastructure construction in China. (Fig 1.2)

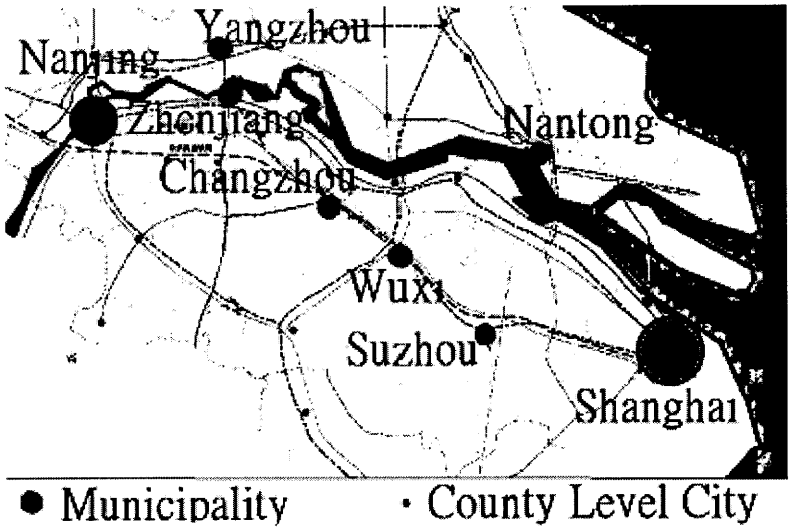


Fig 1.2 Shanghai City, Nanjing Municipality, and the SWC region

Shanghai is the most commercial city not only in East China but also in whole China. National Bureau of Statistics of China calculated the Residential Consumption Level Index (RCLI) of all provinces and province-level cities in 1999. The highest RCLI was 10,328 for Shanghai City, the second highest one was 5,784 for Beijing City, and the average was 3,143 for the all country. With the highest RCLI, there were only 0.3 million people using NG in 1999. In the same year, there were 3 million people using LPG and 6 million people using coal gas in Shanghai.

With a 5 million population, Nanjing Municipality, the capital of Jiangsu Province, is another important central city on the middle and lower reaches of the Yangtze River. Large vessels from overseas cannot sail west to Nanjing

Municipality along the Yangtze River because of the Nanjing Bridge, which is across the Yangtze River and fairly close to the surface of the Yangtze River. It is impossible to build an import terminal in Central-South China to accept imported LPG from a very large gas carrier (VLGC). As a result, import terminals east to Nanjing along the Yangtze River are important not alone for the East Chinese Market but also for the Central-South Chinese Market. The distribution plants in Central-South China have to purchase imported LPG from the import terminals in East China.

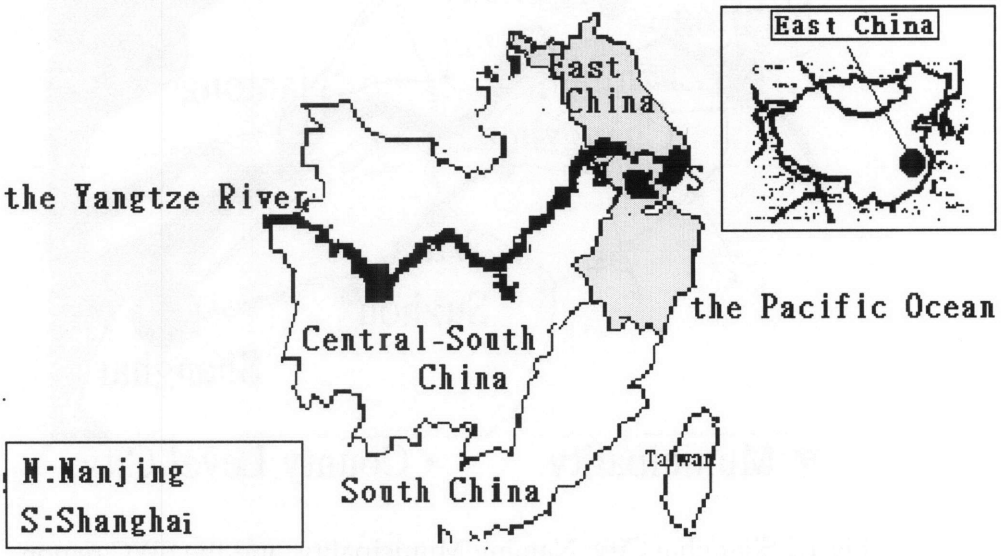


Fig 1.3 East China, Central-South China and the Yangtze River

Suzhou Municipality, Wuxi Municipality, Changzhou Municipality, as well as Zhenjiang Municipality are on the south bank of the Yangtze River between Nanjing and Shanghai. Located in the "Golden Delta" of the lower reaches of the Yangtze River and lies half way between the metropolitans of Shanghai and Nanjing, the Suzhou-Wuxi-Changzhou (SWC) region, enjoying a superior geographical location, is famous for its advanced economy.

Shanghai, Nanjing, and the SWC region consist of a great market for imported LPG and by the cheap water-borne transportation along the Yangtze River, the greatest river in China, East China is the door to another potential market, Central-South China. This is the reason that the thesis is focused on the

East Chinese market, especially on the south bank of the Yangtze River from Shanghai to Nanjing.

§1.2 Purpose of The Thesis

There are three primary objective of the thesis. The first is to formulate and analyze a strategic model for distributing imported LPG in East China. The prices at which the Chinese end users purchase their LPG are around two times as the price at which foreign exporters sell their LPG. In other words, 50% of the money paid by the Chinese consumers is paid for the cost of the distribution system. In proportion as the distribution system becomes more efficient, it will supply LPG at cheaper prices. Both the model and the modeling process (identifying objectives and constraints and collecting data) supply useful information. The information can be use to improve decision-making about distributing imported LPG in China. Second, is to develop recommendations about risk managements. Risk managements are vital to operate a business, especially in China. The Chinese business environment is specific and different from other countries. Success in other places doesn't guarantee the success in China. Take interpersonal relationship as an example. In China, dealing with the government or state-owned enterprises needs complex procedures. Without suitable interpersonal relationship to speed up these procedures, it takes fairly long time to get any license or make a contract. This makes an enterprise uncompetitive. Last, to examine the difference between the model developed in this thesis and the realistic situation. Our model cannot consist of all quantitative problems and the financial issues are not all qualitative problems.

§1.3 Outline

The chapters in this paper illustrate the Chinese imported LPG market and the model of the distribution systems in the market. Chapter 1 gives an introduction and

introduces the purpose of the thesis. The Chinese local governmental structure is also briefly explained to make the thesis more readable. An overview of the global LPG market and a big picture of the Chinese imported LPG market are given in Chapter 2, starting from the introduction of properties and usage of LPG. In Chapter 3 and Chapter 4, we develops the model by defining problems, collecting data, digitizing inputs, developing algorithms, and rechecking the model. The optimization model is the model that can minimum the total cost. With the optimized model, we know where are the suitable locations of import terminals, distribution plants, and retail plants. Furthermore, with the model, we can decide the numbers and scales of import terminals, distribution plants, and retail plants. Chapter 3 is focused on how to establish suitable distribution plants at right places and Chapter 4 is focused on import terminals. In Chapter 5, we discuss certain financial issues dealt with in the model. In China, a good official relationship is not the solution to all problems but the key to make your business more efficient. Almost all enterprises are involved in bad debt problem. Many companies have liabilities greater than its capital. Political risk, currency risk, and price risks are critical to successfully run a LPG business in China. Lastly, Chapter 6 marks the end of the thesis by drawing conclusion and making recommendations.

§1.4 DEFINITIONS OF TERMINOLOGY

In China a vice-mayor can be higher in rank than another mayor because there are different levels of cities. Without explanation, it is not easy to grasp the meaning of the word – city. There are four province-level cities – Beijing City, Shanghai City, Tianjin City, and Chongqing City. A province-level city includes several counties, several cities and a downtown area. In Jiangsu Province, there are 33 counties and 31 county-level cities. Take Wujin City for an example. After reaching specific criteria, Wujin City has been called a city instead of Wujin County. Another kind of cities is between county-level cities and province-level cities in rank. In this thesis this kind of cities is named as municipality, such as Suzhou Municipality, Wuxi Municipality, etc. A Municipality contains a downtown area and several counties or county-level cities. Take Wuxi

Municipality for an example. Wuxi Municipality consists of Wuxi Downtown and three county-level cities - Jiangyin City, Yishing City and Xishan City. In short, there are four province-level cities in China. In Jiangsu Province, there are 13 municipalities. These municipalities are composed of 13 downtown areas, 31 county-level cities and 33 counties. In rank, Shanghai City is higher than municipalities and a municipality is higher than a county-level city. In mandarin, Shanghai, Wuxi, and Wujin are all called "city" and the governors are all called "mayor". In this thesis, except for Shanghai City and Beijing City, the word "city" is used for county-level city.

The terminology "import terminal" generally refers to a terminal that is designed to receive and store LPG from overseas resources. Most large import terminals use refrigeration storage.

The terminology "distribution plant" generally refers a plant that is designed to receive and store LPG from import terminals, domestic gas wells, or domestic oil refineries. Most distribution plants use high-pressurized storages.

The terminology: retail plant" generally refers a plant that is designed to receive and store LPG from distribution plants or import terminals. Most retail plants use cylinders to temporarily store LPG.

CHAPTER 2. CHINESE LPG MARKET

§2.1 PROPERTIES AND USAGE OF LPG

One of the cleanest fossil fuels, liquefied petroleum gas (LPG) is not only globally used for cooking, but LPG is also an important petrochemical feedstock and an environmentally friendly fuel for cars, air conditioners, grain dryers, fuel cells, etc.

Mainly composed of propane (C_3H_8) and butane (C_4H_{10}), LPG, a mixture of light hydrocarbons, is gaseous at atmospheric temperature and pressure. LPG occurs naturally in crude oil refining process and natural gas production fields. Only after Dr. Walter Snelling's new discovery in1912 was LPG no longer treated as waste. Dr. Walter discovered that LPG could be changed into liquids and stored under moderate pressure. Liquefaction can lessen the volume of LPG volume by over 99.5% and makes LPG an efficient medium of energy. A 30 liters cylinder carrying 15 kilograms LPG can supply 600,000 kcal of energy. Today not only by a modest increase in pressure but also by a reduction in temperature LPG is liquefied for storage and transportation all over the world.

LPG can be stored in three types of tanks – the high-pressure tank, the refrigeration tank, and the semi-refrigeration tank. Generally the storage capacity of a high-pressure tank is smaller than the storage capacity of a refrigeration tank. 18 Kg/cm^2, the vapor pressure of propane at 50 degrees Celsius, is set as the design pressure for high-pressure tanks that are designed to store LPG at atmospheric temperature. In order to reach the criteria of pressure, the thickness of a high-pressure tank increases in direct proportion to the storage capacity. For an LPG tank with a storage capacity more than 5,000 M^3, the huge thickness makes the construction cost uneconomical. Lowing the temperature can reduce the vapor pressure of LPG and reduces the design thickness of an LPG tank. At a pressure between atmospheric pressure and the vapor pressure, semi-

refrigeration tanks are used to store LPG with volume between 50,000 M^3 and 5,000 M^3. At a temperature below the boiling point, a refrigeration tank can be economically used to store LPG with volume more than 50,000 M^3 at atmospheric pressure.

The reason that LPG is much easier to be liquefied than liquefied natural gas (LNG), mainly composed of methane (CH_4) and ethane (C_2H_6), is the lower vapor pressure of LPG. (Fig 2.1). As we mention in Chapter 1, with the portability of LPG, the benefits of gas can be brought to consumers, especially in rural areas, without any costly infrastructure.

Table 2.1 Physical properties of natural gas and petroleum gas

	Natural Gas		Petroleum Gas	
	Methane	Ethane	Propane	Butane
Vapor pressure at 20°C (Kg/cm^2)	>100.0	39.2	8.7	2.2
Boiling point of liquid at atmospheric pressure (°C)	161.5	88.6	42.1	-0.4

§2.2 WORLD LPG MARKET

From 1990 to 2000, the average LPG demand growth in the world was around 3.5 %, while total global petroleum demand growth over this same period was below 2% per year. The estimated world LPG consumption in 2001 is about 200 million tons. The United States is the greatest consumption country in the world; nevertheless, it is largely self-sufficient in LPG.

Traditionally the global LPG trading market is spread into two major markets – the East of Suez market and the West of Suez market. In the East of Suez market, more than 85% of export supplies come from the Middle East and over 45% from just one country, Saudi Arabia. The primary transportation method is water-borne shipping in the East of Suez LPG market.

Table 2.2: LPG consumption in selected countries (million tons)

	1950	1960	1970	1980	1990	2000
United States	6.0	2.1	37.4	36.9	41.1	50.5
Western Europe	0.3	3.1	11.0	17.2	23.3	28.2
Japan	0.0	0.4	6.4	13.9	19.0	19.2
China	0.0	0.0	0.0	0.0	2.2	12.9
Brazil	0.1	0.6	1.3	2.4	4.7	6.9
Korea	0.0	0.0	0.0	0.4	3.0	6.5

Table 2.3 Exporters of the LPG traded in the East of Suez Market (million tons)

	1970	1980	1990	2000
Saudi Arabia	1.5	7.9	12.3	12.9
Elsewhere in the Middle East	0.8	3.1	6.8	11.0
Asia / Pacific	0.5	2.1	4.1	3.9
West of Suez	0.2	0.0	0.0	0.0
Total	3.0	13.1	23.2	27.8

Table 2.4 Importers of the LPG traded in the East of Suez Market (million tons)

	1970	1980	1990	2000
Japan	2.9	10.0	14.5	14.8
Korea	0.0	0.1	2.1	4.8
China	0.0	0.0	0.0	5.0
Elsewhere in the East of Suez	0.1	0.4	2.2	0.9
West of Suez	0.0	2.6	4.4	2.3
Total	3.0	13.1	23.2	27.8

Saudi Arabia is the dominant producer and exporter of LPG in the world. Owned by the Saudi Arabian Government, the Saudi Arabian Oil Company (Aramco) is the world's most important LPG producing company. Every month

Aramco announces its official contract price (CP) to reflect worldwide supply and demand fundamentals. CP is not only the bench FOB price of LPG made in the Arabian Gulf but also the world's LPG marker price. On the basis of CP, import terminals in China negotiate their purchase prices with their suppliers and generally CIF prices are expressed as a USD/Ton premium over CP.

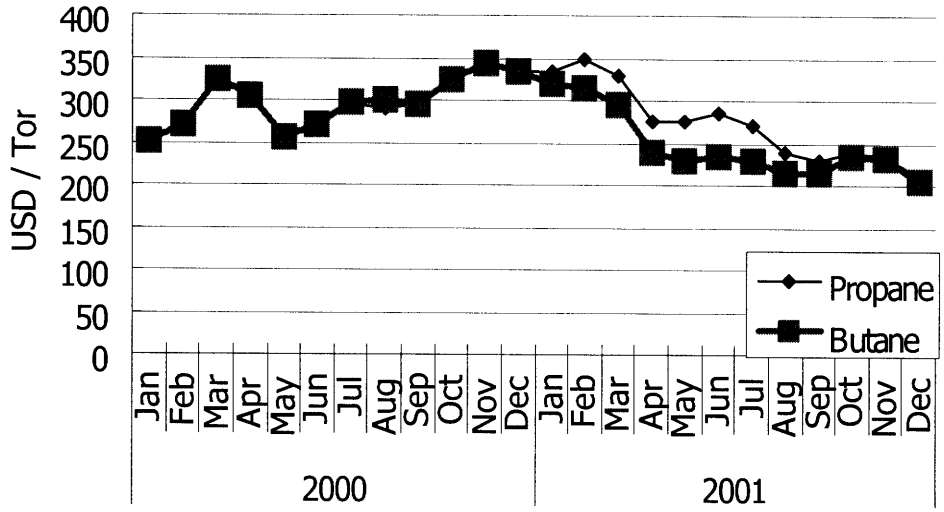


Fig 2.1 Aramco's CP Price (Jan. 2000 – Dec 2001, monthly)

CP is announced monthly but spot prices change every day. It is possible for buyers in the Far East to buy LPG at a price lower than CP. Consequently the premium over CP includes freight, profit, and insurance as well as the difference between CP and spot prices.

§2.3 Chinese LPG Market

In 2000, the LPG consumption per capita was around 10 kilograms in China and 60 kilograms in Japan, with a global average of 30 kilograms. China's relatively low number implies its potential capacity. LPG is broadly applied to different usage. Take LPG cars for an example. Before the end of 2001, LPG will fuel all the taxis in Shanghai City. Other major cities in China are planning or operating their own projects – using LPG, a cheaper and cleaner fuel, to drive numerous taxis that are currently driven by gasoline.

Chinese LPG consumption was 400 thousand tons in 1980, 2 million tons in 1990, and 13 million tons in 2000. With an average 19% growth rate, Chinese LPG consumption has become the third in the world. Because production has been relatively smoothly grown, import LPG is more and more important. In 2000, 39% of LPG consumption relied on import. China, which imported five million tons of LPG, was the greatest importer except for Japan in 2000.

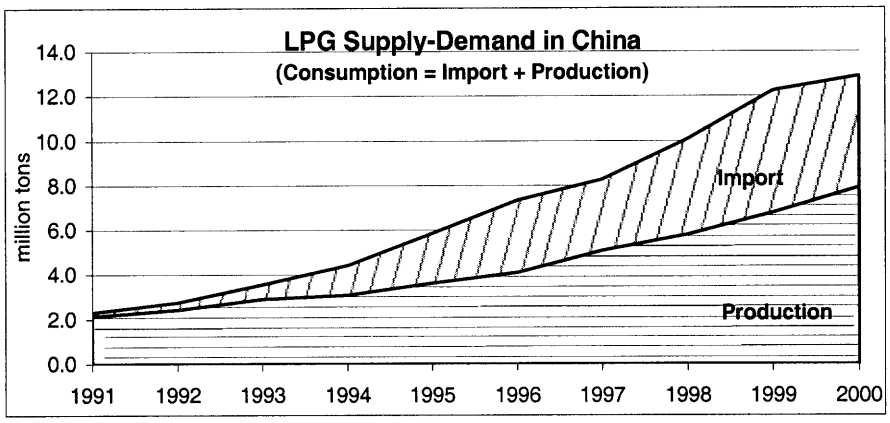


Figure 2.2: Chinese LPG consumption and Production (million tons)

Decreasing transportation cost, no less than rapid economic growth, stimulate China to import more LPG. The technology for storing and transporting LPG under pressure was first utilized on land and then applied in the early ship designs. As we mentioned earlier, thickness of the tanks limits the economical storage capacity of high-pressure vessels below 5,000 M^3. For large vessels, refrigeration is applied and decreases the thickness and weight of the tank. The most efficient transportation for LPG between the Middle East and the Far East is using very large gas carriers (VLGC). The typical carrying capacity for a VLGC ranges from 40,000 to 45,000 tons of LPG. A fully loaded VLGC generally has a draft at 10-12 meters.

In 1994, China imported 1.37 million ton LPG. The drafts of the import terminals were usually below 5 meters and the storage capacities were below 3,000 tons. Without ability of accepting LPG from the VLGC, 50% of the import

volume was from floating storages and 40% was from the terminal of Shell Eastern at Tabangao, Philippine (SETP), and 10% from Korea and other places. Several old VLGC were located off the Chinese coastline as floating storages. Accepting LPG from foreign sources by VLGC, floating storages loaded LPG to high-pressure vessels that were used to ship LPG to the Chinese import terminals. The cost of floating storages and high-pressure vessels was over 30 USD/ton. SETP had a lower fixed cost than floating storages, but the distance was much longer. The cost of SETP and high-pressure vessels was also over 30 USD/ton. If the Chinese import terminals had been able to accept VLGC as Japan, the price would be cheaper by more thank 30 USD/ton. Even the imported LPG was expensive; scarcity of domestic production made it still difficult for distribution plants to purchase imported LPG. The total capacity of the import terminals on the both banks of the Yangtze River was below 5,000 tons (over 100,000 tons in 2000). Dozens of thank lorries from distribution plants often queued in an import terminal and waited for a high-pressure vessel. Unstable supply made distribution plants try their best to expand their storage capacities so that they could store more LPG that they bought from import terminal or domestic sources. At that time, distribution plants in East China sometimes bought domestic LPG from Xinjiang by rail or from Shandong by tank lorry. The distances from East to Xinjiang and Shandong are 4,000 km and 500 km, respectively. In 2001, the travel distance for a tank lorry seldom exceeded 50 km.

Several refrigeration import terminals are operated in China. Inaugurated in 1997, Huaneng Amoco (HA) is the first one. The storage capacity of each refrigeration import terminal exceeds 30,000 tons. Some of them have the ability to accept imported LPG from a full-loaded VLGC. This makes the transportation cost lower. In East China, a 250,000-ton import terminal construction project is estimated to be finished in 2002. The investor of the terminal is BP Ningbo Huadong (BPNH). The BPNH will be the biggest import terminal in China and the storage capacity of the BPNH terminal will be over one hundred times as the

biggest storage capacity in East China in 1994. With sufficient infrastructure, the supply of imported LPG in China is getting more stable. With amplitude purchase volume and excellent capability of accepting VLGC, the transportation costs is getting lower. As we mentioned earlier, the price of LPG in the Far East is in the form of CP + Premium. The premium for a refrigeration import terminal now is very close to the one for a Japanese import terminal. (Fig.2.3 & Fig 2.4)

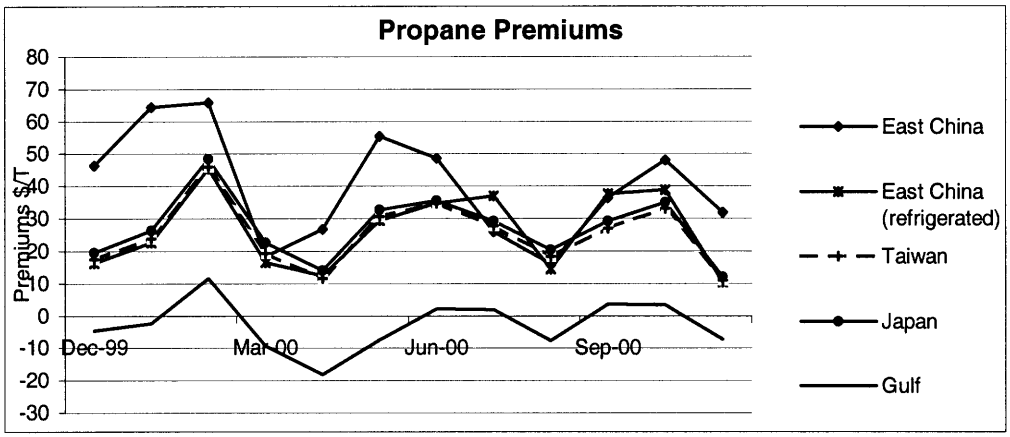


Fig 2.3 Propane Premium (USD/ton)

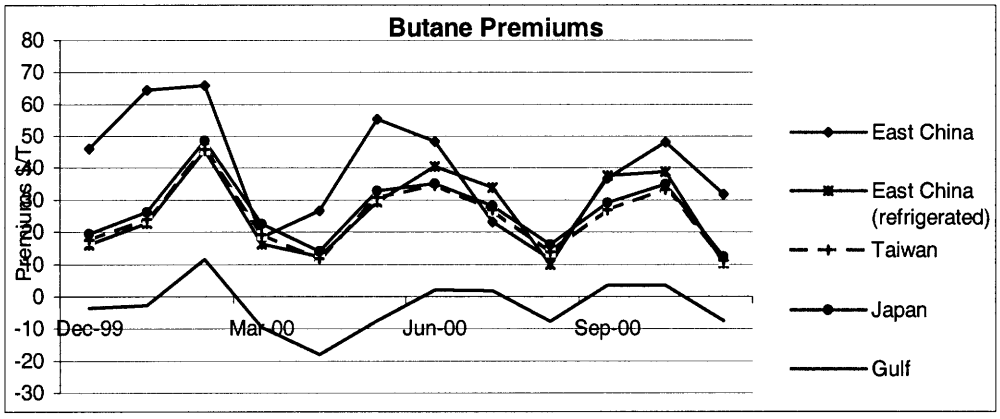
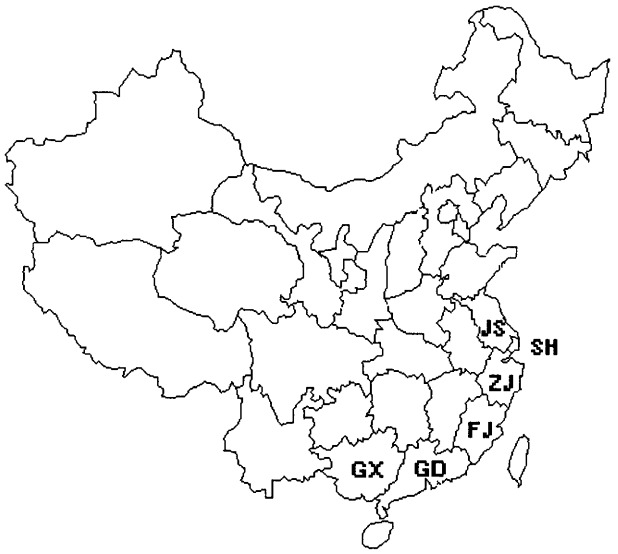


Fig. 2.4 Butane Premium (USD/ton)

The main imported LPG markets are South China and East China. Guangdong, a province with rapid economic growth and shortage of energy, is

the center of the East Chinese market. In the first season in 2001, Guangdong imported more than 70% of the Chinese imported LPG.



2001 Q1 LPG Import (million tons)		
GD	Guangdong	73.6
JS	Jiangsu	7.8
ZJ	Zhejiang	6.3
FJ	Fujian	5.7
SH	Shanghai	4.7
GX	Guangxi	1.9
	Others	1.9
	Total	101.9

Figure 2.5: Destinations of China's imported LPG

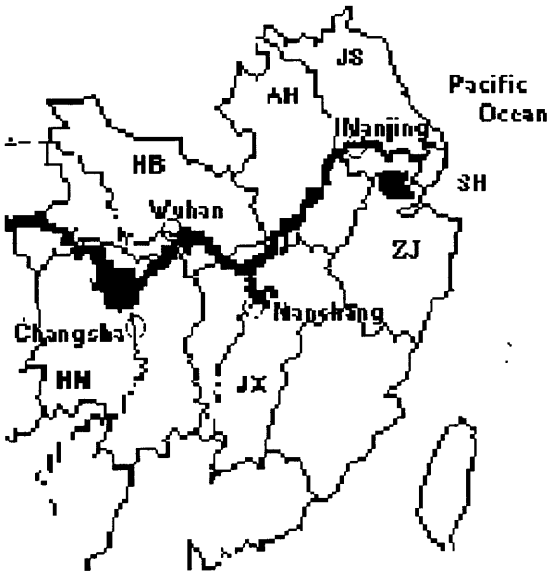
The second greatest imported in China, Jiangsu Province, is the most important importer in East China. Most of the prosperous cities in Jiangsu Province are located on the south bank of the Yangtze River. Nanjing Municipality and the SWC region are the essential areas of Jiangsu Province. Shanghai, the essence of China, is not negligible. Nevertheless, the imported LPG market in Shanghai not the dominant one in East China. In 1999, the ratios of the population using LPG over the population using coal gas were 251% in Jiangsu Province and 59% in Shanghai. Coal gas was more widely used than LPG by householders in Shanghai. Nanjing Municipality, the SWC region and Shanghai City consist of the center of the East Chinese LPG market.

§2.4 LPG Markets of East China and Central-South China

With a total length of 6,300 km, the Yangtze River, China's longest water channel, flows through nine provinces and autonomous regions. There are about

400 million people living in its 1.8 million-km^2 area. The depth of the Yangtze River is only 7 meters and it is difficult for a fully loaded VLGC to enter the Yangtze River. The government of Shanghai City is deepening the mouth. Other dredging projects along the Yangtze River are under way by the Chinese government. By 2004, these projects will enable 5,000-ton vessels to dock at Wuhan, the major city of Hubei Province. These projects will also enable 25,000 – ton vessels to enter the Yangtze River and berth at Nanjing Municipality.

Domestic and foreign investors have entered the Central-South Chinese market and established dozens of distribution plants on the banks of the Yangtze and its branches. Along the Yangtze River, high-pressure vessels are selling between the distribution plants in Central-South China and the import terminals in East China.



		Population (million)	GDP per capita (USD)
SH	Shanghai	15	3300
JS	Jiangsu	72	1300
ZJ	Zhejiang	45	1400
AH	Anhui	62	600
JX	Jiangxi	42	600
HB	Hubei	59	800
HN	Hunan	65	600
	Total	360	
	China	1259	800

Figure 2.6: Population and GDP per capita in East China and Central-South China, 1999

In this thesis, East China consists of Shanghai City, Jiangsu province and Zhijiang province; The GDP per capita in East China is much higher than the one in all China. In 1999, the GDP per capita were US$ 3,300 in Shanghai, US$ 1,300 in Jiangsu Province, US$ 1,400 in Zhejiang, and US$ 800 in all China. Central-

South China consists of Jiangxi province, Hubei province, Hunan province and Anhui province. In these two areas, most major cities are located beside the Yangtze River and its branches, such as Wuhan, Changsha, Nanchang, and Nanjing.

§2.5 Impact of China's Joining the WTO

On December 11, 2001 China formally became a member of the World Trade Organization (WTO). Some of China's regulations and laws had been amended to meet the agreements under which China joined the WTO.

On October 31, 2000 an amendment of the "Law of the People's Republic of China on Wholly Foreign-Owned Enterprises" was issued and came into force. On April 12, 2001 another amendment of the "Detailed Implementing Rules for the Law of the People's Republic of China on Wholly Foreign-Owned Enterprises" was issued and came into force. These amendments remove the requirement that a wholly foreign-owned enterprise (WFOE) must either meet advanced technology requirements or export 50% or more of its product output. These amendments remove the requirement that a WFOE must submit its operation and production plans to the departments in charge. These amendments also remove the requirement that a WFOE must balance its foreign exchange receipts and payments on its own.

Without submitting operation and production plans in advance, a WFOE can take advantage of more operational autonomy. Without balancing foreign exchange receipts and payments, a WFOE can take advantage or more financial opportunities. Without either meeting advanced technology requirements or exporting 50% or more of the product output, a WFOE can take advantage of more strategic flexibility. The other laws governing equity joint ventures had also been amended for China's joining the WTO. China is moving from a planned economy to a socialist market economy and the market, compared to the government, has more and more power.

In order to attract more foreign investors to petroleum industry, two important amendments were adopted. On September 23, 2001 an amendment of the "Regulations of the People's Republic of China on Exploitation of Onshore Petroleum Resources in Cooperation with Foreign Parties" and another amendment of the "Regulations of the People's Republic of China on Exploitation of Offshore Petroleum Resources in Cooperation with Foreign Parties" were issued and came into force. These amendments remove the requirements that the foreign party must apply advanced technology and management experience and transfer its advanced technology and management experience to its joint venture. These amendments also relax the restrictions on sale in China of petroleum obtained through a joint venture by a foreign party.

More foreign capital, technology and management will continuously ripen China's LPG market. However, the impact of China's joining the WTO on China's domestic LPG market is not huge. Compared to China's other domestic markets, China's LPG market is relatively open and many foreign investors have been involved in import terminals, distribution plants, and retail plants. For more than five years the custom duties for LPG have been fixed at 6%, a small number compared to the volatility of LPG's international price. Consequently, China's imported LPG price is strongly connected to the international market.

CHAPTER 3. DISTRIBUTING LPG IN WUJIN CITY

§3.1 INTRODUCTION

Here we demonstrate a model of the distribution system in a county-level city. Wujin City, located in the Suzhou-Wuxi-Changzhou (SWC) region, is taken as an example. We formulate and analyze the cost-minimized model so as to determine the optimal solution for distributing imported LPG in Wujin City. Although the model is developed on the basis of the environments of Wujin City, the model can be easily applied to any other city.

The tradeoff between transportation costs and storages costs is the critical point of the model. Locating more distribution plants close to customers reduces transportation cost; however, more distribution plants raise storage cost. Transportation cost, adding to the spatial value of imported LPG, is primarily composed of depreciation and maintenance of vehicles, manpower, and fuel. In contrast, storage cost, adding the time value of imported LPG, is mainly composed of depreciation and maintenance of storage facilities, manpower, and inventory cost. Our being able to find the optimal solution for distributing imported LPG in Wujin City results in our ability to determine the balance between transportation costs and storage costs.

In order to simplify our model, we assume that a town is the basic units and that each town has its own retail plant to meet its own demand. There are thirty towns in Wujin City. We notate the 30 towns as T_1, T_2, T_3, etc. To distribute efficiently LPG in Wujin City, we have to select some towns in which to build distribution plants so that we can diminish the total cost of the system. Our primary concerns are the number, locations, and storage capacities of these distribution plants.

Import terminal locations, locations of retail plants, and demands of retail plants are assumed fixed and used as inputs of the model.

§3.2 DISTRIBUTION PLANTS IN WUJIN CITY

Jiangsu Province is the second importer in China. Although Wujin City has only 1.3% of the land and 1.6% of the population of Jiangsu Province, Wujin City has 7% of the LPG consumption of the Jiangsu Province. Occupying an area of 1,373 square kilometers and having a population of 1.2 million, Wujin City consumed 46,000 tons of LPG in 1999.

Wujin City is located in the well-developed SWC region. In Chapter 2 we indicate the fact that the GDP per capita of Shanghai City was US$ 3,300 and the population was 15 millions in 1999. In contrast, the GDP per capita of the SWC region was US$ 2,700 and the population was 13.5 millions in the same year. (Table 3.1) Even compared to Shanghai City, the SWC region is significant.

Table 3.1 The GDP per capita and population of the SWC region

	Wujin City	SWC	Changzhou Municipality	Wuxi Municipality	Suzhou Municipality
Population (million)	1.2	13.5	3.4	4.3	4.8
GDP per capita (USD)	2100	2700	1200	3200	2850

There are more than 10 distribution plants in Wujin City. Most of them are state-owned. Take the distribution plant in Benniu Town for example. The government of the town invested 1.8 million USD in the plant. The distribution plant has a 500-ton storage capacity and several luxury buildings. The buildings have more rooms than the buildings in Nanrong terminal (NR). Foreign investors own 95% share of NR, a 9,000-ton import terminal. Generally the construction cost of a 500-ton distribution plant is around US$ 1.2 millions. There are 10 50-ton cylinder tanks in the Benniu plant, but only one or two tanks are often in use. Nevertheless, It is still comfortable for some town governors to possess their own distribution plants.

There are numerous highways between the towns in the SWC region. It takes less than 8 hours for a tank lorry to transport imported LPG to distribution plant form main import terminals, such as Nanrong, Huaneng Amoco, and Donghwa Unocal. On the other hand, it takes less than 4 hours for a cylinder truck to transport LPG from any distribution plant in Wujin City to the retail plant in another town. Foggy days and snowy days are limited in the SWC region. These highways are seldom out of service.

§3.3 DEMAND FORECAST

Forecasting demand is crucial to all organizations involved in the LPG industry. It takes more than two weeks for a VLGC to sail from the Middle East to East China. The whole order cycle for an import terminal to import LPG may take even more than one month. Few customers are willing to wait for such a long time. Consequently, sufficient inventories are necessary. To keep high level of inventory requires high storage cost and reduces profit. Accurate demand forecasts lead to efficient operations – providing a high level service with an economic inventory level.

Several import terminals with huge capacities have been established on the south bank of the Yangtze River. It has been no more necessary for the distribution plants in East China to purchase domestic LPG from oil refineries that are far away. The supply of imported LPG is stable and the price is competitive. An exact demand forecast is essential for a distribution plant to decrease its unnecessary storage capacity.

Knowing the total demand is not sufficient for a distribution system. It is essential to know where and when customer demand materializes. The planning and operation of an effective LPG distribution system require the use of accurate, dis-aggregated demand forecasts. In other words, we must forecast the imported LPG demand not only for Wujin City as a whole but also for each town in Wujin City.

For planning new LPG facilities to match the expected inventory levels, we need to forecast demand many years into the future since the facilities will serve for a long time. We use estimated demand in 2010 as the input of our model.

Demand is forecast by different methods, such as Time Series, Judgment Approach, and Experimental Approach. In this chapter, we forecast the town demand using Relational Approach. Using the Relational Approach, we forecast the towns' demand with the following equation:

Imported LPG consumption = Ph + Pi = P0 x Pm x Pa x Pf + Pi

where,

Ph: imported LPG consumed by householders

Pi: imported LPG consumed in industrial and commercial sectors

Po: population

Pm: users' population / whole population

Pa: equals average LPG consumption per LPG user in household sector

Pf: foreign LPG consumption / Total LPG consumption in household sector

We use the population of 1999 to forecast the population of 2010. The growth rate of population is estimated as 0.5% on average.

The GDP per capita of Wujin City in 1999 was US$ 2,100. From 1999 to 2010, the growth rate of GDP on average is estimated as 7% and the estimated GDP per capita in 2010 is US$ 4,000. In other words, the GDP per capita of Wujin City in 2010 will reach the level of Guangzhou Municipality in 1999 and will exceed the level of Shanghai in 1999. The GDP per capita were around US$ 4,000 for Guangzhou Municipality and about US$ 3,000 for Shanghai City. In 1999, the

Pa was 58 kg/yr in Guangzhou Municipality and 59 kg/yr in Shanghai. The Pa is estimated as 55 kg/yr for Wujin in 2010.

LPG is a by-product of natural gas and oil refining. The facilities of domestic natural gas well and domestic oil refineries are seldom as modern as the ones used overseas. The domestic LPG is cheaper than imported LPG but the quality of domestic LPG is not reliable. Many users buy 15-kilogram domestic LPG and can only use 12 or 13 kilograms. The purity of domestic LPG is not so good as imported LPG.

LPG can be used for residential cooking, space heating in home and industry. In the world, the largest market is as a feedstock for the production of petrochemicals, such as phenol, propylene and benzene. In China the largest usage of LPG is as a fuel. In the future, more domestic LPG will be used as a feedstock instead of a fuel.

In 2010 natural gas from the far western province of Xinjiang will reach Wujin City. It is difficult for LPG to competitive with natural gas. Supplied by pipes, natural gas is much more convenient. Because the construction cost of natural gas distribution system is expensive and natural gas is a daily necessity, the price of natural gas will mainly depend on the attitude of the Chinese government. In the world, the price of natural is usually competitive.

LPG is easier to be liquefied and its volume can be decreased by more than 99.5%. LPG is easier to be stored than natural gas. A natural complement to natural gas, LPG can be used in natural gas pipes during periods of peak demand.

The Pm in 2010 is estimated as 60% and the Pf in the same year is estimated as 70%. As a result, the imported LPG consumption is estimated as 38.5 kg per capita.

In Table 3.2, we use numbers from 1 to 30 to notate the 30 towns in Wujin City.

Table 3.2 Estimated imported LPG consumption of the towns in Wujin City

No.	Town Name	Population	Area (km^2)	Householder Sector	Industrial and Commercial Sectors	Consumption of LPG (T/ year)
1	Hutang	138,452	80.92	3,198	2,131	5,329
2	Benniu	57,856	55.7	1,336	890	2,226
3	Luyang	57,360	55.77	1,325	883	2,208
4	Henglin	55,781	46.63	1,289	858	2,147
5	Weichung	52,502	57	1,213	808	2,021
6	Jiaoxi	50,714	41.2	1,171	781	1,952
7	Xiaohe	47,456	45.68	1,096	730	1,826
8	Yaoguan	47,213	45.29	1,091	725	1,816
9	Roxi	47,199	49.93	1,090	726	1,816
10	Niutang	45,808	42.13	1,058	705	1,763
11	Zhenlu	45,192	47.36	1,044	695	1,739
12	Xixiasu	45,149	49.78	1,043	694	1,737
13	Huangli	44,902	52.36	1,037	691	1,728
14	Jiaze	44,504	55.8	1,028	684	1,712
15	Xiaxi	41,948	50.13	969	645	1,614
16	Quanhuang	41,052	49.03	948	632	1,580
17	Monghe	39,409	42.2	910	606	1,516
18	Zhouqu	38,801	40.62	896	597	1,493
19	Hensanqiao	38,596	37.21	892	593	1,485
20	Caoqiao	37,749	40.81	872	580	1,452
21	Nanxiasu	36,799	46.3	850	566	1,416
22	Boyi	36,692	39.66	848	563	1,411
23	Lijia	35,644	39.38	823	548	1,371
24	Xuejia	35,058	37.11	810	539	1,349
25	Panjia	34,599	48.16	799	532	1,331
26	Zaiqiao	32,763	52.54	757	503	1,260
27	Dongan	31,180	33.58	720	479	1,199
28	Anjia	31,180	37.28	720	479	1,199
29	Xueye	28,788	33.01	665	442	1,107
30	Furong	27,334	20.88	631	420	1,051
Total		1,347,680	1,373.45	31,131	20,723	51,854

§3.4 TRANSPORTATION COST

Transportation costs consists of fixed costs and variable costs. The fixed costs include manpower, insurance, maintenance, depreciation, interest cost and other costs. The primary variable cost is fuel cost. For a ship, the variable cost is composed mainly of fuel cost and harbor fees. We explain our way of estimate using an example of a 45,000-ton LPG vessel that is operated between export terminals in the Middle East and the import terminals on the south bank of the Yangtze River in East China. The price of the vessel is US$ 70,000,000. In Table 3.3 we estimate our annual fixed costs as US$10,000,000.

Table 3.3 Estimated annual fixed cost of a 45,000-ton LPG vessel

Items	Cost (US$)	Remark
Manpower	800,000	25 men with an average annual salary US$ 32,000
Depreciation	3,500,000	20 years, residue is omitted
Insurance	800,000	For vessel, for sailors, and P&I
Maintenance	700,000	1%
Financial Cost	3,500,000	5%
Others	700,000	1%
Total fixed cost	10,000,000	

It takes 36 days for a 45,000-ton LPG vessel to finish a round trip from East China to the Middle East. (See Table 3.4) In other words, the vessel can complete approximate 10 round trips in a year. Thus the average fix cost for a round trip is US $ 1,000,000.

Table 3.4 Estimated time consumed by a 45,000-ton LPG vessel

Sailing	Loading	Unloading	Waiting	Total
30 days	2 days	2 days	2 days	36 days

For a round trip, the sum of harbor fees and fuel cost is estimated as US$200,000. The total cost of a round trip is then US$ 1,200,000. According to our estimate, to ship one ton of LPG from the Middle East to East China by a 45,000-ton LPG vessel costs US& 26.7.

We use similar methods to estimate the transportation costs of tank lorries and cylinder trucks. For tank lorries, which are used to move LPG from import terminals to distribution plants, the unit price is RMB¥ 1 per ton per kilometer. For cylinder trucks, which are used to move LPG to retail plants from distribution plants or import terminals, the unit price is RMB¥ 2 per ton per kilometer.

§3.5 STORAGE COST

We divided storage cost into fixed cost and variable cost. The fixed costs of distribution plants depend on the storage capacities. We list the total fixed costs for different types of distribution plants in Table 3.5.

Table 3.5 Annual fixed costs of distribution plants. (RMB¥)

	50 T	100 T	200 T	300 T	400 T	500 T
Manpower	100,000	110,000	120,000	130,000	140,000	150,000
Depreciation	66,666	133,333	266,666	400,000	533,333	666,666
Maintenance	10,000	20,000	40,000	60,000	80,000	100,000
Financial costs	50,000	100,000	200,000	300,000	400,000	500,000
Others	10,000	20,000	40,000	60,000	80,000	100,000
Total fixed cost	236,666	383,333	666,666	950,000	1,233,333	1,516,666

The variable storage cost consists primarily of inventory cost. According to the local regulations, the storage capacity is designed to match 2% of the annual operation volume. In other words, the turnover is 50 times per year. The maximum inventory should be 2% of the annual operation volume and the average inventory level is 1%. We assume the internal interest rate as 10%.

Consequently, the annual inventory cost is estimated as 0.1% of the cost of the annual operating volume.

§3.6 MODEL FORMULATIONS AND HEURISTIC APPROACH

Our goal is to minimize the sum of the transportation cost and the storage cost. To formalized the problem, we define the following notation:

Inputs

F_j = fixed storage cost of locating a distribution plant at town T_j

V_j = variable storage cost of locating a distribution plant at town T_j

T'_j = annual tonnage of distribution plant at town T_j

T''_i = annual tonnage of retail plant at town T_i

D'_j = distance between NR and distribution plants

D''_{ij} = distance between distribution plants and retail plants

A_1 = unit transportation cost to distribution plant (by tank lorry)

A_2 = unit transportation cost to retail plant (by cylinder truck)

Decision Variables

$X_j = 1$, if we locate distribution plant at town T_j

Or $X_j = 0$ if we don't locate distribution plant at town T_j

In these notations, we can formulate the problem as follows:

MINIMIZE

$$\Sigma (F_j+V_j) X_j + A_1 \times \Sigma T'_j D'_j + A_2 \times \Sigma T''_i Dij$$

SUBJECT TO

$\Sigma T'_j = \Sigma T''_i$

$Xj = 0$ or 1 for all j

A_1 = RMB¥ 1 / km-ton

A_2 =RMB¥ 2 / km-ton

We develop our algorithm as follows:

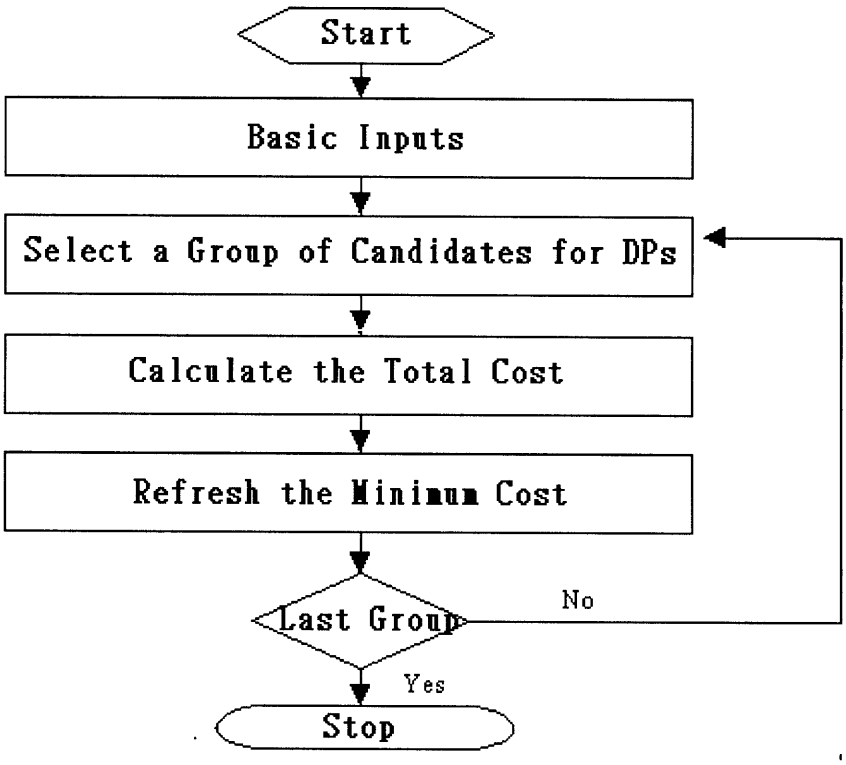


Fig 3.1 Algorithm for the cost-minimized model

§3.7 DISTRIBUTION SYSTEMS IN WES WUJIN CITY

There are several kinds of software designed to solve this kind of problems. Because of its simplicity, we use Visual Basic and Excel to solve this problem. Without refreshing minimum cost every time, we just list all total cost and sort total costs to find the minimum one. In this way, we can save time from calculation.

We begin with fourteen western towns – T_2, T_5, T_7, T_9, T_{12}, T_{13}, T_{14}, T_{15}, T_{17}, T_{18}, T_{22}, T_{24}, T_{27}, and T_{28} (Fig 3.2) Each town has a retail plant and each town is a candidate for a distribution plant. We assume the import terminal Nanrong (NR) as the only suppliers of the distribution plants.

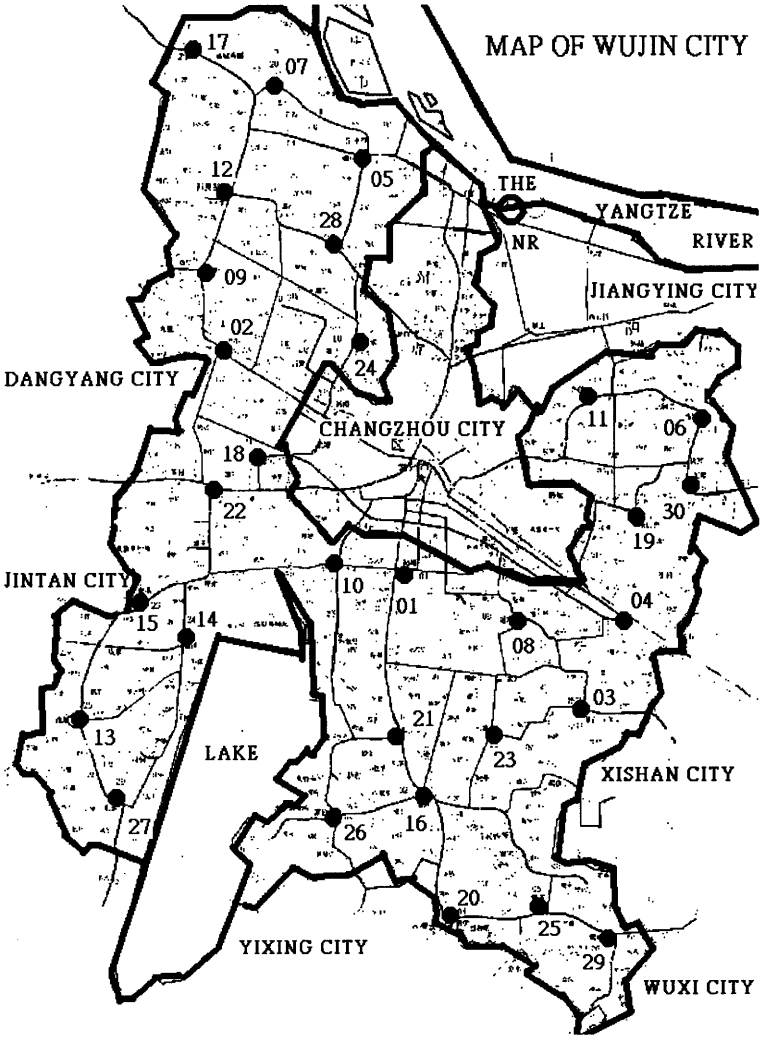


Fig 3.2 Map of Wujin City

Because the transportation cost is in proportion to the distance. The distances from NR to the fourteen towns are listed in Appendix A1. The distance between the towns in west Wujin is also listed. The number of the candidates for distribution plant is 14, so there are 2^{14} combinations. In each combination, distribution plants are established in some specific towns.

In each combination, it is possible for imported LPG to be shipped from NR to a specific retail plants via different plants. If there are five distribution plants, five different paths can be selected for shipping LPG from NR. After calculating the transportation costs of different paths, the most economic path is assigned to each town. Each retail plant is assigned to a distribution plant. (Appendix A2)

The tonnage of a distribution plant is the sum of the tonnage of the retail plants that are assigned to the distribution plant. (Appendix A3)

After knowing the tonnage of a distribution plant, the storage capacity can be determined on the basis of 50 turnovers in a year. Therefore, the inventory cost and the fixed storage cost is figured out.

The annual inventory cost is 1% of the cost of annual operation volume. Compared to the fixed storage cost, the inventory cost is not significant. The unit price of the imported LPG is simply estimated as 3,000 RMB on average. In Appendix A4, we indicate the most economic combination as the optimal solution – to set up two distribution plants in T_{22} and T_{28}. The annual cost of the distribution system is estimated as 2.9 million RMB. The fixed storage cost is 56% of the total cost.

The fixed storage cost and inventory cost can be reduced. Several import terminals with abundant storage are close to Wujin City and the lead times are limit. For an efficient distribution plant with a reliable service level, the turnover should be adjusted to 100 times per year. The maximum inventory is one percent of the annual operation and the average inventory level is half a percent. With a

10% internal interest rate, the inventory cost is estimated as 0.05% of the cost of the annual operating volume.

In Appendix A5, the new optimal solution is to set up three distribution plants in T_5, T_9, and T_{22}. The annual total cost is changed from 2.9 million RMB to 2.2 million RMB.

§3.8 DISTRIBUTION SYSTEM IN WUJIN CITY

With the experience of selecting the optimal locations for distribution plants, we start to deal with all towns in Wujin City, T_1, T_2, T_5, T_8, T_9, T_{11}, T_{14}, T_{16}, T_{18}, T_{20}, T_{21}, T_{23}, T_{24}, and T_{28} are selected as candidates for distribution plants. When the annual turnover is 50 times, the optimal solution is to build distribution plants at T_8 and T_{28}, with a total cost of RMB¥ 6,502,774. When the annual turnover is 100 times, the optimal solution is to build distribution plants at T_1, T_5, T_8, T_9, T_{11}, T_{16} and T_{18}, with a total cost of RMB¥ 4,933,700.

In Table 3.6, we demonstrate the fact that increasing the annual turnover saves the cost of the distribution systems. Changing the annual turnover from 50 times to 100 times saves the cost by about one fourth. On the other hand, the cost of the distribution system of all Wujin City is 2% lower than the one of the west Wujin City. The economy of scale is not significant between these two cases.

Table 3.6 The cost of the distribution systems of different turnovers

	All Wujin City			West Wujin City		
Annual Turnover	50 times	100 times	Save.	50 times	100 times	Save
Transportation Cost (10^6 RMB)	3.2	2.4		1.2	1.1	
Storage Cost (10^6 RMB)	3.3	2.5		1.7	1.1	
Total Cost (10^6 RMB)	6.5	4.9		2.9	2.2	
Tonnage (10^3 ton)	51.9			22.8		
Unit Cost (RMB/ton)	125	94	24.6%	127	96	24.1%

In East China, some import terminals do have the function of the distribution plants. With the function of the distribution plant, an import terminal has a cost advantage because of sharing resources. The storage cost takes an important part of the total cost. (Table 3.6) When an import terminal is used to as a distribution plant, it is not necessary to build extra cylinder tanks. The cost of the cylinder tanks is the dominant part of the storage cost. Furthermore, without extra inventory, the inventory cost can also be reduced.

Here we take NR as a candidate for a distribution plant. When the annual turnover is 50 times, the optimal solution is to build distribution plants at T_{14} and NR, with a total cost of RMB¥ 4,481,103. When the annual turnover is 100 times, the optimal solution is to build distribution plants at T_{14} and NR, with a total cost of RMB¥ 4,186,274.

The result of taking NR as a candidate for a distribution plant is shown in Table 3.7. In this table, we also demonstrate how much can be saved by taking NR as a candidate.

Table 3.7 The cost of the distribution systems by taking NR as a candidate of a distribution plant

	All Wujin City	
Annual Turnover	50 times	100 times
Total Cost (10^6 RMB)	4.5	4.2
Tonnage (10^3 ton)	51.9	
Unit Cost (RMB/ton)	87	81
Save (RMB/ton)	38	13
Save (%)	30.4%	13.8%

§3.9 CONCLUSION

In the long run, the distribution system of the future will be compact, efficient, flexible, and powerful. To locate the distributions at the right places is necessary to reach the minimum cost. With a 100 times annual turnover, the total

cost of taking NR and T_{14} as distribution plants is 4.2 million RMB. If NR and all towns are selected as the locations of distribution plants, the total cost is 6.3 million RMB. In other words, by establishing distribution plants on wrong locations, it is possible for us to raise the cost by 50%.

Increasing the annual turnover can reduce the storage cost by a significant volume. 100 times may not be the best solution. With more efficient management, it is possible to raise the annual turnover over 100 times. Import terminals and distribution plants as well as retail plants consider their inventory levels as commercial secrets. If a distribution plant gets the information that an import terminal keeps high level inventory and a VLGC will get to the import terminal in several days, the distribution plant will try to buy LPG at a fairly low price from the import terminal. Furthermore, if other import terminals get the information, some of them will sell their LPG at a low price and make the import terminal stuck. On the other hand, it is dangerous for a buyer to be knows that he is in emergent need. However, in the long run, a powerful supply chain may be formed with good cooperation between an import terminal, distribution plants and retail plants. With good cooperation, it is possible for a distribution plant to have an annual turnover over 100 times. Without good cooperation, a distribution plant has to keep more inventory as its security deposit.

To make an import terminal function as a distribution plant can reduce the total cost. Some import terminals do have the function and some others just keep the real option – keep the possibility to function as distribution plants. The reason that some import terminals still keep the real option without exercising it is our quantitative analysis doesn't reflect all the truth. When an import terminal directly competes with existing distribution plants, these existing distribution plants will ask help from the other import terminals that can reduce their own profit and supply LPG at more competitive prices. Moreover, these existing distribution plants generally have better local relationships.

Using the cost-minimized model developed in this chapter, we can determine the optimal distribution system between NR and the retail plants in Wujin City. We assume NR as the only suppliers of these distribution plants in Wujin City. In fact, there are several other import terminals located on the both banks of the Yangtze River in East China. In Chapter 4, we use Wujin City as an example again and discuss the competition between NR and its rivals.

CHAPTER 4. NANRONG (JIANGYIN) LPG CO. LTD.

§4.1 INTRODUCTION

LPG traders are involved in the business – moving LPG carefully and economically from load-port to disport. Before large shore-side terminals began to be operated in China, traders put in floating storage vessels off the Chinese coastline to compete Shell's break-bulk terminal at Tabangao in the Philippines. Most floating storage vessels were put off the Pearl River Delta and the Yangtze River Delta.

Since 1997 several large shore-side import terminals have been established. Major oil companies entered the market by joint venture with the Chinese local partners. The operators of these large terminals often make long-term contracts with foreign sources to cover most of their demand. The contract prices are usually based on the CP system.

Some high-pressure import terminals did accept LPG directly from VLGC. The storage capacity of a VLGC is often over 5 times as the storage capacity of a high-pressure import terminal. High-pressurized vessels are used to meet most of the demands of the high-pressure import terminals in China. According to our calculation in Chapter 2, importing LPG via pressurized vessels should raise the unit price by over 30 USD/ton.

The pattern of the LPG trading market is generally a seasonal upswing in demand during the winter season and a search for buyers in the summer. With ability to predict the direction of the market and access to cheaper vessels, traders can often supply high-pressure terminal at more competitive prices. (Fig 2.3 & Fig 2.4)

In Figure 4.1 we demonstrate the FOB price ranges in the second weeks in December 2001. The difference between the unit costs for high-pressure terminals and refrigeration terminals was from 18 USD/ton to 28 USD/ton.

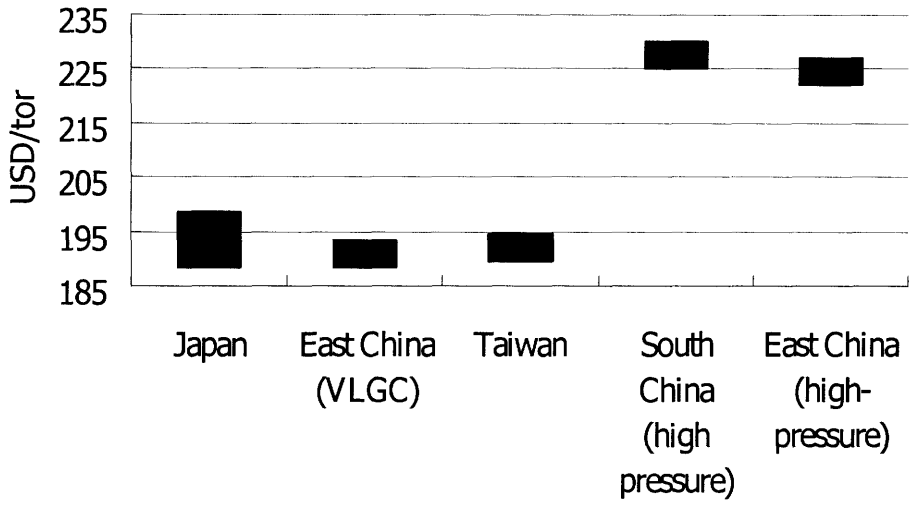


Fig 4.1 FOB Prices in the second weeks in December 2001

In Chapter 3, we discuss the cost-minimization model that can be used to determine the optimal solution for distributing imported LPG in Wujin City and we assume Nanrong (NR) as the only supplier of distribution plants. In fact, more than ten LPG import terminals have been built on the banks of the Yangtze River. Except for NR, Donghua Unocal (DU) and Huaneng Amoco (HA) are the primary import terminals on the south bank of the Yangtze River in the Suzhou-Wuxi-Changzhou (SWC) region. NR is a 9000-ton high-pressure terminal; DU is a 31,000-ton refrigeration terminal and HA is another 31,000-ton refrigeration terminal.

After discussing how to efficiently move imported LPG from an import terminal via distribution plants to retail plants, here we explore the distribution systems between foreign resources and import terminals. In other words, we focus on the competition between NR and its main competitors, DU and HA. In Chapter 5 we use NR as a case study to develop some ideas about risk managements

§4.2 NANRONG (JIANGYIN) LPG CO. LT

Nanrong Group owns a transportation company and two bulk terminal companies in Taiwan. Nanrong Group has been Taiwan's greatest ethylene glycol importer for several years. In 1994, Nanrong Group established Nanrong (Singapore) Pte. Ltd. (NRS) as Nanrong Group's first overseas company. Nanrong (Jiangyin) LPG Co. Ltd. is a joint venture of NRS and the Chinese local LPG distributor, Wuxi LPG Company (WLC). In 1994, the NRS held 52% of NR's share and WLC held the other 48%. The first goal of the joint venture was to finish, in one year and under US$ 6 million, a temporary ferry and a 6,000 cubic meter storage capacity. However, the joint venture did not start to operate until July 1998. At that time, 75% of NR's share belonged to Nanrong Group, 5% belonged to WLC, and 20% belonged to Iwatani, a Japanese gas company.

The final construction cost of the joint venture was US$ 2.6 million. The joint venture now has an 18,000- cubic-meter or a 9,000-ton storage capacity and a 25,000-ton ferry on the Yangtze River.

DU, a joint venture of Unocal and Chinese companies, has a 31,000-ton storage capacity and two ferries. The larger ferry is designed to unload imported LPG from very large gas carriers (VLGC) from foreign resources and the smaller one is designed to load high-pressurized vessels which have a storage capacity below 5,000 tons and are used to ship imported LPG from East China to Central South China along the Yangtze River. The total investment is around US$ 40 million.

HA, a joint venture of BP-Amoco and Chinese companies has a 31,000-ton storage capacity. HA is the first refrigeration import terminal in China. HA doesn't have its own ferry and HA has to share the ferry with Huaneng Group, the greatest shareholder of HA. The total investment is around US$ 30 million.

§4.3 ADVANTAGES AND DISADVANTAGES

As we introduce in Chapter 2, the depth of the mouth of the Yangtze River is only 7 meters. Generally foreign LPG resources load their LPG to a VLGC that is about 40,000 tons and has a draft about 10 meters. The shallow mouth of the Yangtze River makes it difficult for a full-loaded VLGC to enter the Yangtze River. NR, DU, and HA can only accept imported LPG from VLGC which have unloaded part of cargos in Japan, Korea, or other places. After 2004, dredging projects executed by China's government will enable a 25,000-ton vessel to berth at Nanjing. In short, after 2004 a vessel with a tonnage below 25,000 tons will easily sail into the Yangtze River through the mouth near Shanghai to Nanjing.

The bridge across the Yangtze River in Nanjing Municipality makes it difficult for a LPG vessels with storage capacities over 5,000 tons to sail west to Nanjing along the Yangtze River. NR, DU, and HA play break-bulk roles in Central South China's import LPG market.

According to our calculation in Chapter 3, the daily fixed cost of a VLGC is around US$ 30,000. If a VLGC is asked to unload LPG first in Japan and then in East China, the VLGC has to spend 4 more days. A terminal with more flexible conditions deserves better prices.

Compared to DU and HA, NR has a smaller storage capacity and this decreases the flexibility of NR. After 2004, the difference between NR and its competitors will become larger when more LPG can be shipped past the mouth of the Yangtze River at one time.

Sharing the ferry with others makes HA less flexible. It always costs a lot to ask a VLGC to wait. With its own ferry, NR keeps the option to develop more facilities to import more LPG or other goods. We discuss the real option in Chapter 5.

§4.4 TRANSPORTATION COST

When a VLGC sails from the Middle East to East China, the difference between the distances to different terminals in East China can be negligible. The primary factors affecting the transportation costs are annual purchase amount and terminal flexibility.

To compare the different transportation costs from different import terminals, we put the data about the terminals into our model and take Wujin City as an example again. We assume each import terminal itself can be assumed as a DP and the annual turnover of a distribution plant is 100 times. We get the result as follows:

Table 4.1 Cost of Distributing Imported LPG in Wujin City

	NR	DU	HA
Total Cost	RMB¥ 4,186,274	RMB¥ 9,082,020	RMB¥ 12,847,951
Unit Cost	RMB¥ 81/ ton	RMB¥ 175 /ton	RMB¥ 248 / ton

LPG's transportation cost takes an important part in the total cost. As the distance between a specific supplier and its customers increases, the transportation costs more and the specific supplier's product becomes less competitive. A competitive product becomes uncompetitive after long distance transportation.

Take Wujin City as an example, if DU has a product cost less than NR by more than RMB¥ 94 per ton, DU can theoretically keep NR away from the LPG market in Wujin City. If HA has a product cost less than DU by more than RMB¥ 73 per ton, HA can theoretically keep DU away from the LPG market in Wujin City.

§4.5 Storage Cost

In 2001 the province of Jiangsu is estimated to import 700 thousand tons of LPG. On the other hand, the total storage capacity of NR, DU, and HA is 71 thousand tons. Not to mention other importers, we can say the average annual turnover is below 10 times. A ferry used once a month is inefficient.

Depreciation, financial cost, insurance, and maintenance are closely proportional to capital investment and dominate fixed storage cost. We can roughly estimate the storage costs as 18 % of the capital investment.

We assume the average stock level is 50% of the storage capacity, internal interest rate is 10% and average LPG price is US$ 300.

We estimate the storage cost in Table 4.2. A fairly low turn over makes the unit cost unreasonable. According to the experience in other countries, a reasonable operating cost for an import terminal is around US$ 10.

Table 4.2 Estimated Storage Cost

	NR	DU	HA
Fixed Storage (US$ million)	4.68	7.2	5.4
Variable Storage (US$ million)	0.135	0.465	0.465
Total Storage (US$ million))	4.815	7.665	5.865
Annual volume (ton)	90,000	310,000	310,000
Unit Cost (US$/ton)	51	25	19

China's blooming economy makes foreign investors optimistic. NR, DU and HA all have their own expansion projects. If their expansion projects will be all exercised, the total storage capacity will reach 122,000 tons. The huge capacity can meet the most optimistic estimation in 2010.

§4.6 CONCLUSION

One USD equals about 8.3 RMB and the currency is fairly stable. For LPG, the custom duties and the added value tax are 6% and 13%, respectively; hence, the imported LPG that values one USD costs about 10 RMB.

To summarize this chapter, DU looks the unbeatable rival of NR. To distribute LPG in Wujin City, the distribution cost of DU is 9 USD higher than the one of NR. For the other cities in Changzhou Municipality and Nanjing Municipality, the situation are similar. For the cities in Suzhou Municipality and Wuxi Municipality, DU is much more competitive.

In the second weeks in December 2001, the FOB prices of high-pressure terminals were 18 USD/ton to 28 USD/ton higher than the ones of refrigeration terminals. The prices in Figure 4.1 are spot prices. The contract prices were estimated as 30 USD/ton higher than the spot prices at the same time. NR, a high-pressure terminal, primarily depends on the spot market; DU, a refrigeration terminal, primariy depends on the contract market. That the prices of LPG are volatile makes NR have more chance to compete with DU.

In short-term, when profit can cover operating cost, an enterprise will stay in a market. Without any long-term liability, if NR doesn't take any fixed cost into consideration, NR will become more competitive in the Changzhou Market and Nanjing Market.

NR doesn't have to import LPG only from high-pressure vessels. With efficient storage management and cooperation with other import terminals, NR can sometimes directly import LPG from VLGC. Nevertheless, it is difficult for NR to make a long-term contract.

In the long run, NR has to expand more storage capacity to lower the storage cost and purchase cost. NR has bought a land adjacent to the terminal and keeps the project to expand to 27,000 tons. The key point is the East Chinese market may be not large enough for so many import terminals with huge storage

capacities to make profits in the near future. Meetings were held by primary import terminals in order to make the promises to keep the price levels.

Some import terminals have invested money in the distribution plants in East China and in Central-South China, especially on the banks of the Yangtze River.

In Chapter 3 and Chapter 4 we discuss the costs for distributing LPG from foreign sources. The sea borne transportation cost is US$ 25~30; the import terminal operation cost is US$10~50; the distribution cost is US$10~30 in Wujin. In contrast, in Chapter 2 we see the fluctuation of LPG's price is often more than US$ 100. Clearly it is important to manage the risk of the fluctuation of LPG's price. Furthermore, besides price's fluctuation, there are many more other risks in from of foreign investors in Mainland China. In Chapter 5, we deal with this risk with Nanrong's experience.

CHAPTER 5. RISK MANAGEMENT

§5.1 INTRODUCTION

Uncertainty is ineludible. By proper risk managements the impact caused by uncertainty can be narrowed down. Insurance is an example. After a firm takes out insurance, the impact caused by uncertainty – fire, storm, or earthquake – is limited. Risk management is seldom free. To transfer more risk to the insurance company usually costs more.

The impact caused by the uncertainty of price is price risk. The price risk of Liquefied Petroleum Gas (LPG) is huge. On average the highest price in a year is 30% higher than the lowest price in the same year. Without price risk management, the result can be hard to swallow. In this chapter we analyze the price risk of LPG and how to manage the price risk.

Investing in an emerging market exposes investors to some specific risks. China is still a communist country with a specific political environment. Contractual terms can mean different things to different parties. Term obligation has been slow to be appreciated. On December 11, 2001 China became a formal member of the World Trade Organization (WTO). This means China has to obey most rules obeyed by most economies and makes foreign investors more competitive in the Chinese market. In this chapter we draw on China's country level political risk that is decreasing by China's joining the WTO. Because China is a country with a great territory, a great population, various cultures, and different languages, different political risks can be taken in different areas and different times. Furthermore, the Chinese local governors use their administrative quotas to protect their own advantages. They build up numerous entry barriers between different provinces, different cities, and even different towns. The county level political risk is essential. In this chapter we use Nanrong Group's experience to introduce the county level political risk.

An efficient currency market is vital to international companies that face currency risks. Many tools have been developed to hedge or speculate the impact of currency uncertainty. In currency future markets, normally 90% of traders are speculators. With numerous transactions by numerous speculators the currency future market, with a huge turnover, can effectively reflect the price. In addition to currency future markets, forward contracts between banks and enterprises are also an efficient tool that can be used to hedge currency risks. In China there is no legal future currency contract can be traded. In the currency forward contract market, in order to keep speculators away from the market and make the currency market stable, the Chinese government put on a lot of restrictions. With a limited turnover, the Chinese currency market cannot reflect the price efficiently. The Chinese government has become the only big trader in the Chinese currency market. In this chapter we discuss China's currency risk and what Nanrong Group met in 1994.

Debt collection is critical to a company's cash flow. With an unpredictable cash flow, a company cannot executive its operation plan effectively and an unexpected deficit in the cash flow can cause a company bankrupt. Debt collection is difficult in China. Before 1992, all companies in China were state-owned. The debt between these state-owned companies was similar to the debt between different departments in a company. The debt between different departments doesn't affect the cash flow of a company. Moving from a planned economy to a socialist market economy, Chinese enterprises are changing their behaviors step by step. Some companies have noticed the importance of debt collection; however, some state-owned companies still have not paid any attention to their credit history. In this chapter, we try to find the reason causing that bad debt and the solution to the bad debt.

§5.2 PRICE RISK MANAGEMENT

In February 2001, the CP prices were 350 USD/Ton for propane and 315 USD/Ton for butane; in August 2001, the CP prices were 240 USD/Ton for propane and 215 USD/Ton for butane. In the six-month duration, the CP prices went down 100 USD or more. From March 2000 to June 2000, the CP prices for propane and butane both changed from 325 USD/Ton to 270 USD/Ton. We define the Price Fluctuation Index (PFI) to describe the vacillation:

$$PFI = \{ (CP_{max} - CP_{min}) / 2 \} / (CP_{average})$$

where CP_{max} is the highest CP price in the duration, CP_{min} is the lowest CP price in the same duration, and $CP_{average}$ is the average CP price in that duration. The PFI is 15% in 2000 and over 20% in 2001. Since in 1994 the CP price system was applied, the fluctuation of the CP has always been huge.

The primary factors that affect the supply and demand fundamentals primarily affect the CP. The price of LPG, which is competing with crude oil based fuels, is influenced by the cost of crude oil. In Fig 5.3, we set the prices of the first quarter in 1994 as 100% for propane (CP), butane (CP), and crude oil (Brent Crude Oil). The correlation ratios are 98.6% for propane and butane, 74.6% for propane and crude oil, and 73.4% for butane and crude oil for the quarterly prices from 1994 to 2001.

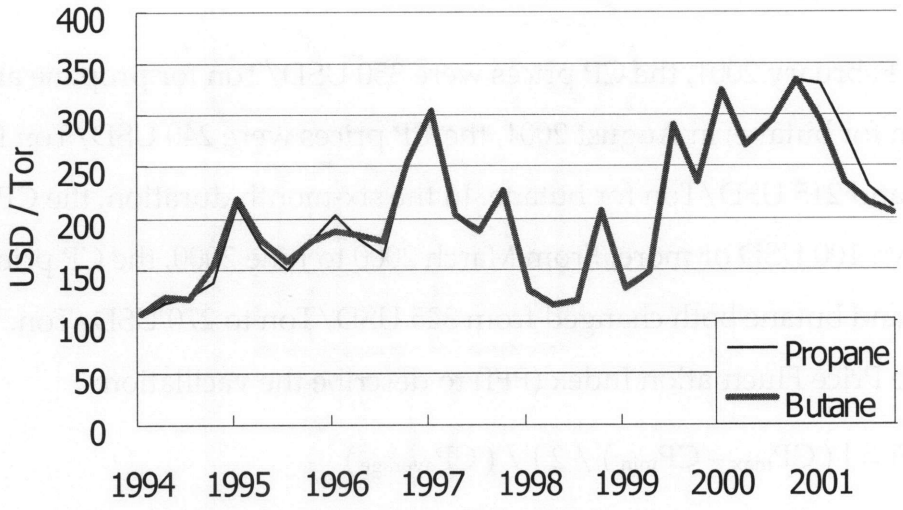


Fig 5.1 Aramco's CP Price (Mar 1994 – Dec 2001, quarterly)

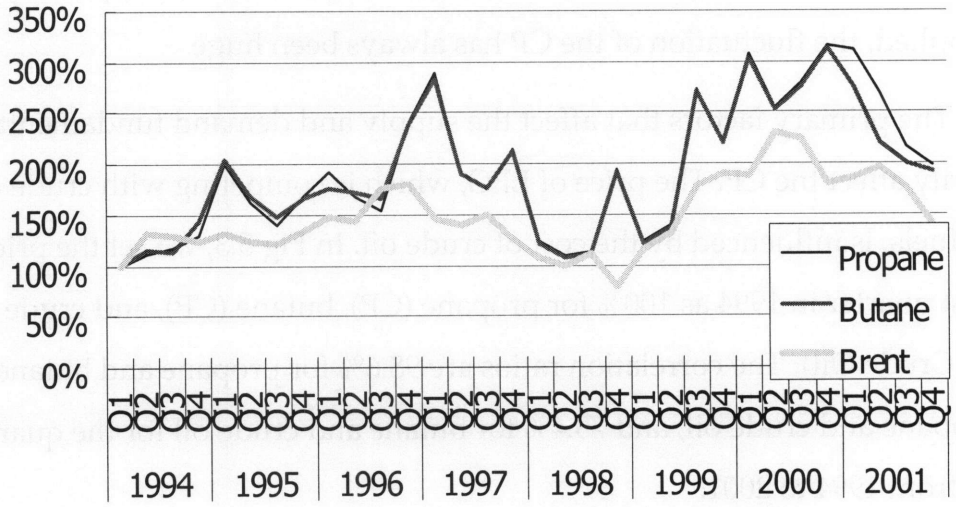


Fig 5.2 Correlations between Crude Oil, Propane, and Butane (quarterly)

LPG production is not seasonal but LPG demand is seasonal. Residential demand is high in the winter. We define a simple index, Seasonal Price Index (SPI) as follows:

$$SPI = \{ (CP_{winter} / CP_{summer} - 1) \times 100\%$$

where CP_{winter} is the CP price in December and CP_{summer} is the CP price in June. On average the CP price in December is 30% higher than the CP price in June in the same year.

Table 5.1 SPI index (1994 – 2001)

	1994	1995	1996	1997	1998	1999	2000	2001	Average
Propane	16.95%	4.09%	42.46%	11.85%	79.57%	58.78%	24.07%	-26.32%	30.21%
Butane	23.39%	-1.11%	39.34%	11.85%	79.57%	58.78%	24.07%	-12.77%	31.88%

CP price, transportation cost and custom duties are the primary part of the cost of imported LPG. Compared to CP price, transportation and custom duties are relatively stable. In China the custom duties for propane, butane, and LPG (the mixture of propane and butane) have been fixed at 6% for more than five years. Since China has become a formal member of the WTO, the custom duties are expected to be 6% or lower in the future. The custom duties for LPG are not one of the primary factors affecting China's imported LPG prices. China's imported LPG prices are strongly affected by the LPG prices in the international market.

In Chapter 3 our optimal solution of distributing imported LPG in Wujin City is to build up at limited distribution plants. In fact, there are more than 10 distribution plants existing in Wujin City. The government of Benniu Town, the second largest town in Wujin City, owns a 500 Ton distribution plant and usually the stock of the distribution plant is below 50 Tons. The spare storage capacity makes seasonal speculation possible. The SPI (average 30%) is high enough to cover the storage cost. However, the SPI in 2001 is –26.32% for propane and –12.77% for butane and it can be a painful experience for a speculator who always buys in June and sells in December. It is essential that hedging in the derivatives markets be used as tools to protect against unexpected losses in the volatile LPG markets. Buying a Brent Crude Oil Put Option contract in New York Mercantile Exchange (NYMEX) can decrease this kind of pain.

A Brent Crude Oil Future Contract also can be used to hedge the fluctuation of CP price. Nevertheless, the option contract and the future contract are not widely used by foreign investors or domestic companies in China. Import terminals prefer making a long-term contract with their suppliers. A CIF contract can hedge both the fluctuation of SP price and the fluctuation of transportation cost. Generally the amount purchased by contract is at least 50% and this makes the purchase costs vary less. The rest of the volume purchased from the spot market can make an import terminal operate its stock level with more flexibility. On the other hand, Chinese distribution plants just use their spare capital and spare storage capacity to speculate on the seasonal price difference and take all the risks

In addition to the fluctuations of CP, transportation cost, and custom duties, currency is another key factor that can affect the price.

§5.3 Currency Risk Management

The movement of international capital is the primary reason that makes currency unstable. The short-term international capital is involved in the buying and selling of stocks, bonds and currencies. The long-term international capital is involved in direct investment. With sensitivity and liquidity, the Euro, the Japanese Yen and the Swiss Franc are all good targets for international short-term speculators. The short-term international capital makes these currencies less stable minute by minute. The Chinese currency, Renminbi (RMB), is less sensitive and relatively conservative. For a short-term speculator, the RMB is not attractive. This makes the Chinese government have more control of China's capital market. The RMB remained stable even during the period of Asia's financial turmoil in 1997.

With control of the capital market, the Chinese government devalued RMB more than 30% in the first month of 1994. The Chinese government has become the greatest source of currency risk.

Although no future contract can be used to hedge Chinese currency risk, it is possible to buy forward contracts from Chinese domestic banks. Most domestic banks also supply loans in Chinese currency to foreign investors. Local loans and forward currency contracts are widely used to hedge the currency risk now.

In 1993, Nanrong Group made an agreement with Wuxi Gas Co. Ltd to build up a joint venture – Jiangyin Nanrong LPG Co. Ltd. The capital of the joint venture was 600 million USD and Nanrong Group held 52% share and Chinese local Wuxi Gas Co. Ltd held another 48% share. According to the agreement, the capital supplied by Nanrong Group was in the form of US currency and the capital supplied by Wuxi Gas Co. Ltd was in the form of land and equipment. After the huge devaluation of the RMB in the first month of 1994, the two partners had different opinions about how many US dollars Nanrong Group should supply. The partners insisted on their own right After devaluation, one US dollar could be exchange for 30% more RMB. Several months after the huge devaluation, the Chinese government announced that the advantage caused by the devaluation of the RMB belonged to joint ventures. In other words, the joint venture had an unexpected profit around 70 million US dollars. At last, when the 600-million capital and the 70-million profit were exhausted, the construction of the joint venture had not yet been finished. Nanrong Group experienced Chinese specific political risks – nebulous information, alleged corruption, and bureaucracy. These political risks are different from the ones in other countries.

§5.4 Political Risk Management

China's joining the WTO has reduced the barriers between China and the other countries. Nevertheless, the barriers between different provinces, different cities, or even different towns are only slightly relaxed.

Financing part of the project with a loan from the World Bank or one of its affiliates can hedge political risks, especially for country-level political risks. A

multinational company can also buy political risk insurance to hedge the country-level political risk.

The Chinese government insist on Taiwan is a part of China and tries to attract more Taiwanese investors. As a result, Taiwanese investors are politically domestic and economically foreign. All the economic regulations applied to Taiwanese investors are the same or similar to the ones applied to foreign investors. It is possible for a political environment to change an economic environment. In order to hedge the risk to become a totally domestic enterprise, most Taiwanese select to register in a third country or joint venture with a politically foreign investor. Take Nanrong as an example. The Taiwanese Nanrong Group established a Singapore-based company and joint venture with a Japanese company.

The departments-in-charge of the China-Singapore Suzhou Industrial Park belong to the Chinese central government; the departments-in-charge of the Wuxi-Singapore Industrial Park belong to the government of Wuxi Municipality. The Singaporean government invested in the two industrial parks and established them in 1993 and 1994. After several years, the Wuxi-Singapore Industrial Park is more successful. To be governed by a higher-level government doesn't mean success.

Wuxi Municipality consists of Wuxi downtown district, and three county level cities – Jiangyin City, Xishan City, and Yihsing City. The mayor of Wuxi Municipality directly governs Wuxi downtown district and supervises the mayors of Jiangyin City, Yihsing City, and Xishan City. Jiangyin City is the only region adjacent to the Yangtze River in Wuxi Municipality and the government of Wuxi Municipality owns Wuxi Gas Co. Ltd. The joint venture of Nanrong Group and Wuxi Gas Co. Ltd was therefore registered in Wuxi Municipality and located in Jiangyin City. From the viewpoint of Nanrong Group, it was natural.

Everything was totally different for the government of Jiangyin City. If the joint venture had registered in Jiangyin City instead of directly registering in Wuxi Municipality, Jiangyin City could keep some of the tax from the joint venture and submit the rest of the tax to Wuxi Municipality. Moreover, the location of the joint venture was indeed in Jiangyin City. Supervised by Wuxi Municipality, the government of Jiangyin City could not argue directly that the joint venture should have registered in Jiangyin City. However, the governors of Jiangyin City didn't help the joint venture when the joint venture had bad time with the town government that is supervised by the Jiangyin City. Nanrong Group found the promise by the town government was not reliable. The land lease contract made between the joint venture and the town government was invalid. According to China's laws, only the county-level city has the right to lease land to enterprises.

In 1997 the joint venture changed its registration from Wuxi Municipality to the Economical Development Zone in Jiangyin City. To register in the Economical Development Zone, the joint venture's income tax changed from 27% to 15%. Three days after the re-registration, the joint venture got the legal land lease contract from the Jiangyin City. It took Nanrong Group four years to find the Win-Win game

To conquer the county level barriers is a kind of know-how. It takes time and effort. A chamber counsel can help an enterprise. There are two Taiwanese and about 10 Hong Kong people have passed China's national qualified lawyer exam. They can bridge the western concept and the Chinese environment. It is still almost impossible to make a stranger reliable in a short time.

§5.5 Debt Collection

In China, distribution chains are generally complicated and inefficient. A slow logistic system not only induces slow movements of goods but also induces slow movements of capital. Much capital is in the form of unnecessary stock.

Banks and enterprises are all fighting the battle to solve the bad debt problems. Moreover, many debtors delay the debt on purpose.

Before China's opening up in 1992, all enterprises in China were state-owned. These state-owned companies had their own cooks, doctors, and in-house lawyers. Now many Chinese companies still have their in-house lawyers. On the other hand, most foreign investors will not hire in-house lawyers. Because in China the loosing party in a lawsuit doesn't have to pay the legal fees of the winning party, a long-time lawsuit usually costs a foreign investor a great deal and costs a state-owned company owing in-house lawyers very little. Taking advantage of employing in-house lawyers, a state-owned company debtor can try its best to make the lawsuit as complicated as possible and the fear of high legal fee for a long-time lawsuit will force the foreign investor debt collector to negotiate and yield some extra discounts.

Some companies also believe if the lawsuit is held in their own city, they can have more chance to win the lawsuits over another company from another city or another country.

Except for law firms, professional debt collection business is illegal in China. It is clear that the best solution to the debt collection is to keep away from being involved in any bad debt. At least decreasing the circle of debt collection or to decrease the amount of debt can help

§5.6 Real Option

As we mentioned earlier, the vapor pressure of propane is higher than the one in butane. That the spheres used to storage propane are thicker than the ones used to storage butane causes a propane sphere costs almost two butane spheres. However, a propane sphere can be used to storage propane, butane, the mixture of propane and butane, and vinyl chloride monomer (VCM). A butane sphere can be only used to storage butane because of its thin thickness. In other words, a propane spheres is with real options.

Import terminals built before 1995 are generally with small storage capacity and were constructed under strict regulations that all LPG spheres should be designed to match the criteria to store pure propane. Under huge competition from new import LPG terminals with 10 times larger or more storage capacities, some small old import terminals now have switched to VCM market. Maybe the spare thickness is not a real option that was bought on purpose. Nevertheless, under the pressure of dearly competition, old import terminals have to explore the real options that they have owned.

Before 1995 the custom duties are 6% for propane, 6% for butane and 9% for LPG (the mixture of propane and butane). Import terminals were glad to build up two sets of pipes to store them separately. When propane and butane were loaded to tank lorries under desired proportion, these two gases would mix well before they were delivered to destinations.

After 1995 the custom duties for propane, butane, and LPG are all 6%. The second set of pipe has lost some of its value, but it is still a valuable real option. Two sets of pipes can separate butane and propane well. Using one set of pipe can also load or unload propane and butane alternatively; nevertheless, the purities of propane and butane are difficult to meet some critical use. Pure propane can be used to cut steel and pure butane can be used in lighters. These are part of the values of the real option of the second set of pipes. This real option – with more than one set of pipes – can also make old terminals to storage VCM and LPG simultaneously.

Some import terminals have to build up their own ferries and roads connected to highways. The ferries and roads are the real options these import terminals have to buy. A ferry is possible to be used by other terminals that will be established close to the ferry. With its own ferry and its own road, Nanrong (Jiangyin), cooperated with the government of Jianyin City, make the area close to Nanrong (Jiangyin) terminal become an economic development zone. They use existing ferry, road and favored tax policy to attract more investors.

A cylinder tank is often 50 tons, welded in factory, and moved to the assigned place. A sphere tank can be designed to fit the requirement and the storage capacity of a sphere tanks is able to vary from 200tons to 4000 tons. If we want to build up a 400-ton distribution plant, we can buy 8 50-ton standard cylinder tank or we can establish two 200-ton sphere tanks. In the East China, few distribution plants own sphere tanks. There are several distribution plants with 10 cylinder tanks and only one or two of the cylinder tanks are often in use. The spare cylinder tanks can be used to speculate on the price of LPG or moved to another

distribution plant. The portability of cylinder tanks has become a real option.

CHAPTER 6. CONCLUSION

§6.1 INTRODUCTION

Most of the world top 500 multinational companies have invested in China. These investments mainly focus on energy projects, high-tech, infrastructure, and petrochemical projects. Large sums of capital and long periods of time are required for these projects to achieve returns. This reflects the confidence of the foreign investors.

When Nanrong entered the liquefied petroleum gas (LPG) market in East China, Nanrong decided to establish an import terminal that would be better than all the existing import terminals. Later the similar stories happened to Huaneng-Amoco (HA) and Donghua-Unocal (DU). In 2002, the 250,000-ton BP Ningbo Huadong (BPNH) terminal is estimated inaugurate in Zhejiang Province in East China. Will BPNH be the largest one in the future?

In the near future, it is difficult for the import volume of the East Chinese market to reach 2 million tons per year. Consequently, what is the estimated annual operation volume of BPNH? What is the estimated annual turnover?

In 2001, after investing 70 million USD in the Chinese LPG market, Shell decided to quit the market. A market with excess profit is dangerous, for it will attract too many investors to join the market.

§6.2 DECISION-MAKING OF NR

How Nanrong decided to join the market? Instead of paper calculation, mental calculation is used as the basis of the decision-making of Nanrong.

Most Taiwanese primary financial groups and medium to small enterprises were established several decades ago. Most of the founders don't have a degree above high school. What they rely on is experience. With their

experience they can get the simple but effective estimate. However, sometimes the estimate is affected by the feelings of the decision- maker.

To be a dominant import terminal was only one of the reason for Nanrong to decide to join the market. To catch the Chinese fever in 1993 was the second season. To make the dream come true was the last but not least reason.

Several decades ago, the licenses to operate a liquefied petroleum gas (LPG) enterprise in Taiwan were fairly limited. At that time Nanrong missed a chance to get a license. Several decades later, Nanrong made its dream come true in China.

After Nanrong made a joint venture to build up a terminal in East China, Nanrong was asked many times to sell the terminal at a fairly attractive price. Nanrong refused all the deals. One reason was the owner didn't want to sell his dream. A mental calculation supplied another reason. If there was someone who wanted to buy the terminal, it meant the terminal valued the price the buyer offered. In contrast, the multinational companies' decision are mainly rely on numerous quantitative analysis.

When Nanrong wanted to select a foreign company to hedge the political risk, Shell was one of the candidates. When Shell asked Nanrong why the storage capacity was designed to match 18,000 cubic meters, the answer from the owner of Nanrong was short. "18 was a lucky number in China", said the owner. If fact, it would be difficult for Nanrong and Shell to discuss the details of their different calculations. Instead of Shell, Mobil, and Marubeni, Nanrong selected Iwantani as their partner. The reason was also simple – Iwatani was compact. Efficiency is the advantage of smaller companies.

§6.3 THE QUANTITATIVE ANALYSES IN THIS THESIS

A lot of numbers are handled in this thesis. These quantitative cannot reflect all the truth in the world. However, the model has reflected the result of

some factors and their interaction in a simpler way. Take risk management as another example. It is impossible to hedge all the risks. It is not difficult for us to hedge the risks that we have known. This reduces the possibility of us to get involved in risks.

The success of a project cannot always be judged by the project itself. Several high-pressure import terminals are treated as real options. Shell did try to establish distribution systems, including import terminals, distribution plants, and retail plants. After evaluation, Shell decided to quit the market. On the other hand, BP-Amoco also built several high-pressure terminals. After evaluation, BP-Amoco decided to exercise the option – to invest more money to build several refrigeration terminals.

The market is dynamic and there is no telling what may exactly happen to the LPG market in East China. LNG will share the market in the future. To estimate the usage of LNG is complex but necessary. The distribution of LNG pipes is vital for estimating the LPG market.

More applications will increase the demand. LPG is used as the fuel for all taxis in Shanghai City and LPG will be used for the taxis in more cities. LPG fuel cells are developing A LPG fuel cell can supply electricity in a rural area without any electricity girder. After knowing the locations of electricity girders, the potential demand of LPG can be more exactly estimated.

Appendix A-1

The distances between the Nanrong (NR) and the towns in Wujin City are shown in this table in kilometer.
For the towns with a distribution plant, the indexs in the first column equal 1. The other indexs equal to zero.
The candidates for distribution plants are in colum 2.
The retail plants are in the first row.

Index	RP / DP	2	5	7	9	12	13	14	15	17	18	22	24	27	28
0	NR	30.82	14.45	26.00	26.64	22.18	67.18	53.55	54.36	34.64	35.55	41.18	20.36	69.73	15.27
0	2	0.00	23.82	22.45	6.73	11.36	36.36	22.73	23.55	23.64	9.82	10.36	10.45	38.91	15.55
0	5	23.82	0.00	11.55	19.64	12.45	60.18	46.55	47.36	20.18	28.55	34.18	13.36	62.73	8.27
0	7	22.45	11.55	0.00	18.27	11.09	58.82	45.18	46.00	8.64	27.18	32.82	24.36	61.36	15.45
0	9	6.73	19.64	18.27	0.00	7.18	40.55	26.91	27.73	16.91	16.55	15.64	16.09	43.09	11.36
0	12	11.36	12.45	11.09	7.18	0.00	47.73	34.09	34.91	12.45	21.00	21.73	20.55	50.27	11.64
0	13	36.36	60.18	58.82	40.55	47.73	0.00	13.64	12.82	55.64	31.64	26.00	46.82	8.18	51.91
0	14	22.73	46.55	45.18	26.91	34.09	13.64	0.00	5.73	42.00	18.00	12.36	33.18	16.18	38.27
0	15	23.55	47.36	46.00	27.73	34.91	12.82	5.73	0.00	42.82	18.82	13.18	34.00	15.36	39.09
0	17	23.64	20.18	8.64	16.91	12.45	55.64	42.00	42.82	0.00	33.45	32.55	33.00	58.18	24.09
0	18	9.82	28.55	27.18	16.55	21.00	31.64	18.00	18.82	33.45	0.00	5.64	15.18	34.18	20.27
1	22	10.36	34.18	32.82	15.64	21.73	26.00	12.36	13.18	32.55	5.64	0.00	20.82	28.55	25.91
0	24	10.45	13.36	24.36	16.09	20.55	46.82	33.18	34.00	33.00	15.18	20.82	0.00	49.36	8.91
0	27	38.91	62.73	61.36	43.09	50.27	8.18	16.18	15.36	58.18	34.18	28.55	49.36	0.00	54.45
1	28	15.55	8.27	15.45	11.36	11.64	51.91	38.27	39.09	24.09	20.27	25.91	8.91	54.45	0.00

Appendix A-2

The unit transportation cost by tank lorry is one RMB. A_1 = 1 $RMB / km-ton

The unit transportation cost by cylinder truck is two RMBs. A_2 = 2 $RMB / km-ton

The unit cost of each pats eequals:

(A_1 * the distance from NR to the distribution plant)+(A_2 * the distance from the distributon plant to the retail plant.

The distances from NR to distribution plants are shown in the parenthesis in the first raw..

Cheapest Paths	46.36	31.82	46.18	38.00	38.54	93.18	65.91	67.54	63.45	52.45	41.18	33.09	98.27	15.27
DP \ RP	2	5	7	9	12	13	14	15	17	18	22	24	27	28
NR (0)	----	----	----	----	----	----	----	----	----	----	----	----	----	----
2 (31)	----	----	----	----	----	----	----	----	----	----	----	----	----	----
5 (14)	----	----	----	----	----	----	----	----	----	----	----	----	----	----
7 (26)	----	----	----	----	----	----	----	----	----	----	----	----	----	----
9 (27)	----	----	----	----	----	----	----	----	----	----	----	----	----	----
12 (22)	----	----	----	----	----	----	----	----	----	----	----	----	----	----
13 (67)	----	----	----	----	----	----	----	----	----	----	----	----	----	----
14 (54)	----	----	----	----	----	----	----	----	----	----	----	----	----	----
15 (54)	----	----	----	----	----	----	----	----	----	----	----	----	----	----
17 (35)	----	----	----	----	----	----	----	----	----	----	----	----	----	----
18 (36)	----	----	----	----	----	----	----	----	----	----	----	----	----	----
22 (41)	61.91	109.54	106.82	72.45	84.63	93.18	65.91	67.54	106.27	52.45	41.18	82.82	98.27	93.00
24 (20)	----	----	----	----	----	----	----	----	----	----	----	----	----	----
27 (70)	----	----	----	----	----	----	----	----	----	----	----	----	----	----
28 (15)	46.36	31.82	46.18	38.00	38.54	119.09	91.82	93.45	63.45	55.82	67.09	33.09	124.18	15.27

Appendix A-3

Column 1 shows the annual operation volumes (ton) of the distribution plants.
Row 1 shows the annual operation volumes (ton) of the retail plants.

DP \ RP		2,226	2,021	1,826	1,816	1,737	1,728	1,712	1,614	1,516	1,493	1,411	1,349	1,199	1,199
		2	5	7	9	12	13	14	15	17	18	22	24	27	28
-	NR	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9,157	22	0	0	0	0	0	1728	1712	1614	0	1493	1411	0	1199	0
-	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-	27	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13,690	28	2226	2021	1826	1816	1737	0	0	0	1516	0	0	1349	0	1199

Appendix A-4

Total Cost of Distribution System = 1,686,391.RMB

Transportation cost **1,184 RMB**

RP	2	5	7	9	12	13	14	15	17	18	22	24	27	28
Tonnage(T)	2226	2021	1826	1816	1737	1728	1712	1614	1516	1493	1411	1349	1199	1199
Unit Price (RMB/T	46.36	31.82	46.18	38.00	38.54	93.18	65.91	67.54	63.45	52.45	41.18	33.09	98.27	15.27
Total(1,000 RMB)	103	64	84	69	67	161	113	109	96	78	58	45	118	18

Storage Cost: **1,685,207 RMB**

	Operatin Tonnage	Inventory Cost	Fixed storage cost
NR	0		0
2	0	0	0
5	0	0	0
7	0	0	0
9	0	0	0
12	0	0	0
13	0	0	0
14	0	0	0
15	0	0	0
17	0	0	0
18	0	0	0
22	9,157	27,471	666,666
24	0	0	0
27	0	0	0
28	13,690	41,070	950,000
Total		68,541	1,616,666

Appendix A-5

Total Cost of Distribution System = 1,038,719.RMB

Transportation cost **1,117 RMB**

RP	2	5	7	9	12	13	14	15	17	18	22	24	27	28
Tonnage(T)	2226	2021	1826	1816	1737	1728	1712	1614	1516	1493	1411	1349	1199	1199
Unit Price (RMB/T)	40.09	14.45	37.54	26.64	39.36	93.18	65.91	67.54	54.81	52.45	41.18	41.18	98.27	31.00
Total(1,000 RMB)	89	29	69	48	68	161	113	109	83	78	58	56	118	37

Storage Cost: **1,037,603 RMB**

	Operatin Tonnage	Inventory Cost	Fixed storage cost
NR	0		0
2	0	0	0
5	9,648	14,472	383,333
7	0	0	0
9	4,042	6,063	236,666
12	0	0	0
13	0	0	0
14	0	0	0
15	0	0	0
17	0	0	0
18	0	0	0
22	9,157	13,736	383,333
24	0	0	0
27	0	0	0
28	0	0	0
Total		34,271	1,003,332

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