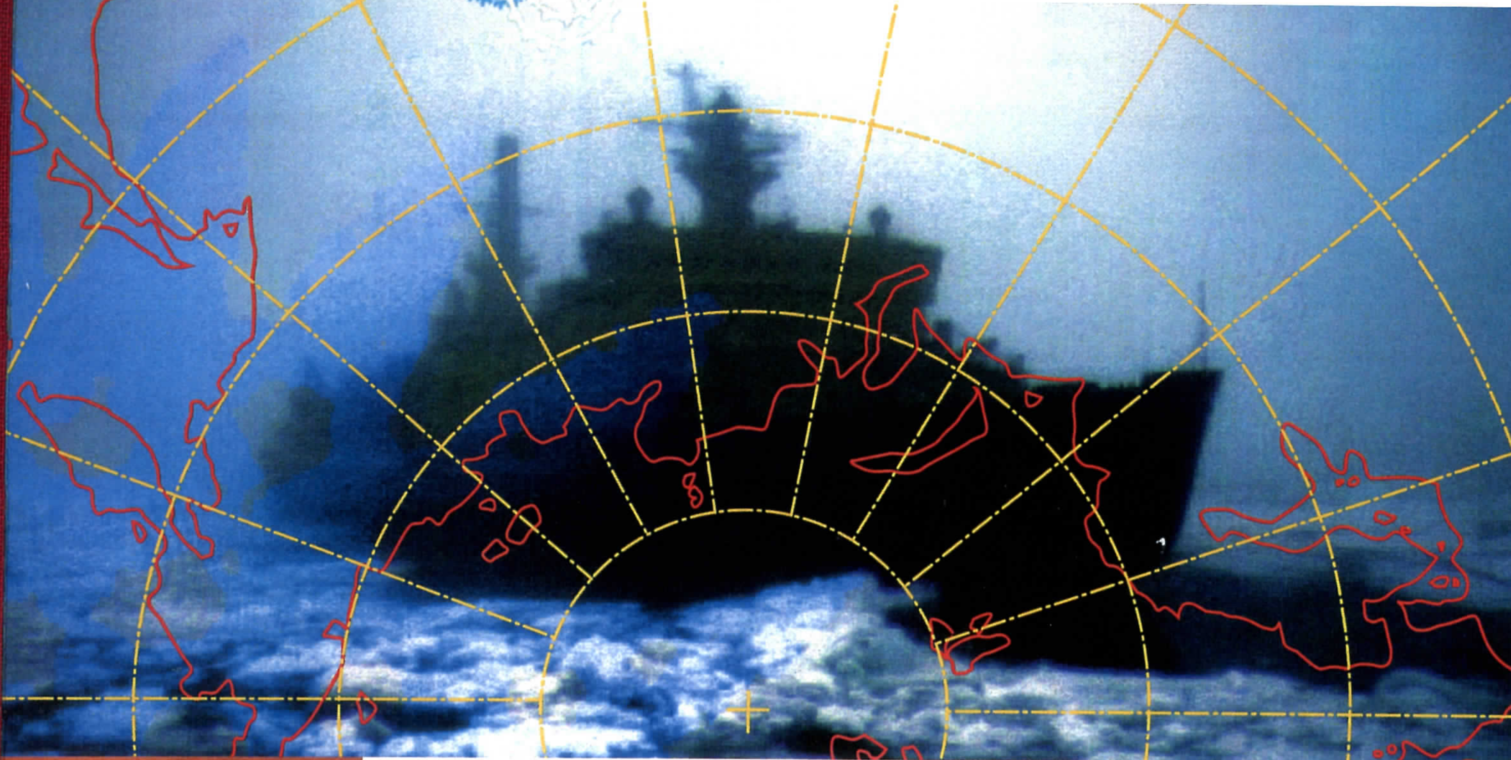

INSROP WORKING PAPER
NO. 48-1996, III.07.3

Marine Transportation of Oil from Timan Pechora and from inland Russian Fields

Dag Andresen and Anders Backlund

INSROP International Northern Sea Route Programme

Central Marine Research & Design Institute, Russia

The Fridtjof Nansen Institute, Norway

Ship and Ocean Foundation, Japan

International Northern Sea Route Programme (INSROP)

Central Marine Research & Design Institute, Russia

The Fridtjof Nansen Institute, Norway

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INSROP WORKING PAPER NO. 48-1996

Sub-programme III: Trade and Commercial Shipping Aspects

Project 07.3: Marine Transportation of Oil from Timan Pechora and from inland Russian fields.

Section 1: The LPG market.
Section 2. Seaborne Transportation of LPG from the OB-Gulf.

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What is an INSROP Working Paper and how to handle it:

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FOREWORD - INSROP WORKING PAPER

INSROP is a five-year multidisciplinary and multilateral research programme, the main phase of which commenced in June 1993. The three principal cooperating partners are **Central Marine Research & Design Institute (CNIIMF)**, St. Petersburg, Russia; **Ship and Ocean Foundation (SOF)**, Tokyo, Japan; and **Fridtjof Nansen Institute (FNI)**, Lysaker, Norway. The INSROP Secretariat is shared between CNIIMF and FNI and is located at FNI.

INSROP is split into four main projects: 1) Natural Conditions and Ice Navigation; 2) Environmental Factors; 3) Trade and Commercial Shipping Aspects of the NSR; and 4) Political, Legal and Strategic Factors. The aim of INSROP is to build up a knowledge base adequate to provide a foundation for long-term planning and decision-making by state agencies as well as private companies etc., for purposes of promoting rational decisionmaking concerning the use of the Northern Sea Route for transit and regional development.

INSROP is a direct result of the normalization of the international situation and the Murmansk initiatives of the former Soviet Union in 1987, when the readiness of the USSR to open the NSR for international shipping was officially declared. The Murmansk Initiatives enabled the continuation, expansion and intensification of traditional collaboration between the states in the Arctic, including safety and efficincy of shipping. Russia, beeing the successor state to the USSR, supports the Murmansk Initiatives. The initiatives stimulated contact and cooperation between CNIIMF and FNI in 1988 and resulted in a pilot study of the NSR in 1991. In 1992 SOF entered INSROP as a third partner on an equal basis with CNIIMF and FNI.

The complete series of publications may be obtained from the Fridtjof Nansen Institute.

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- ARTEC, Norway
- Norwegian Polar Research Institute
- Norwegian School of Economics and Business Administration
- SINTEF NHL (Foundation for Scientific and Industrial Research - Norwegian Hydrotechnical Laboratory), Norway.

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INSROP Project III.07.3 Marine Transportation of oil from Timan Pechora and from inland Russian oil fields

Condensates and Petrochemical Products

Section 1. The LPG market

March 1996

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FOREWORD

The INSROP project III.07.3, Marine Transportation of oil from Timan Pechora and from inland Russian oil fields, has been divided into several subprojects, each representing different products and also representing different geographic regions. This report is the first section of the report on condensates and petrochemical products, as it is described in the project catalogue. In the project starting phase, it was noted that very little work had been done on especially LPG, whereas studies related to other products were more numerous. Because of this, a decision was made to concentrate on LPG.
The first section deals with the world-wide LPG market. A comprehensive study into the supply and demand of LPG has been done, covering both the past and the future. Being a part of the energy-sector, LPG is also influenced by general political actions. A part discussing the political aspects and characteristics of the gas market has been included.

Section 2 concentrates on the actual transportation of LPG from Northern Russia.

i. Definitions

b/d	=	Barrels/day.
cu.ft	=	Cubic feet.
tc. m	=	Tonne cubic meters.
mmt	=	1000 metric tons.
mtoe	=	1000 ton oil equivalent.
mtbe	=	Methyl tertiary butyl ether.
mt/d	=	Metric tons/day.
mt/y	=	Metric tons/year.
mmcfd	=	1000 metric cubic feet/day.
cu.m	=	Cubic meters.
MGS	=	Master Gas System.
nd	=	No detailed data.
na	=	Not available.
U.A.E.	=	United Arab Emirates.
H. feedstock	=	LPG, naphtha, gas oil.
LNG Carriers	=	Vessels designed to carry full loads of liquid cargo in bulk, i.e. crude, refined products, petrochemical carriers, etc.
LPG Carriers	=	All other liquefied gas carriers, i.e. LPG, ammonia carriers, etc.
Rates	=	Both spot and period market rates for tankers and dry bulk carriers are based on reported rates during the month.
DWT	=	Deadweight tonnage. The difference between light and load displacements. It is a measure of the carrying capacity of a vessel and is the weight of cargo, fuel, fresh water, and stores that it is able to carry at specified draught.
INSROP	=	The Northern Sea Route Programme.
NSR	=	Northern Sea Route.
FSU	=	Former Soviet Union.
SEA	=	South East Asia
ULA	=	Russian ice class, same as DNV class, Polar 10, ice 15 and ice 10.
UL	=	Russian ice class, same as DNV class, 1A and 1A-F.

ii. Figure List

iii. Table List

A. INTRODUCTION.

As a part of The International Northern Sea Route Programme (INSROP), Subprogram III, Trade and Commercial Shipping, a study has been made concerning seaborne export of liquefied petrol gas (LPG) from Northern Russia, especially the West Siberian fields in Tyumen. The main purpose of the total project III.07.03, part 2. and this study is to evaluate the economic viability of seaborne export from this area to the European region, mainly with the use of a special ice-strengthened LPG vessel, constructed and designed for such seaborne operations. This study concentrates on both seaborne LPG transportation, about the seaborne demand and supply of LPG in the world, and marine transportation of LPG from West Siberian fields. The main purpose is to see which regions are potential exporters, importers and buyers of seaborne export of LPG from Tyumen. Currently large quantities of liquefied petrol gas are flared off at the West Siberian fields due to insufficient infrastructure, lack of modern processing capacity and capital. Preliminary investigations indicate that condensates/LPG can be obtained marginally above local transport cost. Although large quantities are being flared off, a number of gas processing plants, nine in total, are in operation by the Sibneftegaspererabotka Corporation (SNGP), the main products being polyethylene variants. SNGP, formed in 1975, transports gas from the separation units and processes it. The regional surplus of LPG however, is estimated to increase to 700.000 metric tonnes by 1995 for which limited transportation capacity exists. Some of the main issues due to these estimates are the questions: Would there be transportation at competitive prices to provide acceptable returns to producers and investors ? Will western tanker-owners invest in ice-strengthened tonnage to participate in this shipment ? Already existing reports indicate that it must be a great challenge for the Russian government to develop the port and transportation infrastructure of the Russian North to provide the necessary facilities for increased Russian export of oil and gas. As this development will take place further to the East in the Timan-Pechora and Yamal areas, a part of the Northern Sea Route will be affected by these developments. The results of this analysis are supposed to give a starting point for more detailed comparisons about the potential of seaborne export of LPG to the world market.

B. AIM OF THE PROJECT.

The overall aim of the total project is to analyse the potential for seaborne export of LPG from the Northern Russia-Tyumen region to the world market. The reason is because large quantities of LPG are flared off at the West Siberian fields in Tyumen, and the flaring is expected to continue due to insufficient infrastructure, lack of modern processing capacity and capital. Also preliminary investigations indicate that condensates/LPG can be obtained marginally above local transport costs in this region.

As indicated in the project title, the project is split into several parts. The first part is an introduction to the LPG marke and consumers.

The second part is a discussion and analysis of different issues related to the political and economic environment in the LPG and gas industry.

The third part is an evaluation of the world-wide seaborne demand for LPG, and focus on the estimated traded LPG until the turn of the century. Its main purpose is to estimate the future demand for LPG in each region of the world, and to examine some major factors related to existing and new capacity and production. Behind these predictions, recent trends and future expectations of population growth, economic growth, total energy demand, own gas consumption and refinery capacity are examined, with a focus on the demand for liquefied petrol gas.

The fourth part is an analysis of the supply side on the LPG market emphasising the seaborne export of LPG. The region's LPG reserves, current production, estimated future production, development in gas separation, liquefaction facilities and refinery capacity are accounted for. The primary objective in part three and four is not to analyse and evaluate thoroughly LPG production plants world-wide, locate new production capacity brought on stream, start-up dates or political instability, since such an enormous examination is a task in itself. Only the most significant factors related to the LPG industry are analysed to support the import/export predictions towards year 2000.

The large amount of figures related to these important factors are necessary, in order to quantify the changes that will influence the LPG import/export balance in the near future. Since this work focuses on the West Siberian fields as the exporting region, it is natural that this area is more thoroughly described and analysed, concerning both the demand and supply side.

In chapter five the results from the two latter chapters will be combined, and net balances for major exporters and importers will be calculated. In addition, everything will be put in perspective by quantifying forecasted future net deep-sea balance, between import and export of LPG. By doing so it is possible to see which regions have the greatest potential for seaborne import of the LPG surplus from the Tyumen area.

The final and sixth part is an economic evaluation of seaborne LPG export from West Siberian gas fields to selected importing regions in the world. The main purpose is to analyse and compare transportation costs when operating on the route between Yamal (Novy Port) and the port of Rotterdam. Further, there is a comparison between an open water LPG carrier and an ice breaking LPG carrier, and assisted operation in the Arctic area. The importing region is selected because it shows a significant increase in demand for LPG towards year 2000. In addition, issues such as freight contracts, carrier costs, market strategies and requirements related to this special transport solution are discussed.

C. HISTORY.

A Short History of the International Northern Sea Route Programme.

The International Northern Sea Route Programme (INSROP) is a direct consequence of the Soviet President Mikhail Gorbachev's initiative when he in his speech, delivered in Murmansk on October 1987, spoke in favour of international collaboration in the Arctic, such as inviting international shipping to ply the Northern Sea Route. The Soviet Ministry of the Merchant Marine acted upon the implication of Gorbachevs's statement, seeking contact with the Fridtjof Nansen Institute in the fall of 1988. An agreement was reached to put together an international research project about the Northern Sea Route, open to scientists from many countries. The Central Marine Research & Design Institute was designated as the co-ordinating institution on the Russian side. This co-operative effort resulted in the production of a pilot study of the NSR by the co-ordinated efforts of CNIIMF and FNI in 1990-91. The Pilot study concluded that there was a need for extensive further research. Individual INSROP projects have since then been carried out.

The International Northern Searoute Programme is a comprehensive, multi-national, multi- disciplinary five-year research programme designed to investigate the possibilities for commercial navigation through the north-east Passage. The programme is based on a mutual agreement of co-operation between three principal partners: The Ship & Ocean Foundation, Japan, the Central Marine Research & Design Institute, Russia, and the Fridtjof Nansen Institute, Norway. INSROP has as its goal the production of ascientifically founded knowledge base concerning the conditions for sailing the NSR. The base shall serve operative aims and provide a factual foundation for rational decisions in the public and private sectors in the countries concerned. The precondition for succeeding in this objective is that the store of knowledge making up the base shall be broad, profound and integrated.

History of the Northern Sea Route.

The Northern Sea Route (NSR) or the North-East Passage is the common name for the sea route connecting Europe to the North Pacific and passing north of the landmasses of Asia, see map E on page 16-17. Its existence has been known for a long time. Transit through the NSR was successfully managed for the first time in 1878-79. In recent times the route has been technically navigable, but commercial transits have been very rare for political, economic and environmental reasons. The political restrictions have partly been removed and the environmental ones are nowadays better managed by technical and observational means. The commercial use of the NSR depends on the economies of transit passages.

When discussing the use of the Northern Sea Route for international traffic, one important part is the export and import of goods to the Northern areas of Russia. The import is mostly based on goods for the communities and some raw material for the local industry. Present export is concentrated to the combinates in the Yenisey-region, but the greatest potential for future export lie in oil and gas fields along the northern coast of Russia. In addition to this, export terminals along the northern coast can be used for the export of oil products from larger areas in Russia, as the number of safe export routes from Russia are decreasing.

The western part of the NSR has quite an extensive history of vessels operating in different conditions. Especially on the route Murmansk-Dudinka, there has been year around operation already since the 70's. Thus, vast experience is available of operating vessels in the areas of greater interest. The traffic on the route Murmansk- Dudinka has mostly been transportation of iron ore from the mines in the Igarka region to the steel mills on the Kola Peninsula. This transportation has been handled by SA-15 type vessels of 15000 dwt size. These vessels were built in Finland in the 80's and were originally designed for this specific route. They are able to operate independently for part of the year and for the rest of the year with the assistance of the powerful nuclear ice-breakers.

Their icebreaking capability was originally 1.2 m, but due to increased resistance caused by wear of the ship hull, the ice breaking capability today is about 0.8 m. Because of the changes in Russia and the need for hard currency, many of these very capable vessels are today operating on routes very far from the Arctic.

Other vessels operating in the area are small tankers, today owned by the Latvian Shipping Company, (but ordered and first operated by the Soviet Union). They have been used for the supply of fuel to the communities along the Arctic coast. In recent years, western vessels have also been used for this supply function. The Lunni-class Arctic tankers of 16000 dwt have been operating during the summers 1993 and -94. They have made trips from Murmansk/Archangelsk up to the Kolyma river. These tankers were built in Germany in the 70's and have a long history of operating in Arctic areas of the world. Today one of the vessels, the Uikku, has been fitted with a diesel-electric machinery and an Azipod drive to increase its suitability for operation in the ice conditions along the NSR. A similar re-engining will be done to one of the sister vessels, the Lunni.

The western Russian Arctic, e.g. the area west of the Yenisey River is characterised by thick first-year ice, occasional multi-year ice, heavy ridging and the existence of compressive ice. In short, one can say that almost all possible ice features can be met on this route. Only large icebergs are extremely seldom met. For vessels operating in the area, this places extensive demands on their performance.

D. SOURCES AND METHODOLOGY OF WORK.

The sources used in the first four parts of this work are many. First of all, the conference papers from recent gas summits, information and data from Kværner Shipping a.s, reports from The Oil & Gas Journal, and reports from Poten & Partners and Purwin & Gertz. These papers have given me detailed and thorough information used primarily to estimate the demand and supply of LPG world-wide. In addition , articles from relevant publications and consultant reports from especially Poten & Partners and Purwin & Gertz have given me more objective evaluations. These reports were very valuable when analysing the future demand and supply of LPG, controlling and checking if e.g. the estimates were correct, and have therefore supported most of my findings.

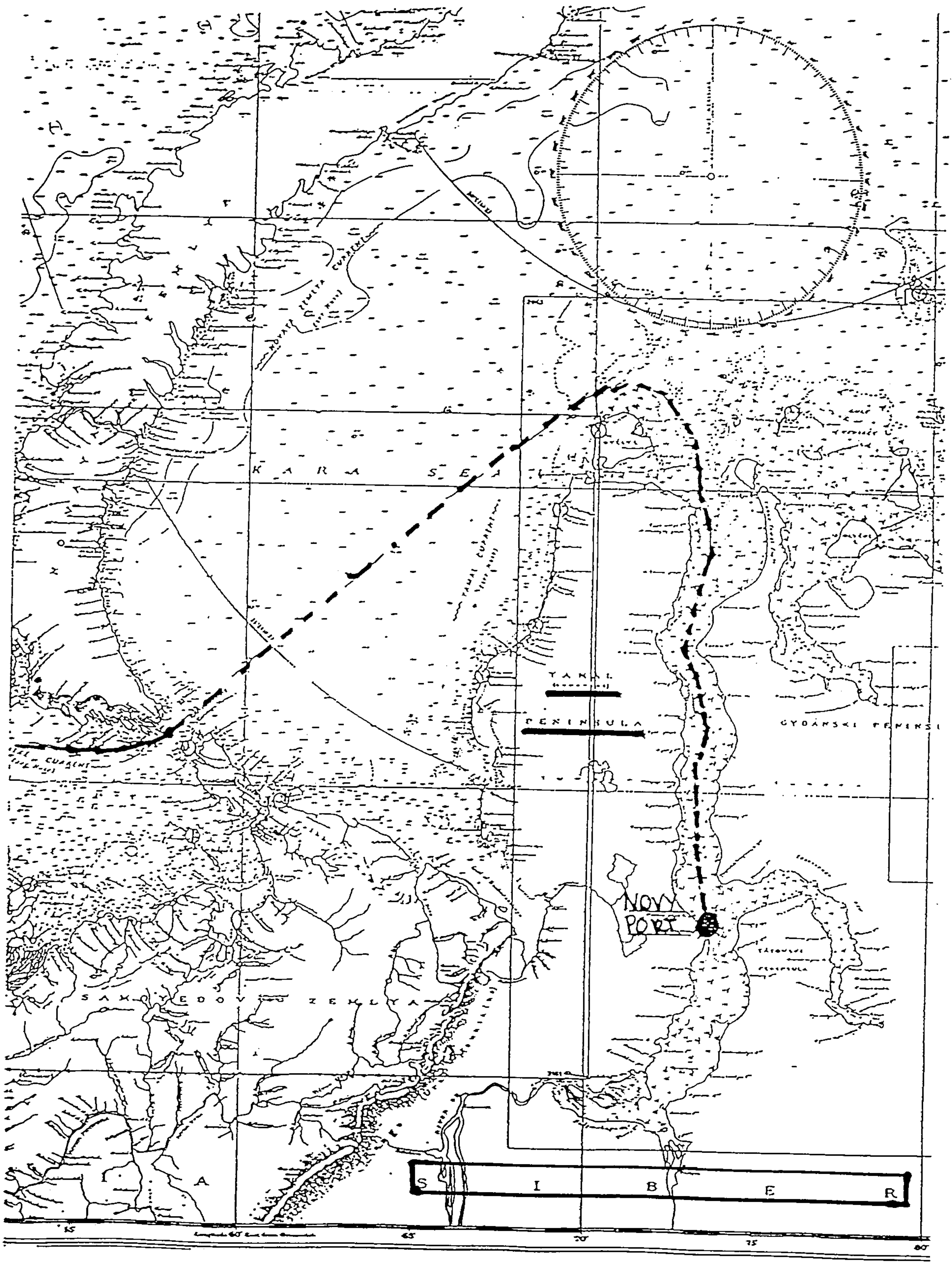
Also a substantial part of the report is based on secondary sources which have been supplemented and verified through telephone and telefax "meetings", with highly qualified persons in the gas, oil and shipping market in Norway.

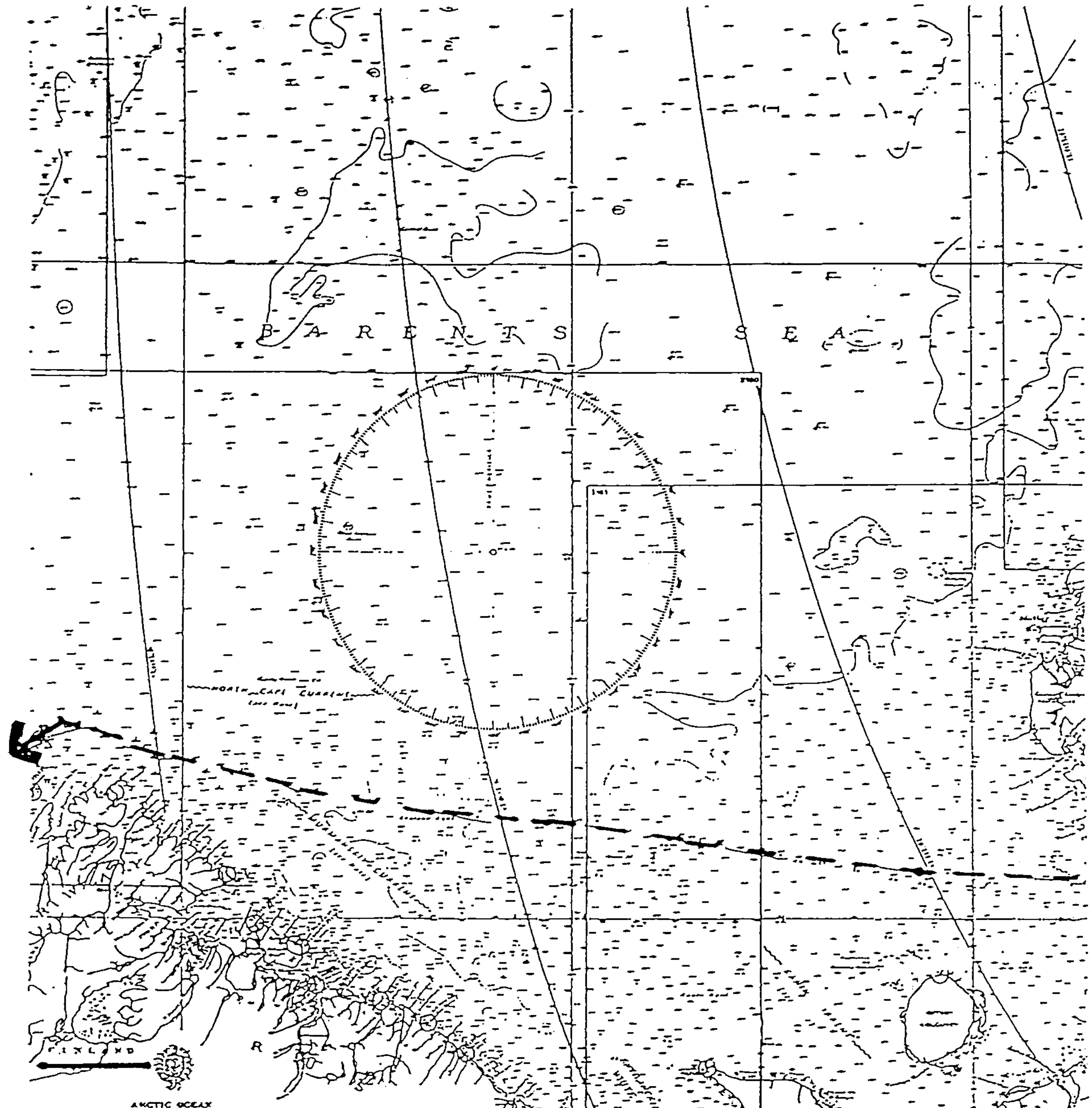
The feasibility study in the last part is based on general knowledge about the LPG industry and the new technology for building ice-strengthened LNG and LPG vessels. In addition, the transit time calculation for the vessel has for the ice-going part been done by using Kværner Masa Yard Technology's computer program, which calculates the speed of different vessels in varying ice conditions. Appendix 1 shows a principal diagram of the program. This program has been developed since the 70`s and continuously checked against full-scale measurements. The cost calculations are based on both published data and non-published information concerning present LPG operating costs for new 75.000 cu.m LPG carriers.

E. TRADING MAP OVER THE ICE COVERED AREA IN WEST SIBERIA.

Route : *Yamal Ob (Novy Port) - Rotterdam - Yamal Ob (Novy Port).*

Distance: *5900 nautical miles, roundtrip.*




B A R E N T S   S E A
NORTH CAPE CURRENT
FINLAND
ARCTIC OCEAN
IE NORTH CAPE TO
EDINYÉNIYA ISLAND
INCLUDING THE
ARENTS AND KARA SEAS
WHITE SEA
30°
35°
40°
45°
50°

PART-1. GAS PRODUCTS AND CONSUMERS.

1. Introduction.

When discussing liquefied petroleum gas demand it is important to differentiate between long-term and short-term demand. Firstly, one should remember that use of gas requires considerable investments in distribution networks and specialised gas burning equipment. Only after these investments have been made, can one state that gas is available for end users. The prices of equivalent fuels are another variable that will influence gas demand. Factors such as e.g. a country's energy policies certainly have an impact on consumption, protecting domestic sources or employment, environmental protection, energy saving, energy taxes, energy laws etc.

In the short run, none of these parameters are expected to change demand to any great extent. Investments that have been made are normally irreversible, and switching costs are high. Some users might not have a choice, e.g. households tied to an area's gas network. In the long run, though, demand is much more elastic: adjustments and necessary investments that are difficult in the short run, can be done over time. Also energy saving programmes bring effects with a time lag, as we have seen happened after recent oil crises.

The end user gas market is usually divided into four segments, in this analysis we operate with:

- power generation
- industrial
- transportation
- commercial/residential

Demand varies in these segments. In Western Europe, we have seen a decline in gas demand in the industrial sector, mainly due to growth of less energy-intensive industries and the moving of the most energy-intensive industries out of Western Europe. In Asia the demand situation has developed in another direction. Today Asia needs to import gas and petrochemicals because the demand is growing so rapidly that deficits for most products in the region will remain the same or increase.

Technological development has been concentrated on energy saving ever since the first oil crisis of 1972-73. In the residential and commercial sectors, consumption has increased due to a wider availability of gas. In power generation, there has been a stagnating tendency, which can be explained by increased use of nuclear power in some countries and protection of the coal industry in others.

Both the different gas products in demand, and the gas consumers are described more thoroughly in the next section, but let us first get some thoughts and a more general perspective on the size of the world gas reserves.

Malcolm Peebles, a former director of Shell International Gas Ltd. and now head of a London consulting company, Gas Advisory Services Ltd., gave a comment from the floor at the Doha Gas Conference last year (1):

Peebles said, "I am a little bit concerned that one goes to all these gas conferences and hears the same big figures. I believe they are misleading. I don't think the size of the world gas reserves is anywhere as big as we are made to believe". He explained that he was not disputing what is in the ground, but he thinks that in many parts of the world it will stay in the ground for the foreseeable future. "The definition of reserves", he said, "is gas known to exist that is economically recoverable with known techniques". In addition he believes there are far too many gas projects, some of them "pipe dreams" chasing far too little demand. He said he finds it intriguing that the industry is so healthy with so many chasing so little. He concluded, "it is far better to find a little gas in the right place than a lot of gas in the wrong place".

1.1. Main Products.

The gas segment can be divided into several subsegments according to the type of product to be transported, the geographical distribution of sea routes, the size of the vessels or vessel technology. The division is based on the technical demands made on the transport of the various gases. Since this report focuses on the LPG market it is necessary to define the different products in order to avoid a mixture between the different products and the different markets in the subsegments.

1.2. Gas Condensates.

Condensates are liquid hydrocarbons generally clear or pale straw-coloured and of high API gravity above 60 degrees, which are produced with wet gas. Gas-condensates and reservoirs are some of the most complicated reservoirs encountered in petroleum engineering. In a gas-condensate reservoir, the reservoir temperature lies between the critical temperature and the cricondentherm of the reservoir fluid. Initial composition components are: carbon dioxide, nitrogen, methane, ethane, propane, butane, pentane, hexane and hepthane.

1.3. Liquefied Petrol Gas, LPG.

LPG is compressed hydrocarbon gas obtained through distillation and usable as motor fuel, heating, and in certain industrial processes. Liquefied petroleum gas is usually defined as propane and butane which are in a gaseous state at atmospheric pressure. Total 5.6 % of the world's energy consumption is based on LPG, and this includes the use of LPG as input to the petrochemical industry. Transportation of LPG usually originates from oil refineries or major production areas for gas and oil, where there are large quantities of associated LPG. When transporting LPG, it is necessary to refrigerate, or use a combination of refrigeration and pressure, down to 42 degrees Celsius. This refrigeration requires technically advanced vessels. In order to obtain economically efficient transportation, fully refrigerated vessels, with no pressure tanks, represent the dominant technology for large transport volumes.

In the FSU, liquefied petrol gas is produced from associated and non associated natural gas, condensate and refinery streams. It also comes from what is known in the FSU as ShFLU, a mixture of propane, butane, pentane, and hexane produced at gas processing plants in Western Siberia and fractionated elsewhere.

1.4. Petrochemical Products.

These gases also include a whole range of some more specialised and complex gases which are created by different methods of “cracking” (molecular crushing) of LPG, ethane or naphtha. The most common petrochemical gases are ethylene, propylene, butadiene and VCM (vinyl chloride monomers). Vinyl chloride monomers is formed by petrochemical gases and is thus an intermediate process product. Ethylene with a boiling point at -104 °C requires very strict rules for transportation, and thus only the most advanced vessels have such capacity. The biggest ethylene tankers are between 10.000-12.000 cu.m.

Petrochemical gases are input factors in the petrochemical industry, and the industry uses LPG mainly for production of olefins, through thermal pyrolysis, and of monomers for the synthetic rubber industry. In that way the petrochemical industry requires LPG as input into its process industry. Outputs from this process are: polyethylene, polypropylene, ethylene, butadiene, benzene, orthoxylene, paraxylene and ammonia.

The demand for marine transport of petrochemical gases is thus marginal in relation to total production, and only 3-4 % of the total production is traded by sea. The reason for this is that it is expensive both to transport and store these products, and consequently the plants in question depend to a large extent on a balanced in-house production. However, imbalance occurs both in the short- and intermediate- term, and is the basis for commercial trade. The highest transport rates are periodically obtained in this part of the gas segment.

1.5. Gas Consumers.

The international LPG industry has expanded rapidly over the last two decades. In general, the traditional premium-captive demand for LPG has increased, but at a slower pace than total supplies. As a result, price-sensitive petrochemical feedstock markets have developed to clear the available supplies. On the demand side, substantial growth is projected for most world LPG end -use applications.

World consumption of LPG increased from 85 million metric tonnes in 1980 to an estimated 138 million metric tonnes in 1993, equal to an average growth rate of 3.8 % a year. U.S., Japan and Western Europe accounted for two thirds of world demand. But markets for LPG in the developed world are mature, with growth rates of 2-3 % a year the norm.

1.5.1. Power Generation.

The power generation sector is dominated by coal, oil or nuclear power in most countries. Economic development also creates a demand for electric power. In both developing and developed countries electricity use is growing faster than energy as a whole. British Petroleum (BP) estimates that over 35 % of the world's incremental fuel input to the power generation sector will be gas, a minor part of it will be LPG. In addition, power generating companies are increasingly turning to natural gas as the preferred fuel, mainly due to new technology and environmental concern. Only in few countries has LPG historically played a major role. For example in FSU 35 million families, totalling 150 million people use LPG for cooking. Half of those families are in Russia. LPG has been used in everyday life by millions of families in the FSU for more than 30 years. Finding a quick replacement would be impossible.

1.5.2. Industrial.

The second largest end-use market is the petrochemical sector which accounts for 22 % of current total world LPG consumption. This market will be enhanced by a significant increase in butane consumption as the MTBE feedstock.

Substantial growth in propane use as petrochemical feedstock is also likely as available supplies exceed premium market demands. This condition will continue to create a need for price-sensitive petrochemical markets, particularly in the U.S., Europe, and the Far East. All other international end-use markets for LPG will also grow throughout the forecast period until year 2000.

Industrial use will face competition from natural gas penetration but is still likely to grow, particularly in the developing regions. Environmental pressures will contribute to the increased utilisation of LPG as an engine fuel. By the end of the year 2000, this market will consume about 7 % of total demand. Poten & Partners projects ne petrochemical industry's demand for LPG to increase by almost 40 % between 1990 and 2010.

1.5.3. Transportation and Alternative Fuels.

The use of LPG as vehicular fuel is expected to increase significantly in the near future and the alternative fuels' requirement of the air-quality regulations is perhaps the best opportunity in history to advance the use of LPG motor fuels. Propane is the most widely used alternative motor fuel in the world today, having been successfully fuelling vehicles for more than 60 years.

In the U.S. approximately 500,000 propane-powered vehicles are in use today, mostly in commercial fleets of light and medium duty trucks, buses, taxis, police cars and carrier services. These fleets consumed about 13 million bbl of propane in 1990- about 4 % of total propane consumption. World-wide there are about 3.5 million LPG-fuelled vehicles, principally in the U.S., Canada, Italy, the Netherlands, and Japan. Total LPG motor-fuel consumption is estimated at about 85 million bbl/year. There is some concern– unjustified– that an expanded propane motor-fuel demand will constrain supplies for traditional fuel and feedstock consumers. Of a fleet of roughly 12 million vehicles in the U.S., only about 4 million will be covered by the clean-air provisions. The gas-processing industry will take all of the new uses it can get, but a realistic ambition would be 25 % of the covered fleet, or about 1 million new vehicles.
A conservative calculation shows that 1 million fleet vehicles would consume approximately 24 million bbl/year of propane- a significant demand but hardly a major strain on the U.S. supply of nearly 400 million bbl/year.

1.5.4. Commercial/Residential.

The largest end-use market related to consumption is the commercial/residential sector.
The residential and commercial sector consumes energy for cooking, lighting and heating in private households, in offices and institutions, small businesses and services. As countries develop and income increases, demand for this sector increases in importance. The premium residential and commercial market currently represents about 47 % of total world LPG consumption. This market share will be maintained as growth continues to be strong, particularly in the developing countries of the Far East, Latin America, and the C.I.S-Eastern Europe

1.5.5. Dimension of the LPG Demand.

Non-chemical demand for LPG is expected to grow about twice as fast as the petrochemical demand. Traditional demand will continue to be the largest consuming sector, but its growth will be relatively slow. By contrast, auto fuel use of LPG is expected to almost quadruple by 2010, and metal cutting and other industrial applications will more than double. The greatest decline in LPG market share will probably occur for the industrial sector. Increasing competition from natural gas continues to penetrate this market sector, although growth in industrial LPG use remains the same for some developing countries in the world.

While projected supplies will keep pace with demand build-ups, any significant delays or cancellations of anticipated new supply projects could aggravate the current global tightness in LPG supply, particularly for butane. This development could accelerate a growing trend of substituting propane for butane in LPG-mix applications, as well as promote the use of alternative fuels in some Far East industrial LPG markets.

While growing supplies will keep pace with demand build-ups, any significant alteration in new supply projects could tighten the global balances. This condition exists today and contributes to the relative firmness in international LPG prices.

PART-2. POLITICAL ASPECTS AND CHARACTERISTICS OF THE GAS MARKET.

2.1. General Political Aspects.

While discussing the LPG market, it is important to remember that we are dealing with a part of the energy sector. This sector is of great concern to governments where the economies are dependent on a reliable access to energy. In addition, gas is an important national resource, vital to the economic performance of the gas exporting countries.
Therefore, the gas industry is subject to many government regulations and control. In producing countries, authorities involve themselves in such important decisions as exploration and the acceptance of supply agreements. They also frequently participate in pipeline construction. Governments on both sides are often involved in negotiations and management of cross-border transactions. Political considerations tend to have a substantial influence on the energy sector's structure as well as the choice of suppliers.

Political relations between Eastern Europe, the Former Soviet Union (FSU) and Western Europe have especially had an impact on energy trade the latest ten years.

Since a part of this work emphasises seaborne trade of LPG from Northern Russia to the North European region (Rotterdam), it is natural to give a more detailed description of the FSU's political and strategic aspects concerning energy and total risk when analysing the supply side. However, one important issue related to political progress between the East and West is the European Energy Charter.

In December 1991, Russia, together with 48 other nations and two intergovernmental organisations from three continents, signed the European Energy Charter, which became the first international agreement signed by the republics of the former U.S.S.R. as independent sovereign states. Included in this Charter is a package of binding legal documents (2). They include the Basic Agreements, which, as opposed to the charter per se, which is a purely political declaration by the signatories, will be a multilateral horizontal commercial, political, economic, and legal agreement, with vertical protocols on co-operation in selected energy sectors.
Among these, the Protocol on Hydrocarbons is the most significant. Pursuant to these documents, a common energy, economic, and legal space for the whole industrially developed world will be created.

Fifty European, North American, Pacific Rim, and C.I.S. states are negotiating the document package. Here, uniform conditions will be created for all participants with respect to access to energy resources, markets, transportation facilities including transit privileges, technologies, capital markets, etc. Such a system would provide a balance of interests for the host countries and potential investors in terms of both investment regimes as well as commercial and political issues.

Development of a system of bilateral and multilateral contractual and legal acts facilitating integration of the FSU national economy into the world economy and into the system of international economic relations has a decreased effect on the present risk, and will create a more stable economic and legal environment in the Russian energy sector.

The existence of such an efficient and balanced package of legally binding documents as a supplement to the European Energy Charter and their ratification by the parliaments of the negotiating parties will undoubtedly help stabilise the business environment in the energy industry in the FSU and make it less risky. Even if this would lead to freer trade in the energy sector, though, this sector will still remain a target of the authorities intervention.

2.2. Risk and Investment Climate in the FSU Oil and Gas Industry.

The Russian energy sector and, in particular, the oil and gas industry have been through hard times. The industry faces a very difficult situation. Oil and gas are among the FSU`s principal sources of wealth. The federation's reserves of hydrocarbons constitute over one third of the world total. They are sufficient to serve as a source of the country's revenues and meet a considerable portion of the world's demand for oil and gas.
The sharp reduction in government investments, the shortage of hard currency resources available to enterprises, and severed economic relations with some republics of the FSU have led to a sharp decline in supplies of oil- and gas fields, drilling materials and equipment. During the last few years, oil and gas production enterprises have been subject to consistent shortages in supply of material and technical resources needed to keep wells producing. From a demand side approach, it is impossible to solve problems of the fuel and energy complex without restructuring the whole system of energy utilisation and implementing energy-saving technologies on a wider basis. Today, foreign investments in the FSU`s oil and gas industry may effectively contribute to the stabilisation in the industry. Only one source of external financing existed for the economy of the U.S.S.R. and Russia in the recent past: foreign loans, almost completely governmental, secured by governmental guarantees. These loans were distributed by government agencies among enterprises at no cost.

Currently, as Russia has been transforming to a market-oriented system of business management, enterprises have become more economically independent, and domestic oil and gas supply can hardly meet demand. The monopolistic form of providing external financing is no longer appropriate. The necessary change is clear: from government loans to direct private investments. At present, competition for internal investments is high. Several firms and financial institutions prefer to keep investing in traditional oil and gas producing countries with stable legal and economic environments, such as the Middle East, Southeast Asia, or the U.S., rather than enter the new and risky Russian oil and gas market, previously closed to most foreign investors. However, this market possesses tremendous appeal. FSU has a large resource base, production costs that compare favourably with many other countries, highly skilled workers, relatively low wages, and the potential for conversion of the former defence industry to production of oil and gas equipment. However, no major rechanneling of cash flows in favour of Russia can be expected until the country creates an investment climate that is at least as favourable as that in the traditional oil and gas producing areas.

Western analysts believe that for the time being many obstacles and uncertainties exist for investment in the FSU oil and gas industry. The points below summarise some general opinions about issues affecting such investments:

- High political instability.
- High (prohibitive) level of taxation.
- Export tariffs (one third of world market prices).
- The negotiation process on new oil and gas projects with participation of foreign capital is riddled with red tape.
- No distinct division of authority between federal, regional, and local governments and the managements of oil and gas producing enterprises and associations.
  The issues pertaining to the operation of oil and gas transportation systems need to be settled on the intergovernmental level.
- Investment climate in general:
  - uncertain and unstable
  - taxation system
  - foreign trade environment
  - currency control.

These opinions can be accepted or questioned. But at least they represent a system that is maintained by most of the oil, gas and shipping industry today. Potential Western investors in an export route from the northern areas of West Siberia to the world market, should take the above opinions into consideration before any further steps are taken.

Nevertheless, despite repeated statements to the effect that this oil and gas business in the northern area is highly risky, many foreign companies spare no effort to secure a place in the industry. In a manner of speaking they are trying to establish a sort of stepping stone for the future large-scale domestic expansion of their businesses in case its legal and economic environment evolves in an investor-friendly direction.

2.3. Governments and Global LPG Taxation.

Maybe its because the fuel isn't "new" enough and therefore not sufficiently "alternative". Or could it be that too many people know too little about it ? For some reason, global policy-making seems to have a blind spot regarding liquid petroleum gas. Governments often use tax laws to force consumers into possible uneconomic fuel choices. But no fuel should be placed at a disadvantage because policy makers do not understand it. Officials too often need reminding that at the point of consumption LPG isn't the same thing as natural gas or gasoline. At present, federal motor fuel taxes apply to LPG at the same rate that they do to gasoline on volumetric basis. The LPG tax rate is higher than the gasoline rate because of LPG's lower energy content per given volume of fuel. Both fuels are often taxed more heavily than fuel from methanol and ethanol, which often enjoy tax breaks, and compressed natural gas, which is exempt.

The LPG marketers have a legitimate complaint about how current and proposed taxes would affect their fuel now and in the future. If the governments must promote "clean" alternatives to gasoline, it certainly should not place a fuel with definite environmental advantages at a competitive disadvantage to others. Subsidies and exemptions already in effect make considerations about fairness somewhat beside the point. Still, unfairness should not have its roots in failure by policy makers to distinguish a fuel with not only unique and valuable properties but also an unsubsidized standing in the energy market. Fuels should compete in markets under reasonable environmental standards, uniformly applied, not in the halls of government. LPG should not have to struggle for official notice. In a fair fight conducted in the proper arena, it will win its share.

2.4. Agents In The LPG Market.

The world LPG market has so far been entirely supplied by the Middle East, Far East, Africa, Northern Europe and Latin America. The greatest supplier is the Middle East which exported by sea over 66 % of the total seaborne LPG in 1994.. Even if many countries have some local production, the five regions mentioned above are the major players on the LPG market today. More specific descriptions of those countries which are the main producers in these regions are given later in this work.
The shifting patterns of global economics and gas are also creating opportunities for the Former Soviet Union in the next 5-10 years. To accurately predict that the FSU, or any other region, will be the next Middle East concerning LPG export is impractical. The

underlying economic and political fundament in this region still appear encouraging, as do the growth prospects for many key LPG producers and suppliers.

There are few agents in the gas market, the five traditional agents are: the producers (who also transport gas from wellhead to terminals), national transmission companies, international sea transport operators, local distributors and end users. To understand how the market functions, we need an insight into the economic interaction between producers and transportation companies on the one hand, and the local distributors vs. transportation companies on the other hand. In this context, end user behaviour is of minor importance.

2.5. Market Structure and Market Price on the Supply and Demand Side.

In this part, the characteristics of a typical gas market will be described and therefore it is natural to give a review of the gas economics on the supply and demand side. The purpose of this section is to improve the understanding of gas economics and the connections between the demand and supply side of the market.

A little over 5.5 % of the world's consumption of energy comes from LPG. This share has been growing, partly due to availability and the increased areas of use, and partly because LPG pollutes less than heavier fossil fuels like oil and coal.

Ever since viable transport systems were established for LPG on advanced gas vessels in the 1960`s, the demand has been steadily increasing in pace with supply. It could be said that the LPG demand is supply generated. LPG can be extracted from natural gas fields, or together with oil from larger oil fields. In addition, LPG is produced as a by-product from the refining of oil.

The price of LPG was originally effectively controlled by oil producers, but it has in recent years become more independent of oil price developments, since gas can be extracted apart from oil production, and also since regulation of gas prices has not been a part of the OPEC co-operation.

The LPG trade is generally characterised by logical trading patterns between net import and net export areas, and there is a close connection between oil prices and LPG prices, and the pace of oil production. High oil production will give a lot of associated gas, and for oil producers high investments in refineries and limited possibilities for storage of gas, as opposed to oil, will lead to a large supply of LPG and low prices. The opposite will be the case with low oil production.

The structure of the total demand for LPG may be subdivided into premium and price-sensitive markets. The former is characterised by supply generated demand and the demand is less sensitive to high prices, while the latter to a great extent competes with other sources of energy. Areas which can be characterised as premium markets are LPG when used as car fuel, household gas and LPG for export purposes. Price sensitive markets are the use of LPG in energy production, as industrial fuel and as chemical raw material. The reason is these latter market's ability to direct demand to other energy products. Generally it has to be said that the patterns of demand are very complex, and in principle the price sensitivity of demand may vary greatly from one sector to another. In total, 25 % of production is exported and imported each year. The major exporting regions are Africa, the Middle East, and certain countries in the Far East, whereas the major net importers are mainly Japan in the North Pacific region, and other countries in the Far East. The increase in LPG consumption is expected to rise steadily in Japan, North America, and Western Europe.

Supply of gas and LPG.

There are several aspects of the supply side that contribute to the specificity of the gas market:

- Producers have exclusive access to the resource, which enables the Ricardian differential rent to occur. This means that units with lower marginal costs will earn profits that will not be reduced by free competition. In this case, this relationship may be somewhat unclear, different marginal costs may occur simultaneously in different regions.
- Gas is an exhaustible resource and gives the producers resource rent. Resource rent is an extra profit that covers opportunity costs of reducing non-renewable reserves.
  The structure of the supply side can be characterised as an oligopoly, which means that the producers will earn monopoly profits.
- The parity pricing i.e. index of gas prices according to oil prices is broadly used. In periods of high oil prices, this relationship will have consequences for gas, creating additional profits.

Although access to the resource gives quite much power to the producers, the decision to extract and sell gas is tied to large investments. Transportation costs account for a large part of necessary investments. These include the capital cost of ports and terminals, loading equipment, compressor stations and pipelines. Their dimensions are largely proportional to the pipeline's length. They are, however, much less than proportional to the system's capacity, which depends on the pipeline's diameter. Therefore, most producers build up considerably grater capacity than existing demand would indicate. As long as there is idle capacity, the average costs of transporting a unit gas will be lower, the more gas that is sent. Thus, economies of scale are likely to occur. The consequence is that the basic market theory rule: Price = Marginal Cost, cannot be met here, as the marginal cost of transporting a unit of gas is less than the average cost.

Pipelines are irreversible investments (sunk cost) and producers must bear the risk. Transporting gas requires large investments in cooling terminals and specialised ships like LNG and LPG carriers, but these costs are far less dependent on distance than transport by pipelines. That is why this method of transportation is normally preferred when distances are large, or when there is insufficient infrastructure as is in the fields of Western Siberia.

Non-cooperative game theory is usually used to describe producers′ behaviour in the gas market. The following two models are normally applied (3):

1. The Nash- Cournot game gives a static equilibrium solution. Its main philosophy is that players choose their own optimal capacities simultaneously, knowing their rival's production volumes. The prices are set as a result of these decisions, and are lower than in the case of monopoly, but higher than in free competition.

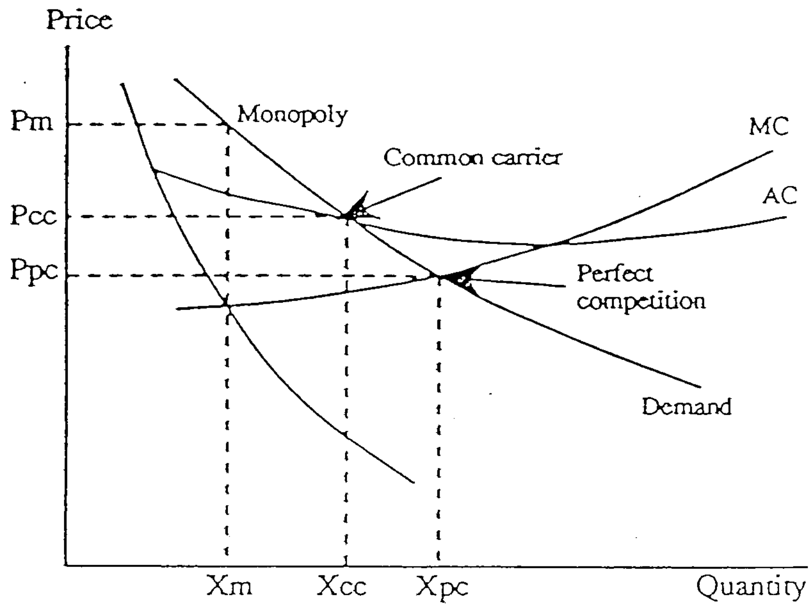
2. The game can also be regarded as dynamic, as in the Stackelberg solution. Here, the parties′ action follow the observations of the rival's steps. We assume that there is a price leader who chooses his capacity first, and the followers make their decisions in such a way as to maximise their profits knowing the leader's volumes. The price is then set as a result of this.

Demand of gas and LPG

The buyer market is usually described as an oligopoly, although it is sometimes regarded as a shifting and heterogeneous monopsony, as the transportation companies often participate in negotiations vis-à-vis producers.

The difference between a monopoly situation and a possible "common carrier" position of distributors can be seen in figure 1.

Figure 1 Market structure and market prices



The monopoly price Pm is reduced to Pcc, and the volume increases from Xm to Xcc. The surplus disappears and tariffs equal average transportation costs. On the whole, consumers will benefit from the change.

The experience of the last decade indicates that gas prices are set in a dynamic market. They are not based on some abstract "estimate" of replacement cost, to provide a desired rate of return for gas transportation, or to ensure a profitable market for gas equipment manufactures (4). This dynamic element presents the gas industry as a formidable challenge in a low price energy market. If the gas industry cannot provide adequate supplies at competitive prices, its vision to play a growing role in energy markets will go unrealised. Estimates in this work show a substantial growth in LPG consumption and seaborne trade, however maybe as much as 75 % of that growth, is in the price sensitive industrial and residential-commercial markets.

To capture this growth, the gas industry must not only expand gas supply at these low prices but must also keep gas transportation and distribution charges under control. Much of the optimism for new gas sales depends on increased supply at low prices.

PART-3. DEMAND AND SEABORNE IMPORT OF LPG.

International trade in gas is increasing for the same reasons that it did much earlier in oil trade; demand growth in traditional consuming areas and new demand in emergent markets, both increasingly separated geographically from the main sources of supply.

3.1. Economic Growth and LPG.

Continuing world economic growth coupled with low energy prices will stimulate the demand for petroleum, natural gas, LPG and petrochemical products in 1995. The demand for LPG should increase despite competition from other fuels and improving consumption efficiency. Boosting consumption of fossil fuel energy will give low output from the major renewable energy sources: nuclear and hydroelectric power. Growth in total energy consumption will lag that of economic activity due to continuing improvement in energy efficiency. But the rate of improvement will decline in the absence of rising prices.

The composite economic growth rate for members of the Organisation for Economic Co-operation and Development (OECD) is projected to increase in 1996 following several sluggish years. In addition, the economic boom in non-OECD Southeast Asia is expected to continue. This world-wide improvement in economic activity will probably boost total world oil and gas demand. Growth in oil and gas demand in those areas will be partially offset by declining consumption in the Former Soviet Union (FSU), still struggling with economic transformation. The expected improvement in world oil and gas demand will be matched by increased production. Gains will occur within and outside the Organisation of Petroleum Exporting Countries, excluding the FSU. Transformation of the FSU economies is an important political event with a major impact on the oil and gas market. To date the decline in oil and gas production has been matched by the decline in consumption, leaving FSU exports relatively stable and the market effects of the region's political turmoil fairly small. All of the primary energy sources will contribute to the increase in consumption in 1996. But growth rates for individual oil, gas and petrochemical products will vary, and market shares will shift.

3.2. Market Background

World energy consumption in the last 20 years- from the first energy crisis through various other crisis until today- has increased by 38 %. Among fossil fuels in this period, gas has been the most dynamic energy source, with a growth of 65 % vs. 12 % for oil and 28 % for coal. In terms of market share, gas has grown from 19 % to 23 % in the past 20 years, while oil has declined from 49 % to 40 %, and coal from 30 % to 27 %. The diverse use patterns of the three energy sources on the final consumer markets cannot be related to reserves. In fact, world coal reserves are equal to 67 % of total fossil fuels, while oil reserves amount to 17 % and gas reserves 16 %.

3.3. Importing Regions.

Since the results of this work shall be used to analyse the potential for seaborne export of LPG from Northern Russia to the world market it is important to identify which regions are importing these products, how much is imported and what are the estimates for the future seaborne trade. Liquefied petroleum gas and petrochemical products which are transported by pipelines and other transportation equipment between regions and countries are not analysed in this work, because such work is a task in itself. The issue is to get a perspective of the world LPG market related to export from Northern Russia, through the Northern Sea Route, and then to the world market. The trading regions used in this analysis are divided into different countries. Since the estimates emphasise aggregate seaborne import and export of LPG, it is necessary to specify which regions that have been used in this work:

Trading regions:

North America	: USA and Canada.
Latin America	: Rest of America.
North Europe	: Scandinavia, Baltic (include E. Europe and FSU),UK, Belgium, Netherlands, France Atlantic Coast.
South Europe	: Rest of Europe, Black Sea, Turkey.
Africa	: Algeria, Libya, Morocco, Nigeria to Angola.

Middle East	: Arabian Gulf, Iran, Yemen.
North Pacific	: Japan, South Korea.
China	: Mainland China.
Indian Sub-cont.	: India, Pakistan, Bangladesh.
Other Far East	: Rest of Southeast Asia, Indonesia, Malaysia, Thailand, Philippines,Vietnam and Myanmar.
Oceania	: Australia, New Zealand.

3.4. Derivation of LPG Trade Flows.

The estimates used and worked out in this demand part of the analysis are based mainly on consultancy work done for Kværner Shipping by various internationally recognised companies like Poten & Partners Inc., New York, and Purvin & Gertz, Dallas. The statistics available for the developed world are reasonably comprehensive, but there are gaps in the figures for trade between developing countries. So in some cases data have been partly estimated, on the basis of ship movements and freight market charter records.

LPG volumes available for exports are derived by looking at crude oil and natural gas production in each country, as well as developments in gas separation and liquefaction facilities, refinery capacities and other infrastructure developments. The basic thesis is that most liquefied petrol gas will find a home somewhere. The consultants estimate likely demand developments by taking into account economic growth, economic transitions etc. while separating price sensitive and captive markets. Price sensitive markets include the use of LPG for petrochemical feedstock during periods when the price of LPG per ton is 90 % or less of naphtha– another feedstock product.

3.5. Seaborne Import of LPG and Regions.

World seaborne LPG import rose 5.15 % to 33,637.0 million metric tons in 1994. As much as 53.41 % were accounted for by the North Pacific region. South Europe imported 14.34 % of all LPG traded in 1994, while Latin America consumed 10.55 % of world import of LPG. North America alone imported by sea 7.83 % of the total traded LPG.
The greatest estimated percentage increase in import is in the Indian Subcontinent region with a 75.76 % growth during 1995. The only negative trend is the decrease in import to the South European region by 9.35 % from 1994 to 1995. Total seaborne import is

expected to rise by 8.82 % at the end of 1995. See table 3A. for the importing regions and estimated seaborne import, and percentage change for each region from 1994 to the end of 1995.

LPG

Importing Countries/ Seaborne trade in 1000 MT, 1994 & 1995.

Country	1994	1995 est.	Percentage change	
North America	2,634.0	2,711.0	+	2.93 %
Latin America	3,549.0	4,016.0	+	13.15 %
North Europe	1,051.0	1,329.0	+	26.45 %
South Europe	4,822.0	4,371.0	-	9.35 %
M.East/Africa	423.0	473.0	+	11.82 %
North Pacific	17,964.0	19,762.0	+	10.00 %
China	1,419.0	1,819.0	+	28.19 %
Indian Subcont.	132.0	232.0	+	75.76 %
Other Far East	1,602.0	1,853.0	+	15.67 %
Oceania	42.0	42.0		0.0
FSU	n.a	n.a.		n.a.
TOTAL	**33,637.0**	**36,607.0**		**+ 8.82 %**

Table 3A: LPG seaborne import, DA Consulting. Source: Kværner Shipping a.s, 1995.

The regions with a positive percentage increase from 1994 to 1995 can primarily be explained by a general growth in demand for both price-sensitive and premium markets. Very roughly, premium use sectors account for two-thirds of demand and the remainder is sold into the more price-sensitive markets such as: chemical feedstock, power generation, industrial fuel and gas utilities. The negative trend in Southern Europe is explained by LPG shipments within the region. The structure of the European import market is a little more complex as sources of supply vary from country to country, while there is a considerable inter-regional trade. Deep-sea imports to Western Europe are to a large extent dependent on North Sea production, which changes continuously and in that way has a major impact on the import/export balance.

3.6. Estimation of Demand and Seaborne LPG Import for Each Region.

This section gives the estimates for the global aggregate future demand for LPG transported by sea. In addition to the methods described earlier, recent trends, important political issues, current growth and future expectations for economic growth for each region are analysed and taken into account. The first part in this section where the evaluations of the FSU are given, will explain more thoroughly and focus on the demand situation at the actual site in the Siberian Fields. Virtually no reports or work has ben done on seaborne LPG demand in the Tyumen region. In addition, there is no more specific information available about production and consumption of LPG at this stage from Russian sources. So the estimates used here will also be used later in the economic feasibility study for seaborne LPG export from Tyumen. By evaluating production, consumption and internal export towards year 2000 it is possible to see the increase in regional LPG surplus that is available for seaborne export. This regional estimated surplus of LPG is estimated to nearly double from 1995 to 1996 and so on, for which limited transportation capacity exists.

3.6.1. FSU/Western Siberia/Tyumen Region.

The Tyumen region of Western Siberia holds vast potential for oil and gas processing investments. Oil and other hydrocarbons for the most part remain unrefined in the region, which despite its huge reserves of oil and gas has to import fuels and chemicals from central Russia. The Tobolsky petrochemical plant in the southwest corner of the region and the Omsk oil refinery in the south are the only major oil and gas upgrading and conversion facilities currently in operation in the Tyumen Oblast.

While Western Siberia has an extraordinary potential for production of crude oil and other hydrocarbons, it has to import 1.5 million metric tons/year of gasoline, more than 3.2 million tons/year of diesel fuel, and about 1 million tons/year of kerosene jet fuel (5). In addition to petroleum products, the region imports: basic petrochemicals, basic plastics, pipes, polyethylene film, textiles, other consumer goods, and speciality chemicals.

Transportation in effect doubles the cost of oil from the Tyumen region in comparison to other parts of the FSU. The cost of transporting a ton of unrefined oil to processing plants elsewhere and importing the refined product back to the Tyumen region is about double the cost of developing and producing a ton of Tyumen crude at gas-oil separation plants.

Long haul transportation is difficult due to challenging winter weather, a limited road network, great distances between widely dispersed major industrial towns and villages, and the multiplicity of oil fields. In spite of its potential, therefore, the Tyumen region is suffering high financial losses because of its inability to produce finished products and its consequent need to rely on other regions of the Former Soviet Union (FSU). Developing of a processing industry would solve not only those regional problems related to the shortage of finished products, but also help to meet expected increase in petrochemical demand throughout the FSU.

The outlook is good for LPG demand inside and outside the FSU, and for exports to world market. In spite of the FSU`s rich reserves of this valuable light hydrocarbon feedstock, however, much is being irrevocably lost. Between 1990 and 1994, LPG production in Russia declined by about 40 % to an estimated 5.2 million metric tons. Russian LPG output averaged about 85 % of the FSU total during 1988-1994. To compare these figures, we can see how much three former republics could produce: Lithuania 250,000 metric tons/year, Belarus about 300,000 metric tons/year, and Ukraine 600,000 metric tons/year of LPG. Even at those levels, however, they would not be self-supporting. If the current downtrend were to continue at Russia's plants, LPG production in 1995 would be less than 5 million tons. Production at that level would not even satisfy Russian demand, let alone provide any surplus for export to adjoining countries – the near abroad.

This could lead to a loss of markets and increased friction between Russia and its neighbours, since 35 million FSU families, totalling 150 million people, use LPG in their daily life.

Just as production of LPG in the FSU is being constrained by lack of investment, so is consumption. Investments must be made in the petrochemical and other industrial sectors to strengthen the economies of the FSU countries. These in turn will increase LPG demand, says Poten & Partners. Most of the LPG demand in the FSU is in traditional uses such as households etc. Petrochemical use of LPG, the second largest market, accounted for one third of 1990 demand. The rest of LPG demand was for auto fuel, metal cutting, and other industrial applications. Poten & Partners projects the petrochemical industry's demand for LPG to increase by almost 40 % between 1990 and year 2010. Non-chemical demand for LPG is expected to grow about twice as fast. Traditional demand will continue to be the largest consuming sector, but its growth will be relatively slow. Metal cutting and other industrial applications will more than double in LPG demand, and exports could increase five-fold, but from smaller base levels. To see how the Tyumen LPG total demand and consumption will develop, see table 3B.

Total demand and estimated regional surplus of LPG in the Tyumen region.

Year	**1993**	**1994**	**1995**	**1996**	**2000**
Tyumen Production		Thousand metric tons			
Sibneftgas.(SNGP)	3,010	3,244	4,037	5,285	5,840
Concern Gas Prom	1,140	1,000	1,100	1,100	960
Total	**4,150**	**4,244**	**5,137**	**6,385**	**6,800**
Consumed in Western Siberia.					
Tobolsky petr.plnt.	2,250	2,300	2,500	3,000	3,000
Consumed outside of Western Siberia.					
Gas processing plnt.	680	620	635	770	350
Petroch.plnt.	822	774	802	915	470
Exports	398	400	500	500	680
Total	**1,900**	**1,794**	**1,937**	**2,185**	**1,500**
Total Demand	*4,150*	*4,094*	*4,437*	*5,185*	*4,500*
Regional Surplus	*0,0*	*150*	*700*	*1,200*	*2,300*

Table 3B: Estimation of LPG in Tyumen. DA Consulting. Source: Valeri S. Plotnikov. Chief engineer at SNGP`s gas processing plant Muravlenko, FSU.

LPG output in the Tyumen region is expected to increase through 2000, creating significant surpluses that could feed new petrochemical facilities, or be exported through the Northern Sea Route to the world market by ice-breaking LPG tankers.
Petrochemical plants use most of the region's output of light hydrocarbons. The main customer and demander is the Tobolsky petrochemical plant as table 3B. shows, which produces 180 000 tons/year of a divinyl raw material for caoutchouc, a synthetic rubber.
Other petrochemical plants are west of the Ural Mountains. LPG destined for these markets must now be transported by railway. The research institute VNIPI Gaspererabotka of Krasnodar expects Tyumen LPG output to exceed the anticipated demand of currently operating facilities by one-third.

The Tobolsky plant will remain a major consumer, but demand for Tyumen LPG outside Western Siberia is likely to decline by 2000 because there will be ShFLU-mixture available from other parts of the FSU, leaving a substantial surplus of Tyumen LPG. VNIPI Gas predicts that 15 % or more of recovered Tyumen LPG will not be distributed under business as usual and may have to be flared. This and SNGP natural gasoline could provide an important energy resource base for further economic development in Western Siberia. In view of the vast resources of Russia, the countries of the FSU should not need to import LPG from anywhere else. Yet in West Siberia, the flaring of 8-10 billion cu.m/year of associated gas wastes 3-4 million tons/year of LPG. This volume is sufficient for traditional supply to near abroad regions if the transportation infrastructure recovers in the near future.

The bottleneck to realisation of the market potential of LPG is lack of investment for production and transportation. Since this work focuses on the potential for seaborne export of this flared LPG, the major question is: "Would there be transportation at competitive prices to provide acceptable returns to producers and investors in this region ?".

3.6.2. North America.

Growth in the U.S. real gross domestic product (GDP) is estimated at 3.8 % for 1994, compared to 3.1 % for 1993 and 2.3 % in 1992. GDP growth in 1995 is projected at 2.7 %. This will be the fourth consecutive year of economic growth.

Economic improvement led to marginal increases in energy and petroleum consumption in 1992 and more significant increases in 1993 and 1994 as the economic growth gathered momentum. However, improvement is expected in 1995 for a number of the major economic indicators. Industrial production, a key component of both economic activity and energy demand, moved up an estimated 5.1 % in 1994 and helped to increase economic growth and consumption of energy. Industrial output is projected to increase another 3.7 % in 1995.

The projected increase in economic activity in 1995 is expected to boost both the total U.S. energy consumption and demand for petroleum and gas energy. Increased manufacturing activity and electricity consumption will be major factors pushing up demand for gas and petrochemical products.

Improvements in energy efficiency and conservation will continue. Increased environmental costs will tend to boost the cost of energy and stimulate investments in energy efficiency. But the rate of improvement will be influenced by the cost of energy. Deregulation has increased competition and efficiency in the LNG and LPG industry and has helped to increase consumption. Federal and state governments also are trying to raise consumption of gas for environmental reasons.

Arguments from the discussion above support the development of import and seaborne demand for LPG from 1990 until year 2000. See table 3C.

Seaborne trade and import to North America , in MMT from 1990 to year 2000.

Product **Year**	**LPG**		**Percentage change in seaborne import**
1990	2,692.0	+	16.38 %
1991	1,793.0	-	50.14 %
1992	1,340.0	-	33.81 %
1993	1,963.0	+	31.74 %
1994	2,634.0	+	34.18 %
1995	2,711.0	+	2.92 %
1996	3,560.0	+	31.32 %
1997	4,110.0	+	15.45 %
1998	4,660.0	+	13.40 %
1999	5,210.0	+	11.80 %
2000	5,760.0	+	10.56 %

Table 3C: Seaborne import estimates, DA Consulting. Source: Kværner Shipping, 1995.

As the table shows, the trend for seaborne import of LPG increased after 1992. The volumes imported are over twice as big in year 2000, related to the number for 1994. There is a predicted slow growth from 1996 to 2000, relative to the strong increase between 1990 and 1995/96. The reason is that most end-use sectors are mature and the only possible growth markets are residential/commercial applications and possibly chemical feedstocks.

North America consumes significantly more LPG than it produces, and seaborne transport is the major supply source to this region. There is a general expected decline in U.S.

production of crude oil and condensate at 160,000 b/d, taking average output to 6,48 million b/d. This follows a decline of 207,000 b/d last year, when output averaged an estimated 6,64 million b/d. And as explained earlier, LPG prices are closely connected to oil production. In that way LPG domestic prices are expected to increase according to the decrease in future oil production.

In Canada major gas plant expansions have recently occurred, are under way, or are planned for the main line straddle plants in western and eastern Alberta.

These expansions combined with reduced domestic demand for LPG are behind the growing volumes of LPG available for export in the second half of this decade. On a purely import basis the United States is third only to Japan and South Europe in the league of LPG importers. But from a shipping point of view, it is less important, because a large part of the import requirement is made up of overland shipments from Canada.

North America imports LPG by sea, mainly from the Middle East, but also Latin America, North Europe and Africa contributed with a significant part. In 1995 seaborne import of LPG from the Middle East accounted for about 25 % of the total volume traded by sea to this region.

3.6.3. Latin America.

In Latin America, historical factors, including inflation, currency instability, and high national debt have been met with responses such as privatisation and deregulation. Coupled with global overcapacity, this situation has led to slower industrial development. Mexico is opening its oil, gas and petrochemical industry to private investments. The Mexican industry faces major trade changes brought about by the North American Free Trade Agreement (Nafta) and the GATT. Expected effects include increased oil and gas trade between Mexico, U.S., and Canada.

Venezuela's economic indicators are weaker than Mexico's, and depressed oil and gas prices there will further reduce domestic growth. Low oil prices are also likely to accelerate this country's trend toward privatisation. In Brazil, the availability of domestic crude oil and gas are increasing and deregulation is also in progress such as: reduced tariff barriers, (non tariff barriers have been reduced or eliminated, and subsidies have been withdrawn most notably from the petrochemical industry). In general, Latin America is a region with great potential. Political and economic conditions in this area, however, will play a big role in the vitality of the oil and gas industry.

Seaborne trade and import to Latin America , in MMT from 1990 to year 2000.

Product	**LPG**	**Percentage change in seaborne import**	
Year			
1990	1,714.0	+	42.83 %
1991	2,076.0	+	21.12 %
1992	2,867.0	+	38.10 %
1993	3,441.0	+	20.02 %
1994	3,549.0	+	3.13 %
1995	4,016.0	+	13.16 %
1996	4,066.0	+	1.25 %
1997	4,328.0	+	6.44 %
1998	4,496.0	+	3.88 %
1999	4,664.0	+	3.74 %
2000	4,831.0	+	3.58 %

Table 3D: Seaborne import estimates, DA Consulting. Source: Kværner Shipping, 1995.

Significant LPG supply build-ups are projected for Latin America. Most of this production, however, will be absorbed in internal domestic markets, and will be unavailable for international trade and commerce.

Table 3D. shows that after 1995 there is just a slight increase in LPG seaborne import from the rest of the world. The reason for this is mainly explained above, in addition to the fact that Latin America also exports a significant volume of LPG. Most of the additional LPG goes to North America, the Indian subcontinent and Oceania, see chapter four for further information about importing regions. Of the overall 1994 production, 454 000 mt/y will be exported, up from 193 000 mt/y in 1992.

Latin America's primary supply source, apart from its own production of LPG, was in 1995 Africa. Of total seaborne LPG import, as much as 1,249.0 mmt came from Africa, and 345.0 mmt of LPG came from the Middle East. Total LPG imported by sea in 1994 was 3,549.0 mmt, predicted import volume in year 2000 is 4,831.0 mmt, an increase by 36 % over 5 years.

3.6.4. Northern Europe.

In Western Europe, interest for gas as an energy source first began in the 1960`s. The European share of global gas consumption was initially small, but has since grown steadily. Growth in European demand for energy and, especially LNG and LPG is part of an already strong world-wide trend. In 1993, 52 % of Western Europe's gas requirements were met by internationally traded gas, including supplies from European exporters such as the Netherlands, Norway, and Denmark as well as volumes outside the region such as Algeria, Libya, and the former Soviet Union.

An important variable, and a reason for the difficult work to estimate seaborne import of LPG to this region in addition to the inter-regional trade, is the demand for electric power generation, which is difficult to predict. The West European electricity generation industry is undergoing far-reaching changes. On the institutional level, there is a policy of privatisation of the major public power generating enterprises in response to a clear European Union directive. On the level of energy resource management, operators in the sector are oriented toward much greater use of LNG and LPG, both because of its technological suitability for use in power stations and because of its environmental advantages. Further gains in gas use for power generation are possible as private industries adopt combined cycle gas turbines and co-generation systems to fill their power needs. Future choices in the power generation sector thus will have a great effect on gas consumption in Europe and therefore, on the need for new supplies. Present seaborne import of LPG and estimates towards year 2000 are given in table 3E. for Northern Europe.

Seaborne trade and import to Northern Europe , in MMT from 1990 to year 2000.

Product	**LPG**	**Percentage change in seaborne import.**	
Year			
1990	2,044.0	-	16.80 %
1991	1,578.0	-	22.80 %
1992	1,676.0	+	00.88 %
1993	1,364.0	-	18.62 %
1994	1,051.0	-	22.95 %
1995	1,329.0	+	26.45 %
1996	1,597.0	+	20.17 %
1997	1,711.0	+	7.14 %
1998	1,823.0	+	6.50 %
1999	1,935.0	+	6.14 %
2000	2,047.0	+	5.79 %

Table 3E: Seaborne import estimates, DA Consulting. Source: Kværner Shipping, 1995.

The demand for seaborne import of LPG is small in Western Europe relative to other regions in this analysis. Seaborne import is expected to double from 1994 to year 2000, from 1,051.0 mmt to 2,047.0 mmt. In 1997 the expected growth is below 10 %, and is estimated to stabilise around 5 % after year 2000. Much of this import is explained by the new use of LPG and an expansion in the European petrochemical capacity. To fill demand at projected levels, therefore, new sources of gas imports must be identified, negotiated and brought on line. In 1995 North Europe imported approximately the same volume in mmt. from the Africa region as from the Middle East.

3.6.5. Southern Europe.

While Europe has been able to exploit the economies of scale of large gas projects to obtain access to the resources of Siberia, the Sahara, and the North Sea, gas market penetration differs greatly from one country to another. The experience of Southern Europe such as France, Italy, and Spain provide a useful comparison. In the 1960`s, the countries relied on their own, national supplies. Now they are highly dependent on foreign supplies and seaborne import. It is important to remember that the Southern Europe region also includes the Black Sea and Turkey. As the table 3F. shows, import of LPG by sea is significantly higher than for Western Europe.

Seaborne trade and import to Southern Europe , in MMT from 1990 to year 2000.

Product	**LPG**	**Percentage change in seaborne import.**	
Year			
1990	3,086.0	-	18.27 %
1991	4,107.0	+	33.08 %
1992	4,345.0	+	5.79 %
1993	4,345.0		00.00 %
1994	4,822.0	+	10.98 %
1995	4,371.0	-	9.35 %
1996	4,679.0	+	7.05 %
1997	5,044.0	+	7.80 %
1998	5,409.0	+	7.24 %
1999	5,774.0	+	6.75 %
2000	6,139.0	+	6.32 %

Table 3F: Seaborne import estimates, DA Consulting. Source: Kværner Shipping, 1995.

The Southern European region accounts for over 75 % of total seaborne LPG import in 1995 if we compare Northern and Southern Europe together. The percentage increase is not on average as high as for the northern region, but overall the volume demanded is higher, also towards year 2000. Southern Europe has virtually no indigenous seaborne export related to the northern part, and is dependent on imports to meet most of its internal LPG demand. Southern European imports of LPG from outside the region are expected to grow by a small amount up to year 1998/99, although thereafter the import is liable to fall as indigenous production in the North Sea rises.

The demand in this region is mainly supplied from Africa and the Middle East, and these two supplying regions are not expected to change. And as for Northern Europe, these two regions accounted for nearly the same volume of seaborne export of LPG to Southern Europe.

3.6.6. Middle East and Africa.

The African seaborne import in addition to the seaborne import to the Middle East is significantly small relative to their production and seaborne export out of these regions.

Both the Middle East and Africa are among the smallest importers of LPG world-wide, the reason is related to their large production and export of LPG to the world market. In addition, Middle East and African suppliers are likely to become a more important supply source for especially the US LPG imports. This increase is likely to be achieved at the expense of Canadian and Latin American suppliers.

Of the major Middle East and African exporters, Saudi Arabia will continue to be the leader in the international LPG trade. The net export availability, however, will probably decline from Saudi Arabia in the midterm as the start-up of new chemical projects, primarily MTBE plants, absorb more of the domestic production. The impact of new expansion projects will noticeably improve the international trade position of Algeria and the U.A.E, and LPG production in Algeria will get a considerable boost later this decade when the first of several major projects comes on stream. These exporters will rank as the second and third largest, respectively, at the end of the forecasted period. Concerning the import to this region see table 3G. for more information.

Seaborne trade and import to M. East/ Africa , in MMT from 1990 to year 2000.

Product Year	LPG	Percentage change in seaborne import.
1990	450.0	- 18.18 %
1991	310.0	- 31.11 %
1992	396.0	+ 27.74 %
1993	415.0	+ 4.80 %
1994	423.0	+ 1.93 %
1995	473.0	- 11.82 %
1996	510.0	+ 7.82 %
1997	560.0	+ 9.80 %
1998	610.0	+ 8.93 %
1999	660.0	+ 8.20 %
2000	710.0	+ 7.58 %

Table 3G: Seaborne import estimates, DA Consulting. Source: Kværner Shipping, 1995.

As we see, these predictions for seaborne import to these two regions are small compared to their LPG seaborne export to the world market. Even if the strongest growth in demand will occur in such developing regions as Asia, the Middle East, and Latin America, these two regions above will meet their own demand and in addition export to the world market. The regions that are importing LPG from the Middle East are explained later in this work.

3.6.7. North Pacific.

This region includes countries such as Japan, South Korea and Taiwan. By 2000, LPG seaborne demand in this region including Japan will be as much as estimated 21,900.0 mmt/year. Japan is currently experiencing slow economic growth. Experts expect that the economic growth will increase by 2.5 % until 2000, and by 3.5 % from 2000 to 2010. Japan accounts for over 30 % of the total energy consumed in East Asia. Based on less than 2 % annual growth in energy demand, forecasts state that the Japanese will demand around 520,0 mtoe in 2000 and around 610,0 mtoe in 2010. Japan is by far the major importer of seaborne LPG. General economic trends in Japan will therefore have a strong impact on this part of the market.

There is a great potential for increased seaborne export of LPG to Japan, mainly because of their need to reduce their dependence on oil and because of environmental concerns. In addition, Japan has virtually no indigenous sources of fossil fuels and is dependent on import to meet most of its energy demand. The petrochemical industry in this region is expanding without any disciplined focus, says Blum in International Consultant Chem Systems Inc. Plants of relatively small scale generally rely on imported feedstocks and marketing in very fragmented regions of Japanese networks and Chinese connections.

The major contributor to the predicted increase shown in table 1J, is the Japanese LPG import. This seaborne LPG import is expected to continue rising in the last part of the 1990`s. In Japan some 40 % of LPG consumed is used in the residential and commercial sectors and the companies marketing to these outlets believe there is a scope to increase sales, particularly in water heating, where LPG has a 28 % share of the market. Other non-premium sectors under consideration include automobiles where there is a potential to use LPG for diesel engined trucks which are presently using gasoline. It is also worth noting that Japan is similar to other major importers, since it has a number of price sensitive markets, which potentially could consume large quantities of LPG.

On the other hand, one factor which may influence future Japanese LPG imports is the availability of storage facilities. Storage is complicated by the fact that the Petroleum Stockpile Law lays down rules governing minimum stock requirements. Importers of LPG are therefore obliged to work within very tight margins and this has led to a demand for smaller cargoes and multi-point unloading.

Taiwan's petrochemical industry has stagnated, primarily because environmental concerns have prevented construction of badly needed new facilities. As a result the country has become a key importer. See table 3H. for further increase in seaborne import.

Seaborne trade and import to the North Pacific , in MMT from 1990 to year 2000.

Product	**LPG**	**Percentage change in seaborne import.**	
Year			
1990	16,400.0	+	5.36 %
1991	17,593.0	+	7.27 %
1992	18,586.0	+	5.64 %
1993	18,273.0	-	1.68 %
1994	17,964.0	-	1.69 %
1995	19,762.0	+	10.01 %
1996	19,900.0	+	0.70 %
1997	20,364.0	+	2.33 %
1998	20,857.0	+	2.42 %
1999	21,408.0	+	2.64 %
2000	21,900.0	+	2.30 %

Table 3H: Seaborne import estimates, DA Consulting. Source: Kværner Shipping, 1995.

The North Pacific is the world´s largest importing region. Of the total seaborne import to this region, over 83,75 % (15,044.0 mmt), came from the Middle East in 1994. Japan is overall the dominant importer of LPG, but also South Korea, and Taiwan are currently importing large volumes. East Asia remains the largest importer of petrochemicals, accounting for about two thirds of the world's shipments. In spite of the new capacity being built, deficits are expected to persist into the next century.

3.6.8. China.

China's economic growth in 1992 was an astonishing 13.0 %, and the last five years growth has averaged 9.3 % per annum. In the future the mainland Chinese economy is expected to grow on the average by 10.0 % annually until year 2000, and at a rate of 8.0 % in the first decade of the new century. The total energy demand is expected to increase to 1085,0 mtoe by the turn of the century. By year 2010, the expected energy consumption is close to 1,780 mtoe. In China , environmental concerns are growing but are not yet a compelling factor in the fuel choice. China is likely to turn increasingly to gas (LNG and

LPG) in order to help satisfy surging energy demand which cannot be met by domestic supplies of oil and coal.

However, China's gas industry is in its infancy and the displacement of coal is not widely accepted. Beijing has plans to switch household energy consumption from coal to gas by the end of the century in a drive to clean up pollution in the Chinese capital. China's outlook for LPG import is given in table 3I.

Seaborne trade and import to China, in MMT from 1990 to year 2000.

Product Year	LPG		Percentage change in seaborne import.
1990	20.0		0.0 %
1991	0.0	-	100.0 %
1992	0.0		0.0 %
1993	369.0	+	undefined
1994	1,419.0	+	284.55 %
1995	1,819.0	+	28.19 %
1996	2,200.0	+	20.95 %
1997	2,503.0	+	13.77 %
1998	2,326.0	-	7.07 %
1999	2,388.0	+	2.67 %
2000	2,450.0	+	2.60 %

Table 3I: Seaborne import estimates, DA Consulting. Source: Kværner Shipping, 1995.

The seaborne import to China was zero between 1991 and 1992, then their petrochemical industry started to import LPG from Latin America, the Middle East and Other Far East regions. Further growth in seaborne LPG import is related to a strong domestic demand both in the premium and price-sensitive markets. This is to a large extent dependent on the future political situation, and if projected chemical plants are to be built. The major exporter to China this year was the Middle East which accounted for ca. 67.75 % of China's seaborne import. The predicted import from 1996 and onwards is expected to be supplied primarily from the Middle East and about 27 % on average from Other Far East regions. The seaborne import to China is expected to stabilise between 2,000.0 and 2,500.0 mmt/year after 2000.

3.6.9. Indian Subcontinent.

India's economic growth in 1993 was 3.4 %. The last five years the growth has averaged 4.2 % per annum. In the future the Indian economy is expected to grow on average 5.3 % annually until year 2000. Total energy demand is expected to increase sharply, and India continues to press plans for a long-term deal with especially Oman, that would match the former's gas supply with the latter's rising demand. India's plan is to fuel continuing robust economic growth with gas and other fossil fuels. Privatisation of India's petroleum industry is seen as inevitable. What has become clear during 1994, is that huge investments required for Indian exploration, refining, and marketing are beyond the scope of even the biggest state-owned firms, such as Oil & Natural gas Commission, and Indian Oil Corp (6).

India's gas demand is expected to grow 15-18 % per year through 2000, creating by 2005 LNG and LPG imports accounting for 4-6 bcf/year. India is the biggest LPG importer in this region and is not expected to have enough surplus of LPG to export at all during this century. The two minor countries in this region are Pakistan and Bangladesh. Both of these are expected to meet increased growth in their economy towards year 2000. The potential for more LPG import is based on their new petroleum policy.

Pakistan has introduced a new petroleum and gas policy that paves the way for increased private investments in the country's petroleum sector. It focuses on cutting red tape and streamline decision-making (7). The government is adjusting price formulas for crude oil, condensates, associated gas, non associated gas, and LPG, generally with an eye to establishing incentives to producers. And it is exempting operating companies and contractors from import duties and licence fees.

Bangladesh is also attracting new interest to its petroleum sector, notably natural gas and LPG. Interest stems in large part from the government's plans to draft a new national energy plan that is expected to include privatisation of petroleum assets.

The energy plan will focus on assessing the current state of Bangladesh's energy sector and long term guidelines for the nation's energy use, including opening the sector to private and foreign investment. The main reason for this change in these two countries' energy policy is their high present growth and expected growth in oil and gas the next 3-5 years. As table 3J. below shows, their LPG seaborne import is relatively small compared to the other regions that are analysed.

Seaborne trade and import to the Indian Subcontinent, in MMT from 1990 to year 2000.

Product Year	LPG	Percentage change in seaborne import.
1990	400.0	0.00 %
1991	12.0	- 97.00 %
1992	42.0	+ 250.00 %
1993	103.0	+ 145.00 %
1994	132.0	+ 28.16 %
1995	232.0	+ 75.76 %
1996	300.0	+ 29.31 %
1997	475.0	+ 58.33 %
1998	650.0	+ 36.84 %
1999	825.0	+ 26.92 %
2000	1,000.0	+ 21.21 %

Table 3J: Seaborne import estimates, DA Consulting. Source: Kværner Shipping, 1995.

This region is being supplied only from the Middle East. There is a significant change in seaborne import from 1990, and in the predicted volume of LPG import in year 2000. The change in this predicted LPG import is mainly because of the shift in their energy policy, and expected foreign interest in building petrochemical plants, as well as exploration and production. But the increased growth in general energy demand in this region explains the radical change in LPG import between 1994 and 1997.

3.6.10. Other Far East.

Economic growth in this region has since the mid 1970`s averaged 6 % per annum. The highest average growth rates since 1985 have been in Thailand, Malaysia and Indonesia. The recent and impressive economic growth rates are strongly related to the openness of the South East Asian (SEA) economies.

International trade has played an increasingly important role. The countries have consciously embarked upon an outward looking strategy of increased exports and attractive incentives for foreign investments. This expansion of trade activity has benefited the countries in several ways. Specialisation according to comparative advantages has increased the effectiveness and capacity utilisation of the industry. The generation of export revenues has also reduced the likelihood of growth-constraining foreign-exchange shortages. As a result, a virtuous circle has emerged, with exports financing the intermediate inputs and capital equipment needed for additional growth. However, although the industrial growth has been impressive, the region still has large, poor rural populations and the income gap between the rural and urban areas has widened.

The Indonesian economy grew by 6.0 % in 1993. Since 1975 the economic growth has averaged 5.8 % annually. The growth rate is expected to stay at 6.0 % until the turn of the century. In Malaysia GDP growth in the past five years has averaged 8.9 %. It is estimated that until the turn of the century, the economy will grow 7.0 % on average per annum.

Thailand, Vietnam and Myanmar will also meet similar high growth in their economies towards year 2000. Only the Philippines are expected to have a lower growth at around 3.0 % until year 2000. Common for this region is that the demand for LPG has increased and future growth in demand is expected to continue until the turn of the century. The table 3K. indicates the seaborne import of LPG towards year 2000.

Seaborne trade and import to Other Far East, in MMT from 1990 to year 2000.

Product	**LPG**	**Percentage change in seaborne import.**	
Year			
1990	1,400.0	+	41.41 %
1991	1,509.0	+	7.79 %
1992	1,774.0	+	17.56 %
1993	1,671.0	-	5.81 %
1994	1,602.0	-	4.13 %
1995	1,853.0	+	15.67 %
1996	2,082.0	+	12.36 %
1997	2,139.0	+	2.74 %
1998	2,193.0	+	2.52 %
1999	2,247.0	+	2.46 %
2000	2,302.0	+	2.45 %

Table 3K: Seaborne import estimates, DA Consulting. Source: Kværner Shipping, 1995.

The other Far East imports LPG from the Middle East, but this region actually exports LPG to the world market with over double the volume they are importing from the Middle East. After 1996 the import of LPG is expected to stabilise around 2.5 % annually. The most significant increase or demand gap is between 1995 and 1996, with seaborne LPG import increases of 229.0 mmt. A combination of strong domestic demand and moderate increase in local supply are liable to lead to further growth in seaborne LPG imports after year 2000. Also in this region the predicted growth is based on a significant increase in LPG demand for both the premium and price-sensitive markets.

3.7. Conclusion.

The volumes of LPG traded and expected growth in seaborne demand for each region have been covered in the previous discussion in this chapter. It remains to underline the relative growth in major LPG sub-markets, and of the major import regions.

The average world LPG demand from 1995 will grow at about 5.2 % a year through the turn of the century. While all end-use markets will grow, total world LPG demand will be led by the residential/commercial, refinery/chemical, and enginefuel sector. The current market share for the residential and commercial sector is about 47 %.

Sub-Markets.
As the LPG market is divided into a number of end-uses, it is important to remember that its response to changes in price is complex. In most of its uses LPG is always subject to possible substitution by other products and, therefore each sub-market is faced with different substitution economics.

Commercial/Residential.
Continued commersial demand in the developing countries of the Far East, Latin America, and Eastern Europe will help sustain this market share despite the more moderate growth rates in the mature regions of North America, Western Europe, and Japan. Overall, the residential and commercial market for LPG will enjoy growth rates of 3.5-4.0 % per year.

Petrochemical Sector.
The petrochemical sector currently accounts for about 23 % of total world LPG consumption. Despite downward revisions in the MTBE demand forecasts, the increased use of butane as MTBE feedstock will still result in very strong growth for the

petrochemical sector. Continued strong growth in propane use as petrochemical feedstock (particularly in the FSU) is also expected to contribute to the firm base petrochemical demand for LPG in many regions of the world.

The expected availability of future LPG supplies for price-sensitive market development (as olefin plant feedstock) will also result in increased use of LPG in the petrochemical sector, particularly in the U.S. and Europe. The recently commissioned flexible feedstock plants in the Middle East and Far East will also participate in the price-sensitive market for LPG. Overall, the petrochemical market for LPG will exhibit growth rates in the range of 5.5-6.0 % per year. By 2000, the market share for LPG use in the petrochemical sector should expand to about 26 %.

Engine Fuel.

Increasing environmental pressures and clean-air initiatives will enhance the future growth prospects for LPG as engine fuel, particularly in regions which can offer significant tax incentives or impose federal mandates. Throughout the forecasted period, LPG use in the engine-fuel sector will also grow in the range of 5.5-6.0 % per year. This will result in a market share of about 7 % by the turn of the century.

Refinery Use.

Refinery use of LPG is being affected by a general tendency toward reduced gasoline vapour pressure. While reduced normal-butane consumption in gasoline blending is being offset somewhat by increased isobutane consumption as feedstock for alkylation and for international production of MTBE, the overall market share for refinery LPG use will decline. By 2000, the market share for refinery use of LPG will drop to about 6 %. The market share for industrial use of LPG will decline to about 11 % in 2000. Increasing competition from natural gas continues to erode this market, despite growth projected in some developing countries. Although the current outlook for LPG demand appears to be in step with forecasted supply build-up, it must be emphasised that several new supply projects are being developed in countries with some degree of political instability like the FSU and the Tyumen region.

The expectation that future world LPG supplies will exceed premium market demand makes it clear that there is a continual need to develop price-sensitive markets. This condition will contribute to additional growth of LPG use in the petrochemical sector, particularly in the U.S and Europe. The Far East and Middle East will also participate in the clearing of available world LPG supplies in the soon-to-be-completed new olefin plants with LPG feedstock flexibility.

Seaborne LPG demand.

Substantial growth is projected for world seaborne LPG demand/import. Total world-wide import of LPG transported by sea in 1990 was 26,206.0 mmt. In 1995 estimated LPG import is 33,637.0 an increase by 28.35 % in five years. This volume of LPG is expected to increase to 47,149.0 mmt by year 2000.

Major Import Regions.

The North Pacific region will be the largest seaborne importer of LPG with as much as 46 % of total imported LPG in year 2000. Southern Europe is estimated to import by sea 6,139 mmt of LPG, ca. 13 % of total seaborne import by year 2000. The third largest importing region will be North America that will account for an estimated 5,760.0 mmt, over 12 % of all LPG imported by sea year 2000.

The forecasted trend in seaborne imports among individual geographical regions between 1990 and 2000 is summarised in table 3L. From this table we can see that the total growth in 1994 was 5,969.0 mmt of LPG. In this period, the Middle East and Africa were the main suppliers to these regions. Seaborne demand for liquefied petrol gas will almost double by the turn of the century to 10,578.0 mmt, and supplied from the main regions as in the first period. This substantial growth in demand is supporting the estimated increase for most of the world LPG end-use markets. This outlook is also supported by continuing strong demand in the developing countries of the Far East, Latin America, the North Pacific and Eastern Europe including the former Soviet Union.

Summary of Seaborne LPG Demand and main Supply Regions

Region	Import 1994 in 1000 Mt	Present growth 1990 to 1994 aver. %	/ tot. Mt	Expected growth 1995 to 2000 aver. %	/ tot. Mt	Main Supply Region
FSU / Tyumen	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
North America	**2,634**	- 0,33	- 58	+ 14,24	+ **3,049**	M. East
Latin America	**3,549**	+ 25,04	+ 1,835	+ 5,42	+ **850**	L. America
North Europe	1,051	- 16,04	- 993	+ 12,03	+ 718	Africa/M.East
South Europe	**4,822**	+ 6,32	+ 1,736	+ 7,42	+ **1,768**	Africa/M.East
M.East/ Africa	423	- 2,96	- 27	+ 5,09	+ 237	Africa
North Pacific	**17,964**	+ 2,98	+ 1,564	+ 3,40	+ **2,138**	M. East
China	1,419	+ 36,91	+ 1,399	+ 10,19	+ 631	M. East
Indian Subc.	132	+ 65,23	- 268	+ 41,40	+ 768	M. East
O. Far East	1,602	+ 11,36	+ 202	+ 6,37	+ 449	M. East
Oceania	42	undef.	+ 42	undef.	- 30	L. America
TOTAL	**33,637**	**+ 14,28**	**+ 5,969**	**+ 11,73**	**+10,578**	**M. East**

Table 3L: Sum. of seaborne LPG import, DA Consulting. Source: Kværner Shipping a.s

LPG carrier demand.

Measuring LPG carrier demand is not a precise science, especially when it comes to the fleet below 10,000 cu.m, which is often engaged in complex inter-regional trading patterns e.g. between European regions. Demand relates to the volume of tonnage or cubic capacity required to move a given volume of cargo, assuming ships operate at a designated efficiency in terms of speed, port time, cargo capacity, etc.

Total seaborne LPG trade is expected to continue. What does this expected growth imply for LPG carrier demand ? The increase in LPG and chemical gas trading has spawned a growing tanker fleet with two distinct shipbuilding booms. The last of these was 1990-94, when the fleet capacity rose by 37 % to 11.2 million cu.m (8).

The problem for carrier operators is that the expansion in the fleet during these periods has been way in excess of changes in demand. The current surplus capacity in the LPG fleet is estimated at 20 %. Drewry predicts that the current fleet of capacity will grow to 11.7 million cu.m in 1995, and 12 million cu.m. in 2000. Because of this increase in seaborne trade of LPG, carrier demand is expected to grow by 0.9 million cu.m between 1993 and 1995, and by 1.1 million cu.m from 1995 to year 2000. The result of such rapid development will be a steep and persistent rise in demand for LPG vessels.

<u>Other important factors related to an increase in seaborne LPG trade.</u>

- Iran is now exporting LPG after over ten years out of the market, while Saudi Arabia wishes to increase its market share by changing its LPG pricing strategies. Other methods of sale from the Arab petrochemical operators have been to link the sales of oil and gas at lower joint prices in order to maintain or increase their market share. These three factors may lead to lower and more stable LPG prices, which is an important precondition for long term growth in LPG demand.

- New exporting areas may be taken into consideration as a consequence of the importing countries′ wish for reliable supplies. In some areas pipelines may be a potential competitor for marine transport. In addition, a commercial opening of the Northeast Passage could in the long run increase the supply situation on the LPG market.

- Environmental taxes favouring the use of LPG may give demand a strong push (see earlier discussion about LPG taxes). Since the LPG share of the world's total energy consumption is low, a small absolute increase may give a considerable relative growth in consumption. In U.S. we witnessed, as mentioned earlier, examples of a change to the use of LPG as car fuel on the West Coast. A more pronounced focus on the environment, better distribution and lower prices may contribute strongly to further growth in this market.

Any significant start-up delays, build-up delays, or cancellations of projects being implemented could alter the forecast supply/demand outlook. This could perpetuate the recent tight market conditions, particularly during 1996-1998 when the full commissioning of several major projects is anticipated.

PART-4. SUPPLY AND SEABORNE EXPORT OF LPG TO THE WORLD MARKET.

4.1. Total LPG Supply, a World-wide Review.

The international LPG industry generally had ample supplies during most of the 1980`s. Since the Gulf War, however, growth in world LPG supplies has slowed relative to growth in traditional premium captive demand. This situation has led to tighter LPG supply/demand balances, excess shipping capacity, firmer pricing, and a reduced need to develop price-sensitive markets to clear available supplies. By 2000, world LPG supplies are estimated to increase to nearly 203 million mt/d, (6.6 million b/d). LPG supplies for international trade will increase sharply through 2000 and begin to outstrip demand by 1997 or 1998. This outlook depends on several production projects proceeding as planned.

Leading the way to increased volumes are projects in Algeria, Nigeria, the FSU, and Australia, among others. Purvin & Gertz, Dallas, projected this trend in 1994 at an international LPG seminar near Houston. Representatives from LPG supplying countries also presented information to support this view and subsequently supplied more specific data to this work in response to correct estimates towards year 2000.

Overall, LPG supply will increase by 17.1 % to 193.9 million metric tons in 1998 from 164.7 million metric tons in 1994. Refinery production of LPG will remain relatively flat to 1998, growing only to 70.6 million metric tons from 62.4 million metric tons in 1994. Projected gas-plant LPG production will increase to 123.3 million metric tons in 1998 from 102.3 million in 1994, a jump of 20.5 %.

International LPG markets will be relatively tight for the remainder of the 1990s, but demand growth in developing countries, particularly Asia, will remain strong.

World-wide, increased supplies of LPG from the North Sea and Venezuela, in addition to the potential from the Tyumen area, are showing up this year, but most new large, export-oriented LPG projects currently being developed will start up in 1996-1997 or later. Assuming that LPG supply projects proceed according to schedule in Algeria, Nigeria, Australia and the FSU, international LPG supplies should expand faster than world LPG demand in the latter part of the 1990s, and contribute to increased seaborne trade of LPG.

To see the how the future supply and seaborne export of LPG are going to develop towards year 2000, it is necessary to analyse each region for itself concerning both present production, planned production and future supply, and then how much of this LPG is planned to be exported by sea. The result from this investigation is not described in detail, because the major issue is the results, which are used to provide forecasts for the seaborne export of LPG. In the last part in which seaborne export is analysed, LPG volumes available for export are derived by looking at crude oil and natural gas production in each country, in addition to developments in gas separation and liquefaction facilities, refinery capacities and other infrastructural developments in each region. In addition, total production, future production, and added capacity in each region is evaluated when the estimates for seaborne export are calculated.

Since a part of this work emphasises the potential in the Tyumen region, it is natural that the section concerning this area is analysed and described more thoroughly than the other regions.

4.2. Seaborne Export and Derivation of LPG Trade Flows.

In part three, the estimates for future seaborne import of LPG are given for each region. In this part trends of recent years will be given and forecasts provided of LPG export traded by sea for the major exporting regions in the world. These predictions also indicate the size and estimated total production in each region towards year 2000, key producers and which regions are the major exporters of LPG to the world market.

In addition this analysis will give us information about which region imports this LPG, and if there are shifting trends in demanding regions between 1990 and 2000. There is a lack of total estimated production and supply of LPG in some of the regions mainly because such information is not available from the sources, or such predictions don't exist for the end of this decade.

Demand for liquefied petroleum gas in the world is rising faster than average world consumption, causing a corresponding rise in seaborne LPG trade. That's the general view from most of the oil & gas and shipping companies in the world today. To see how this growth in LPG demand is leading to increased seaborne export of LPG, it is necessary to use the time horizon from 1990 to the end of this decade.

4.2.1. FSU/ Western Siberia/Tyumen Region.

Production and Future Supply.

The natural gas resources of the Former Soviet Union (FSU), are immense, with an officially estimated initial recoverable endowment of 250.7 trillion cu.m (8,852 trillion cu.ft). Of this volume, 85 % or 212 tcm (7,486 tcf) is located in the Russian Federation, which will be the dominant world supplier of gas through 2015.

Although Russia possesses an amazing gas resource base, official figures overstate both the recovery factor for gas in place and appear to systematically overestimate volumes of recoverable gas in undiscovered fields. Of the 212 tcm of initial recoverable resources in Russia, approximately 33 tcm of the remaining recoverable gas is concentrated in 16 fields that constitute the nation's key gas resources. It is this gas which will support most of the volumes supplied over the next 20 years. These key resources are very unequally distributed with respect to the technology and investment required to bring the gas to the market. The cheapest and most easily accessible sources of new productive capacity will come from development of the deeper, condensate-laden reservoirs at supergiant Urengoy and Yamburg fields. These are followed by Zapolyarnoye field and the Urengoy satellites, a group of seven fields close to the Urengoy production/ transportation complex.
Production and transportation of gas from the Yamal peninsula and the new discoveries in the Kara and Barents seas will cost many times the current average cost of gas production in Russia. These resources will also require long lead times, new technology, and in the case of Yamal onshore gas, substantial efforts for environmental protection (9).

Western estimates describe the collective resources of the FSU nations as the largest in the world. The world record for resource volumes is matched by world records in current production and production and reserve growth over the last three decades. With over a third of the world's gas resources, there is no doubt that Russia will lead the planet's gas production for at least the next 20 years.

Production of natural gas liquids has fallen seriously behind its potential in the former Soviet Union. Restoration of the gas liquids business thus represents a rich investment opportunity. Capital, however, must come from international sources, which remain uncertain about the FSU's legal, commercial, and political systems. If these hurdles can be overcome, FSU output of LPG alone might double between 1990 and 2010.
In the FSU, LPG is produced from associated and non-associated natural gas, condensate, and refinery streams. It also comes from what is known in the FSU as ShFLU- a mixture

of propane, butane, pentane, and hexane produced at gas processing plants in Western Siberia and fractionated elsewhere.

In Russia, the FSU's main gas liquids supplier, approximate LPG production shares are:

- 40 % from the Sintezkauchuck Association, which is responsible for LPG production at petrochemical plants.
- 25 % from the Oil Refinery Committee.
- 20 % from processing of associated gas by Rosneft and Neftegazpererabotka.
- 15 % from processing of non associated gas and condensate by Gazprom.

Any review of FSU production of gas liquids must focus on West Siberia's Tyumen Oblast, more than 95 % of the economy of which depends on the oil and gas industry. Tyumen Oblast's Yamalo-Nenetsk District provides nearly 90 % of Russia's natural gas, while Khanty-Mansiynsk accounts for three quarters of the country's oil. Thirteen crude oil production enterprises operate in Tyumen Oblast. Each collects associated gas at separation units. Sibneftgazpererabotka (SNGP), formed in 1975, transports gas from the separation units and processes it. SNGP's nine processing plants have a total capacity of 28 billion cu.m/year. SNGP, which also operates compressor stations, gas collecting pipelines, and gas and product pipelines, delivers ShFLU to transportation companies and dry gas- mostly methane and ethane- to Gazprom's pipeline system. ShFLU moves by pipeline to the Tobolsk petrochemical combine or by railroad to European Russia.

Associated gas makes up a large part of hydrocarbon production in Tyumen Oblast, totalling 28.1 billion cu.m, about 30 million tons of oil equivalent in 1993. Associated gas utilisation in 1993 was 23.3 billion cu.m, or 83 % of production. Official reports state that 4.8 billion cum of gas was flared, about 17 % of production. This appears to be a major improvement from 1980, when about 50 % of production was flared.
In fact, there has been no significant improvement since 1990 according to Poten & Partners Inc. Furthermore, official statistics understate the extent of flaring. At least 10 billion cum was flared in 1993. Despite the apparent levelling off in the portion of gas flared, the situation for gas in general continues to worsen. Poten & Partners believes flaring probably increased in 1994. In addition, there has been no construction of plants or gathering pipelines to handle associated gas during the last 4 years due to a lack of central financing. Furthermore, the economics of gas processing in Western Siberia are poor. Prices of LPG in Russia increased from 2 % of the world rate in 1990 to 20-30 % of the world rate in 1994, but remain regulated by the government. Gas processing costs have

increased more rapidly than prices, especially for equipment, energy, and transportation. For example, in the middle of 1993, transporting 1 ton of SfFLU from Tyumen Oblast to the Finnish border cost about 4 dollars. In December 1994, transporters were asking as much as 80 dollars/ton for the same trip.

The problem of flaring and poor economics would be alleviated if prices were allowed to increase to the world level. To redress the lack of capital, legislative organisations should develop legal and financial structures to encourage Russian and foreign investments. They should also change the tax-price system to make construction of gas processing plants economically attractive.

The outlook for oil production in Russia in the late 1990s is cloudy at best. Even if it continues to fall, however, this may not be the case for associated gas production because of the planned development of new oil fields in the north of Tyumen Oblast. These fields have a higher gas content than those in centre of the region. This will increase pressure to reduce flaring.

The FSU`s gas liquids resource is clearly under-utilised. Based on resources (Poten & Partners Inc, 94), the estimated production potential for LPG in West Siberia alone is about 20 million tons/year, of which 9 million tons could come from Urengoy and its surrounding fields.

Although expectations have become more realistic than they were before throughout the FSU, the economic situation makes development of LPG production more important than ever. According to a World Bank forecast, after the mid-1990s oil production will stop declining, and gas production will level off in the FSU. Legal and financial organisational structures will be one of the main factors for encouraging private investments, at first from foreign countries and by 2000 from internal financing.

According to Poten & Partners current outlook, total LPG production in the FSU could climb to about 20 million tons/year by 2010 from 10.5 million tons in 1990 if capital becomes available for required investments. They also estimate LPG production from gas processing plants based on non associated gas could be 4 times the 1990 level by 2010. By then it may be possible to produce not just ethane and ShFLU from natural gas and condensate processing, but also nearly 4 million tons/year of LPG.

Growth in production of LPG at non associated gas processing plants depends mainly on the construction of facilities by Gazprom. LPG production at refinery is expected to increase by about 70 % between 1990 and 2010. This output serves traditional markets as well as the transportation and petrochemical sectors.

Estimated Seaborne LPG Export.

The overall question in the total project primarily concerns the economic viability of seaborne export of LPG from inland Russian fields to the world market: Would there be transportation of LPG at competitive prices to provide acceptable returns to producers and investors ? Since investigations indicate that LPG can be obtained marginally above local transport cost, due to large quantities of LPG flared off at the West Siberian fields in the Tyumen region, it is important to have the estimates for LPG surplus towards year 2000. Table 4A. is based on Valeri S. Plotnikov's (SNGP) estimates for production, consumption, demand and regional surplus of LPG towards year 2000.

As the table shows, LPG output in the Tyumen region is expected to increase substantial to the end of the decade. This surplus could feed new petrochemical plants, or be exported through the Northern Sea Route. The bottleneck to realisation of this market potential for LPG, is lack of investment for processing plants, infrastructure and transportation.

The advantages of developing the downstream energy industry in Western Siberia are that transportation costs will be reduced, and that regional demand for petrochemical products will be satisfied by using new gas pipelines and petrochemical enterprises. Today, planned projects that could handle such demand include: Obpolimer, a petrochemical enterprise that will produce 80,000 tons/year of polypropylene, feed will be LPG from the Krasnoleninsky gas processing plant, the Noyabrsky motor fuel plant, which will produce gasoline and aromatics from 700,00 tons/year of LPG from the Muravlenko and Gubkinsky plants and Surgutpolimer, a petrochemical enterprise to produce 150,000 tons/year of polypropylene from 600,00 tons/year of LPG from the Surgutsky plant. But as mentioned earlier, the Tyumen region offers raw materials and a vast market area but lacks modern processing capacity and capital. So all of these planned projects depend on financing from international oil and gas companies outside the FSU.

Total consumption and estimated regional surplus of LPG in the Tyumen region.

Year	**1993**	**1994**	**1995**	**1996**	**2000**
Tyumen Production		Thousand metric tons			
Total	**4,150**	**4,244**	**5,137**	**6,385**	**6,800**
Consumed in Western Siberia.					
Tobolsky petr.plnt.	**2,250**	**2,300**	**2,500**	**3,000**	**3,000**
Consumed outside of Western Siberia.					
Total	**1,900**	**1,794**	**1,937**	**2,185**	**1,500**
Total Demand	**4,150**	**4,094**	**4,437**	**5,185**	**4,500**
Regional Surplus	*0.0*	*150.0*	*700.0*	*1,200.02,300*	

Table 4A: Estimate of LPG in Tyumen. Source: Valeri S. Plotnikov. Chief engineer at SNGP`s gas processing plant Muravlenko, FSU.

There is such a condensate/LPG barge fleet present today, that could be used for transportation of this LPG surplus to the port in Tyumen, and from this port to the world market by ice-strengthened LPG vessels. Such design and investment analysis on LPG/condensate barges and specially designed deep water LPG carriers has to be done before seaborne export solutions can be predicted accurate in this area. If commercial transportation solutions show a significant potential, a permanent tanker route could be established along the northern coast to the most realistic and nearest market. This transportation solution has to be coupled with sea and ice conditions that never have before been experienced in the history of seaborne gas trade.

The Arctic remains one of the most hostile environments challenging mankind's commercial exploits, and the savings in distance offered by the Northern Sea Route do not necessarily translate into time and reduced supplied LPG prices, especially in the case of ships with insufficient ice strengthening.

But today's situation is that flaring in West Siberia of 8-10 billion cu.m/year of associated gas wastes 3-4 million tons/year of LPG, and this volume is sufficient for traditional supply to near foreign countries.

4.2.2. North America

Production and Future Supply.

The single largest producer of LPG is the U.S., although nearly all its 30-32 million metric tons/year output is used in the domestic market. U.S. LPG processing economics have improved dramatically from the low processing margins of the late 1980s. The improvement in margins so far this decade has resulted from firmer LPG demand and pricing, and- until late 1992- generally low LPG prices. With the U.S. likely to play a greater role in the international LPG trade, the North American gas-processing industry will be influenced by emerging global trends.

In Canada, major gas-plant expansions have recently occurred, are under way, or planned for the main line .straddle plants in western and eastern Alberta. These expansions combined with reduced domestic demand for LPG are behind the growing volumes of LPG available for export in the second half of this decade. This region will continue to produce approximately 50 million metric tons/year of LPG towards the end of the decade according to Purvin & Gertz. Most of the LPG imports into the USA are overland from Canada and Mexico. Therefore the deep-sea requirement is much less significant than Japan.

Estimated Seaborne LPG Export.

Table 4B. shows how seaborne export from North America has changed and the forecasted predictions towards year 2000. In 1993, total waterborne export reached its top level by 321,0 mmt of LPG. The sharp decrease in export between 1990 and 1993 is explained primarily by an increase in the internal premium use sector. The period from 1994 to the end of the century shows a significant decrease in this seaborne trade. Continued expansion in North American petrochemical feedstock requirements explains much of this growth in own consumption. Another major factor behind the decrease in export from North America are related to the large part of LPG import is made up by overland shipments from Canada.

Seaborne Export of LPG from North America, (000 MT).

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
L.Am	50	52	53	251	157	95	50	12	8	4	0
N.Eur.	119	40	31	16	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S.Eur.	110	4	56	37	17	17	17	17	17	17	17
N.Pac.	0.0	0.0	30	15	0.0	0.0	0.0	0.0	0.0	0.0	0.0
O.East	22	0.0	6	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	**302.0**	**96.0**	**176.0**	**321.0**	**174.0**	**112.0**	**67.0**	**29.0**	**25.0**	**21.0**	**17.0**

Table 4B: Seaborne export of LPG, DA Consulting. Source : Kværner Shipping a.s

In the first half of 1990 North America exported mainly to Latin America, Northern Europe and Southern Europe. After the end of 1995 this export is expected to decrease from a total of 112.000 metric tons to just 67.000 metric tons by 1996. After that, a slight decrease is expected to reach just 17.000 metric tons by year 2000. The remaining importing region from USA would then be Southern Europe. On the other hand increased use of LPG in the petrochemical sector could stimulate both import and export. The key issue here, however, remains the competitive pricing of LPG versus other feedstock.

4.2.3. Latin America.

Production and Future Supply.

To assess the LPG prospects in Latin America, one must consider the state of both economic and political reforms in the six countries that account for almost 100 % of Latin Americas LPG capacity: Brazil, Mexico, Argentina, Venezuela, Colombia, and Chile. The economic climates and the petrochemical market prospects vary significantly between these countries. Latin American LPG production will be paced by a near doubling of supplies from several new gas-processing plants in Venezuela. Significant expansions in refinery and gas-plant production are also forecasted for Mexico, Brazil, and Argentina.
Latin American supplies will be lead by major gas-processing expansions, particularly in Brazil and Venezuela. Increasing production in Argentina and Mexico will also contribute to the growing supplies in the region. The most significant increase in production, apart form Venezuela, is in Argentina.

The production in Argentina reached 1.8 million metric tons in 1994, up from 1.62 million metric tons for 1992, according to YPF S.A.`s Oscar Roig. By 1998 production could reach as much as 1.9 million metric tons of LPG. Of the 1994 production, 454,000 million tons were exported, up from 193,000 million tons of LPG. With current facilities, total export of LPG will grow to 463,000 mt in 1995, then begin to decline, reaching 312,000 mt in 1997, then rising again in 1998 to 332,000 million tons. Of this production, a major part will be exported by sea as table 4C. shows.

Roig projects that with adequate investment, however, and especially with expansion of Latin America`s gas processing plants, LPG export would rise steadily towards year 2000. Total available LPG supply in Latin America in 1996 is estimated at just above 28 million metric tonnes according to Purvin & Gertz Inc.

Estimated Seaborne LPG Export.

Currently, most export volumes go to Latin America itself and North America. The exported LPG moves from Bahia Blanca by tanker to Brazil, Uruguay, Peru, and other countries of Latin America. LPG exports move by truck to Chile from Loma La Lata in the Neuquen province, Lujan de Cuyo in Mendoza province, San Lorenzo in Santa Fe, and are also trucked from la Plata in Buenos Aires province to Uruguay. The export to North America is primarily done overland and by LPG tankers. Table 4C. gives the development in this region´s waterborne LPG export, and as we see Latin America supplies most of its own production input.

Seaborne Export of LPG from Latin America, (000 MT).

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
N.Am.	1,175	893	652	662	671	480	600	825	1,050	1,275	1,500
L.Am	348	783	1,454	1,785	1,960	2,073	2,148	2,238	2,178	2,118	2,058
N.Eur.	0.0	20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S.Eur.	76	45	0.0	6	6	6	0.0	0.0	0.0	0.0	0.0
M.E/Afr	0.0	0.0	0.0	13	13	13	0.0	0.0	0.0	0.0	0.0
China	0.0	0.0	0.0	19	19	19	0.0	0.0	0.0	0.0	0.0
I. Sub.	0.0	0.0	0.0	32	32	32	0.0	0.0	0.0	0.0	0.0
Ocean	0.0	0.0	0.0	32	32	32	0.0	0.0	0.0	0.0	0.0
Total	**1,599**	**1,741**	**2,106**	**2,527**	**2,732**	**2,654**	**2,748**	**3,063**	**3,228**	**3,393**	**3,558**

Table 4C: Seaborne export of LPG, DA Consulting. Source : Kværner Shipping a.s

As the table shows, after 1995 only North America and Latin America itself are importing LPG from this region by sea. There would be a significant increase from this year and towards 2000, and doubling of this export is supported by all the planned and new gas processing plants for LPG explained above. By 2000, this region will be rated as the fourth largest seaborne exporter of LPG in the world, if rated only by total sea trade. A net deep-sea balance calculation done in part five changes Latin America's position to one of the smallest LPG exporters.

4.2.4. Northern and Southern Europe.

Production and Future Supply.

LPG supplies in this region will increase through the mid-1990s as LPG supplies become available from new gas condensate fields in the North Sea. The build-up in supplies from this source was significant in 1994, as the first full year of production from the Sleipner field development was realised.

LPG production from the former Soviet Union (except the northern part), and the eastern part of Northern Europe will increase in the medium term as the region reaps the benefits of economic restructuring and the continued introduction of Western capital and technology. By 2000 LPG export will increase as domestic production exceeds the anticipated significant growth in internal consumption. Total production, future production, and added capacity in this region is evaluated when the estimates for seaborne export are calculated. Western Europe's total estimated supply in 1996 is approximately 25 million metric tons of LPG, with a slight increase in 1997, and then stable growth until the end of this decade.

Estimated Seaborne LPG Export.

Of the total estimated production in 1996, only 1,244 million metric tons are expected to be traded by sea, mainly to North America. Between 1998 and 2000, the volume of LPG exported to this region will decrease by 84 %, to only 440 mmt. For the period between 1997 and 2000, Latin America will import from the European region only 100 mmt, 18 % of the total exporting volume. See table 4D. for further information.

Seaborne Export of LPG from North and South Europe, (000 MT).

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
N.Am.	17	68	8	163	318	835	1,180	995	810	625	440
L.Am	44	0.0	98	98	100	240	60	100	100	100	100
M.E/Afr	0.0	10	42	23	4	4	4	4	4	4	4
O.East	0.0	0.0	3	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	**61.0**	**78.0**	**151.0**	**285.0**	**422.0**	**1,0791**	**1,244**	**1,099**	**914.0**	**729.0**	**544.0**

Table 4D: Seaborne export of LPG, DA Consulting. Source : Kværner Shipping a.s

Seaborne trade in this region, as mentioned before, is made up of inter-regional movements. The movements, and the small volume of LPG exported outside the region, are some of the major factors behind such a negative predicted export development between 1996 and year 2000.

Northern Europe will continue to supply the domestic market from the North Sea as local petrochemical uses grow in the region. There may be an small increase in seaborne LPG export between 95/96 as some of the maintenance work carried out on the North Sea gas installations are finished.

4.2.5. Africa

Production and Future Supply.

The second largest increase in LPG supply will be from Africa. Major production increases from new gas processing projects in Algeria and Nigeria will significantly increase LPG supplies in Africa during the latter half of the 1990s. By the end of this decade, LPG exports from Africa will increase substantially. The doubling of exports from Algeria and the emergence of Nigeria as a major supplier will result in the region becoming more important to the growing international LPG trade.

Virtually all of Africa's LPG goes to export, while refinery production meets domestic demand. This region has massive reserves of gas and a production capacity for LPG which well exceeds current export levels, so there are no signs that this region will decrease export of LPG in the near future. Political instability, however, could disturb these supply predictions, since the main supplier of LPG to the deep-sea export market is Algeria. The expected emergence of Africa as a more dominant region for LPG exports assumes a successful resolution of the political and economic struggles within the two largest producing countries: Algeria and Nigeria. Any disruption in the development of the currently advanced supply projects in these countries could alter the expected growth in the international LPG trade.

Liquefied petrol gas production in Algeria will get a considerable boost later this decade when several major projects come on stream. Projected 1995 LPG production for the fields of Hassi R`Mel and Messaouds is 3.6 million metric tons a year, lowest since 1989, but new production from these fields is expected. They will begin producing associated LPG in 1996 and 1997. Other production will come on stream from Hamra (1995), Gassi Touil (1997), and Oued Noumer (1995). Additional Algerian LPG production in 1997 will be on the order of 3.12 million metric tons a year, an 87 % increase over 1994 production. Gas treatment plants for the production of condensates, LPG and treated gas will also be built in other parts of Algeria later towards year 2000. With these projects coming into production in 1999 and 2000, additional LPG production should peak in 2001 at near 5.6 million metric tons, then decline gradually to 3.9 million metric tons by 2014, compared to 1994 production.

Also arriving on the export market in 1998 will be 1.5 million metric tons of LPG from Nigeria's Oso export project, according to Godwin Adamolekun, Mobil Producing Nigeria. This company has plans to build what it believes would be the world's largest offshore extraction plant alongside current gas compression equipment in approximately 50 ft of water. This is one of the international LPG-export projects, however, whose completion in anything like the planned timetable is believed to be problematic by Purvin & Gertz.

Estimated Seaborne LPG Export

Africa is the world's second largest seaborne exporter of LPG, supplying the American continent and the European region with significant volumes of LPG. South Europe and Latin America are predicted to import as much as 67,92 % of LPG from Africa in 1996. Towards year 2000, both North Europe and America will emerge as an important demander of LPG from this region, reaching 29,6 % (2,392.0 mmt) of total LPG export from Africa. Today, these regions together import 1,235.0 mmt of LPG from the above region. See table 4E. for export estimates from the African region.

Seaborne Export of LPG from Africa, (000 MT).

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
N. Am.	941	460	230	534	838	718	625	780	935	1,090	1,245
L.Am	344	732	704	527	340	1,249	1,315	1,564	1,793	2,021	2,250
N.Eur.	966	693	930	664	397	638	797	885	972	1,060	1.147
S.Eur.	973	1,820	1,445	1,787	2,129	2,129	2,768	2,759	2,750	2,742	2,733
M.E/Afr	400	300	354	390	406	456	506	556	606	656	706
O.F.E.	0.0	5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	**3,624**	**4,010**	**3,663**	**3,891**	**4,110**	**5,190**	**6,011**	**6,544**	**7,056**	**7,569**	**8,081**

Table 4E: Seaborne export of LPG, DA Consulting. Source : Kværner Shipping a.s

War in the Middle East had a domino effect on other producers, and major importers switched their source of supplies from the Middle East to areas such as the Mediterranean and North Africa. An increase in North African production therefore helped to fill the vacuum in supplies up to 1994/95, whilst Iraq and Kuwait repaired the damage on their facilities. The predicted increase in seaborne LPG export between 1995 and 2000 is based on growth in demand for both price-sensitive and premium markets, especially in North and Latin America, and Western Europe.

4.2.6. Middle East.

Production and Future Supply

The largest increase in LPG supplies will be from the Middle East where today, they are almost totally related to crude-oil production. In the future, however, LPG production from the region will depend more on processing of non-associated gas and gas-condensate reserves.

Saudi Arabia will continue to dominate LPG production from the Middle East. By 2000, Saudi Arabia will expand its Master Gas System which is currently operating at capacity. Throughout the forecasted period, Iran will likely increase significantly its LPG production with the full commissioning of its Bandar Imam facilities. The prospects for recovery of LPG from non-associated gas production in Iran will also improve by 2000.
In 1995, Iraq will likely emerge as a major LPG producer and exporter assuming a resolution of the United Nations sanctions and the completion of repairs or reconstruction

of war-damaged LPG production and export facilities. Kuwait resumed LPG recovery in 1992 and will reach full production levels consistent with crude oil rates by 1995.

Qatar significantly increased LPG production in 1992 with the commissioning of the first phase of its North field project. The prospects for additional LPG supplies have been enhanced by the probable implementation of an LNG project by early in the next century. The development of an onshore gas-condensate recycling project and the commissioning of a third train on Das island will also likely increase significantly LPG production from Abu Dhabi in 1995/96. While exports from the Middle East will continue to dominate the international LPG trade, Saudi Arabia's role will diminish somewhat, as increasing domestic requirements reduce export availability's. Throughout the period, the United Arab Emirates (U.A.E.) will emerge as a more significant source of Middle East supplies. Total LPG supply and production from the Middle East is estimated at approximately 37.5 to 40.0 million metric tons in 1996. By 2000 total supply is predicted to increase to 44.0 million metric tons of LPG, according to Purvin & Gertz.

Estimated Seaborne LPG Export.

The second largest producer- and most important for seaborne export- is the Middle East. There, production has risen from 13 million metric tons in 1980 to 27 million metric tons in 1993, of which 20 million metric tons came from Saudi Arabia. See table 4F. for this enormous seaborne export capacity from this region.

Seaborne Export of LPG from Middle East, (000 MT).

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
N. Am.	273	266	401	600	799	678	1,155	1,510	1,865	2,220	2,575
L.Am	928	500	550	782	964	345	450	400	400	400	400
N.Eur.	959	825	672	663	654	691	800	826	851	875	900
S.Eur.	1,927	2,203	2,359	2,493	2,626	2,175	1,850	2,224	2,598	2,971	3,345
M.E/Afr	50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
N.Pacific	12,956	13,681	14,830	14,937	15,044	15,641	15,870	16,268	16,685	17,063	17,460
China	0.0	0.0	0.0	250	500	1,500	1,600	1,675	1,750	1,825	1,900
Ind.sub.	392	12	42	71	100	200	300	475	650	825	1,000
O.F.E.	1,288	1,263	1,484	1,528	1,571	1,617	1,951	1,970	1,987	2,004	2,021
Total	**18,773**	**18,794**	**20,338**	**21,323**	**22,258**	**22,847**	**23,976**	**25,348**	**26,766**	**28,183**	**29,601**

Table 4F: Seaborne export of LPG, DA Consulting. Source : Kværner Shipping a.s

Japan is totally reliant on imports and is therefore significantly more important in terms of seaborne LPG import than no other country in the world. In 1990, the Middle East exported as much as 66,63 % of all LPG in terms of total world-wide seaborne trade, making Middle East the largest LPG exporter in the world, 12,956 mmt went to the North Pacific, primarily Japan. Today, seaborne exports are going to reach about 22,847 million metric tons of LPG. Of this, 15,641 million metric tons, or 68.45 % are exported to the Pacific region. By year 2000, total seaborne export from this region is estimated at 29,601 mmt, an increase by 6,754 million metric tons in five year.

4.2.7. Other Far East

Production and Future Supply.

LPG production in this region, which includes countries such as Malaysia, Thailand, the Philippines and Vietnam, are expanding in the near term with growing refinery production, particularly in Thailand, Indonesia and Malaysia.

Thailand is building a world class petrochemical industry. This region with one of the world fastest growing economies, is rapidly adding both LPG and petrochemical capacity in response to feverish growth in domestic demand. Most of the projects are being planned or implemented under a common view that the Thai petrochemical market will continue to grow robustly at least through the turn of the century. Thailand has the only ethane (LPG) cracker in the region today. But a LPG/naphtha -based olefins plant is under construction there and another LPG complex is planned for the late 1990s.

In Indonesia, Petrokimia Nusantara Inc. recently started up an LPG/polyethylene plant and is planning an expansion. Petronas is operating LPG dehydrogenation, MTBE, and polypropylene plants in Kuantan and Malaysia. However, the Indonesian government excludes LPG projects requiring local financing and feedstock guarantees. Of the total LPG produced in this region, as much as 4,458 mmt is estimated to be available for waterborne export in year 2000.

Estimated Seaborne LPG export.

Other Far East is the third largest seaborne exporter of LPG in the world, and predictions towards year 2000 are supporting this rating. This region mainly supplies the North Pacific, China and Other Far East (O.F.E). In 1990 the exported volume reached 2,959.0 mmt of LPG, 97 % of it went primarily to Japan. This export to the North Pacific is predicted to increase to 3,550.0 mmt by 2000. In China's case the rate of import from O.F.E. peaked in 1994 with 900.0 million metric tons of LPG. After 1998 the export to China is expected to stabilise between 5-600.0 million metric tons. The export situation from this region is open for a change depending on its plant expansions and future domestic demand for LPG in its petrochemical industry.

Seaborne Export of LPG from Other Far East, (000 MT).

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
N. Am.	13	0.0	0.0	4	8	0.0	0.0	0.0	0.0	0.0	0.0
L.Am	0.0	0.0	0.0	13	29	15	44	15	18	21	24
S.Eur.	0.0	0.0	0.0	22	44	44	44	44	44	44	44
N.Pacific	2,870	3,052	2,766	2,533	2,304	3,210	3,100	3,176	3,301	3,425	3,550
China	20	0.0	0.0	100	900	300	600	828	575	563	550
Ind.sub.	8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
O.F.E.	48	241	279	138	31	236	131	169	206	243	281
Oceania	0.0	0.0	10	17	10	10	10	10	10	10	10
Total	**2,959**	**3,293**	**3,055**	**2,826**	**3,325**	**3,814**	**3,928**	**4,241**	**4,153**	**4,306**	**4,458**

Table 4G: Seaborne export of LPG, DA Consulting. Source : Kværner Shipping a.s

4.2.8. Oceania.

Production and Future Supply.

LPG exports from this region will take an 800 mmt bump sometime early in 1996 when extraction and export facilities are completed at Australia's North West Shelf project, according to Rich Farley, Chevron Asiatic Ltd. In October 1993, joint-venture participants in North West Shelf- BP, BHP, Chevron, Shell, and Woodside agreed to build and operate LPG extraction and export facilities at the site.

Currently, LPG produced with natural gas from the North Rankin field offshore Western Australia is used to satisfy energy specifications in the project's three products: LNG for Japan, domestic natural gas, and condensate. Early in 1996, two fields 30 km east of North Rankin will start up. Chevron Asiatic Ltd. estimates these fields contain about 200,000 of recoverable oil and are rich in LPG.

LPG from these two developments will exceed Woodside`s product specifications.
Production at 800 mmt a year is anticipated to continue for at least 10 years with small liquids-rich fields nearby coming on stream in later years to maintain that rate.
The decision to produce LPG complies with government requests that gas flaring be eliminated from oil and gas projects whenever possible. During the second half of the

1990s, LPG supplies in Oceania will be further enhanced with the development of the Northwest Shelf LPG recovery project.

Estimated Seaborne LPG Export.

Until 1997 this region is predicted to be the sixth largest sea-exporter of LPG in the world. From 1998 Northern Europe and Oceania will change places, and this region is advancing to the fifth largest in the world. Both the new production and available LPG for export will stabilise between 8-900 mmt / year by 2000.

There is a potential for further increase in seaborne export after 1996, but it depends on the start up of the two fields east of North Rankin. As the production estimates above indicate, nearly all of this available LPG will be exported by sea. The major importing region is the North Pacific, primarily Japan, which will take as much LPG as possible from Australia. This is the main reason for not supplying any of the other regions after 1993. In this region, Australia in particular expects to export by sea only 890 million metric tons of LPG by year 2000, or 1.89 % of total world-wide sea traded volume.

Seaborne Export of LPG from Oceania, (000 MT).

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
N. Am.	273	106	49	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
L.Am	0.0	9	9	5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
N.Eur.	0.0	0.0	43	22	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S.Eur.	0.0	36	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
N.Pacific	574	860	960	788	616	911	930	920	891	920	890
O.F.E.	42	0.0	3	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	**889.0**	**1,011**	**1,064**	**816**	**616.0**	**911.0**	**930.0**	**920.0**	**891.0**	**920.0**	**890**

Table 4H: Seaborne export of LPG, DA Consulting. Source : Kværner Shipping a.s

4.3. Conclusion.

The commissioning of several new international LPG supply projects will result in a rapid build-up of LPG production over the next 5 years. Despite strong demand for LPG world-wide, the supply outlook provides some relief from relatively thigh LPG supply/demand balances which have emerged over the last few years. The definitive outlook for the international LPG industry will, however, depend upon the start-up schedule and build-up profile for these new emerging supply projects. These factors, in turn, will be influenced by political as well as commercial realities of the industry.

Production and Supply.

World LPG supplies in 1992 grew to an estimated level of 151 million metric tons/day, a 5 % increase from levels of 1991. The improvement is highlighted by record LPG production in Saudi Arabia, renewal of supplies from Kuwait, and build-up of North Sea production.

International LPG supplies in 1993 grew to an estimated 158 million metric tons a day. This growth represents a 4 % increase from the previous year and is highlighted by near record production in the U.S., significant build-up of Canadian exports, record exports from Saudi Arabia, a more than doubling of supplies from Kuwait, and the beginning of a major build-up in North Sea production.

By 2000, world LPG supplies are forecasted to increase to more than 203 million metric tons, (6.6 million b/d). The Middle East will continue to lead future growth in international LPG supplies in the medium term. Significant supply growth, however, is also expected from Africa, Latin America, Asia and areas of the C.I.S., including the West Siberian fields in Tyumen.

Saudi Arabia will continue to dominate LPG production from the Middle East. No major production increases are likely in the medium term due to a level crude oil production outlook and constraints within Saudi Arabia's master gas system.

The expected emergence of Africa as a more dominant region for LPG exports assumes a successful resolution of the political and economic struggles within the two largest producing countries: Algeria and Nigeria. Any disruption in the development of the currently advanced supply projects in these countries could alter the expected growth in the international LPG trade.

Seaborne LPG Export.

In 1994, exports from the Middle East and Africa accounted for over 78 % of total large volume waterborne movements. Future international trade will also be influenced by export availability from these two regions. By the end of the century, waterborne trade from the Middle East and Africa will increase by nearly 50 % according to R. Haun and

W. Otto in Purvin & Gertz, Inc. This will cause a corresponding rise in total seaborne LPG trade. However, LPG exporters are likely to see transportation costs rise between 1995 and 2000 as the current tanker fleet is trimmed.

The U.S., Japan, and Western Europe account for two thirds of world demand. But markets for LPG in the developed world are mature, with growth rates of 2-3 % a year the norm. Whereas the U.S. and Europe almost meet their LPG requirements from domestic production, Japan is totally reliant on imports and is therefore significantly more important in terms of seaborne trade. Outside the Organisation for Economic Cooperation & Development, demand for LPG has been rising for some time, with rapidly growing imports by countries such as South Korea stimulating the market during the last 10 years. Other key producers as far as the shipping market is concerned are Algeria, Norway, the U.K., Indonesia, Malaysia, West Siberia and Australia.

LPG Carrier Supply.

The growth in LPG and chemical gas trading has spawned a growing tanker fleet with two distinct shipbuilding booms. The last of these was 1990-94, when fleet capacity rose by 37 % to 11.2 million cu.m. The problem for carrier operators is that the expansion in the fleet during these periods has been very much in excess of changes in demand. There was a spike in new orders between 1988 and 1990, as the freight market picked up.
However, a weakening of the supply/demand balance occurred that led to an accompanying stagnation and fall in freight rates, the result was an increase in the LPG orderbook and a shipbuilding boom.

Current surplus capacity in the LPG fleet is estimated at 20 % by January 1995. Indications are that the size of the fleet is about to level out again at a time when vessel demand shows every sign of continuing to increase. Over-capacity will be trimmed, leading to improvements in the balance between supply and demand. Drewry predicts that the current fleet of 11.2 million cu.m. capacity will grow to 11.7 million cu.m. in 1995 and 12 million cu.m. in 2000. Carrier demand is expected to grow from 8.8 million cu.m. in 1993 to 9.7 million cu.m. by 1995 and 10.8 million cu.m. by 2000.

Overview.

The growth in seaborne transport of LPG has been strong, and trading measured in tons has doubled over the last ten years. Japan and Europe emerge as the major importers, and the vast growth in imports to the far East in recent years is particularly interesting. With regard to LPG production, it is worth noting that North America is the greatest producer of LPG. The declining growth in production in the U.S. and Europe is noticeable too, and may be seen in relation to the fact that the largest reserves are to be found in the FSU and the Middle East. These are factors which suggest a long-term increase in seaborne transport. The growth in production in the Middle East is a consequence of changes in the price policy and has very positive effects on seaborne transport. The strong growth in LPG production in Asia, however, points in the other direction; it contributes to increased self-supply and reduces the need for transport considerably.

PART-5. NET BALANCES- MAJOR EXPORTERS/IMPORTERS.

5.1. Introduction.

The objectives of this section are to calculate and quantify the changes in future seaborne movements by looking at positive and negative LPG balances for some of the major exporting and importing regions in the world.

It is the geographical differences between the LPG exporters and importers which give rise to both the overall volume and pattern of seaborne trade in LPG. Including inter- regional trade, total seaborne movements of LPG in 1995 are provisionally estimated at 36.6 million tonnes. The equivalent figure in 1990 was 26.2 million tonnes. Figures for inter-regional trade are almost non-existent, so again any assessments are largely estimated. Furthermore, no attempt has been made to quantify movements within national boundaries. By using the previous estimates of seaborne export and import, it is possible to summarise the geographical differences between the regions described in part three and four. Table 5A. focuses on the predicted situation in year 2000 for each of the main LPG regions of the world. Only the most significant regions from this table will be discussed further, with a focus on net LPG balances from 1996 to year 2000.

Predicted World Seaborne LPG Transportation in Year 2000, million tonnes.

Region	Seaborne export	Seaborne import	Net balance: Exp/Imp.	
N. America	*17*	*5,760*	*Import =*	***5,743***
L. America	3,558	4,631	Import =	1,073
West Eur.	*544*	*8,186*	*Import =*	***7,642***
M. East	*29,601*	*550*	*Export =*	***29,051***
Africa	*8,081*	*160*	*Export =*	***7,921***
N. Pacific	*0*	*21,900*	*Import =*	***21,900***
China	0	1,000	Import =	1,000
O.F. East	4,458	2,302	Export =	2,156
Oceania	890	10	Export =	880
Total	47,149	47,149		

Table 5A: Net Seaborne LPG Trade, DA Consulting. Source: Kværner Shipping.

5.2. Net Positive Balances- Major Exporters.

The major exporters of LPG have been identified as being: The Middle East and Africa, when looking at net balances for seaborne import and export. Also Western Europe can be classed as an exporter, but most of the surplus LPG originating in North and South Europe are traded within the region, so Western Europe is analysed in the next part of this chapter. Also Canada has surplus LPG, but most of this is supplied overland to the United States. It is therefore not a significant contributor to the seaborne LPG trade.

The Middle East.

The Middle East is still the most important source of LPG for the international market., despite the loss of supplies from Kuwait and Iraq. Apart from these two countries, the other major exporters of LPG in the Middle East are Saudi Arabia, the UAE and Qatar. In particular, Saudi Arabia is likely to see a much higher level of LPG output to be exported, because production of lighter crude oils will lead to more associated LPG. The net export availability from this region is expected to grow from 23,546 million tonnes in 1996 to 29,051 million tonnes in year 2000. This increase in export capacity is explained in chapter four. Absolute levels will, however, be determined by the speed at which supplies are restored in Iraq and Kuwait, and just-how LPG is consumed locally in new petrochemical projects, also described in part four. Overall these two factors could restrain the growth in Middle East LPG export in the next few years. A good proportion of this export is sold under five year term contracts, and Japanese companies are by far its most important customers. Other significant markets for this export are South Korea and Brazil. The net seaborne LPG balance is given in table 5B.

Forecast of LPG Seaborne Net-positive Balance in Mmt, Middle East.

Year	**1996**	**1997**	**1998**	**1999**	**2000**
Tot.Seab.Ex.	23,976	25,348	26,766	28,183	29,601
Tot.Seab.Imp.	430	455	480	515	550
Deep S.Bal.	**23,546**	**24,893**	**26,286**	**27,668**	**29,051**

Table 5B. Net LPG balances, Da Consulting. Source: Kværner Shipping, 1995.

Africa.

In Africa the main supplier of LPG to the deep-sea export market is Algeria. At the moment the African region has available nearly 6.0 million tonnes for seaborne export during 1996. Algeria is a principal supplier of LPG to Europe, but it also exports to the United States. At one time Algeria also supplied LPG to Japan, but no shipments have been recorded on this route since 1989, primarily because Japanese buyers have been able to source cheaper supplies from the LPG producers in the Far East. Other African exporters of LPG include Libya, Tunisia, Angola and Nigeria.

Although Libya has the capacity to produce more LPG than today, most output is used locally. What export surplus there is, passes through Marsa el Brega for onwards shipment to Spain and Italy. Angola started producing LPG in 1983, and approximately one-third of its production is exported to Brazil. As for Nigeria, most gas output is flared and so LPG production is limited to refinery output.

Table 5C. summarises total seaborne export and import to this region and gives the deep sea balance available towards year 2000.

Forecast of LPG Seaborne Net-positive Balance in Mmt, Africa.

Year	**1996**	**1997**	**1998**	**1999**	**2000**
Tot.Seab.Ex.	6,011	6,544	7,056	7,569	8,081
Tot.Seab.Imp.	80	105	130	145	160
Deep S.Bal.	**5,931**	**6,439**	**6,926**	**7,424**	**7,921**

Table 5C. Net LPG balances, Da Consulting. Source: Kværner Shipping, 1995.

5.3. Net Negative Balances- Major Importers.

In the discussion in chapters three and four it was apparent that the major consumers of LPG, and hence the areas with the greatest import requirements, are: Japan, the United States and Western Europe, (Northern and Southern Europe). The fundamental difference between the main OECD areas as consumers is that whereas the USA and to a lesser extent Europe almost meet their LPG requirements by domestic production, Japan is reliant on imports to fill its needs. Japan is therefore significantly most important when seaborne trade is considered.

By using the previous estimates of seaborne import and export, the development of net LPG seaborne import towards year 2000 are calculated for these major consuming regions.

North Pacific.

The Japanese net seaborne import demand represents the core of the deep-sea shipping market and it currently accounts for around 45 % of all seaborne movements. Seaborne import of LPG has risen steadily over the last ten years, the result of rising domestic demand and limited domestic supply. Today about 80 % of Japan's total import requirement is met by The Middle East, with Saudi Arabia as the major supplier. This has been the case for a number of years, although gradually new sources of supply are being introduced. Indeed, there is a growing reliance on supplies from nearer to home. One example is the Indonesian jump in export to Japan when new production capacity was brought on stream. Without doubt, producers in this region stand to benefit not only from the closeness to the Japanese market, and hence lower freight charges, but also from the fact that Japanese LPG purchasers wish to diversify their sources of supply, if only to increase customer confidence in LPG as a reliable source of energy. In the meantime

Japanese imports of LPG are expected to continue rising in the 1990s. This net deep-sea balance indicates that imports are expected to reach 21,900 million tonnes by year 2000, nearly 25 % above the 1995 level. Assuming no change in domestic LPG supply, seaborne imports will have to rise to meet the new levels of demand in the period from 1996 to year 2000.

The seaborne import could be higher than projected for this period according to the latest official Japanese government forecast. This is based on the view that the import of ethylene grade LPG from Saudi Arabia will become an even more important feature of the Japanese market. The expected trend in net import balance is shown in table 5D.

Forecast of LPG Seaborne Net-negative Balance in Mmt, North Pacific.

Year	**1996**	**1997**	**1998**	**1999**	**2000**
Tot.Seab.Ex.	0,0	0,0	0,0	0,0	0,0
Tot.Seab.Imp.	19,900	20,364	20,857	21,408	21,900
Deep S.Bal.	**-19,900**	**-20,364**	**-20,857**	**-21,408**	**-21,900**

Table 5D. Net LPG balances, Da Consulting. Source: Kværner Shipping, 1995.

North America.

In purely volume terms, the United States is second only to Japan in the league of LPG importers. However, from a shipping point of view the market is less important, because a large part of the import business is made up by overland shipments from Canada. Nevertheless, the net amount of LPG imported into the United States by sea is growing as illustrated in table 5E., albeit slowly. The USA is expected to have a net import volume of 3,493 million tonnes of LPG during 1996, and this seaborne import is expected to reach 5,743 million tonnes by year 2000. The trend in upwards LPG import could fluctuate between 4-6 million tonnes, depending on price, local availability, and the volume of overland shipments. Demand could also be a lot higher than predicted if LPG were used more extensively as a petrochemical feedstock. But here the key issue remains price, and for that reason the predictions are very cautious.

Nevertheless, the availability of LPG from gas-processing plants is expected to decline in the current decade because of declining natural gas production, and this, combined with the projected increase in consumption described in part three, should lead to a rise in imports.

As mentioned, a proportion of this additional requirement will be made up by additional overland supplies from Canada, but deep-sea traffic is also liable to rise towards year 2000. The Middle East, Latin America and Africa are the major regions supplying significant quantities of LPG to USA by sea. There is no reported change concerning these suppliers towards year 2000.

Forecast of LPG Seaborne Net-negative Balance in Mmt, North America.

Year	1996	1997	1998	1999	2000
Tot.Seab.Ex.	67	29	25	21	17
Tot.Seab.Imp.	3,560	4,110	4,660	5,210	5,760
Deep S.Bal.	**- 3,493**	**-4,081**	**-4,635**	**-5,189**	**-5,743**

Table 5E. Net LPG balances, Da Consulting. Source: Kværner Shipping, 1995.

Western Europe.

The structure of the European import market is a little more complex as sources of supply vary from country to country, while there is also considerable inter-regional trade. The provisional estimate of West European seaborne net import in 1995 is 5.032 million tonnes of LPG. Overall, the figures point to seaborne traffic of nearly 7.7 million tonnes in year 2000, of which perhaps 4.5 -6 million tonnes would be accounted for by inter-regional supplies.

The inter-regional trade originates from either the UK or Norway, and is based on the supply of LPG from the North Sea. The net balance of LPG import in table 5F., comes from the Middle East, Africa and, to a lesser extent, North America, France, Spain, the Netherlands and Turkey are principal destinations for Middle East product, while Algerian supplies go predominantly to Italy and the Netherlands.

Europe represents a mature LPG market, and expected growth rates in traditional end-use sectors are liable to be low. Deep-sea net imports are to a large extent dependent on North Sea LPG production.

European imports outside the region are expected to grow by a small amount until the end of 2000, although thereafter they are liable to fall as production rises in the North Sea.

Forecast of LPG Seaborne Net-negative Balance in Mmt, West Europe.

Year	1996	1997	1998	1999	2000
Tot.Seab.Ex.	1,244	1,099	914	729	544
Tot.Seab.Imp.	6,276	6,755	7,232	7,709	8,186
Deep S.Bal.	**-5,032**	**-5,656**	**-6,318**	**-6,980**	**-7,642**

Table 5F. Net LPG balances, Da Consulting. Source: Kværner Shipping, 1995.

5.4. Conclusion.

Above all else, the deep-sea balance tables in chapter 5.3 indicates the concentrated nature of LPG trade, with a few key routes accounting for a disproportionate share of all sea movements. The routes in question are:

- Middle East - Japan.
- Far East - Japan.
- Middle East - North America.
- Middle East - W. Europe.
- North Africa - W. Europe.
- W. Europe - W. Europe.

The Middle East - Japan run represents the heart of the deep-sea market. In recent years the United States and, to a lesser extent, Latin America have also become larger importers of LPG. This has added a cross-Atlantic element to trade, which has hitherto been dominated by the North Pacific and inter - European routings. However, in volume terms both of these markets remain small compared to Japan. This is also evident from the figures from chapter three and four in this work.

Using the previous regional assessments of predicted future import and export of LPG, in addition to net balance estimates, it is possible to select potential customers and buyers for LPG exported from West Siberian fields in the next section.

Positive Balances.

Middle East- Of the countries with surplus production Saudi Arabia had the highest volume of LPG free for export in 1994. This was helped by the removal of OPEC production quotas so that Saudi Arabia could help to make up the deficit caused by the loss of Iraqi and Kuwait production. The other Middle Eastern exporters include Sharjah, Qatar, Abu Dhabi and Dubai. The increase in net deep-sea export is expected to continue during the next five years as table 5A. indicates.
African LPG production rose in 1994 due to increased capacity and demand from importers such as North America, Latin America and West Europe, in addition to the increasing domestic demand. From North Africa, seaborne export is likely to grow over the next five year period as the net balance shows in table 5B.

Negative balances.

Japan- Of the countries reporting a negative balance Japan continues to be the largest importer of LPG with a predicted shortfall in supply of approximately 20,0 million tonnes in 2000.

The USA- This country has the next largest negative balance at 3,493 million tonnes, (if we divide Europe into South and North). Most of the LPG imports into the USA are overland from Canada and some from Mexico. Therefore the deep-sea requirement is much less significant than Japan.

West Europe- The negative balance in Northern and Southern Europe together is predicted to be 5,032 million tonnes in 1996, showing a decreasing degree of negative seaborne export and an increasing need for seaborne import towards 2000. In Europe the UK and Norway were the only major exporters of LPG.

INSRP Project III.07.3 Marine Transportation of oil from Timan Pechora and from inland Russian oil fields

Condensates and Petrochemical Products

Section 2. Seaborne Transportation of LPG from the Ob-Gulf

March 1996

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FOREWORD

This report is a continuation to Section 1 of the same INSROP project. Section 1 concerns the LPG market, while Section 2 concentrates on the seaborne export of LPG from the Ob Gulf.

This report discusses the technical and economical feasibility of export of LPG from the area in the vicinity of the Ob Gulf. LPG is at present known to be flared off, which means that a potential interest in export should exist. The study has concentrated on the economic feasibility of the seaborne transportation, at the same time not forgetting the challenges created by the prevailing environmental conditions.

To tie the theoretical studies and the reality of the actual world tighter together, a comparison with the costs of an existing trade has been carried out.

All in all, the study aims at giving possible operators a first view into the economics of such a trade. It is obvious that before concrete actions can be taken, further, more detailed studies must be made. However, the study gives a reliable view of the potential and of the necessity of further studies.

PART-6. ECONOMIC EVALUATION OF SEABORNE LPG EXPORT FROM WEST SIBERIA TO EUROPE/ROTTERDAM.

6.1. Introduction.

The Arctic continental shelf contains huge oil and gas reserves. So far these reserves have not been effectively utilised due to the severe environmental conditions and high production costs involved.

Profitable oil and gas production in the Arctic depends on a cost-effective means of transporting these products to major consumption areas. To analyse the economic feasibility, a special LPG vessel designed to operate both in open water and ice conditions is one solution to the problem of utilising remote Arctic gas reserves.

The main purpose of this part is to compare the transportation costs from Northern Russia to the most potential LPG import market, with costs and time charter rates from a competing area. This study concentrates on LPG transportation from the West Siberian fields and tries to evaluate and include most cost factors that can differ compared to present seaborne transportation. The economic feasibility study is made on LPG seaborne export from Novy Port (map E, page 16-17) to North Europe (Rotterdam). The westbound routes are selected because of their natural suitability compared to different competitors. The LPG is assumed to be supplied from the gas fields in the Tyumen/West Siberian basin by barge or pipeline to Novy Port. The importing region used in this analysis is selected because it shows significant demand for LPG towards year 2000, the demand situation described in part three in this work supports the choice of region. The structure of LPG demand in this region is not divided into premium and price sensitive markets because the major issue is the transportation to Northern Europe, Rotterdam. The LPG supply analysis in part four is used to evaluate and find major competing LPG exporters. On the basis of this calculation, other markets can be compared with little extra work.

In addition, the freight market, freight contracts, LPG carrier costs, NSR-insurance, market strategies for NSR operators and market requirements related to potential buyers and operators in this area are analysed and discussed. The reason is to give a pilot study with some recommendations, and to raise questions about important issues related to future operations on this route. The results are supposed to give a starting point for more detailed transport solutions of LPG from this region, and hopefully some valuable information that will motivate investors and ship owners to go into this market in the future.

6.2. Types of LPG Tankers.

LPGs and chemical gases are transported in a liquid state in specially designed tanks, in one of the following ways:

- Under pressure at ambient temperature.
- Under a combination of pressure and reduced temperature.
- At reduced temperature alone.

Fully Pressurised Vessels.

In modern fully pressurised gas carriers the cargo is carried in 2-6 cylindrical or spherical pressure containers below or partly below the deck, mounted on two or more cradle-shaped foundations. Because the cargo is carried at ambient temperature, ordinary grades of steel can be used. An insulation and reliquefaction plant is not required. However, there are certain drawbacks associated with fully pressurised vessels: The shape of the tanks lead to poor utilisation of the cargo space available. The necessary tank weight is high in relation to the size of the cargo carried, and as the tanks increase in size, the wall thickness must be correspondingly increased for the same design pressure.

Fully pressurised LPG carriers are normally small- generally under 2,000 cu.m capacity. Above this capacity range the thickness and weight of steel required and high construction costs make refrigeration of cargo the optimal economic alternative. For smaller LPG carriers, however, the fully pressurised design is very suitable.

Semi-pressurised/Refrigerated Vessels.

In vessels of this design, pressure is still employed to keep the product liquid, but part of the liquefaction process is a result of refrigeration. When cooled, the cargo can be transported at lower pressure, thus allowing reduced wall thickness on the tanks of semi-pressurised/refrigerated vessels compared to fully pressurised vessels. Typical carriage pressure on this vessel type is 7-9 bar, compared to 18 bar for fully pressurised vessels.
The tanks themselves can be spherical or cylindrical, as in fully pressurised vessels. But as the tanks are built for a lower pressure, a "twin-lobe" design is often used, whereby two cylindrical tanks are welded together, therefore using the hull volume more effectively. Most carriers can transport two or more types of cargo simultaneously. On fully pressurised

carriers, there is no need for a secondary barrier, because the integrity of the tanks is maintained.

The capacity of semi-pressurised/ fully refrigerated vessels is typically within the range 2-15,000 cu.m, with some carriers as large as 30,000 cu.m.

Fully Refrigerated Vessels.

Vessels with a capacity of 15,000 cu.m plus are normally fully refrigerated carriers. They can, however, range in size from 10-100,000 cu.m. The design temperature is usually linked to the boiling point of LPGs. Many of these carriers can carry a wide range of products simultaneously, requiring tanks with independent piping and reliquefaction systems. Tanks are often prismatic in shape and in these cases the IMO insist that the ships hulls act as a secondary barrier. The tanks must be separated from the hull and the gap filled with an inert gas. Different types of cargo containment systems are: Independent tanks with a double hull, integral tanks and semi-membrane tanks.

The number of the varies with the capacity of the ship and for instance a vessel of 25,000 cu.m. can have three independent, self-supporting tanks.

As LPG and ammonia are not normally corrosive, the insides of the tanks are often uncoated; but the outside of the tank is often insulated to reduce heat loss and use of the reliquefaction plant. The vessels in the fully refrigerated fleet tend to have a larger capacity than other types of LPG carriers. Although there are several with capacities under 10,000 cu.m the majority range quite evenly between 10,000 cu.m and 100,000 cu.m.

The supply of LPG carriers is determined by the following key variables:

- The size and age structure of the existing LPG carrier fleet.
- The current orderbook.
- Future new ordering and deliveries.
- The level of scrapping and loss.

6.3. The LPG Freight Market.

This section of the report looks at the freight market in terms of the chartering method used in this analysis, routes and freight rates on the common market. To move the LPG product charterers have three main ways of securing tonnage:

- The time charter market.
- The spot market.
- Contracts of affreightment.

The relative importance of each option varies from product to product, and also between ship type and size. Hence among the smaller semi-refrigerated/pressurised fleet, contracts of affreightment are generally more popular than, say, time chartering, which is the main way of chartering in the large ship sector. In this feasibility study the time charter market and the spot market are used, and the rates are calculated in USD per operating day and USD per tonne LPG.

6.3.1. The time charter market.

The relative merits of this form of chartering vary depending on market conditions, and its attractiveness is usually more pronounced when one or more of the following features are evident:

- The charterer can foresee an upswing in freight rates, hence he can hedge against future increase in freight costs.
- There is a specific transportation requirement over a period of time which is suitable for dedicated tonnage, as in the Northern Sea Route case.
  To seek commercial advantages, traders take control of more tonnage.
- Charterers have access to other cargoes which can be combined on a time chartered ship, a possibility during seasons when the NSR-area is closed for seaborne export.
- Owners have overbooked COAs.
- Charters take a speculative position.

Seen from the point of view of ship size and type, it is evident that any owners of small semi-refrigerated/pressurised ships have avoided placing their ships on long-term time charter, and this has limited the number of vessels available for time chartering. This is in contrast to the

large LPG carrier market as used in this analysis, where time chartering is a more common way of securing tonnage. In the large ship sector, in situations where the pendulum of bargaining power moves from seller to buyer, spot chartering will often gain ground on time chartering. By purchasing LPG on a spot basis the buyer will be able to introduce an element of flexibility into the logistics chain, rather than tie himself to a somewhat inflexible delivery schedule that could be the situation for operators in the northern area of Russia. There may also be a tendency on the part of buyers of LPG from the Tyumen area to use spot purchases as a means of diversifying sources of supply. Potential charterers operating on the Northern Sea Route have to be aware of some special trends in the time charter rates for different sizes of LPG carriers. These trends are common on the market today and could absolutely happen in a vessel market that is designed and equipped for the northern area as described earlier.
If we get growth in the vessel supply and weak demand for LPG from West Siberia, rates will fall sharply across the board, reaching a low rate point very fast. If the market then begins to exhibit signs of a recovery- it will possibly be the result of:

- More or less static vessel supply designed and built for the NSR.
- Increase in long-haul imports to major importing regions, thereby reducing the tonnage surplus.
- The concentration of vessel ownership among powerful independent groups and pools operating in the northern area.

When, and if the market becomes tight, however, the balance tends to swing in favour of long-term chartering in order to ensure availability of shipping capacity. Hence during the last couple of years there has been an increasing number of LPG time charters fixed for periods in excess of twelve months. This could also be the situation for potential charters after the discussed sea route has been opened for commercial trading.

6.3.2. Potential Operators on the NSR.

The table below lists some of the charterers that can be active in an LPG market described in this report. The list is by no means comprehensive, but it does provide an indication of types of organisations that have the potential to be involved in taking tonnage on a time charter basis, though it should be remembered that in some cases organisations have dual functions, as some trading companies also own ships outright.

Company name	Type of company	Ship size or ship chartered	
Contichem	International trader	75,000	cu.m.
Enron	Producer/trader	50/75,000	cu.m.
Exmar	Ship Owner/Mgs	7/15/75,000	cu.m.
Geogas	Ship owner/trader	70-80,000	cu.m.
Naftomar	Ship owner/trader	75,000	cu.m.
Sitco	International trader	3-78,000	cu.m.
Stargas	Ship owner	3-75,000	cu.m.
Trammo	International trader	50-75,000	cu.m.

Table 6A: Potential NSR traders, DA Consulting. Source: Own Research, June 1995.

As expected, the trading organisations dominate the search and the list, mainly active in the large ship market. Apart from traders, other producers and shipping companies are the two main types of organisation that have the potential to be involved in a time charter market operating on the NSR.

6.3.3. Another Freight Contract Possible for the NSR.

Contracts of affreightment (COAs), have been popular in the petrochemical gas sector for a number of years and this influence is gradually extending to LPG. For many charterers the COAs represent the most convenient and flexible way of securing tonnage, and in most COAs it is possible to allow some flexibility in:

- The products to be shipped.
- Quantities to be shipped.
- Cargo size.
- Load/discharge ports.
- Time period.

Once the cargo is nominated, the charterer places the responsibility on the ship owner/operator to provide a suitable vessel at the right time and in the correct place. In practice, for the charterer, this should reduce the administrative problems associated with either spot or time charter.

For the owner, the COAs represent valuable base business, and this can often be supplemented with other COAs and spot charters. To some extent the COA is also indicative of a longer-term relationship between charterer and ship owner.

In the chemical gas sector there is a wide variation in charterer requirements over time, in terms of: types of cargo, cargo sizes, load/discharge areas and cargo volumes. Accordingly, most operators have tended to favour placing their vessels in pools, where the fleet is of sufficient strength and flexibility to win and service COAs.
With proper management, and combined with spot chartering, the COA enables the ship owner/operator to minimise time spent in ballast, cleaning or awaiting orders.

Finally, it should be said that charterers can, and do, own ships, which are used for transportation. But a high proportion of the LPG tanker fleet is controlled by independent companies or operated within pools, and the number of vessels owned by either LPG producers, consumers or chartering interests is not large. This will also be the situation for actors operating on the NSR in the future. The reasons for this are:

- There is, and will be an absence of long-term supply contracts in the FSU industry. Hence very few companies are in a position where there is a stable transportation demand for the life of such specially designed vessels, say 20-25 years.

- The return on investment on gas carriers designed for the NSR can be poor because of no alternative use, political uncertainty in the area and a weak state of the freight market.

Very few companies today have a shipping requirement sufficient to justify the size of NSR fleet ownership, suitable to gain economies of scale trading on the NSR.

6.4. Environmental conditions on the Route to Novy Port

The environmental conditions on the route from Murmansk to the west coast of Yamal (the Kharasevey area) have been described in /11/. This route is in wintertime dominated by the relatively thick level ice and the heavy ridging in the southern Kara Sea. The ice conditions in the Kara Strait are also heavy and cause severe problems to the vessels in transit through the Strait. A more detailed description of the conditions can be found in reference 11.

The route from the Kharasevey area to the northern tip of Yamal - the Belyi Island - is much alike the route across the Kara Sea. Heavy ridging occurs and level ice of around 1.6 meters is met.

The route from the Belyi Island to the Novy Port area is dominated by the special features of a sheltered area like the Ob Gulf. Ridging is not so frequent and the ridges are of a smaller size than in the Kara Sea.

However, there are ice conditions of great severity in the Ob Gulf. The level ice is thicker than in the Kara Sea. Because of the restricted water depth, some ice features may be bottom founded, which makes progress with vessels very difficult.

A special feature that dominates a frequent operation of vessels in restricted waters like the Ob and Yenisey Gulfs and Rivers, is the accumulation of ice in frequently broken channels. The ice-free water surface that is created with the passing of a vessel will freeze again. The broken ice will only partly be in the channel, the rest being pushed under the ice. When the vessels pass through the created channel, the ice floes in the channel will be rounded by the interaction. As a result of this process, the channel will be filled with a thick layer of small ice pieces frozen together to a condition very difficult to overcome. At a certain moment, it will be easier for the vessels to break up a new channel instead of using the old but ice filled channel.

In some areas, the water depth in the Gulf will restrict the possibility of making new channel in the level ice, forcing the vessels to use the old and difficult channels.

The operation in old channels places new demands on the vessels. They must be able to operate in ice conditions where the propellers are constantly covered by ice and where the vessel floats in an ice-water-mixture, causing additional friction.

In the transit time estimates, the above mentioned problem has not been included. The vessels are thought to operate in new, not earlier broken, ice. This simplification is justified, since the traffic density is such that the above mentioned problem will not occur in its actual sense.

6.5. LPG Carrier Costs and Input Data to the Computer Model.

Costs for LPG carriers, as for all vessel types, can be split into three main components. Voyage costs, which include the cost of fuel , port charges and any canal dues. Operating costs, which can be broken into elements such as manning, insurance, R & M and capital costs- would relate to the costs occurred when purchasing a ship. This section of the report looks at the development of these costs for an ordinary LPG vessel and a specially designed LPG vessel for use on the NSR. Profitability is determined by simply comparing total costs against total revenues. Before this can be done, however, some comments on the representative ship sizes/operating parameters are warranted.

6.5.1 Operating Parameters

Ships chosen

The vessel-type used in this study is of the DAT-concept type. DAT stands for Double Acting Tanker, meaning that the vessel is designed for operation astern in ice and ahead in open water. This allows the use of an open water bulbous bow form and excellent ice breaking capabilities at the same time.

The vessels are designed for year-round independent operation all the way from Europe (e.g. Rotterdam) to the Ob Gulf (Novy Port).

As the water depth on the route to Novy Port is restricted, allowing a maximum draught of about 9 meters, a somewhat non-standard design has been chosen. This design maximises the LPG-payload in the restricted draught. No actual design has been done, only estimates from similar projects within KMY have been used.

The target vessel cargo capacity has been 60.000 cubic meters. The propulsion power has been chosen to give the vessel a performance level securing continuous progress in the most severe ice conditions in an average year.

An optional solution would be to continue the operation by barges to deeper water, allowing larger, for instance 75.000 cubic meter, vessels to be used for the rest of the route. This option is studied only for the open sea part (Rotterdam to large vessel loading point) to give the economic frames for a larger barge system.

Vessel parameters

As mentioned earlier, the vessels are of DAT-type. The bow is a bulbous type, having excellent open water characteristics, while the stern is designed for ice breaking. To allow such a design, the propulsion must be by Azipod-type propulsors. These vessels are equipped with two Azipod units. The machinery is diesel-electric with medium-speed engines driving the generators and cyclo-converters controlling the rotating speed of the propellers.

The main dimensions for the two different vessel designs (60.000 and 75.000 cubic meters) are given in the following table.

Sources of input data in the model:
The technological input data are collected from Kværner's LPG shipping industry. Ship sailing data, rate and price data and gas carriers cost data are collected from Lloyds Shipping Economist, information provided by Fearnleys A/S and market information from Trade Winds. For more thorough specifications about each input data in the model, see appendices 1-3.

Main data for ice breaking LPG vessel:

Shallow draught, 60.000 m^3

Length OA	: 280.0 m	Propulsion power	: 30.000 kW
Beam	: 37 m	Trial speed	: 16.0 knots
Draught	: 9.0 m	Auxiliary power	: 3.000 kW
Building price	: 73 MUSD		

Full draught, 75.000 m^3

Length OA	: 223.0 m	Propulsion power	: 40.000 kW
Beam	: 34.7 m	Trial speed	: 16.0 knots
Draught	: 12.3 m	Auxiliary power	: 3.000 kW
Building price	: 88 MUSD		

Cargo Volume, LPG:
The amount of cargo to be transported is estimated to develop to about 1.2 million tonnes in 1996, as shown earlier. In the calculation, the amount is fitted to fully utilise the transportation capacity. In the limited draught case this leads to an amount of about. 1.5 million tonnes and in the full draught case about. 1.6 million tonnes.

transportation capacity. In the limited draught case this leads to an amount of about. 1.5 million tonnes and in the full draught case about. 1.6 million tonnes.

Cargo type:

The tankers carry LPG from Tyumen at a low temperature with the design temperature linked to the boiling point of LPG.

Routes/length of the voyage:

The specially designed LPG carriers are employed on a round-trip voyage between Novy Port/Belyi Island and Rotterdam, totally a distance of 5900/5050 nm.

Operating speeds:

The assumption is made that both vessels will be operating at a speed of 16 knots in open water. The speed in ice has not been calculated specifically for these vessels, but estimated on the basis of calculations done for an LNG-vessel operating to Kharasevey /11/. The power level of the vessels has been estimated to compensate for the differences in vessel characteristics (length of parallel mid body, mass of vessel, etc.).

Port time:

The turnaround time per port visit is estimated at two days. The normal discharge time, even for the largest LPG carriers, is generally less than twenty-four hours. Port time therefore allows time for port delays, vessel manoeuvring, hose, connection/ disconnection activities, and so forth. The input data in the model is 40 hours for total loading and discharging.

Operating days per annum:

It is assumed that the vessels will have no days off-hire per annum and so the vessel(s) will be operating for a total of 365 days each year. The effect of normal off-hire days is assumed to affect only the total amount of cargo transported. The shortage can easily be estimated on the basis of the daily production.

Bunker and lub. oil consumption:

The 75,000 cu.m vessel consumes mostly HFO, around 130 tonnes per day while steaming. The load factor for propulsion machinery is 0 % in harbour, 40 % in open water and 100 % in ice. The auxiliary machinery will have a load factor of 20 % at sea, 70 % when loading and 20 % when waiting. The propulsion machinery and the auxiliary machinery is in the diesel-electric power station machinery physically the same engines. The power is separated only for the calculation.

The shallow draught vessel consumes on average about. 100 tonnes of HFO per day.

Resale values

This study is based on the assumption that the vessels are active on this trade during their whole lifetime. Because of this, no resale value has been included. It must however be noted, that the resale value is one of the negative characteristics of the specially designed vessels.

6.5.2. Voyage Costs.

LPG carrier voyage costs comprise three elements:

- Fuel costs.
- Port charges.
- Channel dues, where applicable.

In addition there can be a whole host of other minor or miscellaneous expenses such as commission.

Bunker prices:

The cost of fuel per voyage is dependent on a number of factors:

- Length of the voyage.
- Bunker consumption.
- Length of loading/discharge procedure.
- Time consumed using canal facilities.
- Bunker costs and prices.

The statutory installation of reliquefaction plants aboard LPG carriers with refrigeration capacity precludes the use of boil-off gases as a supplementary fuel in the main-engines. Thus, LPG carriers exclusively consume bunker fuel of varying quality. The cost of bunker is therefore a major costhead faced by ship owners or potential charterers trading on the NSR. At any time there are considerable differences in bunker costs in different regions.

Mention must be made of a number of important influences affecting prices at a regional and operational level, amongst which are:

1. Geo-economic factors. These cover a number of global, regional and local factors and their influence on prices. At the global level the world splits into traditional low- and high-cost supply areas. The former is characterised by readily available local crude and competing refineries. The latter tends to be characterised by areas where refining capacity is directed primarily to domestic needs or where state or quasi-state agencies are highly influential.

2. Ship operating factors. Frequent, due to the nature of different forms of LPG operation like on the NSR. Owners or operators are not always at liberty to capitalise on advantageous bunker options.

3. Supply factors. In some instances the supplier may have ship owning/operating interests and these vessels may therefore, in some circumstances, benefit on price or through priority stemming. Typically suppliers differentiate between the oil majors, national oil companies, oil storage and distribution companies and various traders. For an LPG carrier trading on the NSR this could have a bearing on availability, quality consistency and the likelihood of price discounts.

The input price on bunker is 106 USD/ton, and 1500 USD/ton for lub.oil. These prices are the latest reported data available.

Port charges:
Expenditure incurred by vessels in port tend to be the most complex if not the largest of the voyage costs. The complexities arise due to the variety of individual cost components involved and also the distribution of costheads between owner and charterer. Port costs can, however, be categorised into one of the following types:

1. Costs incurred by the carrier itself. These vessel-related costs are likely to arise as a miscellaneous series of relatively small individual cost items. The components of these costs will differ from port to port and even between different facilities covered by the same authorities. In additional to local and geographical variations, there will be currency factors to take into account as most service charges will arise in domestic currencies. For ports in northern Russia, charges are paid in USD or Rubles.

2. Costs attributed to cargo handling. This is a particularly difficult area to quantify for ports related to NSR. There is a problem in distributing responsibility between port authorities and stevedoring companies. Commercial confidentiality also comes into the costing due to

competition between ports or stevedores. Also an area of particular relevance to the LPG operator is that most LPG loading and discharging terminals are privately owned and are for the sole use of particular operators.

Estimates from Drewry Shipping Consultants Ltd., shows that of the total voyage costs for existing LPG carriers, bunkers are the most significant costs to be considered, followed by channel tolls where relevant. In the computer calculations, port charges are 0.2 USD/GRT.

6.5.3. Operating Costs.

Operating costs can broadly speaking be broken down into five components: manning, insurance, repair and maintenance (R & M), stores and lubes and administration costs. Details of each of these categories are described below.

Manning:

LPG carriers are very sophisticated ships demanding the highest calibre crews to ensure their safe operation. Due to this fact, manning costs tend to be high. In the past the crew on an LPG carrier would often consist of Norwegian, North American or Japanese officers with few - if any less skilled seamen from developing countries. This has had to change in recent years due to economic necessity.

Manning costs consist of several direct and indirect expenses, including crew salaries and wages, leave pay, crew travelling, victualing, insurance cover as well as employers' contribution to pensions and social security. Input data for both carrier sizes are based on information from Bergesen dy. AS, concerning the cost picture for new 75.000 cu.m LPG carriers.

Insurance:

There are two main areas where LPG operators seek insurance. These are for physical loss or damage to the vessel (Hull & Machinery), and against liability against a third party (Protection & Indemnity).

Before a further discussion related to the NSR, it is important to remember that LPG carriers have a very good safety record when owned by reputable owners so insurance costs have been low compared to other tankers.

Hull & Machinery:

The risk caused by NSR transits are often risks to the vessel itself due to the ice conditions. The commercial operations on the NSR have such a short history that the normal way of defining insurance premiums by the damage statistics.is not possible. For this reason there are no tariffs or listed premiums for NSR insurance so far. The NSR operations could be referred to the traffic on the St. Lawrence Seaway or in northern Canada in wintertime. These regions are under so-called Warranty limitations and the normal premium of the vessel is increased for the time the vessel stays in the region. The increase in premium could be defined by the following principles described on the next page (10):

- Fixed extra premium according to gross tonnage of the vessel.
- Certain percentage of the insured value of the vessel.
- Both of these extra premiums vary according to seasonal changes and the average ice conditions.
- Premiums effected by costs of re-insurance abroad.
- The shipowner can compensate the higher premium levels by using higher own risk levels.
- In individual cases the premium is affected by the importance of the client and the client's other insurance.
- Premium estimation on this basis: Extra premium per operating year := 2 x the normal annual hull insurance premium of the vessel.

Another Finnish maritime insurer estimated the NSR premiums on the basis of the vessel's total capital costs. The investment is to bear certain capital costs, financed by borrowed capital investments or by the shareholders' equities. The normal hull premium is calculated to be 1/10 - 1/15 of the capital costs of a vessel. This share would be at least threefold for the time of the NSR operations. Premium estimations on this basis:

- The capital value of the vessel: USD 88,000,000
- The rate of interest for calculations: 8 % p.a.
- The capital costs of the vessel: USD 7,040,000 a year
- The normal hull premium: USD 704,000 a year
- The NSR hull premium: USD 2,112,000 a year.

This estimation is a guestimate because the damage statistics are not available. The Russians have little damage statistics for the NSR operations but they are based on (Soviet) rubles paid for repairing the damages and are of less importance today. The Russians have also reported two totally lost vessels in the last 30 years (river craft not included). The final premium credited for NSR operations will be affected also by the competitive situation between the maritime insurers. In the model 2.5 % a year of the ship price is used. This estimation gives a NSR hull premium of 2,200,000 USD/year for the larger vessel and 1,825,000 USD/year for the shallow draught version.

The P & I insurance:

The Protection & Indemnity insurance is often managed by the shipowner's mutual P & I clubs. The insurance incident may occur when the shipowner is responsible for indemnification for an error made by somebody working for his account. The principal aim for this is that somebody, not the environmental conditions for example, has caused the damage. If the vessel is seaworthy (and iceworthy enough, in the NSR conditions) there is no reason to have higher premiums for the P & I insurance.

In the case of possible damage the suffering party will in all probability attempting to prove some errors made by the ship operator. This may lead to a long and difficult juridical process and the possible impact upon P & I insurance activities will be seen in future.

Repair and maintenance:

Another substantial operating cost category is that of repair and maintenance, which is usually the second largest expenditure after manning. Under exceptional circumstances ship repair costs can be the largest cost component. A variety of different motives and influences affect repair and maintenance expenditure. At the most fundamental level are found the statutory requirements of governments and classification societies, which generally mean that the vessel must be dry docked at least once every five years to undergo a periodic survey.

This would probably be the situation for LPG vessels trading on the NSR. The actual cost involved can vary considerably from one vessel to another. Factors such as ice classification, age, and the condition of the ship obviously affect on the level of costs. However, there are also ulterior considerations such as classification society rules plus the market situation in general. The R & M costs tend to provide between 10 % and 20 % of the total operating costs of an LPG vessel. For specially designed LPG carriers used on the NSR there are no such estimates available today. In the model 1% of the ship price has been used on R&M costs.

Stores and lubes:

Stores include a wide-ranging list of consumable items which are usually categorised in three main groups:

1. Marine stores.
2. Engine stores.
3. Steward's room stores.

These costs generally vary with the type of LPG carrier but are a relatively small proportion of the fully built-up LPG carrier costs. Input data are available in appendix 1, page 9, "Consumables and Supplies".

Administration:

The administrative costs of owning and operating a vessel trading on the NSR are probably the hardest to calculate since they can vary widely from company to company. Basically administrative costs are divided into two independent sections, the corporate administration,, which directs the company as an owner and co-ordinates long term decisions; and the management of specific ships including the day-to-day running of expenses and revenues associated with the vessel. This latter category often includes subcontractors under management companies which exist to provide specialist services to shipowners. This often goes hand-in-hand with registering a ship under low cost flag.
Much of the cost of administration depends on the degree to which ship owners "opt-out" of the administrative function. Ship management companies in the NSR case can be used to administer all elements of crewing and operations in return for a single management fee, while brokers can be given extensive authoroty to fix business in return for their particular level of commission. Such an approach almost certainty minimises administrative costs by securing some of the advantages of economies of scale.

Competition between ship management companies has been such that fees have been contained in recent years. It is not known how the level of administration cost will vary for management companies specialised in operation of LPG vessels on the NSR. In this case, the data used in the computer calculations are based on information from Kværner Shipping as and Havtor as.

Total operating costs:
For all the different capacity LPG carriers today, manning is by far the largest costhead. This is followed quite far behind by R & M, but all these costs rise with the capacity of the LPG carrier. There have been significant increases in LPG operating costs over the past three years. The growing cost of R & M is a significant factor contributing to this rise.

6.5.4. Capital Costs.

Capital costs encompass all those charges related to the purchasing of an asset- in this instance an LPG carrier specially designed for the Northern Sea Route.

Within the shipping industry the capital costs are interpreted in a variety of ways reflecting differing accounting procedures, cash considerations and investment appraisal techniques. For the consideration of the potential investor of an icebreaking LPG carrier, there are three elements beyond the initial purchase price agreement:

1. The level and phasing of cash outgoings. The first of these is likely to be the deposit, normally around 10 % of the purchase price. The remainder of the purchase price will be met by a mixture of loans and equity/cash reserves. In terms of repayment periods, five years has tended to be the norm for second-hand ship acquisitions, but for a newbuilding, a specially designed LPG carrier, longer term loans are most available reflecting the expected life of the acquisition.

2. Capital cost recovery factor. This involves an analysis of the freight rate level required to cover the capital cost.

3. The potential return on the investment. This is particularly important for those contemplating investment in second-hand tonnage. This involves the potential owner considering whether the money would be better invested elsewhere, and also factors such as inflation are important. Despite the lack of hard evidence, it is clear that the newuilding price for a specially designed LPG carrier suitable for the NSR will be considerably higher than for an ordinary LPG carrier. Calculations indicate that such a vessel will cost

approximately 30% more to build than the average costs. This gives the 75,000 m^3 -vessel a price of 88 MUSD and the shallow draught vessel a price of 73 MUSD.

6.6. Transport Solutions and Vessel Profitability for an Ice Breaking LPG Carrier.

The main issue in this chapter is to describe and compare the results from the computer model calculations for an ice-breaking LPG carrier in appendix 2 and 3. LPG transportation costs are a variable factor, determined by the trading distance, assuming a fixed volume of LPG movement. The other capital costs of the liquefaction plant, gasification plant, etc. are also deermined by the trade volume, but are not dependent on distance. Hence, assuming a fixed contract volume, LPG transportation costs will increase as the trading distance increases and because the other project capital costs are fixed, the proportion of transportation costs in total project costs will also rise.

The total transportation costs used in the model include all costs related to the operation of the vessel; but do not include costs for the land-based facilities, storage, loading, LPG plant, etc. In both cases costs of barge transportation must also be added.

6.6.1. Build-Up Costs.

The intention here is to present the calculations of the transportation costs for the LPG carrier operating on the route between Novy Port/Bely Island and Rotterdam. The objective is to show the composition of the cost structure. In order to calculate these cost assessments, it has been necessary to make a number of assumptions based on data from Kværner`s technology unit, which are explained earlier in this chapter. The data in appendices 1-3 show the calculations and summarise the cost calculations. The data more or less speak for themselves, but they do show the differences in transportation costs associated with different winter conditions. In the following only the calculations for the shallow draught vessel are described in more detail.

Route & Schedule:

The round-trip is calculated for three different number of trips related to the different ice conditions (representing a mild, a normal and a severe winter). The total number of trips in a mild winter is calculated to 16.5 when operating 365 days/year 14.3 if a normal and 13.3 if a strong winters occurs. These numbers represent the capacity. When the schedule is corrected according to production, the total number of trips is calculated to 14.0 trips in a mild and normal year, 13.2 in a severe year. This number is based on the ice conditions, different sailing distances related to different ice thickness and speed through the ice.

Voyage Costs:

60.000 m^3

The voyage costs for this LPG carrier are calculated to 5.04 USD/cubic meter, or 4,139.000 USD for total cargo carried in 1997, if a normal winter. The most significant cost head that can vary related to the different ice conditions is the fuel costs (bunker & lub.oil). The difference between such consumption for a mild and a severe winter is 998,000 USD/year. Consumables, supplies and channel charges are of minor importance when operating on the NSR, these costs are calculated at 179,000 USD per year independent of the ice condition.

75.000 m^3

The voyage costs for this vessel are 3.57 USD/cubic meter.

Operating Expenses:

The operation costs are broken down into ship personnel and ship expenses, where they together contain the costheads that are possible to calculate for an ice-breaking LPG carrier. The total payroll for the ship crew is 1,463,000 USD per operating year for both vessels. Other ship expenses have a total of 2,920,000 USD and 3,520,000 USD per year respectively. The major part and important costhead is the insurance premium. Of the total operating expenses, this premium accounts for as much as 62.5 %. And as discussed earlier, this premium could be even higher than the estimated 2.5 % of the ship price. Signals from the insurance companies are indicating that the normal hull premium would be at least threefold for NSR operations.

Total Operating Expenses:

The total annual operating expenses for an ice-breaking LPG carrier on the round-trip between Novy Port and Rotterdam are calculated at 8,684,000 USD for a normal winter. The expenses include voyage, operating and shore side expenses when operating 365 days a year on this route. For the shorter route and larger vessel the costs are 9,994,000 USD.

The capital cost for this hypothetical LPG carrier is based on newbuilding prices in 1995. In this case, the capital charge is based on a 20 year vessel life, and a cost of capital of 6.5 % on the borrowed amount, (68 % of the total value), and 4.5 % on the own capital, (32 % of the total value). The interest cost is 5,157,000 USD the first year and depreciation is 4,400.000 USD. This LPG tanker is a technically advanced ship, containing expensive and sophisticated equipment for operating in different ice conditions without icebreaker assistance. It follows that the newbuilding price is high in relation to other types of LPG vessels. Therefore, the capital element is a predominant component of the fully built-up costs for an ice-breaking LPG carrier.

The Cost Structure:

The objective here is to present the indicative total transportation costs for an LPG vessel operating on the route Novy Port-Rotterdam. The different cost structures are shown on page 15 in appendix 2.

The figures show quite clearly how capital costs (41 % of total), bunker and lub.oil (26 % of total) and ship expenses (20 % of total) are the major costheads for such operation. The capital cost is explained by the special design and newbuilding price related to requirements for transportation in areas with ice. The bunker consumption is related to the speed through the ice and could also increase as the carrier faces more severe winter conditions. The propulsion machinery would then increase its fuel consumption by up to 30 % if the environment changes from normal to harsh winter. The high share of ship expenses is related to the NSR insurance estimate.

6.6.2. Time Charter and Average Costs.

An LPG carrier (LPGC) owner's revenue accrues from the receipt of charter hire payments on his ships(s). The LPGC owner has a minimum charter hire rate by which his costs (including an allowance for a target percentage rate of return on his invested capital) will equal to his revenues. If, then, the LPGC owner's level of costs determines his minimum target charter rate, this minimum rate will differ according to the type of charter contract employed. This is because the owner's costs vary according to the type of charter contract being used.

Spot Charter:

A single voyage and consecutive voyage charter, the LPGC owner must aim for the highest charter hire revenues he can secure, because under these contracts his total costs are at their highest levels. The owner is directly responsible for the payment of all components in the LPG carriers fully built-up costs under single voyage and consecutive voyage charters. As such, the owner must seek to achieve a minimum charter hire which covers his fully built-up costs. Thus, the required charter hire revenue from short-term contracts should be sufficient to cover costs of trading (operating and voyage costs) plus capital costs, including return on investment.

Shallow draught, 60.000 m^3

The calculations in appendix 2 make it possible to estimate the required spot rate in USD/cu.m. and USD/tonne for an ice-breaking LPG carrier. The base case in this appendix then calculates the total operating and voyage costs for a normal winter to 10.57 USD/cu.m. or 17.62 USD/tonne, and the total capital costs the first year at 9.62 USD/cu.m .or 16.03 USD/tonne of LPG delivered from Novy Port to Rotterdam. This gives a minimum required charter hire revenue or rate from short-term contracts (total fully built-up costs) fn 20.19 USD/cu.m. or 33.65 USD/tonne. These costs are based on first year costs. If we consider the whole lifetime (20 years) the corresponding numbers will be 16.96 and 28.26.

Full draught, 75.000 m^3

The full draught case has total operating and voyage costs for a normal winter of 7.50 USD/cu.m. or 12.5 USD/tonne, and total capital costs the first year of 7.21 USD/cu.m or 12.02 USD/tonne of LPG delivered from Belyi Island to Rotterdam. This gives a minimum required charter hire revenue or rate from short-term contracts (total fully built-up costs) of 14.71 USD/cu.m. or 24.52 USD/tonne. Life-time costs are 12.18 USD/m^3 and 20.3 USD/tonne.

These calculations show that 5.5 USD/m^3 can be placed on the transportation of the LPG further from the Novy Port area to the loading point at Belyi Island. These costs will have to cover also possible additional loading facilities.

Since the LPG carrier spot market always will fluctuate in response to seasonal shifts in production and demand it is not appropriate to do a comparison with the LPG spot rate (USD/ton) today and conclude that the transport from Novy Port is economically feasible. It is not unusual for rates to fluctuate by anything up to one-third from one fixture to another which, from a charterer's and owner's point of view can have serious repercussions on trading profitability. One example of such a spread between spot rates is the dip to a low 20 USD/ tonne of LPG in 1989 and the jump to the mid 70 USD/tonne by the end of the same year for all 75,000 cu.m LPG vessels. In addition, there is a possible risk related to the total start-up of such an operation in terms of the investment costs, insurance premiums and inflation. These major issues will change the costs of transportation significantly as the sensitivity analysis shows in chapter 6.6.3.

Time Charter:

Under a time charter the LPGC (LPG carrier) owner must seek to achieve a charter rate which will generate sufficient revenues to cover his costs. The owner's costs under time charter are only capital costs plus operating costs (voyage costs are paid by the charterer). Therefore, under time charter, the owner requires a charter rate which will cover his operating costs plus his capital costs, plus an allowance for his target percentage rate of return on invested capital. Since the voyage costs are paid by the charterer under time charter, only one set of minimum charter hire rates is required by the owner irrespective of the trading distance involved.

The vessel calculations in appendices 2 and 3. give a time charter rate of 27,000 USD per operating day for the 60,000 m^3 case and 32,000 USD for the 75,000 m^3 case.
These numbers change the economic feasibility when operating from Novy Port. The highest reported average T/C for 75,000 cu.m carriers in 1994 was 900,000 USD/month, or approximately 29,000 USD/day, and the lowest reported T/C so far in January 1995 was 630,000 USD/month or approximately 20,300 USD/day. When comparing the minimum time charter required for an ice-breaking LPG carrier with T/C rates from the existing market, it is not appropriate to recommend potential investors to invest in such expensive LPG carriers. The major reason for the calculated T/C rate is above all the high capital and operation costs. The case for the smaller vessel is similar.
It must however be noted, that the whole trade of LPG from Novy Port is depending on these special design vessels. Without them, there will be no trade. Thus the profitability of the ship is dependent on the time frame in which the vessels are utilised in trades where competition from cheaper, open water vessels do not exist.

The LPGC charterer's minimum required freight charges are the same under every type of charter contract. His costs are always the same under every type of charter contract and are equivalent to the sum of fully built-up costs and cargo insurance costs. Under each of the charter types discussed, the LPGC owner will pass on the fully built-up costs of shipping to the charterer, either directly- e.g. passing on the direct responsibility for payment of operating and/or voyage costs in time charter contracts- or indirectly, in charter hire rates. Another issue related to required freight rates is the close negative correlation between the product prices of LPG and the attained time charter rate. This is probably due to lower product prices leading to increased total demand for the product.

6.6.3. Sensitivity Analysis for an Ice-Breaking LPG Carrier.

The transportation element in the total cost picture for seaborne export of LPG through the Northern Sea Route is, as stated above, a critical factor. Transportation costs in this context are taken to include all costs associated with acquiring and operating an ice-breaking LPG carrier, and they are typically broken down into the three components of capital, operating and voyage expenses. The capital element in this study is considerable, because such an ice-strengthened LPG carrier is expensive to build, to the extent that the cost of the ship is the single largest item in the cost of the entire project. This is because the capital element tends to be the predominant component of fully built-up costs.

Intuitively, we know that many of the variables which determine this project's minimum required charter hire (spot charter and time charter) are subject to some type of uncertainty. By using sensitivity analysis, which is a technique that indicates exactly how much the cost per cargo unit, average costs per cu.m, capital cost and time charter will change in response to a given change in a single input variable, other things held constant. The sensitivity analysis for this LPG carrier begins with a base case situation developed by using the expected input values. The objective in this chapter is to provide potential decision maker(s) with answers to the following questions: "What happens to the cost picture if":

- The NSR insurance premium changes !
- The building price changes !
- Inflation changes !
- The financing interest rate changes !

The extended computer model was ideally suited for performing this kind of sensitivity analyses, and to see what happens with the project as the above variables change. The base case for this study is provided in appendix 2 where the expected input values related to present situation have been used. The sensitivity analysis is done only for the shallow draught case, and the results are presented in table 6B.

Insurance:

The base case insurance premium of 2.5 % gives the minimum expected time charter per day (27,000 USD/day) and a minimum required spot rate (20.29 USD/cu.m.). This input value is the lowest possible that operators can expect when operating on the NSR. When the premium increases, the response immediately affects the total operating costs and, thus, both the time charter and spot rate per tonne required. This result has an effect on both the LPG shipowner and the charterer since the owner's cost determine his minimum hire rate and the charterer's costs also determine his minimum required freight charge.

INSURANCE	TIME CHARTER PER DAY	TOT.OPER. EXPENSES.	CAP. COST PER CUBIC	REQ. LIFETIME RATE
1.0 %	24,000 USD	9.24 US/CU	6.39 US/CU	15.63 USD/CU
2.0 %	26,000 USD	10.13 US/CU	6.39 US/CU	16.52 USD/CU
2.5 %	**27,000 USD**	**10.57 US/CU**	**6.39 US/CU**	**16.96 USD/CU**
3.0 %	28,000 USD	11.02 US/CU	6.39 US/CU	17.41 USD/CU
4.0 %	30,000 USD	11.91 US/CU	6.39 US/CU	18.30 USD/CU
BUILD.PRICE				
53 MUSD	21,000 USD	9.60 US/CU	4.78 US/CU	14.38 USD/CU
63 MUSD	24,000 USD	10.09 US/CU	5.58 US/CU	15.67 USD/CU
73 MUSD	**27,000 USD**	**10.57 US/CU**	**6.39 US/CU**	**16.96 USD/CU**
83 M. USD	30,000 USD	11.06 US/CU	7.46 US/CU	18.52 USD/CU
INFLATION				
Inc. 0.0 % Cost 0.0 %	**27,000 USD**	**10.57 US/CU**	**6.39 US/CU**	**16.96 USD/CU**
Inc. 2.5 % Cost 1.5 %	29,000 USD	12.57 US/CU	6.39 US/CU	18.96 USD/CU
Inc. 3.5 % Cost 2.5 %	31,000 USD	14.14 US/CU	6.39 US/CU	20.53 USD/CU
CAPITAL COST				
Loan: 6.5 % Own cap.:4.5 %	**27,000 USD**	**10.57 US/CU**	**6.39 US/CU**	**16.96 USD/CU**
Loan: 8.5 % Own cap.: 6.5 %	29,000 USD	10.57 US/CU	7.37 US/CU	17.94 USD/CU
Loan: 10.5 % Own cap.: 8.5 %	31,000 USD	10.57 US/CU	8.35 US/CU	18.92 USD/CU

Table 6B: Sensitivity Analysis for ice breaking LPG carrier, Novy Port-Rotterdam.

Building Price:

The building price in the model (73/88 MUSD) is based on rough estimations on additional costs for additional steel and power compared to a standard open water carrier. A more accurate estimation of the price would require a detailed design of the specific vessel. Because of this uncertainty, a sensitivity analysis has been done to reflect the impact of changes in the building price. Steps of 10 million USD have been used. The result of a 10 MUSD lower building price is a significantly lower time charter (24,000 USD/day), and lower operating expenses and capital costs. The minimum transportation costs or the spot rate per cu.m is then 15.67 USD/cu.m. This is a positive signal for potential investors and charterers operating with such specially designed LPG carriers.

Inflation:

Changes in inflation do not alter the base case solution, but change the average cost per cu.m transported, which increases as the inflation for income and costs are different.

Capital Cost:

Capital costs for the hypothetical trade between Novy Port and Rotterdam is based on 1995 newbuilding prices, delivered 1997. The major issue here is not to hit the right interest rates, but to show how changes affect both the time charter and the minimum required spot rate per cu.m LPG transported. As the analysis table indicates, a two percentage increase in capital cost for both borrowed and own capital gives a significant increase in time charter per day, up to 29,000 USD and capital cost per cu.m to 7.37 USD. The last case study for borrowed and own capital related to the capital charge supports this trend in the sharp increase for both minimum time charter required and increased operating costs. Financial strength is required to invest in such special LPG carriers, especially since there are certain economies of scale in the market. And the differences in the charter rates are due to the fact that an ice-strengthened LPG vessel has capital as dominant cost element.

6.6.4 Different pricing policies

All time charter rates have so far in this study been based on lifetime costs. This will however lead to losses in the first part of the period, when the mortgages are high and profit in the later stage. If the rates are based on first year costs, securing profitable operation from the beginning, the result will change remarkably. The base case (60,000 m^3 case) had a required time charter rate of 27,000 USD per day, when the costs are based on lifetime costs. To cover the first year costs, a charter rate of more than 45,000 USD per day would be required.

6.6.5. Conclusion.

Finally, what conclusion can be drawn as to vessel profitability, on the basis of comparing fully built-up costs against required minimum time charter and spot rate per cu.m ? In appendix 2 and in the sensitivity analysis in table 6B where the calculations are done, it is possible to compare these numbers with present rates on the LPG market. As is expected, time charter rates for the ice-breaking vessels are higher than for the open water vessel, because of the higher construction costs. However, the costs per transported cargo cubic fall into a longer term price range on the LPG-market. If in addition to this, we take into account the expected lower free-on-board-prices for LPG in Northern Russia compared to the general world market average, the situation is very interesting. However, investments in such special vessels can be justified only if long-term transportation can be secured.

6.7. Comparison with Present Transportation for an Open Water LPG Carrier.

To evaluate the competitiveness of LPG from Novy Port to Rotterdam, a comparison is done with the costs for present transportation. This part concentrates on the transportation of LPG from Aden to Rotterdam, a round-trip on 9226 nautical miles. The calculations are shown in appendix 1.

6.7.1. Comparison Between Open Water and Ice Breaking LPG Carrier.

The comparison is made with transportation from Aden through Suez canal to Rotterdam. The vessels used are newbuildings of the same size as the arctic LPG carrier (75.000 cu.m). The vessels operate at a speed of 16.0 knots and are assumed to use heavy fuel oil.

The newbuilding price is 68 million USD according to latest presented newbuilding data. LPG transported is selected to be the same as in the base case in appendix 2, so that the transportation capacity is fully used. All basic assumptions are taken as the same expect the

NSR insurance premium. As it is expected for the arctic operations, this was significantly higher.

Comparison of transportation costs:

The calculations show, that the total daily running cost for the Aden- Rotterdam route is 3.04 USD/cu.m transported, that is 2.25 USD/cu.m lower than the Novy Port operations. The reason is the higher insurance premium for the NSR operation.

When comparing the voyage costs, the Aden case has two significant differences. Firstly, the consumption of bunker and lub.oil is 40 % lower than for the ice going LPG carrier (4.82 USD/cu.m vs. 2.87 USD/cu.m), even if the round-trip route is 3326 nm longer than from Novy Port. Secondly, the Suez canal charge when trading from Aden is as much as 5.46 USD/cu.m. So when comparing total voyage costs, the NSR case is 1.27 USD lower than for the Aden operation. The effect on the total operating expenses, including total shore side, is a total cost of 11.84 USD/cu.m when exporting from Arabian Gulf, and a total cost of 10.57 USD/cu.m. when transporting the LPG from Novy Port to Rotterdam.

The capital cost estimate changes the situation. The ice-strengthened LPG carrier requires a higher newbuilding price as discussed above, and this requires a first year capital cost of 9.62 USD/cu.m transported from Novy Port. This is 2.42 USD/cu.m higher than for the open water LPG carrier. The net effect on the minimum charter hire required per cu.m transported is then for the Aden case 19.04 USD, or 31.73 USD/tonne. When transporting from Novy Port, the minimum charter hire is 33.65 USD/tonne LPG transported. The situation has now changed to 1.92 USD/tonne in favour of the Aden case. However, if we look upon the lifetime costs, the two alternatives come much closer, the difference being only 0.43 USD/tonne (2.5 %). This emphasises the importance of long term operation.

The Aden operating LPG vessel gives a time charter rate of 23.000 USD per operating day. That fits into the variation of reported time charter rates for 75.000 cu.m LPG vessels (Lloyds Shipping Economist). The lowest time charter required when operating from Belyi Island with a vessel of the same size was 32.000 USD per operating day. So when comparing these two different operation routes, the Aden case is more favourable for LPG-vessel owners and charterers.

Figure 2 and the figures on page 15 in appendices 1 and 2 show the cost breakdown for the sea transportation in the two compared alternatives. It is evident that the capital costs play a major role in both cases, and an even larger role in the Novy Port alternative.

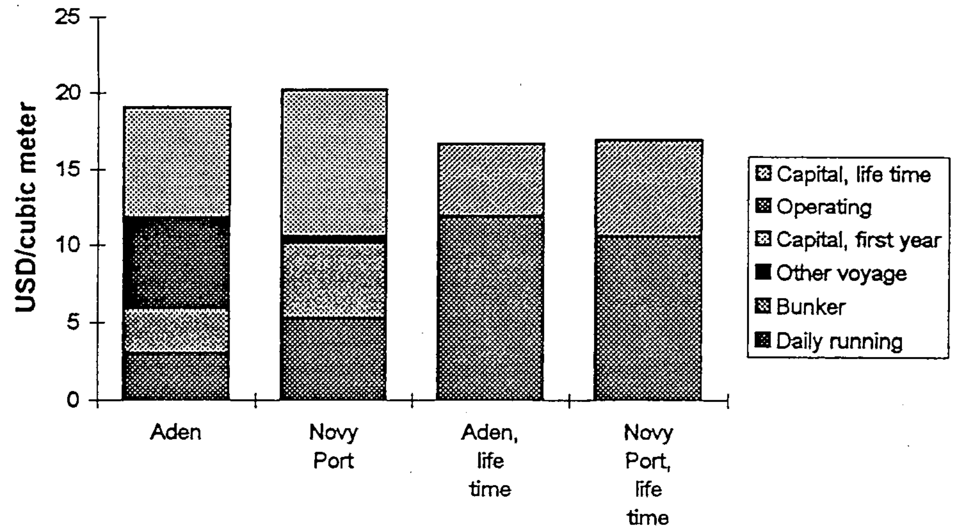

Figure 2. Cost breakdown of the two alternatives, both first-year and life-time costs

The differences are relatively significant, mainly due to the high price for the ice-breaking LPG carrier. Thus, the additional cost caused by extra fuel when operating in ice-covered waters is evened out by the high Suez Canal fee.

However, there is one issue that remains, and that is when the ice-breaking LPG carrier operates under assistance of one or more icebreakers. These two operating modes have been described more in detail in reference 11.

6.7.2. Costs of icebreaker assistance, NSR-fees

On the basis of published fees for operating along the NSR, the costs for the LPG-carrier were estimated. If we assume constant traffic with the LPG carrier with 60.000 displacement tonnes, we get a fee per trip of 195,600 USD equalling 2.60 USD/cubic metre. This is an additional cost of about 13 % to the total costs per cu.m LPG transported. If we restrict the fees to be paid for only 10 trips a year (as in the Baltic), this reduces the cost to 1.90 USD/cu.m LPG transported.

The effect on this fee (2.6 USD/cu.m) gives a total voyage cost of 13.17 USD/cu.m, increasing the required charter hire rate to 22.79 USD/ cu.m of LPG transported, or to 38.60 USD/tonne LPG. So when comparing the Novy Port and Aden operation, this extra icebreaker fee gives an additional cost of 2.32 USD/cu.m compared to the cost of operating with an open water LPG carrier. This icebreaker assistance fee has an even higher effect on the total minimum required spot rate per cu.m LPG than a building price of 83 million USD, which results in a total of 22.02 USD/cu.m.

6.7.3. Conclusion.

In the development of transportation along the NSR, one of the most interesting subjects is transportation of oil and gas from Northwest Russia. At present a large number of projects are going on to determine the feasibility of producing oil and gas in the Ob, Yamal, Tyumen and Timan-Pechora areas.

The evaluation done above is for the transportation of LPG produced in the Tyumen gas and oil fields, transported to Novy Port on the Yamal Peninsula, and then exported to Rotterdam with specially designed ice-breaking LPG carriers. This study has investigated the different subjects influencing the selection of such a seaborne transportation system. Detailed calculations together with a thorough aggregation of non published data and information, have been done, in order to produce accurate results regarding the costs for seaborne LPG transportation along the Northern Sea Route.

It can be concluded that the transportation of LPG from the Novy Port area to Rotterdam is economically competitive if long-term actions can be secured and if the free-on-board-prices can be kept below that of the competing suppliers.

Technical Feasibility:
The technical feasibility of seaborne transportation of LPG from Novy Port, across the Kara Sea to Rotterdam does not seem to be a problem. Although the ice conditions in the Kara Sea are severe, with thick level ice, heavy ridging and compressive ice, much experience has been gained about the performance of different ships in such ice conditions. Both powerful icebreakers and cargo vessels of 15.000 dwt have been transiting the sea for 20 years, which gives a good standpoint in the design of tankers and LPG carriers for the route mentioned above.

The greatest problem is caused by the shallow waters in the Ob Gulf. The larger vessel used in this study (with a draught of more than 12 metres) will have to be loaded outside the actual Ob Bay. The water depth at the mouth of the Bay limits the vessel draught to about 9 metres.

The smaller vessel can operate directly from the Novy Port area. To this area, the LPG has to be brought by shallow draught barges from the production facilities.

Economic Feasibility:
This economic calculation shows an average cost of 10.57 USD/cu.m for the transportation of LPG from Novy Port to Rotterdam by ib. 60,000 cu.m LPG carriers. The minimum required charter hire (min.req. spot rate/cu.m LPG) the LPG owner must aim for is 20.19 USD/cu.m.

Under a time charter the potential LPG owner must seek to achieve a charter hire rate which will generate sufficient revenues to cover his costs (operating, capital and target percentage rate of return). Therefore, under a time charter, the hypothetical LPG owner will require at least a TC of 27,000 USD per operating day, irrespective of the ice conditions and the trading distance involved when operating in this area.

If we take into consideration that the highest TC rate in 1994 for 75,000 cu.m LPG carriers was 900,000 USD per month, or about 29.000 USD per day, the decision to enter this special ship market will probably be neglected. The major reason is the required minimum TC rate for the ice breaking LPG carrier, with a variation between 37,000 to 50,000 USD per operating day according to the sensitivity analysis. The minimum required spot rate for the same carrier poins in the other direction, since the spot rate per tonne can vary from 20 USD/tonne and upward to as much as 80-100 USD/tonne LPG. But this argument should not be the final decision criterion for potential shipowners, the free on board prices (FOB) for LPG in the Tyumen region also have to be evaluated in this context.

Another positive factor that supports the reality of the export solution is that the LPG/FOB prices from Novy Port will maybe be significantly lower than LPG/FOB prices from the world market, which vary between 149-178 USD/tonne free on board. This means that there is a potential in the supply of LPG from Yamal/Tyumen area not only to Europe, but also to the world market. So with significantly lower LPG/FOB prices than the world average, it is possible to extend the economic transport comparison to include, in addition to the Aden-Rotterdam route, the key routes that account for a disproportionate share of all seaborne LPG movements, (see chapter 5.4 for information about the key routes).

General:

The components lacking in this comparison are the loading terminal in the Arctic alternative and production, storage and loading in the Aden/Arabian Gulf version. It should also be noted that the Arctic version is expected to include some extra costs due to uncertainty of design data. Thus, from a transportation point of view, the LPG supply from West Siberia to the European market can be competitive primarily because of the significantly low LPG/FOB prices in this area. On the other hand, when we look at the high time charter costs when operating in the NSR with LPG carriers, the transport solution changes. The ice-going LPG owner requires a minimum charter hire rate too high to compete with other operators, mainly because of the high capital and operation costs connected with such special ice-breaking LPG carriers. The high required time charter costs then increases the uncertainty and the risk when shipowners purchase such expensive technically advanced ships as ice going LPG carriers. In addition, there is no alternative use of such vessels at competitive prices so far.

The detailed calculation was done for an independent operation. This mode was selected because of the advantages this gives. It is reasonable to expect that the number of icebreakers assisting along the NSR will provide assistance frequencies that lead to remarkable lead times. When operating on a route with transit times of about one week, an additional waiting time of several days, is very difficult to accept. In a case where the traffic along the NSR grows markedly, the effect of assistance may change. If the number of icebreakers grows, or a permanent lead is created, the need for independently operating vessels can change. However, this would require large, constant traffic, which is not expected in the near future.

6.8. Market Strategies and Requirements for Operations on the NSR.

The key issue for the future market situation in northern Russia in the forthcoming years, apart from the fundamental relations of world-wide supply and demand for LPG, is which business strategies the shipping companies are going to adopt. In short, mainly one element will be crucial for long-term survival related to the NSR and this area's gas market.
The individual shipping company operating on this route must ensure good access of management and crew personnel. As the ice-breaking LPG carriers become older, the competition will increase and the earnings decline, efficient management becomes essential, both from a technical and economic point of view. The shipping companies that will succeed in establishing and maintaining the best competence for such specialised LPG transport will be in a strong position.

Unlike the conventional tanker trade, one cannot simply exit from the NSR segment by selling out and then re-enter as the market and also the political situation in the FSU recovers. In many ways the individual operators in this market may be considered different "brand names", which indicates that the market position is of much greater value than the market value of the vessels themselves. It will take a long time to obtain a strong position in the NSR market, and it is therefore crucial to maintain this position even through recessions.

Consequently in the short to intermediate term after a commercial opening of the NSR, the operators' position will depend on the financial success of the shipping companies established in this area.

The following discussion about market strategies is not limited to just analysing the potential strategy for operator(s) exporting LPG from Novy Port, but will capture all the different strategies within the different LPG markets.

Marine transportation from this area will in the future also include specially designed ice breaking vessels that can export: oil, LNG, petrochemical gases and ammonia from the West Siberian fields to the world market. Potential operators in the different product segments will therefore probably establish pools and start some kind of market co-operation. The objective of this part is to discuss one of many strategic alternatives that can occur in the shipping industry when the necessary infrastructure and shoreside facilities are established along the northern coast of West Siberia. The volume of oil and gas available for export from West Siberia is not the bottleneck for new operators in this region, but the present lack of investments in different shoreside facilities. The transport calculations estimate the necessary fleet size at three LPG carriers to handle the present LPG export from Novy Port. When discussing future market strategies in this chapter, the available volume of oil and gas is not taken as a limitation. Finally, a more thorough discussion about potential entrants, suppliers, different buyers and the internal competition operating on the NSR is considered outside the scope of this report.

6.8.1. Economics Behind Potential Strategic Choices in LPG Shipping.

The free oil, LNG and LPG fleet, where the potential NSR operators will compete, is going to be characterised by few suppliers of virtually equal tonnage. Markets with few competitors are characterised by mutual dependencies among the operators, and the name for such markets is oligopolies. Strategic games take place in this type of market, often in connection with pricing or capacity increases. The actions of one operator are bound to be met by reactions from others. Anticipations of a competitor's actions are also bound to determine the actions of individual operators. Any NSR oligopolist will attempt to position himself in such a way that his market power and profits from oil and gas trade may be extended. If the operator succeeds in this, however, the high profits can attract other NSR operators to the market, and, furthermore, the buyers of transport services, such as Rurhrgas AG of Germany (already LPG contracts with Gazprom), may have little interest in a strong consolidation on the supply side. As a result of these factors, it is important for the potential operator to pursue strategies which contribute to maintaining the oligopolistic position over time.

Oligopolies usually occur as a result of economies of scale or differentiation strategies. Such strategies in LPG shipping are very closely related. This is because cheaper and more flexible and customer-adapted transport services may be offered when the arctic LPG fleet under control exceeds a certain size.

The degree of market power in this area may, for instance, be measured according to the market share of each individual operator, but this relation is likely to change over time. Another factor influencing the market power is the degree to which the buyer of the LPG transport services may change to another operator.

In the NSR case, there are maybe only two or three successful oil and gas shipping companies operating at full scale in the future. With regard to economies of scale in LPG shipping, it is not known how large the ice strengthened LPG fleet should be. After operations start on a more commercial basis in the northern area, a strong consolidation of the existing ice-strengthened LPG fleet, through market co-operation or fully controlled fleets, will probably lead to a great proportion of freight contracts being reserved for the major operators. In order to survive over time, trading on the NSR, it seems necessary to obtain long term contracts, which for new entrants as well for small operators is going to be very difficult. To close contracts and ship oil and gas from northern Russia to other countries will as mentioned earlier require financial solidity and good access of skilled management and crew personnel already before entering this market.

6.8.2. Strategy for Future Shipping Operators on the NSR.

One way to attain a strong position in this market, a kind of oligopolistic position, is through market co-operation in the form of joint sailings, also known as establishing pools. In such joint sailings on the NSR, investments, administrative costs and the pool earnings may be distributed according to certain keys, and normally a separate marketing organisation is established for the pool, with participants representing some or all operators. This is a strategy chosen by both Kværner and NGC for their market segments, and market co-operation has been chosen many times throughout history.

The motivation behind such a potential market co-operation in this area, and some of the more important pros and cons of this organisational form will be discussed below.

Market Information.

The gathering of market information is easier with a wide, decentralised network. With many oil, LNG and LPG vessels operating in the NSR market, and a wide network of personal contacts in West Siberia's Tyumen Oblast it is easier to acquire first-hand knowledge of market developments. This factor is presumably particularly important within those segments that are less characterised by logical trading in products, e.g., the West Siberian petrochemical gas market.

The incentive to establish market co-operation would, however, not be constant over time. Establishing one's own ice-strengthened fleet is also likely to contribute to the gathering of information, together with the personal contacts which are established through a long-term presence in the West Siberian oil and gas industry. A factor which points against this line of argument is the possibility that it may be more difficult for a large, dominating shipping company to encounter open doors, as important oil and gas customers wish to reduce their dependence on few operators.

Reduced Financial and Market Risk.

By gathering several ice-strengthened LPG vessels in a fleet, for instance in order to obtain contracts, it becomes possible to reduce the financial and market risk of each participant, compared with a fully owned LPG fleet. Moreover, as far as increasing pool capacity is concerned, it may be easier, provided there is agreement, to finance a major LPG fleet expansion, since financing presumably will be made easier due to the reduced risk of each individual participant. Nor do investments weigh heavily on one party only, since investments, costs and earnings may be distributed according to separate rules.

One counter argument in this connection would be that increases in LPG capacity are often subject to disagreement, which may lead to conflicts. In such cases the flexibility of the pool will be considerably reduced.

The argument for reduced risks has been particularly prominent in bad markets, where financial difficulties have made it necessary to reduce the exposure by involving more owners. However, it does not seem as if operators in good markets have had any wish to avoid exposure at the expense of possible profits.

Reduction of risk in times of recession has been, and will be, an important incentive behind future oil and gas shipping pool organisations operating in this area..

Marketing.
This argument has to do with the advantages obtained from the strategies of differentiation and exploitation of economies of scale, which may be attained through a larger ice-strengthened LPG fleet. Both the marketing itself and the transport service offered in this area, will become easier and cheaper to offer to major charterers when quality, flexibility and cost efficiency are high and homogeneous. Regularity of the different sailing routes from the NSR increases when the fleet is large, which is a good marketing argument. Generally, a large, well-managed and stable oil and gas fleet will be a god marketing argument, and this is going to be an important factor behind future pool co-operation strategies in the Arctic area.

Products and Flexibility.
A joint sailing often contributes to the gathering of more vessels than are under the control of one individual company only, and this provides strength in contract negotiations and is an important reason behind the pool co-operation strategies followed in this special market for oil and gas shipping.

It has already been pointed out that the LPG/ammonia and ethylene fleet may to a large extent carry the same products, and charterers frequently need to transport several types of products from this Arctic area. By offering a cost-efficient transport service for different vessels trading in the NSR, this may prove to be a competitive advantage for future shipowners.

Reliable Deliveries.
Another argument for a flexible fleet within the transport of LPG in this area is the lack of knowledge among charterers about their transport needs. When demand arises it is often

inelastic with regard to time and price aspects. Consequently, if the transporter in the negotiation phase is able to make sure that the transport service is carried out within certain time and price intervals, this may be an obvious advantage. The motivation behind the employment of COA (discussed earlier), lies in this factor.

What is essential is that the LPG is transported from West Siberia. In this context, regularity in terms of sailings plays an important role. A relatively large number of ice strengthened LPG vessels may guarantee efficient transport from this area. A final argument for the increased flexibility represented by a large LPG fleet is the opportunity to accept profitable back haul cargoes. As mentioned in chapter 3, West Siberia must import gasoline, diesel fuel, kerosene jet-fuel and different petroleum products because of poor gas and oil conversion and processing facilities, and because of its inability to produce finished products. These products represent some of the back haul cargoes that will alter the transport solution and the vessel profitability calculations done in chapter 6.6 and 6.7., to a more favourable solution regarding the transportation costs. This possibility is not accounted for in my analysis, the reason is the total lack of shoreside storage, loading and discharging facilities at the ports in question for these products . In addition, there are no available building costs for such special facilities in this area today (CNIIMF has done some investigations about costs for such shore-based activities in this area, but the information is not released so far).

Internal Competition.

Market co-operation contributes strongly to increased market power and may make it possible to force an increase in freight rates, or to stabilise freight rates in bad times. It is, however, important to remember that this is rarely a situation which lasts over time. Instead the willingness to refrain from a short-term increase of contract prices in periods of high spot rates may prove to give long-term advantages for the potential pool in question, which would thus inspire more confidence among the major charterers. Likewise, market co-operation in weak markets may contribute to maintaining proper management of the LPG vessels in cases where, and if the West Siberian market normally might have forced freight rates below reasonable operational costs in the short term.

Bargaining Power.

Historically, this was frequently the motivation behind market co-operation. In the early LPG markets, the few dominant charterers had vast market power. The objective of the co-operation between the independent operators was to strengthen their market power. Over time, the number of charterers has increased, but it will still be possible for them to increase the competitive pressure among the transport operators and thus exploit bad transport markets to their own advantage.

As a concluding comment, all advantages mentioned above are possible to achieve within one individual company operating on the NSR, but at a much greater financial and market risk. It has, moreover, turned out both in LPG and other shipping segments that joint sailings organisations seem to be unstable for longer periods of time.

The choice between pool or self-controlled activities when operating on the Northern Sea Route must depend on the degree to which the different advantages of a pool co-operation are considered important, when compared to the advantages represented by a fully owned ice strengthened LPG fleet, or a combination of an oil and gas fleet.

Power of LPG customers and threats from Ships and Products.

In the LPG market, customers traditionally have had a great negotiation power, and there is a strong threat of vertical integration due to the price sensitivity of the customer demand in relation to changes in product and transport prices. The customers buying LPG from West Siberia will be major oil companies, trading houses and importers.

The threat from substitutes must also be considered in connection with the products to be carried through the NSR. There exists no other types of vessels which may be substituted for special ice-strengthened LPG vessels as far as the transportation is concerned. This is possible if shipowners convert existing LPG vessels to transport LPG in Arctic waters by reinforcing the hull and installing a diesel-electric Azipod propulsion system.

Regarding the demand for LPG from northern Russia, the biggest threat is from other energy sources and the prices of these, but also the uncertain political and economic prospects for the republics of the Former Soviet Union will influence this LPG demand. Other elements in this connection are the wishes of the importing countries to spread their supplies of LPG from different sources of production as a hedge. This may influence the LPG transport from this area both positively and negatively.

An improved balance of production within the importing regions may also lead to a lower demand for LPG transport. The development of more production plants close to the major consumer areas may also have a negative effect on LPG transport from northern Russia, and may change the trade structure. At the same time, liberalisation in international trade may limit the transport demand for LPG. It will, however, always be necessary to cover short-term imbalances in the consumer market for LPG.

6.8.3. Market Requirements and Perspectives of LPG export.

The main objective in this part is to give some minimum requirements and views about LPG export from Northern Russia. After presenting some non-confidential results from this work to Statoil, Norway's state oil company, it was possible to get their common view on this project. As an experienced operator of offshore oil and gas fields, in addition to being the world's leading operator of shuttle tankers for offshore loading, this company's requirements and specifications for such a transport solution is extremely valuable for further investigations, concerning the technical and economic feasibility of LPG export from Northern Russia.

Product quality.

Statoil defines product quality as a very important parameter, in addition to the resultant and end-user segments accessible through different LPG specifications. The following specifications define the product requirements of LPG delivered from the Tyumen area:

When the product is a LPG-mix, it should have a quality from C1 to C7 +. End-users are then defined as petrochemicals, power plants and as clean fuel. Its value is then low, or some small percentage of C5. When the quality is between C2 to C5 +, the end-use is then as petrochemical feedstock, and its value should be 80 % of naphtha.

When LPG has a chemical grade as propane and butane its quality should be at least 95 % or more related to purity. It should not contain free water, H_2O, other sulphur or metals and should have a max. 100 ppm weight of methanol.
End-users are then any petrochemical refinery (alkylation), or heating market where the customer demand has no real limitations. The value of this LPG product is then the world market price.

When the products chemical grade is less than 95 % purity, or includes any of above limitations related to pollutants, the end-user market is heating and may be some petrochemical plants. Its value is less than world market LPG prices, how much less depends on the degree “off-spec”.

The product from the Tyumen area has mostly a purity degree of 95 % or more, and in that way, the same value as the average world market prices for liquefied petrol gas.

Infrastructure.

The infrastructure on the production site will obviously determine the product quality. Investments in fractionation capacity, tank farms, etc. will have to be decided on the basis of net present value calculations. The main challenge from a marketing point of view is to secure good regularity in shipping from the Northern Sea Route.

This will probably have an impact on the production rate, which can be solved either by having adequate storage in the Novy Port area, flaring capacity on site or interruptible production capacity, e.g. re injection.

Market acceptance.

According to Statoil, the world LPG market should not have any problems in accepting the product, but this requires stable production (flaring), quality and timely/predictable shipping.

Vessel parameters.

In addition to being fit for NSR navigation, the LPG carriers should be able to load and discharge fully refrigerated LPG, either as a mixture, or as chemical grade product.
Further, the vessel should be able to heat/discharge LPG into pressurised tank facilities, but this is not an absolute requirement. The vessel should also have segregated tanks (which is normally the case), to facilitate more than one grade LPG. The ice-breaking LPG carrier should also be able to load any LPG, mixed or chemical grade, with no significant implications for the time used.

Seasonality.

If LPG exports are feasible only eight months a year through the NSR, this will tend to favour the non-heating markets world-wide. In other words, petrochemical plants will be the primary market, given a stable product chemical grade.

Conclusion.

The final comment from Statoil`s expertise should be a motivating factor for potential shipowners and operators on the Northern Sea Route: "If economic analysis indicates satisfactory returns on required investments, the project should be quite feasible. The higher upgrading of product quality, the easier will the market entry be".

Both the product quality and the vessel parameters are met in NSR operations. The infrastructure and seasonality will, however, change in the nearest future. The reason is the present capability to build ice strengthened vessels that can operate year-around in these areas, and the huge Western investments going on in the Siberian oil and gas industry today.

6.9. Conclusion.

The Northern Sea Route is the shortest sea route from North West Russia to the Far East, the American West Coast and North Europe. The NSR proceeds via the Siberian North Coast for a distance of nearly 3,000 nautical miles through ice covered waters from the North Cape to the Bering Strait. The NSR transits have been technically possible in summertime from July to October. By assistance of powerful icebreakers and extremely ice capable merchant vessels it is possible to navigate through the whole route even in wintertime. In the 90s the international commercial transit traffic has also become possible for political reasons. Technics and politics now allow this new trade. This study confirms and documents that there is also an economic feasibility of using this route. The investments made in the arctic infrastructure will be in advance as well for the international transit traffic, as for the transportation of the Siberian based natural resources.

The economies of the NSR also depend on the cost structure of trades on traditional sea routes. The canal authorities of the Suez and Panama Canals have priced the canal transit fees according to the prevailing competitive situation between them, and the longer sea routes around southern Africa and America. They may be ready for fee adjustments in the new situation. This will also change the cost comparison between an open water LPG carrier trading from the AG, and the ice going LPG carrier exporting from West Siberia. The potential of the NSR seems, however, to mean so little for the Suez and Panama Canals, that no fee adjustments were probable. But for shipowners the possible decreases in cargo volumes would initiate some countermeasures.

This study has investigated the different issues influencing seaborne LPG export from West Siberia through the NSR. And by doing so, tried to answer the question if there could be transportation at competitive prices to provide acceptable returns to producers and investors. However, one of the main issues related to the start-up of LPG export from West Siberia, is the price of this liquefied gas delivered free on board. In addition, further investigation and evaluation about storage and loading costs in Novy Port have to be done before these additional costs can be taken into consideration.

Concerning the question if western shipowners will invest in ice-strengthened tonnage to participate in such shipments, the answer remains uncertain. But, positive responses have been found, when presenting some key information from this work to major Norwegian LPG operators and shipowners. At this stage, their company names and their attitude to such transport solutions is "off the record" information. But, first of all, somebody must show that traffic with big LPG, LNG and oil carriers via the NSR isprofitable, regular and safe.

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APPENDIX 1

Economic calculations
Aden - Rotterdam, 75.000 m^3 LPG carrier

SEAKEY ICEGOING SHIP ECONOMICS

User: D.G.A.
Date: 25.9.95

SHIP IDENTIFICATION	
Project:	75 000 cu.m. ib LPG carrier, Aden-Rotterdam-Aden
Name:	North Barrier
Owner:	INSROP
Operator:	DA Management Ltd.

MAIN PARTICULARS

Deadweight:	50 000 ton	Propulsion Power:	15000 kW
Cargo Payload:	45 000 ton	Trial Speed:	16.0 knots
Gross tonnage:	37000 tonnes	Auxilliary Power:	3000 kW
Length OA:	223.0 m	Currency:	USD
Beam:	34.7 m	Building Price:	68 Millions
Draught:	12.3 m	Start of Operation:	1997
		Operating days/year	365 days
		Production	5630 cu.m/day
		Required transportation	2.05 M cu.m/ye

CARGO PAYLOAD

Type of Cargo: LPG from Arabian Gulf

Cargo Unit: cu.m.

CARGO CAPACITY

Cargo Category	Name	No of Units	Unit volume	Unit weight	Cargo volume	Cargo weight
Cargo 1:	LPG	75000	1.00	0.60	75000	45000
Cargo 2:		0	0.00	0.00	0	0
Cargo 3:		0	0.00	0.00	0	0
Cargo 4:		0	0.00	0.00	0	0
Cargo 5:		0	0.00	0.00	0	0
Cargo 6:		0	0.00	0.00	0	0
Total Cargo Payload		75000			75000	45000

ROUTE & SCHEDULE			
Route	Novy Port-Rotterdam-Novy Port		
Distance	9226 nm (roundtrip)		
Schedule	Mild	Normal	Strong
Months : September - October	61 days	61 days	61 days
Number of trips	2.37 per year	2.37 per year	2.37 per year
Time per Leg:	25.7 days	25.7 days	25.7 days
Time at Sea:	24.0 days	24.0 days	24.0 days
Average Speed:	16.0 knots	16.0 knots	16.0 knots
Month : November	30 days	30 days	30 days
Number of trips	1.17 per year	1.17 per year	1.17 per year
Time per Leg:	25.7 days	25.7 days	25.7 days
Time at Sea:	24.0 days	24.0 days	24.0 days
Average Speed:	16.0 knots	16.0 knots	16.0 knots
Month : December	31 days	31 days	31 days
Number of trips	1.21 per year	1.21 per year	1.21 per year
Time per Leg:	25.7 days	25.7 days	25.7 days
Time at Sea:	24.0 days	24.0 days	24.0 days
Average Speed:	16.0 knots	16.0 knots	16.0 knots
Month : January	31 days	31 days	31 days
Number of trips	1.21 per year	1.21 per year	1.21 per year
Time per Leg:	25.7 days	25.7 days	25.7 days
Time at Sea:	24.0 days	24.0 days	24.0 days
Average Speed:	16.0 knots	16.0 knots	16.0 knots
Month : February	28 days	28 days	28 days
Number of trips	1.09 per year	1.09 per year	1.09 per year
Time per Leg:	25.7 days	25.7 days	25.7 days
Time at Sea:	24.0 days	24.0 days	24.0 days
Average Speed:	16.0 knots	16.0 knots	16.0 knots
Month : March	31 days	31 days	31 days
Number of trips	1.21 per year	1.21 per year	1.21 per year
Time per Leg:	25.7 days	25.7 days	25.7 days
Time at Sea:	24.0 days	24.0 days	24.0 days
Average Speed:	16.0 knots	16.0 knots	16.0 knots
Month : April	30 days	30 days	30 days
Number of trips	1.17 per year	1.17 per year	1.17 per year
Time per Leg:	25.7 days	25.7 days	25.7 days
Time at Sea:	24.0 days	24.0 days	24.0 days
Average Speed:	16.0 knots	16.0 knots	16.0 knots
Month : May	31 days	31 days	31 days
Number of trips	1.21 per year	1.21 per year	1.21 per year
Time per Leg:	25.7 days	25.7 days	25.7 days
Time at Sea:	24.0 days	24.0 days	24.0 days
Average Speed:	16.0 knots	16.0 knots	16.0 knots
Month : June	30 days	30 days	30 days
Number of trips	1.17 per year	1.17 per year	1.17 per year
Time per Leg:	25.7 days	25.7 days	25.7 days
Time at Sea:	24.0 days	24.0 days	24.0 days
Average Speed:	16.0 knots	16.0 knots	16.0 knots
Month : July	31 days	31 days	31 days
Number of trips	1.21 per year	1.21 per year	1.21 per year
Time per Leg:	25.7 days	25.7 days	25.7 days
Time at Sea:	24.0 days	24.0 days	24.0 days
Average Speed:	16.0 knots	16.0 knots	16.0 knots

Month : August	31 days	31 days	31 days
Number of trips	1.21 per year	1.21 per year	1.21 per year
Time per Leg:	25.7 days	25.7 days	25.7 days
Time at Sea:	24.0 days	24.0 days	24.0 days
Average Speed:	16.0 knots	16.0 knots	16.0 knots
Total number of Trips	14.2	14.2	14.2
Operating Days:	365 days	365 days	365 days

Corrected schedule (acc. to production capacity)

Month: January			
Production	0.17 M cu.m.	0.17 M cu.m.	0.17 M cu.m.
Acc. Prod.	0.17 M cu.m.	0.17 M cu.m.	0.17 M cu.m.
Transp. cap.	0.18 M cu.m.	0.18 M cu.m.	0.18 M cu.m.
Transp.	0.17 M cu.m.	0.17 M cu.m.	0.17 M cu.m.
Number of trips/ship	1.19	1.19	1.19
Tot. transp.	0.17 M cu.m.	0.17 M cu.m.	0.17 M cu.m.
Month: February			
Production	0.16 M cu.m.	0.16 M cu.m.	0.16 M cu.m.
Acc. Prod.	0.33 M cu.m.	0.33 M cu.m.	0.33 M cu.m.
Transp. cap.	0.16 M cu.m.	0.16 M cu.m.	0.16 M cu.m.
Transp.	0.16 M cu.m.	0.16 M cu.m.	0.16 M cu.m.
Number of trips/ship	1.07	1.07	1.07
Tot. transp.	0.33 M cu.m.	0.33 M cu.m.	0.33 M cu.m.
Month: March			
Production	0.17 M cu.m.	0.17 M cu.m.	0.17 M cu.m.
Acc. Prod.	0.51 M cu.m.	0.51 M cu.m.	0.51 M cu.m.
Transp. cap.	0.18 M cu.m.	0.18 M cu.m.	0.18 M cu.m.
Transp.	0.17 M cu.m.	0.17 M cu.m.	0.17 M cu.m.
Number of trips/ship	1.19	1.19	1.19
Tot. transp.	0.51 M cu.m.	0.51 M cu.m.	0.51 M cu.m.
Month: April			
Production	0.17 M cu.m.	0.17 M cu.m.	0.17 M cu.m.
Acc. Prod.	0.68 M cu.m.	0.68 M cu.m.	0.68 M cu.m.
Transp. cap.	0.17 M cu.m.	0.17 M cu.m.	0.17 M cu.m.
Transp.	0.17 M cu.m.	0.17 M cu.m.	0.17 M cu.m.
Number of trips/ship	1.15	1.15	1.15
Tot. transp.	0.68 M cu.m.	0.68 M cu.m.	0.68 M cu.m.
Month: May			
Production	0.17 M cu.m.	0.17 M cu.m.	0.17 M cu.m.
Acc. Prod.	0.85 M cu.m.	0.85 M cu.m.	0.85 M cu.m.
Transp. cap.	0.18 M cu.m.	0.18 M cu.m.	0.18 M cu.m.
Transp.	0.17 M cu.m.	0.17 M cu.m.	0.17 M cu.m.
Number of trips/ship	1.19	1.19	1.19
Tot. transp.	0.85 M cu.m.	0.85 M cu.m.	0.85 M cu.m.
Month: June			
Production	0.17 M cu.m.	0.17 M cu.m.	0.17 M cu.m.
Acc. Prod.	1.02 M cu.m.	1.02 M cu.m.	1.02 M cu.m.
Transp. cap.	0.17 M cu.m.	0.17 M cu.m.	0.17 M cu.m.
Transp.	0.17 M cu.m.	0.17 M cu.m.	0.17 M cu.m.
Number of trips/ship	1.15	1.15	1.15
Tot. transp.	1.02 M cu.m.	1.02 M cu.m.	1.02 M cu.m.
Month: July			
Production	0.17 M cu.m.	0.17 M cu.m.	0.17 M cu.m.
Acc. Prod.	1.19 M cu.m.	1.19 M cu.m.	1.19 M cu.m.
Transp. cap.	0.18 M cu.m.	0.18 M cu.m.	0.18 M cu.m.
Transp.	0.17 M cu.m.	0.17 M cu.m.	0.17 M cu.m.
Number of trips/ship	1.19	1.19	1.19
Tot. transp.	1.19 M cu.m.	1.19 M cu.m.	1.19 M cu.m.

Month: August			
Production	0.17 M cu.m.	0.17 M cu.m.	0.17 M cu.m.
Acc. Prod.	1.37 M cu.m.	1.37 M cu.m.	1.37 M cu.m.
Transp. cap.	0.18 M cu.m.	0.18 M cu.m.	0.18 M cu.m.
Transp.	0.17 M cu.m.	0.17 M cu.m.	0.17 M cu.m.
Number of trips/ship	1.19	1.19	1.19
Tot. transp.	1.37 M cu.m.	1.37 M cu.m.	1.37 M cu.m.
Month: September - October			
Production	0.34 M cu.m.	0.34 M cu.m.	0.34 M cu.m.
Acc. Prod.	1.71 M cu.m.	1.71 M cu.m.	1.71 M cu.m.
Transp. cap.	0.35 M cu.m.	0.35 M cu.m.	0.35 M cu.m.
Transp.	0.34 M cu.m.	0.34 M cu.m.	0.34 M cu.m.
Number of trips/ship	2.34	2.34	2.34
Tot. transp.	1.71 M cu.m.	1.71 M cu.m.	1.71 M cu.m.
Month: November			
Production	0.17 M cu.m.	0.17 M cu.m.	0.17 M cu.m.
Acc. Prod.	1.88 M cu.m.	1.88 M cu.m.	1.88 M cu.m.
Transp. cap.	0.17 M cu.m.	0.17 M cu.m.	0.17 M cu.m.
Transp.	0.17 M cu.m.	0.17 M cu.m.	0.17 M cu.m.
Number of trips/ship	1.15	1.15	1.15
Tot. transp.	1.88 M cu.m.	1.88 M cu.m.	1.88 M cu.m.
Month: December			
Production	0.17 M cu.m.	0.17 M cu.m.	0.17 M cu.m.
Acc. Prod.	2.05 M cu.m.	2.05 M cu.m.	2.05 M cu.m.
Transp. cap.	0.18 M cu.m.	0.18 M cu.m.	0.18 M cu.m.
Transp.	0.17 M cu.m.	0.17 M cu.m.	0.17 M cu.m.
Number of trips/ship	1.19	1.19	1.19
Tot. transp.	2.05 M cu.m.	2.05 M cu.m.	2.05 M cu.m.
Total number of trips/ship	14.0	14.0	14.0

Maximum transported cargo	2 M cu.m.	2 M cu.m.	2 M cu.m.
Excess capacity	0.03 M cu.m.	0.03 M cu.m.	0.03 M cu.m.

SEAKEY ICEGOING SHIP ECONOMICS: Route & Schedule

OPERATION PROFILE								
Route	Novy Port-Rotterdam-Novy Port							
Distance	9226 nm (roundtrip)							

Operation Season September - October	Logged Distance	Mild winter Speed	Mild winter Hours	Normal winter Speed	Normal winter Hours	Strong winter Speed	Strong winter Hours
Operation Profile	nm	knots	h	knots	h	knots	h
Harbour			40.0		40.0		40.0
Open water, mild	9226	16.0	576.6				
Open water, normal	9226			16.0	576.6		
Open water, strong	9226					16.0	576.6
Ice, mild	0	14.5	0				
Ice, normal	0			13.8	0		
Ice strong	0					11.0	0
Total	9226	16.0	616.6	16.0	616.6	16.0	616.6

Operation Season November	Logged Distance	Mild winter Speed	Mild winter Hours	Normal winter Speed	Normal winter Hours	Strong winter Speed	Strong winter Hours
Operation Profile	nm	knots	h	knots	h	knots	h
Harbour			40.0		40.0		40.0
Open water, mild	9226	16.0	576.6				
Open water, normal	9226			16.0	576.6		
Open water, strong	9226					16.0	576.6
Ice, mild	0	13.6	0				
Ice, normal	0			12.2	0		
Ice strong	0					9.2	0
Total	9226	16.0	616.6	16.0	616.6	16.0	616.6

Operation Season December	Logged Distance	Mild winter Speed	Mild winter Hours	Normal winter Speed	Normal winter Hours	Strong winter Speed	Strong winter Hours
Operation Profile	nm	knots	h	knots	h	knots	h
Harbour			40.0		40.0		40.0
Open water,mild	9226	16.0	576.6				
Open water, normal	9226			16.0	576.6		
Open water, strong	9226					16.0	576.6
Ice, mild	0	10.0	0				
Ice, normal	0			8.4	0		
Ice strong	0					6.9	0
Total	9226	16.0	616.6	16.0	616.6	16.0	616.6

Operation Season January	Logged Distance	Mild winter Speed	Mild winter Hours	Normal winter Speed	Normal winter Hours	Strong winter Speed	Strong winter Hours
Operation Profile	nm	knots	h	knots	h	knots	h
Harbour			40.0		40.0		40.0
Open water, mild	9226	16.0	576.6				
Open water, normal	9226			16.0	576.6		
Open water, strong	9226					16.0	576.6
Ice, mild	0	8.4	0				
Ice, normal	0			7.9	0		
Ice strong	0					6.4	0
Total	9226	16.0	616.6	16.0	616.6	16.0	616.6

Operation Season February / Operation Profile	Logged Distance nm	Mild winter Speed knots	Mild winter Hours h	Normal winter Speed knots	Normal winter Hours h	Strong winter Speed knots	Strong winter Hours h
Harbour			40.0		40.0		40.0
Open water, mild	9226	16.0	576.6				
Open water, normal	9226			16.0	576.6		
Open water, strong	9226					16.0	576.6
Ice, mild	0	8.7	0				
Ice, normal	0			7.4	0		
Ice strong	0					6.3	0
Total	9226	16.0	616.6	16.0	616.6	16.0	616.6

Operation Season March / Operation Profile	Logged Distance nm	Mild winter Speed knots	Mild winter Hours h	Normal winter Speed knots	Normal winter Hours h	Strong winter Speed knots	Strong winter Hours h
Harbour			40.0		40.0		40.0
Open water, mild	9226	16.0	576.6				
Open water, normal	9226			16.0	576.6		
Open water, strong	9226					16.0	576.6
Ice, mild	0	2.3	0				
Ice, normal	0			1.7	0		
Ice strong	0					2.5	0
Total	9226	16.0	616.6	16.0	616.6	16.0	616.6

Operation Season April / Operation Profile	Logged Distance nm	Mild winter Speed knots	Mild winter Hours h	Normal winter Speed knots	Normal winter Hours h	Strong winter Speed knots	Strong winter Hours h
Harbour			40.0		40.0		40.0
Open water, mild	9226	16.0	576.6				
Open water, normal	9226			16.0	576.6		
Open water, strong	9226					16.0	576.6
Ice, mild	0	2.1	0				
Ice, normal	0			1.3	0		
Ice strong	0					1.7	0
Total	9226	16.0	616.6	16.0	616.6	16.0	616.6

Operation Season May / Operation Profile	Logged Distance nm	Mild winter Speed knots	Mild winter Hours h	Normal winter Speed knots	Normal winter Hours h	Strong winter Speed knots	Strong winter Hours h
Harbour			40.0		40.0		40.0
Open water, mild	9226	16.0	576.6				
Open water, normal	9226			16.0	576.6		
Open water, strong	9226					16.0	576.6
Ice, mild	0	2.7	0				
Ice, normal	0			1.4	0		
Ice strong	0					1.7	0
Total	9226	16.0	616.6	16.0	616.6	16.0	616.6

Operation Season June / Operation Profile	Logged Distance nm	Mild winter Speed knots	Mild winter Hours h	Normal winter Speed knots	Normal winter Hours h	Strong winter Speed knots	Strong winter Hours h
Harbour			40.0		40.0		40.0
Open water, mild	9226	16.0	576.6				
Open water, normal	9226			16.0	576.6		
Open water, strong	9226					16.0	576.6
Ice, mild	0	4.0	0				
Ice, normal	0			2.4	0		
Ice strong	0					2.7	0
Total	9226	16.0	616.6	16.0	616.6	16.0	616.6

Operation Season July	Logged Distance	Mild winter		Normal winter		Strong winter	
		Speed	Hours	Speed	Hours	Speed	Hours
Operation Profile	nm	knots	h	knots	h	knots	h
Harbour			40.0		40.0		40.0
Open water, mild	9226	16.0	576.6				
Open water, normal	9226			16.0	576.6		
Open water, strong	9226					16.0	576.6
Ice, mild	0	8.3	0				
Ice, normal	0			3.7	0		
Ice strong	0					2.7	0
Total	9226	16.0	616.6	16.0	616.6	16.0	616.6

Operation Season August	Logged Distance	Mild winter		Normal winter		Strong winter	
		Speed	Hours	Speed	Hours	Speed	Hours
Operation Profile	nm	knots	h	knots	h	knots	h
Harbour			40.0		40.0		40.0
Open water, mild	9226	16.0	576.6				
Open water, normal	9226			16.0	576.6		
Open water, strong	9226					16.0	576.6
Ice, mild	0	13.0	0				
Ice, normal	0			10.0	0		
Ice strong	0					7.1	0
Total	9226	16.0	616.6	16.0	616.6	16.0	616.6

SEAKEY ICEGOING SHIP ECONOMICS: Cargo Revenue

CARGO LOAD FACTORS AND FARES	in USD			
	Out		Back	
Category Name	LF%	Fare/Unit	LF%	Fare/Unit
LPG	98	0.0	0	0.0
Total Cargo	98	0.0	0	0.0

CARGO CARRYING CAPACITY PER YEAR						
	Mild		Normal		Strong	
Cargo Category	Per Trip	Total	Per Trip	Total	Per Trip	Total
LPG	73500	1044168	73500	1044168	73500	1044168
Total Cargo	73500	1044168	73500	1044168	73500	1044168

AVERAGE LOAD FACTORS FOR THE WHOLE YEAR	Cargo LF	49 %

CARGO FREIGHT INCOME				*1000
Cargo Category	Mild	Normal	Severe	
LPG	0	0	0	
CARGO GROSS REVENUE	0	0	0	

COST OF SALES					*1000
Reduction of Full Fare Prices		Mild	Normal	Severe	
Fare Dilution	2 %	0	0	0	
Commissions	2 %	0	0	0	
Advertising	2 %	0	0	0	
Total Cost of Sales	0 %	0	0	0	

CARGO NET REVENUE	0	0	0	

SEAKEY ICEGOING SHIP ECONOMICS: Operating Expenses

SHIP PERSONEL				Annual	Soc. cost	*1000
		Onboard	Ashore	Salary	%	Payroll
Deck and Engine	Officers	6	7	30000	50	585
	Crew	16	14	17000	50	765
Additional Crew	Repaire-special eng.	2	1	17000	50	77
Total Payroll		24	22			1427

CONSUMABLES AND SUPPLIES	Crewday USD / per	*1000
Provision	7.0	61
Hotelsupply	1.5	13
Other	0	0
Total Consumables and Supplies	8.5	74

PORT CHARGES, CANAL FEES	Ports/trip	USD/GRT	USD/Trip	*1000
Dues and Charges	1	0.2		78
Canal fees			400000.0	5592
Towing & Mooring	1	0.1		52
Total Port and Cargo Handling Costs				5721

ICEBREAKER ASSISTANCE		USD/day	day/year	h / Trip	USD/TON	USD/Hour	*1000
One assisting iceb.		45000.0	0.0	--	-		0
Broken Channel			0	0		100	0
Towing			0	0		200	0
Total							0

SHIP EXPENSES	% of ship price	*1000
Maintenance	1.0	680
Insurance	1.0	680
Other	0.5	340
Total Ship Expences		1700

SHORE SIDE EXPENSES (Excluding Advertising)	Personel No	Annual salary	Overhead % of wages	*1000
Wages	2	85000	0	170
Social cost			50	85
Office cost			100	170
Administration			100	170
TOTAL SHORE SIDE EXPENSE				595

BUNKER AND LUB. OIL							
Propulsion Machinery	Load %	Mild winter		Normal winter		Strong winter	
		Hours	MWh	Hours	MWh	Hours	MWh
FO							
Harbour	0	559.2	0	559.2	0	559.2	0
Open water	100	8060.8	120 912	8060.8	120 912	8060.8	120 912
Ice	0	0	0	0	0	0	0
Total	94	8620.0	120 912	8620.0	120 912	8620.0	120 912
g/kWh	185						
ton			22 369		22 369		22 369
LO							
g/kWh	2						
ton			242		242		242

Auxiliary Machinery	Load %	Mild winter		Normal winter		Strong winter	
		Hours	MWh	Hours	MWh	Hours	MWh
Aux. power, at sea	20	8060.8	4 836	8060.8	4 836	8060.8	4 836
Aux. power, loading	70.0	559	1 174	559	1 174	559	1 174
Aux. power, waiting	20.0	140	84	140	84	140	84
Total			6 095		6 095		6 095
FO							
g/kWh	185.0						
ton			1 128		1 128		1 128
LO							
g/kWh	2						
ton			12		12		12

Total Consumption	Price / ton	Mild winter		Normal winter		Strong winter	
		ton	USD	ton	USD	ton	USD
Propulsion	106	22369	2371080	22369	2371080	22 369	2371080
Aux Power	106	1128	119518	1128	119518.1	1128	119518.1
Boilers	106	700	74200	700	74200	700	74200
Lub.Oil	1500	254	381020	254	381019.6	254	381019.6
Total Bunker and Lubricating Oil Cost * 1000			2946		2946		2946

SEAKEY ICEGOING SHIP ECONOMICS: Profitability of Operation

SUMMARY OF OPERATING INCOME AND COSTS

Evaluated Year: 1997
Cargo carried: 1027475 cu.m.

CARGO REVENUE			*1000
	Mild	Normal	Severe
Cargo Gross Revenue	0	0	0
Cost of Sales	0.00	0.00	0
CARGO NET REVENUE	0	0	0

OPERATING EXPENSES / SHIP			*1000
		Per Cargo Unit	Total Costs
Daily Running Costs:			
Payroll		1.39	1427
Ship Expences		1.65	1700
Total Daily Running Costs		3.04	3127
Voyage Costs:			
Bunker and Lub Oil			
	Mild winter	2.87	2946
	Normal winter	2.87	2946
	Strong winter	2.87	2946
Consumables and Supplies		0.07	74
Port and Canal Charges		5.57	5721
Icebreaker Assistance		0.00	0
Total Voyage Costs	Mild winter	8.51	8741
	Normal winter	8.51	8741
	Strong winter	8.51	8741
Total Shore Side Expence		0.29	298
TOTAL OPERATING EXPENSES	Mild winter	11.84	12165
	Normal winter	11.84	12165
	Strong winter	11.84	12165
OPERATING INCOME	Mild winter	-11.84	-12200
	Normal winter	-11.84	-12200
	Strong winter	-11.84	-12200

CAPITAL COST ESTIMATE						*1000
Newbuilding Price:	68	Million USD				
	Amount	Interest		Depreciation		First Year
Financing:	% of price	%	First year	Years	Cost/year	cost
Loan 1	68	6.5	3006	20.0	2312	5320
Loan 2	32	4.5	979	20.0	1088	2070
CAPITAL COST	100		3985		3400	7400

FIRST YEAR CASH BALANCE	Per Cargo Unit	*1000
Operating Income	-11.84	-12200
First Year Capital Cost	7.20	7400
NET CASH FLOW (First Year)	-19.04	-19600

FLEET SIZE		
Amount to be transported	2.05 M cu.m.	
Required number of ships	2 (mild)	
	2 (normal)	
	2 (strong)	
AVERAGE COST /CUBIC METER	USD	16.70 per cubic meter
TIME CHARTER RATE (incl. voyage costs)	USD	47000 per operating day
TIME CHARTER RATE (no voyage costs)	USD	23000 per operating day

SEAKEY ICEGOING SHIP ECONOMICS:
Cash Flow Calculation / Ship

ANNUAL INFLATION RATES.		AVERAGE LOAD FACTOR	
Income:	0.0 %	Cargo LF:	49 %
Costs:	0.0 %		

ANNUAL CASH FLOW — MUSD

Year	1995	1996	Start Up 1997N	1998N	1999S	2000N
Income escalation:	1	1.00	1.00	1.00	1.00	1.00
Cost escalation:	1	1.00	1.00	1.00	1.00	1.00
Operating Revenue:	0	0	0	0	0	0
Operating Expense:	0	0	12	12	12	12
Operating Income:	0	0	-12	-12	-12	-12
Capital Costs						
Loan 1 Amount	0	0	46	44	42	39
Loan 1 Interest	0	0	3	3	3	3
Loan 1 Depreciation	0	0	2	2	2	2
Loan 2 Amount	0	0	22	21	20	18
Loan 2 Interest	0	0	1	1	1	1
Loan 2 Depreciation	0	0	0	0	0	0
Prepayments						
Amount	7	7				
Interest	0	0				
Total Capital Cost	0	0	6	6	6	6
Start Up Cost, etc.	2	3	5	0	0	0
Total income			0	0	0	0
Total costs	2	3	24	18	18	18
Net Cash Flow	-2	-3	-24	-18	-18	-18
ACCUMULATED COSTS	2	6	29	48	66	84
ACCUMULATED CF	-2	-6	-29	-48	-66	-84

Year	2001M	2002N	2003S	2004N	2005M	2006N
Income escalation:	1.00	1.00	1.00	1.00	1.00	1.00
Cost escalation:	1.00	1.00	1.00	1.00	1.00	1.00
Operating Revenue	0	0	0	0	0	0
Operating Expense	12	12	12	12	12	12
Operating Income	-12	-12	-12	-12	-12	-12
Capital Costs						
Loan 1 Amount	37	35	32	30	28	25
Loan 1 Interest	2	2	2	2	2	2
Loan 1 Depreciation	2	2	2	2	2	2
Loan 2 Amount	17	16	15	14	13	12
Loan 2 Interest	1	1	1	1	1	1
Loan 2 Depreciation	0	0	0	0	0	0
Total Capital Cost	6	5	5	5	5	5
Start Up Cost, etc.	0	0	0	0	0	0
Total income	0	0	0	0	0	0
Total costs	18	18	17	17	17	17
Net Cash Flow	-18	-18	-17	-17	-17	-17
ACCUMULATED COSTS	101	119	136	153	170	187
ACCUMULATED CF	-101	-119	-136	-153	-170	-187

SEAKEY ICEGOING SHIP ECONOMICS: MUSD

Cash Flow Calculation

contin.

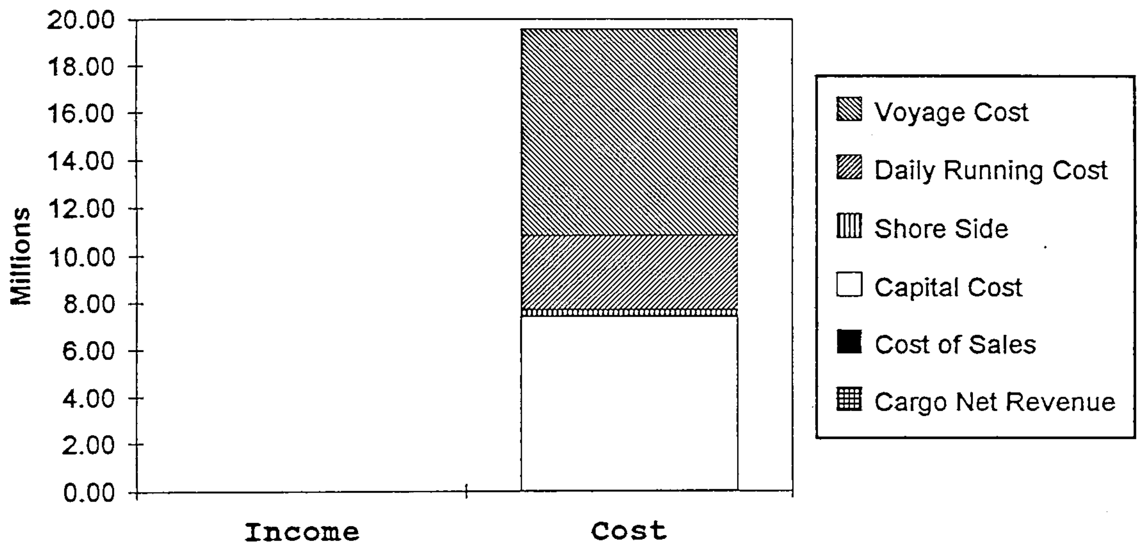
Year	2007N	2008N	2009S	2010N	2010M	2011N
Income escalation:	1.00	1.00	1.00	1.00	1.00	1.00
Cost escalation:	1.00	1.00	1.00	1.00	1.00	1.00
Operating Revenue	0	0	0	0	0	0
Operating Expense	12	12	12	12	12	12
Operating Income	-12	-12	-12	-12	-12	-12
Capital Costs						
Loan 1 Amount	23	21	18	16	14	12
Loan 1 Interest	2	1	1	1	1	1
Loan 1 Depreciation	2	2	2	2	2	2
Loan 2 Amount	11	10	9	8	7	5
Loan 2 Interest	0	0	0	0	0	0
Loan 2 Depreciation	0	0	0	0	0	0
Total Capital Cost	4	4	4	4	4	3
Start Up Cost, etc.	0	0	0	0	0	0
Total income	0	0	0	0	0	0
Total costs	17	16	16	16	16	16
Net Cash Flow	-17	-16	-16	-16	-16	-16
ACCUMULATED COSTS	204	220	236	252	268	283
ACCUMULATED CF	-204	-220	-236	-252	-268	-283

Year	2012S	2013N	2014M	2015N	2016N	2017N
Income escalation:	1.00	1.00	1.00	1.00	1.00	1.00
Cost escalation:	1.00	1.00	1.00	1.00	1.00	1.00
Operating Revenue:	0	0	0	0	0	0
Operating Expense:	12	12	12	12	12	12
Operating Income:	-12	-12	-12	-12	-12	-12
Capital Costs						
Loan 1 Amount	9	7	5	2	0	0
Loan 1 Interest	1	0	0	0	0	0
Loan 1 Depreciation	2	2	2	2	0	0
Loan 2 Amount	4	3	2	1	0	0
Loan 2 Interest	0	0	0	0	0	0
Loan 2 Depreciation	0	0	0	0	0	0
Prepayments						
Amount	0	0				
Interest	0	0				
Total Capital Cost	3	3	3	3	0	0
Start Up Cost, etc.	0	0	0	0	0	0
Total income	0	0	0	0	0	0
Total costs	15	15	15	15	12	12
Net Cash Flow	-15	-15	-15	-15	-12	-12
ACCUMULATED COSTS	298	314	329	343	355	368
ACCUMULATED CF	-298	-314	-329	-343	-355	-368

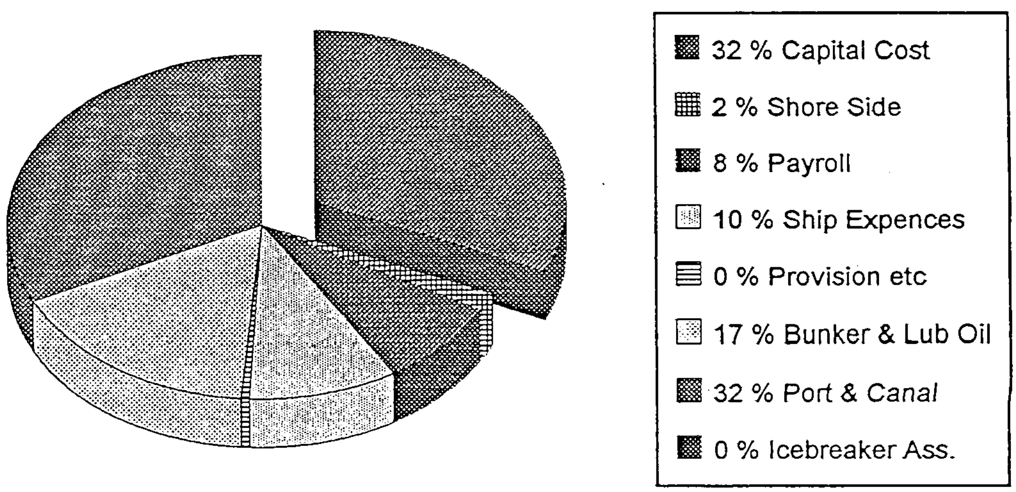
SEAKEY ICEGOING SHIP ECONOMICS

Project: 75 000 cu.m. ib LPG carrier, Aden-Rotterdam-Aden
Name: North Barrier
Currency USD

FIRST YEAR (NORMAL) INCOME AND COST STRUCTURES



COST STRUCTURE



APPENDIX 2

Economic calculations
Novy Port - Rotterdam, 60.000 m^3 LPG carrier

SEAKEY ICEGOING SHIP ECONOMICS

User: D.G.A.
Date: 25.9.95

SHIP IDENTIFICATION	
Project:	60 000 cu.m. ib LPG carrier, Novy Port-Rotterdam-Novy Port.
Name:	North Barrier
Owner:	INSROP
Operator:	DA Management Ltd.

MAIN PARTICULARS			
Deadweight:	40 000 ton	Propulsion Power:	30000 kW
Cargo Payload:	36 000 ton	Trial Speed:	16.0 knots
Gross tonnage:	30000 tonnes	Auxilliary Power:	3000 kW
Length OA:	280.0 m	Currency:	USD
Beam:	37.0 m	Building Price:	73 Millions
Draught:	9.0 m	Start of Operation:	1997
		Operating days/year	365 days
		Production	6750 cu.m/day
		Required transportation	2.46 M cu.m/ye

CARGO PAYLOAD

Type of Cargo: LPG from West Siberia

Cargo Unit: cu.m.

CARGO CAPACITY

Cargo Category	Name	No of Units	Unit volume	Unit weight	Cargo volume	Cargo weight
Cargo 1:	LPG	60000	1.00	0.60	60000	36000
Cargo 2:		0	0.00	0.00	0	0
Cargo 3:		0	0.00	0.00	0	0
Cargo 4:		0	0.00	0.00	0	0
Cargo 5:		0	0.00	0.00	0	0
Cargo 6:		0	0.00	0.00	0	0
Total Cargo Payload		60000			60000	36000

ROUTE & SCHEDULE			
Route	Novy Port-Rotterdam-Novy Port		
Distance	5900 nm (roundtrip)		
Schedule	Mild	Normal	Strong
Months : September - October	61 days	61 days	61 days
Number of trips	3.57 per year	3.54 per year	3.43 per year
Time per Leg:	17.1 days	17.2 days	17.8 days
Time at Sea:	15.4 days	15.5 days	16.1 days
Average Speed:	16.0 knots	15.8 knots	15.3 knots
Month : November	30 days	30 days	30 days
Number of trips	1.74 per year	1.65 per year	1.49 per year
Time per Leg:	17.3 days	18.2 days	20.2 days
Time at Sea:	15.6 days	16.5 days	18.5 days
Average Speed:	15.8 knots	14.9 knots	13.3 knots
Month : December	31 days	31 days	31 days
Number of trips	1.60 per year	1.48 per year	1.34 per year
Time per Leg:	19.4 days	21.0 days	23.2 days
Time at Sea:	17.8 days	19.3 days	21.5 days
Average Speed:	13.8 knots	12.7 knots	11.4 knots
Month : January	31 days	31 days	31 days
Number of trips	1.49 per year	1.41 per year	1.27 per year
Time per Leg:	20.9 days	21.9 days	24.4 days
Time at Sea:	19.2 days	20.3 days	22.8 days
Average Speed:	12.8 knots	12.1 knots	10.8 knots
Month : February	28 days	28 days	28 days
Number of trips	1.35 per year	1.23 per year	1.10 per year
Time per Leg:	20.8 days	22.7 days	25.5 days
Time at Sea:	19.1 days	21.1 days	23.8 days
Average Speed:	12.9 knots	11.7 knots	10.3 knots
Month : March	31 days	31 days	31 days
Number of trips	0.69 per year	0.54 per year	0.69 per year
Time per Leg:	44.9 days	57.4 days	45.1 days
Time at Sea:	43.2 days	55.8 days	43.4 days
Average Speed:	5.7 knots	4.4 knots	5.7 knots
Month : April	30 days	30 days	30 days
Number of trips	0.62 per year	0.41 per year	0.48 per year
Time per Leg:	48.7 days	72.5 days	62.3 days
Time at Sea:	47.1 days	70.8 days	60.6 days
Average Speed:	5.2 knots	3.5 knots	4.1 knots
Month : May	31 days	31 days	31 days
Number of trips	0.79 per year	0.46 per year	0.51 per year
Time per Leg:	39.0 days	66.9 days	61.0 days
Time at Sea:	37.4 days	65.2 days	59.3 days
Average Speed:	6.6 knots	3.8 knots	4.1 knots
Month : June	30 days	30 days	30 days
Number of trips	1.11 per year	0.73 per year	0.72 per year
Time per Leg:	27.1 days	41.1 days	41.6 days
Time at Sea:	25.4 days	39.4 days	40.0 days
Average Speed:	9.7 knots	6.2 knots	6.2 knots
Month : July	31 days	31 days	31 days
Number of trips	1.70 per year	1.14 per year	0.80 per year
Time per Leg:	18.3 days	27.1 days	38.5 days
Time at Sea:	16.6 days	25.5 days	36.9 days
Average Speed:	14.8 knots	9.7 knots	6.7 knots

Month : August	31 days	31 days	31 days
Number of trips	1.81 per year	1.74 per year	1.51 per year
Time per Leg:	17.1 days	17.8 days	20.5 days
Time at Sea:	15.4 days	16.2 days	18.8 days
Average Speed:	15.9 knots	15.2 knots	13.1 knots
Total number of Trips	16.5	14.3	13.3
Operating Days:	365 days	365 days	365 days

Corrected schedule (acc. to production capacity)

Month: January			
Production	0.21 M cu.m.	0.21 M cu.m.	0.21 M cu.m.
Acc. Prod.	0.21 M cu.m.	0.21 M cu.m.	0.21 M cu.m.
Transp. cap.	0.26 M cu.m.	0.25 M cu.m.	0.22 M cu.m.
Transp.	0.21 M cu.m.	0.21 M cu.m.	0.21 M cu.m.
Number of trips/ship	1.19	1.19	1.19
Tot. transp.	0.21 M cu.m.	0.21 M cu.m.	0.21 M cu.m.
Month: February			
Production	0.19 M cu.m.	0.19 M cu.m.	0.19 M cu.m.
Acc. Prod.	0.40 M cu.m.	0.40 M cu.m.	0.40 M cu.m.
Transp. cap.	0.24 M cu.m.	0.22 M cu.m.	0.19 M cu.m.
Transp.	0.19 M cu.m.	0.19 M cu.m.	0.19 M cu.m.
Number of trips/ship	1.07	1.07	1.07
Tot. transp.	0.40 M cu.m.	0.40 M cu.m.	0.40 M cu.m.
Month: March			
Production	0.21 M cu.m.	0.21 M cu.m.	0.21 M cu.m.
Acc. Prod.	0.61 M cu.m.	0.61 M cu.m.	0.61 M cu.m.
Transp. cap.	0.12 M cu.m.	0.10 M cu.m.	0.12 M cu.m.
Transp.	0.12 M cu.m.	0.10 M cu.m.	0.12 M cu.m.
Number of trips/ship	0.69	0.54	0.69
Tot. transp.	0.52 M cu.m.	0.49 M cu.m.	0.52 M cu.m.
Month: April			
Production	0.20 M cu.m.	0.20 M cu.m.	0.20 M cu.m.
Acc. Prod.	0.81 M cu.m.	0.81 M cu.m.	0.81 M cu.m.
Transp. cap.	0.11 M cu.m.	0.07 M cu.m.	0.08 M cu.m.
Transp.	0.11 M cu.m.	0.07 M cu.m.	0.08 M cu.m.
Number of trips/ship	0.62	0.41	0.48
Tot. transp.	0.63 M cu.m.	0.57 M cu.m.	0.60 M cu.m.
Month: May			
Production	0.21 M cu.m.	0.21 M cu.m.	0.21 M cu.m.
Acc. Prod.	1.02 M cu.m.	1.02 M cu.m.	1.02 M cu.m.
Transp. cap.	0.14 M cu.m.	0.08 M cu.m.	0.09 M cu.m.
Transp.	0.14 M cu.m.	0.08 M cu.m.	0.09 M cu.m.
Number of trips/ship	0.79	0.46	0.51
Tot. transp.	0.77 M cu.m.	0.65 M cu.m.	0.69 M cu.m.
Month: June			
Production	0.20 M cu.m.	0.20 M cu.m.	0.20 M cu.m.
Acc. Prod.	1.22 M cu.m.	1.22 M cu.m.	1.22 M cu.m.
Transp. cap.	0.20 M cu.m.	0.13 M cu.m.	0.13 M cu.m.
Transp.	0.20 M cu.m.	0.13 M cu.m.	0.13 M cu.m.
Number of trips/ship	1.11	0.73	0.72
Tot. transp.	0.96 M cu.m.	0.78 M cu.m.	0.82 M cu.m.
Month: July			
Production	0.21 M cu.m.	0.21 M cu.m.	0.21 M cu.m.
Acc. Prod.	1.43 M cu.m.	1.43 M cu.m.	1.43 M cu.m.
Transp. cap.	0.30 M cu.m.	0.20 M cu.m.	0.14 M cu.m.
Transp.	0.30 M cu.m.	0.20 M cu.m.	0.14 M cu.m.
Number of trips/ship	1.70	1.14	0.80
Tot. transp.	1.26 M cu.m.	0.98 M cu.m.	0.96 M cu.m.

Month: August			
Production	0.21 M cu.m.	0.21 M cu.m.	0.21 M cu.m.
Acc. Prod.	1.64 M cu.m.	1.64 M cu.m.	1.64 M cu.m.
Transp. cap.	0.32 M cu.m.	0.31 M cu.m.	0.27 M cu.m.
Transp.	0.32 M cu.m.	0.31 M cu.m.	0.27 M cu.m.
Number of trips/ship	1.81	1.74	1.51
Tot. transp.	1.58 M cu.m.	1.29 M cu.m.	1.23 M cu.m.
Month: September - October			
Production	0.41 M cu.m.	0.41 M cu.m.	0.41 M cu.m.
Acc. Prod.	2.05 M cu.m.	2.05 M cu.m.	2.05 M cu.m.
Transp. cap.	0.63 M cu.m.	0.63 M cu.m.	0.61 M cu.m.
Transp.	0.47 M cu.m.	0.63 M cu.m.	0.61 M cu.m.
Number of trips/ship	2.66	3.54	3.43
Tot. transp.	2.05 M cu.m.	1.91 M cu.m.	1.84 M cu.m.
Month: November			
Production	0.20 M cu.m.	0.20 M cu.m.	0.20 M cu.m.
Acc. Prod.	2.25 M cu.m.	2.25 M cu.m.	2.25 M cu.m.
Transp. cap.	0.31 M cu.m.	0.29 M cu.m.	0.26 M cu.m.
Transp.	0.20 M cu.m.	0.29 M cu.m.	0.26 M cu.m.
Number of trips/ship	1.15	1.65	1.49
Tot. transp.	2.25 M cu.m.	2.20 M cu.m.	2.10 M cu.m.
Month: December			
Production	0.21 M cu.m.	0.21 M cu.m.	0.21 M cu.m.
Acc. Prod.	2.46 M cu.m.	2.46 M cu.m.	2.46 M cu.m.
Transp. cap.	0.28 M cu.m.	0.26 M cu.m.	0.24 M cu.m.
Transp.	0.21 M cu.m.	0.26 M cu.m.	0.24 M cu.m.
Number of trips/ship	1.19	1.48	1.34
Tot. transp.	2.46 M cu.m.	2.46 M cu.m.	2.33 M cu.m.
Total number of trips/ship	14.0	14.0	13.2

Maximum transported cargo	2.90 M cu.m.	2.53 M cu.m.	2.35 M cu.m.
Excess capacity	0.44 M cu.m.	0.07 M cu.m.	0.02 M cu.m.

SEAKEY ICEGOING SHIP ECONOMICS: Route & Schedule

OPERATION PROFILE

Route Novy Port-Rotterdam-Novy Port
Distance 5900 nm (roundtrip)

Operation Season	Logged	Mild winter		Normal winter		Strong winter	
September - October	Distance	Speed	Hours	Speed	Hours	Speed	Hours
Operation Profile	nm	knots	h	knots	h	knots	h
Harbour			40.0		40.0		40.0
Open water, mild	5738	16.0	358.6				
Open water, normal	5473			16.0	342.1		
Open water, strong	5265					16.0	329.1
Ice, mild	162	14.5	11.2				
Ice, normal	427			13.8	30.9		
Ice strong	635					11.0	57.7
Total	5900	16.0	409.8	15.8	413.0	15.3	426.8

Operation Season	Logged	Mild winter		Normal winter		Strong winter	
November	Distance	Speed	Hours	Speed	Hours	Speed	Hours
Operation Profile	nm	knots	h	knots	h	knots	h
Harbour			40.0		40.0		40.0
Open water, mild	5418	16.0	338.6				
Open water, normal	4490			16.0	280.6		
Open water, strong	4260					16.0	266.3
Ice, mild	482	13.6	35.4				
Ice, normal	1410			12.2	115.6		
Ice strong	1634					9.2	177.6
Total	5900	15.8	414.1	14.9	436.2	13.3	483.9

Operation Season	Logged	Mild winter		Normal winter		Strong winter	
December	Distance	Speed	Hours	Speed	Hours	Speed	Hours
Operation Profile	nm	knots	h	knots	h	knots	h
Harbour			40.0		40.0		40.0
Open water,mild	4489	16.0	280.6				
Open water, normal	4226			16.0	264.1		
Open water, strong	4102					16.0	256.4
Ice, mild	1411	9.7	145.5				
Ice, normal	1674			8.4	199.3		
Ice strong	1798					6.9	260.6
Total	5900	13.8	466.0	12.7	503.4	11.4	557.0

Operation Season	Logged	Mild winter		Normal winter		Strong winter	
January	Distance	Speed	Hours	Speed	Hours	Speed	Hours
Operation Profile	nm	knots	h	knots	h	knots	h
Harbour			40.0		40.0		40.0
Open water, mild	4270	16.0	266.9				
Open water, normal	4063			16.0	253.9		
Open water, strong	4003					16.0	250.2
Ice, mild	1630	8.4	194.0				
Ice, normal	1837			7.9	232.5		
Ice strong	1897					6.4	296.4
Total	5900	12.8	500.9	12.1	526.5	10.8	586.6

Operation Season February	Logged Distance	Mild winter		Normal winter		Strong winter	
Operation Profile	nm	Speed knots	Hours h	Speed knots	Hours h	Speed knots	Hours h
Harbour			40.0		40.0		40.0
Open water, mild	4188	16.0	261.8				
Open water, normal	4021			16.0	251.3		
Open water, strong	3790					16.0	236.9
Ice, mild	1712	8.7	196.8				
Ice, normal	1879			7.4	253.9		
Ice strong	2110					6.3	334.9
Total	5900	12.9	498.5	11.7	545.2	10.3	611.8

Operation Season March	Logged Distance	Mild winter		Normal winter		Strong winter	
Operation Profile	nm	Speed knots	Hours h	Speed knots	Hours h	Speed knots	Hours h
Harbour			40.0		40.0		40.0
Open water, mild	4104	16.0	256.5				
Open water, normal	4056			16.0	253.5		
Open water, strong	3906					16.0	244.1
Ice, mild	1796	2.3	780.9				
Ice, normal	1844			1.7	1084.7		
Ice strong	1994					2.5	797.6
Total	5900	5.7	1077.4	4.4	1378.2	5.7	1081.7

Operation Season April	Logged Distance	Mild winter		Normal winter		Strong winter	
Operation Profile	nm	Speed knots	Hours h	Speed knots	Hours h	Speed knots	Hours h
Harbour			40.0		40.0		40.0
Open water, mild	4061	16.0	253.8				
Open water, normal	4016			16.0	251.0		
Open water, strong	3834					16.0	239.6
Ice, mild	1839	2.1	875.7				
Ice, normal	1884			1.3	1449.2		
Ice strong	2066					1.7	1215.3
Total	5900	5.2	1169.5	3.5	1740.2	4.1	1494.9

Operation Season May	Logged Distance	Mild winter		Normal winter		Strong winter	
Operation Profile	nm	Speed knots	Hours h	Speed knots	Hours h	Speed knots	Hours h
Harbour			40.0		40.0		40.0
Open water, mild	4185	16.0	261.6				
Open water, normal	4064			16.0	254.0		
Open water, strong	3895					16.0	243.4
Ice, mild	1715	2.7	635.2				
Ice, normal	1836			1.4	1311.4		
Ice strong	2005					1.7	1179.4
Total	5900	6.6	936.7	3.8	1605.4	4.1	1462.8

Operation Season June	Logged Distance	Mild winter		Normal winter		Strong winter	
Operation Profile	nm	Speed knots	Hours h	Speed knots	Hours h	Speed knots	Hours h
Harbour			40.0		40.0		40.0
Open water, mild	4614	16.0	288.4				
Open water, normal	4272			16.0	267.0		
Open water, strong	3983					16.0	248.9
Ice, mild	1286	4.0	321.5				
Ice, normal	1628			2.4	678.3		
Ice strong	1917					2.7	710.0
Total	5900	9.7	649.9	6.2	985.3	6.2	998.9

Operation Season July Operation Profile	Logged Distance nm	Mild winter Speed knots	Mild winter Hours h	Normal winter Speed knots	Normal winter Hours h	Strong winter Speed knots	Strong winter Hours h
Harbour			40.0		40.0		40.0
Open water, mild	5381	16.0	336.3				
Open water, normal	4738			16.0	296.1		
Open water, strong	4223					16.0	263.9
Ice, mild	519	8.3	62.5				
Ice, normal	1165			3.7	314.9		
Ice strong	1677					2.7	621.1
Total	5900	14.8	438.8	9.7	651.0	6.7	925.0

Operation Season August Operation Profile	Logged Distance nm	Mild winter Speed knots	Mild winter Hours h	Normal winter Speed knots	Normal winter Hours h	Strong winter Speed knots	Strong winter Hours h
Harbour			40.0		40.0		40.0
Open water, mild	5792	16.0	362.0				
Open water, normal	5392			16.0	337.0		
Open water, strong	4843					16.0	302.7
Ice, mild	108	13.0	8.3				
Ice, normal	508			10.0	50.8		
Ice strong	1057					7.1	148.9
Total	5900	15.9	410.3	15.2	427.8	13.1	491.6

SEAKEY ICEGOING SHIP ECONOMICS: Cargo Revenue

CARGO LOAD FACTORS AND FARES	in USD			
	Out		Back	
Category Name	LF%	Fare/Unit	LF%	Fare/Unit
LPG	98	0.0	0	0.0
Total Cargo	98	0.0	0	0.0

CARGO CARRYING CAPACITY PER YEAR						
	Mild		Normal		Strong	
Cargo Category	Per Trip	Total	Per Trip	Total	Per Trip	Total
LPG	58800	967732	58800	843704	58800	784245
Total Cargo	58800	967732	58800	843704	58800	784245

AVERAGE LOAD FACTORS FOR THE WHOLE YEAR	Cargo LF	49 %

CARGO FREIGHT INCOME				*1000
Cargo Category	Mild	Normal	Severe	
LPG	0	0	0	
CARGO GROSS REVENUE	0	0	0	

COST OF SALES					*1000
Reduction of Full Fare Prices		Mild	Normal	Severe	
Fare Dilution	2 %	0	0	0	
Commissions	2 %	0	0	0	
Advertising	2 %	0	0	0	
Total Cost of Sales	0 %	0	0	0	

CARGO NET REVENUE	0	0	0	

SEAKEY ICEGOING SHIP ECONOMICS: Operating Expenses

SHIP PERSONEL		Onboard	Ashore	Annual Salary	Soc. cost %	Payroll *1000
Deck and Engine	Officers	6	7	30000	50	585
	Crew	16	14	17000	50	765
Additional Crew	Repaire-special eng.	2	1	17000	50	77
Total Payroll		24	22			1427

CONSUMABLES AND SUPPLIES	Crewday USD / per	*1000
Provision	7.0	61
Hotelsupply	1.5	13
Other	0	0
Total Consumables and Supplies	8.5	74

PORT CHARGES, CANAL FEES	Ports/trip	USD/GRT	USD/Trip	*1000
Dues and Charges	1	0.2		63
Canal fees			0.0	0
Towing & Mooring	1	0.1		42
Total Port and Cargo Handling Costs				105

ICEBREAKER ASSISTANCE		USD/day	day/year	h / Trip	USD/TON	USD/Hour	*1000
One assisting iceb.		45000.0	0.0	--	-		0
Broken Channel			0	0		100	0
Towing			0	0		200	0
Total							0

SHIP EXPENSES	% of ship price	*1000
Maintenance	1.0	730
Insurance	2.5	1825
Other	0.5	365
Total Ship Expences		2920

SHORE SIDE EXPENSES (Excluding Advertising)	Personel No	Annual salary	Overhead % of wages	*1000
Wages	2	85000	0	170
Social cost			50	85
Office cost			100	170
Administration			100	170
TOTAL SHORE SIDE EXPENSE				595

BUNKER AND LUB. OIL							
Propulsion		Mild winter		Normal winter		Strong winter	
Machinery	Load %	Hours	MWh	Hours	MWh	Hours	MWh
FO							
Harbour	0	558.7	0	558.4	0	529.1	0
Open water	40	4359.0	52 308	4114.6	49 375	3675.0	44 100
Ice	100	2744.1	82 322	3879.7	116 390	4491.2	134 736
Total	59	7661.7	134 630	8552.7	165 765	8695.3	178 836
g/kWh	185						
ton			24 907		30 666		33 085
LO							
g/kWh	2						
ton			269		332		358

Auxiliary		Mild winter		Normal winter		Strong winter	
Machinery	Load %	Hours	MWh	Hours	MWh	Hours	MWh
Aux. power, at sea	20	7103.1	4 262	7994.3	4 797	8166.2	4 900
Aux. power, loading	70.0	559	1 173	558	1 173	529	1 111
Aux. power, waiting	20.0	1098	659	207	124	65	39
Total			6 094		6 094		6 050
FO							
g/kWh	185.0						
ton			1 127		1 127		1 119
LO							
g/kWh	2						
ton			12		12		12

Total Consumption	Price / ton	Mild winter		Normal winter		Strong winter	
		ton	USD	ton	USD	ton	USD
Propulsion	106	24907	2640097	30666	3250649	33 085	3506978
Aux Power	106	1127	119504	1127	119496.3	1119	118634.7
Boilers	106	700	74200	700	74200	700	74200
Lub.Oil	1500	281	422172	344	515575.5	370	554657.7
Total Bunker and Lubricating Oil Cost * 1000			3256		3960		4254

SEAKEY ICEGOING SHIP ECONOMICS:
Profitability of Operation

SUMMARY OF OPERATING INCOME AND COSTS

Evaluated Year: 1997
Cargo carried: 821250 cu.m.

CARGO REVENUE			*1000
	Mild	Normal	Severe
Cargo Gross Revenue	0	0	0
Cost of Sales	0.00	0.00	0
CARGO NET REVENUE	0	0	0

OPERATING EXPENSES / SHIP		*1000
	Per Cargo Unit	Total Costs
Daily Running Costs:		
Payroll	1.74	1427
Ship Expences	3.56	2920
Total Daily Running Costs	5.29	4347
Voyage Costs:		
Bunker and Lub Oil		
Mild winter	3.96	3256
Normal winter	4.82	3960
Strong winter	5.18	4254
Consumables and Supplies	0.09	74
Port and Canal Charges	0.13	105
Icebreaker Assistance	0.00	0
Total Voyage Costs Mild winter	4.18	3435
Normal winter	5.04	4139
Strong winter	5.40	4434
Total Shore Side Expence	0.24	198
TOTAL OPERATING EXPENSES Mild winter	9.72	7980
Normal winter	10.57	8684
Strong winter	10.93	8978
OPERATING INCOME Mild winter	-9.72	-8000
Normal winter	-10.57	-8700
Strong winter	-10.93	-9000

CAPITAL COST ESTIMATE						*1000
Newbuilding Price: 73 Million USD						
	Amount	Interest		Depreciation		First Year
Financing:	% of price	%	First year	Years	Cost/year	cost
Loan 1	68	6.5	3227	20.0	2482	5710
Loan 2	32	4.5	1051	20.0	1168	2220
CAPITAL COST	100		4278		3650	7900

FIRST YEAR CASH BALANCE	Per Cargo Unit	*1000
Operating Income	-10.57	-8700
First Year Capital Cost	9.62	7900
NET CASH FLOW (First Year)	-20.19	-16600

FLEET SIZE		
Amount to be transported	2.46 M cu.m.	
Required number of ships	3 (mild)	
	3 (normal)	
	4 (strong)	
AVERAGE COST / CUBIC METER	USD	16.96 per cubic meter
TIME CHARTER RATE (incl. voyage costs)	USD	38000 per operating day
TIME CHARTER RATE (no voyage costs)	USD	27000 per operating day

SEAKEY ICEGOING SHIP ECONOMICS:

Cash Flow Calculation

ANNUAL INFLATION RATES		AVERAGE LOAD FACTOR	
Income:	0.00 %	Cargo LF:	49 %
Costs:	0 %		

ANNUAL CASH FLOW — MUSD

Year	1995	1996	Start Up 1997N	1998N	1999S	2000N
Income escalation:	1	1.00	1.00	1.00	1.00	1.00
Cost escalation:	1	1.00	1.00	1.00	1.00	1.00
Operating Revenue:	0	0	0	0	0	0
Operating Expense:	0	0	9	9	9	9
Operating Income:	0	0	-9	-9	-9	-9
Capital Costs						
Loan 1 Amount	0	0	50	47	45	42
Loan 1 Interest	0	0	3	3	3	3
Loan 1 Depreciation	0	0	2	2	2	2
Loan 2 Amount	0	0	23	22	21	20
Loan 2 Interest	0	0	1	1	1	1
Loan 2 Depreciation	0	0	0	0	0	0
Prepayments						
Amount	7	7				
Interest	0	0				
Total Capital Cost	0	0	7	7	6	6
Start Up Cost, etc.	2	3	5	0	0	0
Total income			0	0	0	0
Total costs	2	3	20	15	15	15
Net Cash Flow	-2	-3	-20	-15	-15	-15
ACCUMULATED COSTS	2	6	26	42	57	72
ACCUMULATED CF	-2	-6	-26	-42	-57	-72

Year	2001M	2002N	2003S	2004N	2005M	2006N
Income escalation:	1.00	1.00	1.00	1.00	1.00	1.00
Cost escalation:	1.00	1.00	1.00	1.00	1.00	1.00
Operating Revenue	0	0	0	0	0	0
Operating Expense	8	9	9	9	8	9
Operating Income	-8	-9	-9	-9	-8	-9
Capital Costs						
Loan 1 Amount	40	37	35	32	30	27
Loan 1 Interest	3	2	2	2	2	2
Loan 1 Depreciation	2	2	2	2	2	2
Loan 2 Amount	19	18	16	15	14	13
Loan 2 Interest	1	1	1	1	1	1
Loan 2 Depreciation	0	0	0	0	0	0
Total Capital Cost	6	6	6	5	5	5
Start Up Cost, etc.	0	0	0	0	0	0
Total income	0	0	0	0	0	0
Total costs	14	14	15	14	13	14
Net Cash Flow	-14	-14	-15	-14	-13	-14
ACCUMULATED COSTS	86	100	115	129	142	155
ACCUMULATED CF	-86	-100	-115	-129	-142	-155

SEAKEY ICEGOING SHIP ECONOMICS: MUSD

Cash Flow Calculation

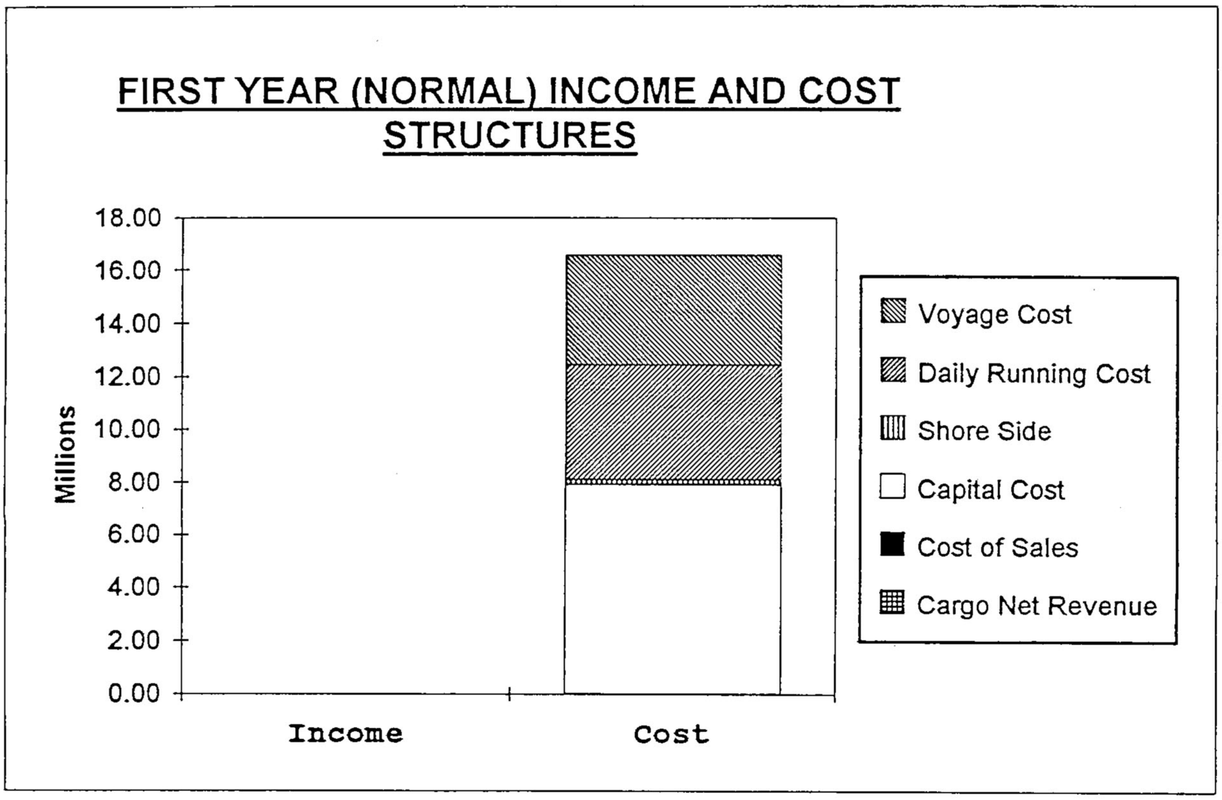
contin.

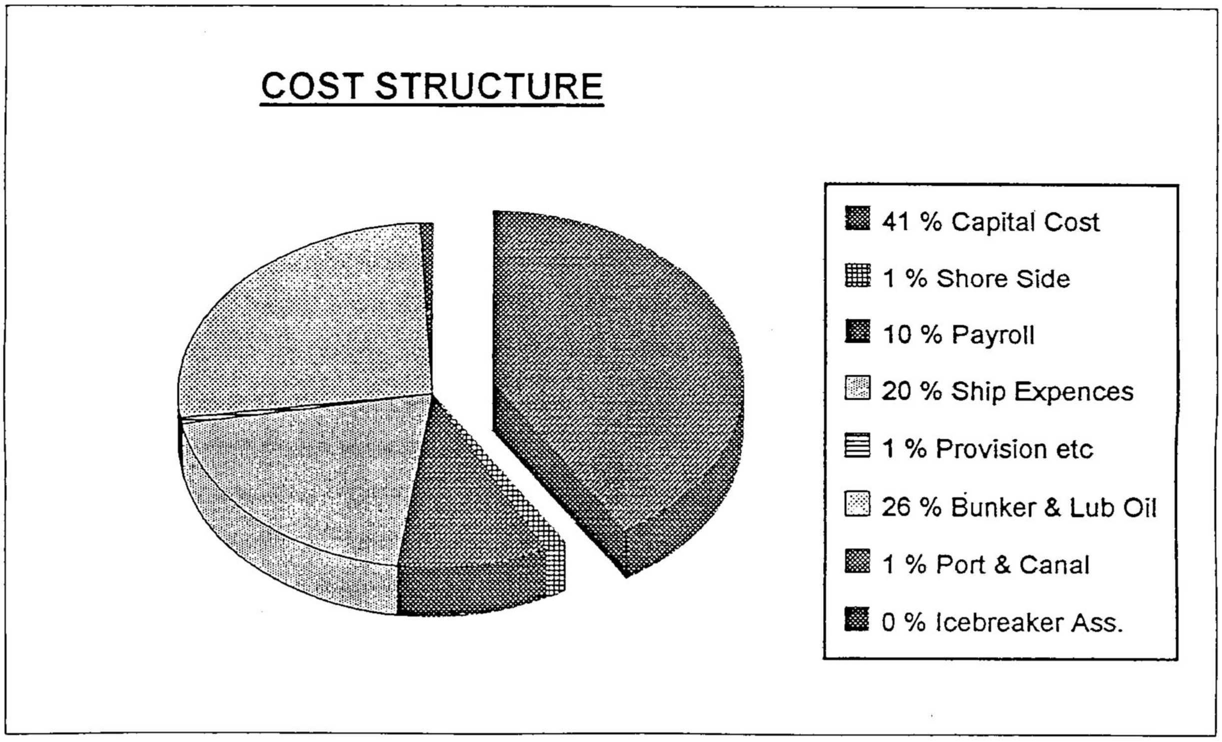
Year	2007N	2008N	2009S	2010N	2010M	2011N
Income escalation:	1.00	1.00	1.00	1.00	1.00	1.00
Cost escalation:	1.00	1.00	1.00	1.00	1.00	1.00
Operating Revenue	0	0	0	0	0	0
Operating Expense	9	9	9	9	8	9
Operating Income	-9	-9	-9	-9	-8	-9
Capital Costs						
Loan 1 Amount	25	22	20	17	15	12
Loan 1 Interest	2	1	1	1	1	1
Loan 1 Depreciation	2	2	2	2	2	2
Loan 2 Amount	12	11	9	8	7	6
Loan 2 Interest	1	0	0	0	0	0
Loan 2 Depreciation	0	0	0	0	0	0
Total Capital Cost	5	4	4	4	4	4
Start Up Cost, etc.	0	0	0	0	0	0
Total income	0	0	0	0	0	0
Total costs	13	13	13	13	12	12
Net Cash Flow	-13	-13	-13	-13	-12	-12
ACCUMULATED COSTS	169	182	195	208	220	232
ACCUMULATED CF	-169	-182	-195	-208	-220	-232

Year	2012S	2013N	2014M	2015N	2016N	2017N
Income escalation:	1.00	1.00	1.00	1.00	1.00	1.00
Cost escalation:	1.00	1.00	1.00	1.00	1.00	1.00
Operating Revenue:	0	0	0	0	0	0
Operating Expense:	9	9	8	9	9	9
Operating Income:	-9	-9	-8	-9	-9	-9
Capital Costs						
Loan 1 Amount	10	7	5	2	0	0
Loan 1 Interest	1	0	0	0	0	0
Loan 1 Depreciation	2	2	2	2	0	0
Loan 2 Amount	5	4	2	1	0	0
Loan 2 Interest	0.2	0.2	0.1	0.1	0.0	0.0
Loan 2 Depreciation	0	0	0	0	0	0
Prepayments						
Amount	0	0				
Interest	0	0				
Total Capital Cost	3	3	3	3	0	0
Start Up Cost, etc.	0	0	0	0	0	0
Total income	0	0	0	0	0	0
Total costs	12	12	11	11	9	9
Net Cash Flow	-12	-12	-11	-11	-9	-9
ACCUMULATED COSTS	244	256	267	279	287	296
ACCUMULATED CF	-244	-256	-267	-279	-287	-296

SEAKEY ICEGOING SHIP ECONOMICS

Project: 60 000 cu.m. ib LPG carrier, Novy Port-Rotterdam
Name: North Barrier
Currency USD





APPENDIX 3

Economic calculations
Belyi Island - Rotterdam, 75.000 m^3 LPG carrier

SEAKEY ICEGOING SHIP ECONOMICS

User: D.G.A.
Date: 25.9.95

SHIP IDENTIFICATION	
Project:	75 000 cu.m. ib LPG carrier, Belyi Island-Rotterdam-Belyi Island
Name:	North Barrier
Owner:	INSROP
Operator:	DA Management Ltd.

MAIN PARTICULARS			
Deadweight:	50 000 ton	Propulsion Power:	40000 kW
Cargo Payload:	45 000 ton	Trial Speed:	16.0 knots
Gross tonnage:	30000 tonnes	Auxilliary Power:	3000 kW
Length OA:	223.0 m	Currency:	USD
Beam:	34.0 m	Building Price:	88 Millions
Draught:	12.3 m	Start of Operation:	1997
		Operating days/year	365 days
		Production	7300 cu.m/day
		Required transportation	2.66 M cu.m/ye

CARGO PAYLOAD

Type of Cargo: LPG from West Siberia   Cargo Unit: cu.m.

CARGO CAPACITY

Cargo Category	Name	No of Units	Unit volume	Unit weight	Cargo volume	Cargo weight
Cargo 1:	LPG	75000	1.00	0.60	75000	45000
Cargo 2:		0	0.00	0.00	0	0
Cargo 3:		0	0.00	0.00	0	0
Cargo 4:		0	0.00	0.00	0	0
Cargo 5:		0	0.00	0.00	0	0
Cargo 6:		0	0.00	0.00	0	0
Total Cargo Payload		75000			75000	45000

ROUTE & SCHEDULE			
Route	Belyi Island-Rotterdam-Belyi Island		
Distance	5050 nm (roundtrip)		
Schedule	Mild	Normal	Strong
Months : September - October	61 days	61 days	61 days
Number of trips	4.12 per year	4.12 per year	4.12 per year
Time per Leg:	14.8 days	14.8 days	14.8 days
Time at Sea:	13.2 days	13.2 days	13.2 days
Average Speed:	16.0 knots	16.0 knots	16.0 knots
Month : November	30 days	30 days	30 days
Number of trips	2.02 per year	1.96 per year	1.84 per year
Time per Leg:	14.8 days	15.3 days	16.3 days
Time at Sea:	13.2 days	13.6 days	14.7 days
Average Speed:	16.0 knots	15.5 knots	14.3 knots
Month : December	31 days	31 days	31 days
Number of trips	1.97 per year	1.85 per year	1.72 per year
Time per Leg:	15.8 days	16.8 days	18.1 days
Time at Sea:	14.1 days	15.1 days	16.4 days
Average Speed:	14.9 knots	13.9 knots	12.8 knots
Month : January	31 days	31 days	31 days
Number of trips	1.86 per year	1.78 per year	1.64 per year
Time per Leg:	16.7 days	17.5 days	18.9 days
Time at Sea:	15.0 days	15.8 days	17.2 days
Average Speed:	14.0 knots	13.3 knots	12.2 knots
Month : February	28 days	28 days	28 days
Number of trips	1.68 per year	1.56 per year	1.41 per year
Time per Leg:	16.7 days	17.9 days	19.9 days
Time at Sea:	15.0 days	16.3 days	18.2 days
Average Speed:	14.0 knots	12.9 knots	11.6 knots
Month : March	31 days	31 days	31 days
Number of trips	1.05 per year	0.85 per year	1.00 per year
Time per Leg:	29.5 days	36.6 days	30.9 days
Time at Sea:	27.8 days	34.9 days	29.2 days
Average Speed:	7.6 knots	6.0 knots	7.2 knots
Month : April	30 days	30 days	30 days
Number of trips	0.94 per year	0.66 per year	0.72 per year
Time per Leg:	31.9 days	45.3 days	41.5 days
Time at Sea:	30.2 days	43.6 days	39.8 days
Average Speed:	7.0 knots	4.8 knots	5.3 knots
Month : May	31 days	31 days	31 days
Number of trips	1.20 per year	0.75 per year	0.77 per year
Time per Leg:	25.9 days	41.6 days	40.1 days
Time at Sea:	24.2 days	39.9 days	38.5 days
Average Speed:	8.7 knots	5.3 knots	5.5 knots
Month : June	30 days	30 days	30 days
Number of trips	1.65 per year	1.14 per year	1.05 per year
Time per Leg:	18.2 days	26.3 days	28.5 days
Time at Sea:	16.6 days	24.6 days	26.8 days
Average Speed:	12.7 knots	8.5 knots	7.8 knots
Month : July	31 days	31 days	31 days
Number of trips	2.09 per year	1.77 per year	1.22 per year
Time per Leg:	14.8 days	17.5 days	25.4 days
Time at Sea:	13.2 days	15.9 days	23.8 days
Average Speed:	16.0 knots	13.3 knots	8.9 knots

Month : August	31 days	31 days	31 days
Number of trips	2.09 per year	2.09 per year	2.00 per year
Time per Leg:	14.8 days	14.8 days	15.5 days
Time at Sea:	13.2 days	13.2 days	13.8 days
Average Speed:	16.0 knots	16.0 knots	15.2 knots
Total number of Trips	20.7	18.5	17.5
Operating Days:	365 days	365 days	365 days

Corrected schedule (acc. to production capacity)

Month: January			
Production	0.23 M cu.m.	0.23 M cu.m.	0.23 M cu.m.
Acc. Prod.	0.23 M cu.m.	0.23 M cu.m.	0.23 M cu.m.
Transp. cap.	0.27 M cu.m.	0.26 M cu.m.	0.24 M cu.m.
Transp.	0.23 M cu.m.	0.23 M cu.m.	0.23 M cu.m.
Number of trips/ship	1.54	1.54	1.54
Tot. transp.	0.23 M cu.m.	0.23 M cu.m.	0.23 M cu.m.
Month: February			
Production	0.20 M cu.m.	0.20 M cu.m.	0.20 M cu.m.
Acc. Prod.	0.43 M cu.m.	0.43 M cu.m.	0.43 M cu.m.
Transp. cap.	0.25 M cu.m.	0.23 M cu.m.	0.21 M cu.m.
Transp.	0.20 M cu.m.	0.20 M cu.m.	0.20 M cu.m.
Number of trips/ship	1.39	1.39	1.39
Tot. transp.	0.43 M cu.m.	0.43 M cu.m.	0.43 M cu.m.
Month: March			
Production	0.23 M cu.m.	0.23 M cu.m.	0.23 M cu.m.
Acc. Prod.	0.66 M cu.m.	0.66 M cu.m.	0.66 M cu.m.
Transp. cap.	0.15 M cu.m.	0.12 M cu.m.	0.15 M cu.m.
Transp.	0.15 M cu.m.	0.12 M cu.m.	0.15 M cu.m.
Number of trips/ship	1.05	0.85	1.00
Tot. transp.	0.59 M cu.m.	0.56 M cu.m.	0.58 M cu.m.
Month: April			
Production	0.22 M cu.m.	0.22 M cu.m.	0.22 M cu.m.
Acc. Prod.	0.88 M cu.m.	0.88 M cu.m.	0.88 M cu.m.
Transp. cap.	0.14 M cu.m.	0.10 M cu.m.	0.11 M cu.m.
Transp.	0.14 M cu.m.	0.10 M cu.m.	0.11 M cu.m.
Number of trips/ship	0.94	0.66	0.72
Tot. transp.	0.72 M cu.m.	0.65 M cu.m.	0.68 M cu.m.
Month: May			
Production	0.23 M cu.m.	0.23 M cu.m.	0.23 M cu.m.
Acc. Prod.	1.10 M cu.m.	1.10 M cu.m.	1.10 M cu.m.
Transp. cap.	0.18 M cu.m.	0.11 M cu.m.	0.11 M cu.m.
Transp.	0.18 M cu.m.	0.11 M cu.m.	0.11 M cu.m.
Number of trips/ship	1.20	0.75	0.77
Tot. transp.	0.90 M cu.m.	0.76 M cu.m.	0.80 M cu.m.
Month: June			
Production	0.22 M cu.m.	0.22 M cu.m.	0.22 M cu.m.
Acc. Prod.	1.32 M cu.m.	1.32 M cu.m.	1.32 M cu.m.
Transp. cap.	0.24 M cu.m.	0.17 M cu.m.	0.15 M cu.m.
Transp.	0.24 M cu.m.	0.17 M cu.m.	0.15 M cu.m.
Number of trips/ship	1.65	1.14	1.05
Tot. transp.	1.14 M cu.m.	0.93 M cu.m.	0.95 M cu.m.
Month: July			
Production	0.23 M cu.m.	0.23 M cu.m.	0.23 M cu.m.
Acc. Prod.	1.55 M cu.m.	1.55 M cu.m.	1.55 M cu.m.
Transp. cap.	0.31 M cu.m.	0.26 M cu.m.	0.18 M cu.m.
Transp.	0.31 M cu.m.	0.26 M cu.m.	0.18 M cu.m.
Number of trips/ship	2.09	1.77	1.22
Tot. transp.	1.45 M cu.m.	1.19 M cu.m.	1.13 M cu.m.

Month: August			
Production	0.23 M cu.m.	0.23 M cu.m.	0.23 M cu.m.
Acc. Prod.	1.77 M cu.m.	1.77 M cu.m.	1.77 M cu.m.
Transp. cap.	0.31 M cu.m.	0.31 M cu.m.	0.29 M cu.m.
Transp.	0.31 M cu.m.	0.31 M cu.m.	0.29 M cu.m.
Number of trips/ship	2.09	2.09	2.00
Tot. transp.	1.76 M cu.m.	1.50 M cu.m.	1.43 M cu.m.
Month: September - October			
Production	0.45 M cu.m.	0.45 M cu.m.	0.45 M cu.m.
Acc. Prod.	2.22 M cu.m.	2.22 M cu.m.	2.22 M cu.m.
Transp. cap.	0.61 M cu.m.	0.61 M cu.m.	0.61 M cu.m.
Transp.	0.46 M cu.m.	0.61 M cu.m.	0.61 M cu.m.
Number of trips/ship	3.15	4.12	4.12
Tot. transp.	2.22 M cu.m.	2.10 M cu.m.	2.03 M cu.m.
Month: November			
Production	0.22 M cu.m.	0.22 M cu.m.	0.22 M cu.m.
Acc. Prod.	2.44 M cu.m.	2.44 M cu.m.	2.44 M cu.m.
Transp. cap.	0.30 M cu.m.	0.29 M cu.m.	0.27 M cu.m.
Transp.	0.22 M cu.m.	0.29 M cu.m.	0.27 M cu.m.
Number of trips/ship	1.49	1.96	1.84
Tot. transp.	2.44 M cu.m.	2.39 M cu.m.	2.30 M cu.m.
Month: December			
Production	0.23 M cu.m.	0.23 M cu.m.	0.23 M cu.m.
Acc. Prod.	2.66 M cu.m.	2.66 M cu.m.	2.66 M cu.m.
Transp. cap.	0.29 M cu.m.	0.27 M cu.m.	0.25 M cu.m.
Transp.	0.23 M cu.m.	0.27 M cu.m.	0.25 M cu.m.
Number of trips/ship	1.54	1.85	1.72
Tot. transp.	2.66 M cu.m.	2.66 M cu.m.	2.55 M cu.m.
Total number of trips/ship	18.1	18.1	17.4

Maximum transported cargo	3.04 M cu.m.	2.72 M cu.m.	2.57 M cu.m.
Excess capacity	0.37 M cu.m.	0.06 M cu.m.	0.02 M cu.m.

SEAKEY ICEGOING SHIP ECONOMICS: Route & Schedule

OPERATION PROFILE

Route: Belyi Island-Rotterdam-Belyi Island
Distance: 5050 nm (roundtrip)

Operation Season	Logged	Mild winter		Normal winter		Strong winter	
September - October	Distance	Speed	Hours	Speed	Hours	Speed	Hours
Operation Profile	nm	knots	h	knots	h	knots	h
Harbour			40.0		40.0		40.0
Open water, mild	5050	16.0	315.6				
Open water, normal	5050			16.0	315.6		
Open water, strong	5050					16.0	315.6
Ice, mild	0	14.5	0				
Ice, normal	0			13.8	0		
Ice strong	0					11.0	0
Total	5050	16.0	355.6	16.0	355.6	16.0	355.6

Operation Season	Logged	Mild winter		Normal winter		Strong winter	
November	Distance	Speed	Hours	Speed	Hours	Speed	Hours
Operation Profile	nm	knots	h	knots	h	knots	h
Harbour			40.0		40.0		40.0
Open water, mild	5050	16.0	315.6				
Open water, normal	4490			16.0	280.6		
Open water, strong	4260					16.0	266.3
Ice, mild	0	13.6	0				
Ice, normal	560			12.2	45.9		
Ice strong	790					9.2	85.9
Total	5050	16.0	355.6	15.5	366.5	14.3	392.1

Operation Season	Logged	Mild winter		Normal winter		Strong winter	
December	Distance	Speed	Hours	Speed	Hours	Speed	Hours
Operation Profile	nm	knots	h	knots	h	knots	h
Harbour			40.0		40.0		40.0
Open water,mild	4489	16.0	280.6				
Open water, normal	4226			16.0	264.1		
Open water, strong	4102					16.0	256.4
Ice, mild	561	9.7	57.8				
Ice, normal	824			8.4	98.1		
Ice strong	948					6.9	137.4
Total	5050	14.9	378.4	13.9	402.2	12.8	433.8

Operation Season	Logged	Mild winter		Normal winter		Strong winter	
January	Distance	Speed	Hours	Speed	Hours	Speed	Hours
Operation Profile	nm	knots	h	knots	h	knots	h
Harbour			40.0		40.0		40.0
Open water, mild	4270	16.0	266.9				
Open water, normal	4063			16.0	253.9		
Open water, strong	4003					16.0	250.2
Ice, mild	780	8.4	92.9				
Ice, normal	987			7.9	124.9		
Ice strong	1047					6.4	163.6
Total	5050	14.0	399.7	13.3	418.9	12.2	453.8

Operation Season February / Operation Profile	Logged Distance nm	Mild winter Speed knots	Mild winter Hours h	Normal winter Speed knots	Normal winter Hours h	Strong winter Speed knots	Strong winter Hours h
Harbour			40.0		40.0		40.0
Open water, mild	4188	16.0	261.8				
Open water, normal	4021			16.0	251.3		
Open water, strong	3790					16.0	236.9
Ice, mild	862	8.7	99.1				
Ice, normal	1029			7.4	139.1		
Ice strong	1260					6.3	200.0
Total	5050	14.0	400.8	12.9	430.4	11.6	476.9

Operation Season March / Operation Profile	Logged Distance nm	Mild winter Speed knots	Mild winter Hours h	Normal winter Speed knots	Normal winter Hours h	Strong winter Speed knots	Strong winter Hours h
Harbour			40.0		40.0		40.0
Open water, mild	4104	16.0	256.5				
Open water, normal	4056			16.0	253.5		
Open water, strong	3906					16.0	244.1
Ice, mild	946	2.3	411.3				
Ice, normal	994			1.7	584.7		
Ice strong	1144					2.5	457.6
Total	5050	7.6	707.8	6.0	878.2	7.2	741.7

Operation Season April / Operation Profile	Logged Distance nm	Mild winter Speed knots	Mild winter Hours h	Normal winter Speed knots	Normal winter Hours h	Strong winter Speed knots	Strong winter Hours h
Harbour			40.0		40.0		40.0
Open water, mild	4061	16.0	253.8				
Open water, normal	4016			16.0	251.0		
Open water, strong	3834					16.0	239.6
Ice, mild	989	2.1	471.0				
Ice, normal	1034			1.3	795.4		
Ice strong	1216					1.7	715.3
Total	5050	7.0	764.8	4.8	1086.4	5.3	994.9

Operation Season May / Operation Profile	Logged Distance nm	Mild winter Speed knots	Mild winter Hours h	Normal winter Speed knots	Normal winter Hours h	Strong winter Speed knots	Strong winter Hours h
Harbour			40.0		40.0		40.0
Open water, mild	4185	16.0	261.6				
Open water, normal	4064			16.0	254.0		
Open water, strong	3895					16.0	243.4
Ice, mild	865	2.7	320.4				
Ice, normal	986			1.4	704.3		
Ice strong	1155					1.7	679.4
Total	5050	8.7	621.9	5.3	998.3	5.5	962.8

Operation Season June / Operation Profile	Logged Distance nm	Mild winter Speed knots	Mild winter Hours h	Normal winter Speed knots	Normal winter Hours h	Strong winter Speed knots	Strong winter Hours h
Harbour			40.0		40.0		40.0
Open water, mild	4614	16.0	288.4				
Open water, normal	4272			16.0	267.0		
Open water, strong	3983					16.0	248.9
Ice, mild	436	4.0	109.0				
Ice, normal	778			2.4	324.2		
Ice strong	1067					2.7	395.2
Total	5050	12.7	437.4	8.5	631.2	7.8	684.1

Operation Season July Operation Profile	Logged Distance nm	Mild winter Speed knots	 Hours h	Normal winter Speed knots	 Hours h	Strong winter Speed knots	 Hours h
Harbour			40.0		40.0		40.0
Open water, mild	5050	16.0	315.6				
Open water, normal	4738			16.0	296.1		
Open water, strong	4223					16.0	263.9
Ice, mild	0	8.3	0				
Ice, normal	312			3.7	84.3		
Ice strong	827					2.7	306.3
Total	5050	16.0	355.6	13.3	420.4	8.9	610.2

Operation Season August Operation Profile	Logged Distance nm	Mild winter Speed knots	 Hours h	Normal winter Speed knots	 Hours h	Strong winter Speed knots	 Hours h
Harbour			40.0		40.0		40.0
Open water, mild	5050	16.0	315.6				
Open water, normal	5050			16.0	315.6		
Open water, strong	4843					16.0	302.7
Ice, mild	0	13.0	0				
Ice, normal	0			10.0	0		
Ice strong	207					7.1	29.2
Total	5050	16.0	355.6	16.0	355.6	15.2	371.8

SEAKEY ICEGOING SHIP ECONOMICS: Cargo Revenue

CARGO LOAD FACTORS AND FARES	in USD			
	Out		Back	
Category Name	LF%	Fare/Unit	LF%	Fare/Unit
LPG	98	0.0	0	0.0
Total Cargo	98	0.0	0	0.0

CARGO CARRYING CAPACITY PER YEAR						
	Mild		Normal		Strong	
Cargo Category	Per Trip	Total	Per Trip	Total	Per Trip	Total
LPG	73500	1518840	73500	1361664	73500	1285424
Total Cargo	73500	1518840	73500	1361664	73500	1285424

AVERAGE LOAD FACTORS FOR THE WHOLE YEAR	Cargo LF	49 %

CARGO FREIGHT INCOME				*1000
Cargo Category	Mild	Normal	Severe	
LPG	0	0	0	
CARGO GROSS REVENUE	0	0	0	

COST OF SALES					*1000
Reduction of Full Fare Prices		Mild	Normal	Severe	
Fare Dilution	2 %	0	0	0	
Commissions	2 %	0	0	0	
Advertising	2 %	0	0	0	
Total Cost of Sales	0 %	0	0	0	

CARGO NET REVENUE	0	0	0	

SEAKEY ICEGOING SHIP ECONOMICS: Operating Expenses

SHIP PERSONEL						*1000
		Onboard	Ashore	Annual Salary	Soc. cost %	Payroll
Deck and Engine	Officers	6	7	30000	50	585
	Crew	16	14	17000	50	765
Additional Crew	Repaire-special eng.	2	1	17000	50	77
Total Payroll		24	22			1427

CONSUMABLES AND SUPPLIES	Crewday	*1000
	USD / per	
Provision	7.0	61
Hotelsupply	1.5	13
Other	0	0
Total Consumables and Supplies	8.5	74

PORT CHARGES, CANAL FEES				*1000
	Ports/trip	USD/GRT	USD/Trip	
Dues and Charges	1	0.2		82
Canal fees			0.0	0
Towing & Mooring	1	0.1		54
Total Port and Cargo Handling Costs				136

ICEBREAKER ASSISTANCE							*1000
		USD/day	day/year	h / Trip	USD/TON	USD/Hour	
One assisting iceb.		45000.0	0.0	–	-		0
Broken Channel			0	0		100	0
Towing			0	0		200	0
Total							0

SHIP EXPENSES		*1000
	% of ship price	
Maintenance	1.0	880
Insurance	2.5	2200
Other	0.5	440
Total Ship Expences		3520

SHORE SIDE EXPENSES (Excluding Advertising)				*1000
	Personel No	Annual salary	Overhead % of wages	
Wages	2	85000	0	170
Social cost			50	85
Office cost			100	170
Administration			100	170
TOTAL SHORE SIDE EXPENSE				595

BUNKER AND LUB. OIL							
Propulsion Machinery	Load %	Mild winter Hours	MWh	Normal winter Hours	MWh	Strong winter Hours	MWh
FO							
Harbour	0	725.0	0	724.7	0	694.8	0
Open water	40	5287.2	84 595	5138.8	82 221	4738.3	75 812
Ice	100	1808.2	72 326	2723.7	108 948	3272.6	130 903
Total	50	7820.4	156 921	8587.3	191 169	8705.7	206 716
g/kWh	185						
ton			29 030		35 366		38 242
LO							
g/kWh	2						
ton			314		382		413

Auxiliary Machinery	Load %	Mild winter Hours	MWh	Normal winter Hours	MWh	Strong winter Hours	MWh
Aux. power, at sea	20	7095.3	4 257	7862.5	4 718	8010.9	4 807
Aux. power, loading	70.0	725	1 523	725	1 522	695	1 459
Aux. power, waiting	20.0	940	564	173	104	54	33
Total			6 344		6 343		6 298
FO							
g/kWh	185.0						
ton			1 174		1 173		1 165
LO							
g/kWh	2						
ton			13		13		13

Total Consumption	Price / ton	Mild winter ton	USD	Normal winter ton	USD	Strong winter ton	USD
Propulsion	106	29030	3077220	35366	3748822	38 242	4053695
Aux Power	106	1174	124397	1173	124388.2	1165	123507.7
Boilers	106	700	74200	700	74200	700	74200
Lub.Oil	1500	327	489793	395	592536	426	639041.7
Total Bunker and Lubricating Oil Cost * 1000			3766		4540		4890

SEAKEY ICEGOING SHIP ECONOMICS:
Profitability of Operation

SUMMARY OF OPERATING INCOME AND COSTS

Evaluated Year: 1997
Cargo carried: 1332250 cu.m.

CARGO REVENUE			*1000
	Mild	Normal	Severe
Cargo Gross Revenue	0	0	0
Cost of Sales	0.00	0.00	0
CARGO NET REVENUE	0	0	0

OPERATING EXPENSES / SHIP		*1000
	Per Cargo Unit	Total Costs
Daily Running Costs:		
Payroll	1.07	1427
Ship Expences	2.64	3520
Total Daily Running Costs	3.71	4947
Voyage Costs:		
Bunker and Lub Oil		
Mild winter	2.83	3766
Normal winter	3.41	4540
Strong winter	3.67	4890
Consumables and Supplies	0.06	74
Port and Canal Charges	0.10	136
Icebreaker Assistance	0.00	0
Total Voyage Costs Mild winter	2.98	3976
Normal winter	3.57	4750
Strong winter	3.83	5101
Total Shore Side Expence	0.22	298
TOTAL OPERATING EXPENSES Mild winter	6.92	9220
Normal winter	7.50	9994
Strong winter	7.76	10345

OPERATING INCOME Mild winter	-6.92	-9200
Normal winter	-7.50	-10000
Strong winter	-7.76	-10300

CAPITAL COST ESTIMATE *1000

Newbuilding Price: 88 Million USD

Financing:	Amount % of price	Interest %	Interest First year	Depreciation Years	Depreciation Cost/year	First Year cost
Loan 1	68	6.5	3890	20.0	2992	6880
Loan 2	32	4.5	1267	20.0	1408	2680
CAPITAL COST	100		5157		4400	9600

FIRST YEAR CASH BALANCE	Per Cargo Unit	*1000
Operating Income	-7.50	-10000
First Year Capital Cost	7.21	9600
NET CASH FLOW (First Year)	-14.71	-19600

FLEET SIZE

Amount to be transported	2.66 M cu.m.	
Required number of ships	2 (mild)	
	2 (normal)	
	3 (strong)	
AVERAGE COST / CUBIC METER	USD	12.18 per cubic meter
TIME CHARTER RATE (incl. voyage costs)	USD	44000 per operating day
TIME CHARTER RATE (no voyage costs)	USD	32000 per operating day

SEAKEY ICEGOING SHIP ECONOMICS:
Cash Flow Calculation

ANNUAL INFLATION RATES		AVERAGE LOAD FACTOR	
Income:	0.00 %	Cargo LF:	49 %
Costs:	0 %		

ANNUAL CASH FLOW MUSD

Year	1995	1996	Start Up 1997N	1998N	1999S	2000N
Income escalation:	1	1.00	1.00	1.00	1.00	1.00
Cost escalation:	1	1.00	1.00	1.00	1.00	1.00
Operating Revenue:	0	0	0	0	0	0
Operating Expense:	0	0	10	10	10	10
Operating Income:	0	0	-10	-10	-10	-10
Capital Costs						
Loan 1 Amount	0	0	60	57	54	51
Loan 1 Interest	0	0	4	4	4	3
Loan 1 Depreciation	0	0	3	3	3	3
Loan 2 Amount	0	0	28	27	25	24
Loan 2 Interest	0	0	1	1	1	1
Loan 2 Depreciation	0	0	0	0	0	0
Prepayments						
Amount	9	9				
Interest	1	1				
Total Capital Cost	1	1	8	8	8	7
Start Up Cost, etc.	2	3	5	0	0	0
Total income			0	0	0	0
Total costs	3	4	23	18	18	17
Net Cash Flow	-3	-4	-23	-18	-18	-17
ACCUMULATED COSTS	3	6	29	47	65	83
ACCUMULATED CF	-3	-6	-29	-47	-65	-83

Year	2001M	2002N	2003S	2004N	2005M	2006N
Income escalation:	1.00	1.00	1.00	1.00	1.00	1.00
Cost escalation:	1.00	1.00	1.00	1.00	1.00	1.00
Operating Revenue	0	0	0	0	0	0
Operating Expense	9	10	10	10	9	10
Operating Income	-9	-10	-10	-10	-9	-10
Capital Costs						
Loan 1 Amount	48	45	42	39	36	33
Loan 1 Interest	3	3	3	3	2	2
Loan 1 Depreciation	3	3	3	3	3	3
Loan 2 Amount	23	21	20	18	17	15
Loan 2 Interest	1	1	1	1	1	1
Loan 2 Depreciation	0	0	0	0	0	0
Total Capital Cost	7	7	7	6	6	6
Start Up Cost, etc.	0	0	0	0	0	0
Total income	0	0	0	0	0	0
Total costs	16	17	17	16	15	16
Net Cash Flow	-16	-17	-17	-16	-15	-16
ACCUMULATED COSTS	99	116	133	150	165	181
ACCUMULATED CF	-99	-116	-133	-150	-165	-181

SEAKEY ICEGOING SHIP ECONOMICS: MUSD

Cash Flow Calculation

contin.

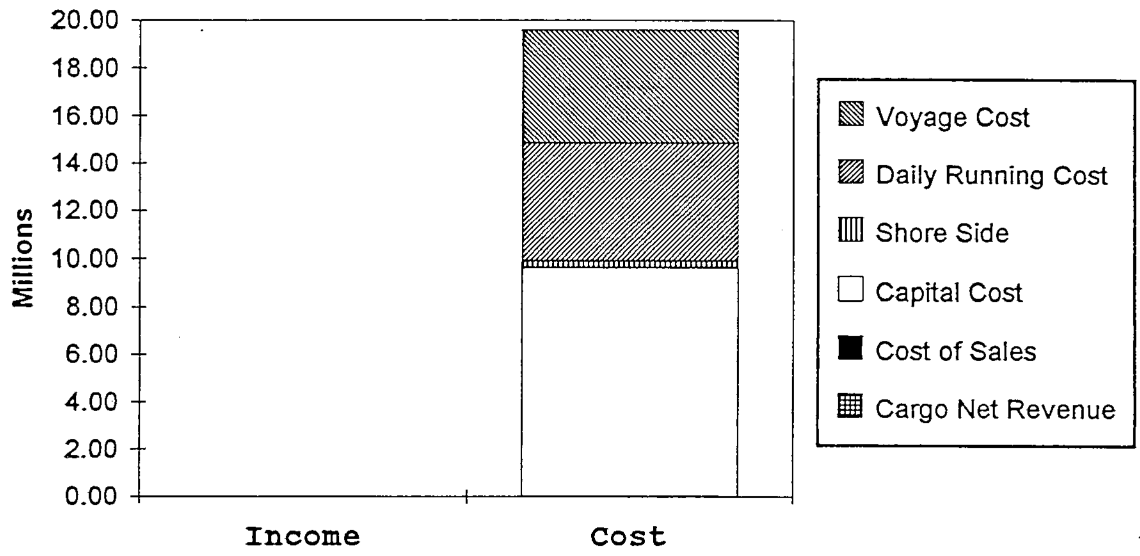
Year	2007N	2008N	2009S	2010N	2010M	2011N
Income escalation:	1.00	1.00	1.00	1.00	1.00	1.00
Cost escalation:	1.00	1.00	1.00	1.00	1.00	1.00
Operating Revenue	0	0	0	0	0	0
Operating Expense	10	10	10	10	9	10
Operating Income	-10	-10	-10	-10	-9	-10
Capital Costs						
Loan 1 Amount	30	27	24	21	18	15
Loan 1 Interest	2	2	2	1	1	1
Loan 1 Depreciation	3	3	3	3	3	3
Loan 2 Amount	14	13	11	10	8	7
Loan 2 Interest	1	1	1	0	0	0
Loan 2 Depreciation	0	0	0	0	0	0
Total Capital Cost	6	5	5	5	5	4
Start Up Cost, etc.	0	0	0	0	0	0
Total income	0	0	0	0	0	0
Total costs	16	15	15	15	14	14
Net Cash Flow	-16	-15	-15	-15	-14	-14
ACCUMULATED COSTS	196	212	227	242	256	270
ACCUMULATED CF	-196	-212	-227	-242	-256	-270

Year	2012S	2013N	2014M	2015N	2016N	2017N
Income escalation:	1.00	1.00	1.00	1.00	1.00	1.00
Cost escalation:	1.00	1.00	1.00	1.00	1.00	1.00
Operating Revenue:	0	0	0	0	0	0
Operating Expense:	10	10	9	10	10	10
Operating Income:	-10	-10	-9	-10	-10	-10
Capital Costs						
Loan 1 Amount	12	9	6	3	0	0
Loan 1 Interest	1	1	0	0	0	0
Loan 1 Depreciation	3	3	3	3	0	0
Loan 2 Amount	6	4	3	1	0	0
Loan 2 Interest	0.3	0.2	0.1	0.1	0.0	0.0
Loan 2 Depreciation	0	0	0	0	0	0
Prepayments						
Amount	0	0				
Interest	0	0				
Total Capital Cost	4	4	4	3	0	0
Start Up Cost, etc.	0	0	0	0	0	0
Total income	0	0	0	0	0	0
Total costs	14	14	13	13	10	10
Net Cash Flow	-14	-14	-13	-13	-10	-10
ACCUMULATED COSTS	285	298	311	325	335	345
ACCUMULATED CF	-285	-298	-311	-325	-335	-345

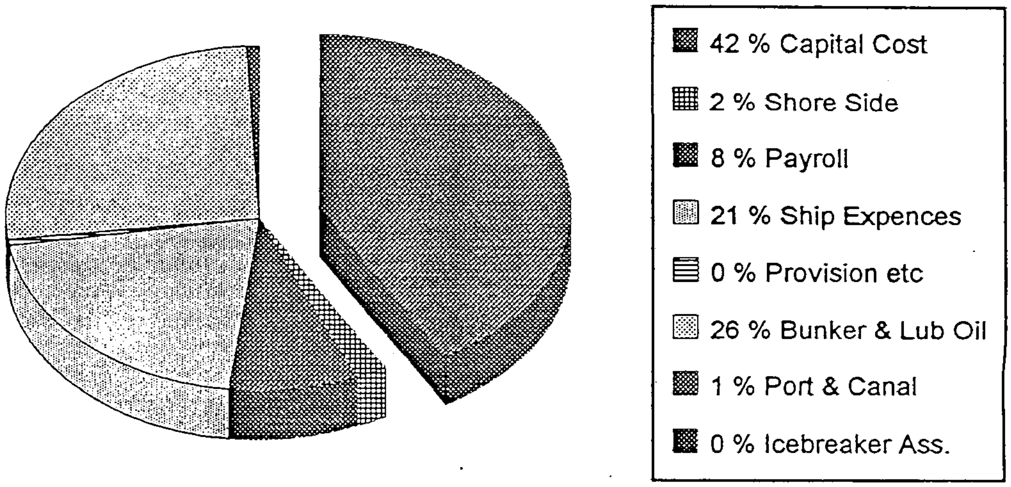
SEAKEY ICEGOING SHIP ECONOMICS

Project: 75 000 cu.m. ib LPG carrier, Belyi Island-Rotter
Name: North Barrier
Currency USD

FIRST YEAR (NORMAL) INCOME AND COST STRUCTURES



COST STRUCTURE



SEAKEY ICEGOING SHIP ECONOMICS

User: D.G.A.
Date: 25.9.95

SHIP IDENTIFICATION

Project:	60 000 cu.m. ib LPG carrier, Novy Port-Rotterdam-Novy Port.
Name:	North Barrier
Owner:	INSROP
Operator:	DA Management Ltd.

MAIN PARTICULARS

Deadweight:	40 000 ton	Propulsion Power:	30000 kW
Cargo Payload:	36 000 ton	Trial Speed:	16.0 knots
Gross tonnage:	30000 tonnes	Auxilliary Power:	3000 kW
Length OA:	280.0 m	Currency:	USD
Beam:	37.0 m	Building Price:	73 Millions
Draught:	9.0 m	Start of Operation:	1997
		Operating days/year	365 days
		Production	6750 cu.m/day
		Required transportation	2.46 M cu.m/ye

CARGO PAYLOAD

Type of Cargo: LPG from West Siberia

Cargo Unit: cu.m.

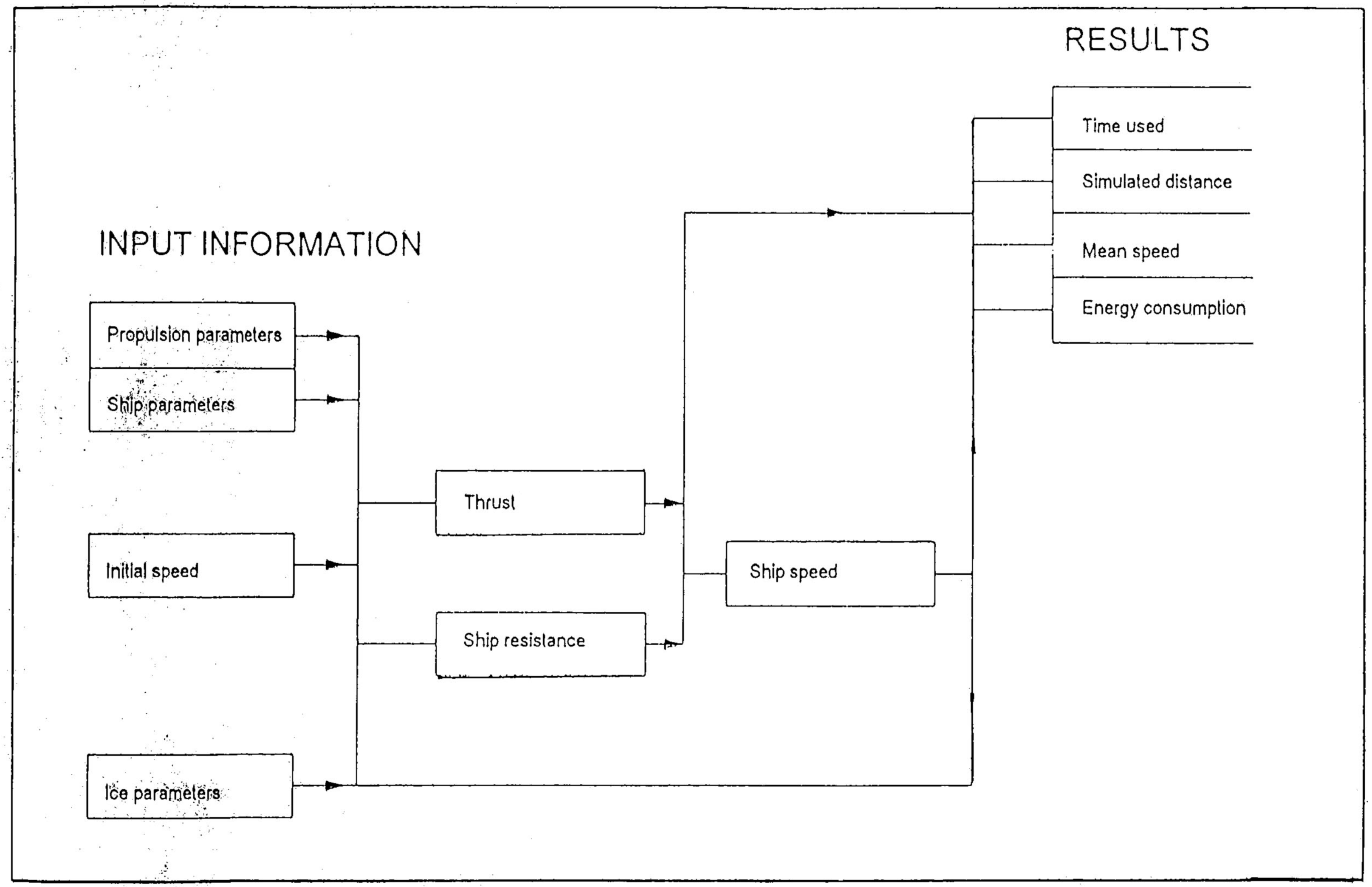
CARGO CAPACITY

Cargo Category	Name	No of Units	Unit volume	Unit weight	Cargo volume	Cargo weight
Cargo 1:	LPG	60000	1.00	0.60	60000	36000
Cargo 2:		0	0.00	0.00	0	0
Cargo 3:		0	0.00	0.00	0	0
Cargo 4:		0	0.00	0.00	0	0
Cargo 5:		0	0.00	0.00	0	0
Cargo 6:		0	0.00	0.00	0	0
Total Cargo Payload		60000			60000	36000

APPENDIX 4

Transit speed calculation program diagram

MODEL FOR THE TRANSIT PROGRAM



APPENDIX 5

REVIEW AND AUTHORS' COMMENTS

Bjørn K. Markussen
C/O Westgas AS
Teatergaten 35,
5010 Bergen

Bergen 6. March 1996

SNF
(Foundation for Research in Economics and Business Administration)
Breivikveien 2,
5035 Bergen - Sandviken.

Att. Mr. Trond Ragnvald Ramsland.

Re.: Review of INSROP Project III.7.3 Report.

Dear Mr. Ramsland,

Enclosed, please find my comments to the draft of the above report. I apologise for the late response which is partly due to my late entry into the picture after Mr. Trygve Serch-Hansens retirement from Westgas, and partly due to my own travelling schedule.

I have quickly gone through Section 1. The LPG market. This part is extensively covered. The main conclusion that the world markets will absorb the available supplies seems reasonable. Historically all available LPG has found its markets. Due to the clean-burning properties of LPG there will always be a clearing market with the ability to absorb almost unlimited supplies. In my opinion any future supplies coming out of the Russian Arctic will be able to find ready markets in Europe and USA provided reasonable quality and security of supplies can be provided.

In going through Section 2. Seaborne Transportation of LPG from the Ob-Gulf I have focused only on the conceptual elements. No attempt have been made to check calculations etc.

Plaese revert if you have questions or whish to discuss further.

Best regards

Bjørn K. Markussen

INSROP Project III.07.3 Marine Transportation of oil from Timan Pechora and from inland Russian oil fields.
Section 2. Seaborne Transportation of LPG from the Ob-Gullf.

Comments prepared by: Bjørn K. Markussen (M. SC , MBA)

The specialised ice strengthened vessels required to transport the LPG from the Ob river will have no alternative markets which can pay freightrates required to cover the extra vessel costs. In my opinion there will be no independent shipowner prepared to invest in such vessels unless he is covered by a transportation contract which is guaranteeing an income stream required to repay the vessels. The likely contract form will be long term Time Charters or long term Concecutive voyage charters. The Time Charter solution will be the preferred solution seen from a shipowner point of view. Contract of Affreightment solutions and spot markets will not be feasible solutions until such time that the overall markets for Arctic LPG transport have grown to a size which will employ around 100 vessels (order of magnitude).

Assuming the vessels are purpose built newbuilding built by a first class international shipyard experienced in building ice stregthened vessels and gas carriers my estimate of newbuilding prices today will be around:
USD 75 mill. for a fully ref. 75000 cbm standard vessel
USD 56 mill. fro a fully ref. 60000 cbm standard vessel.
Using your estimate of 30 % extra price for a ice strengthened vessel the contract price for a 60000 cbm arctic vessel will be abt. 85 mill. USD.
Additionally we will have financing cost during construction and owners extra cost. The into service cost is estimated at abt. USD 90 mill.
Assuming 70 % loan financing at 7 % interest and 30 % equity at 12 % interest (average 8.6 %). Further estimating 11 months in service per year and operating cost at 13000 USD per day (including dry docking, but excluding the extra insurance for Arctic service).
Based on the above the Time Charter Rate (T/C-rate) required by a shipowner will be about 40000 USD/day.
This is significantly higher than the figures arrived at in your report and I recommend that the assumptions made are again carefully evaluated.

In my opinion one should aim at maximising the use of the expensive icebreaking vessels to trading in ice conditions.
As an alternative conceptual solution I suggest to perform a study of a system where the Arctic vessels are bringing the LPG to a intermediate storage and distribution terminal in a nearby ice free port. (Murmansk area or Northern Norway).
Such a solution will provide the following additional benefits:
- supply LPG to local markets (Murmansk area).
- reduce the required size and investments in Arctic LPG vessels
- reduce transportation cost from the distribution terminal to markets in Europe and also open up the US markets.
- increase security of supplies and thereby obtain higher prices in the markets.

INSROP Project III.07.3 Marine Transportation of oil from Timan Pechora and inland Russian Oil Fields

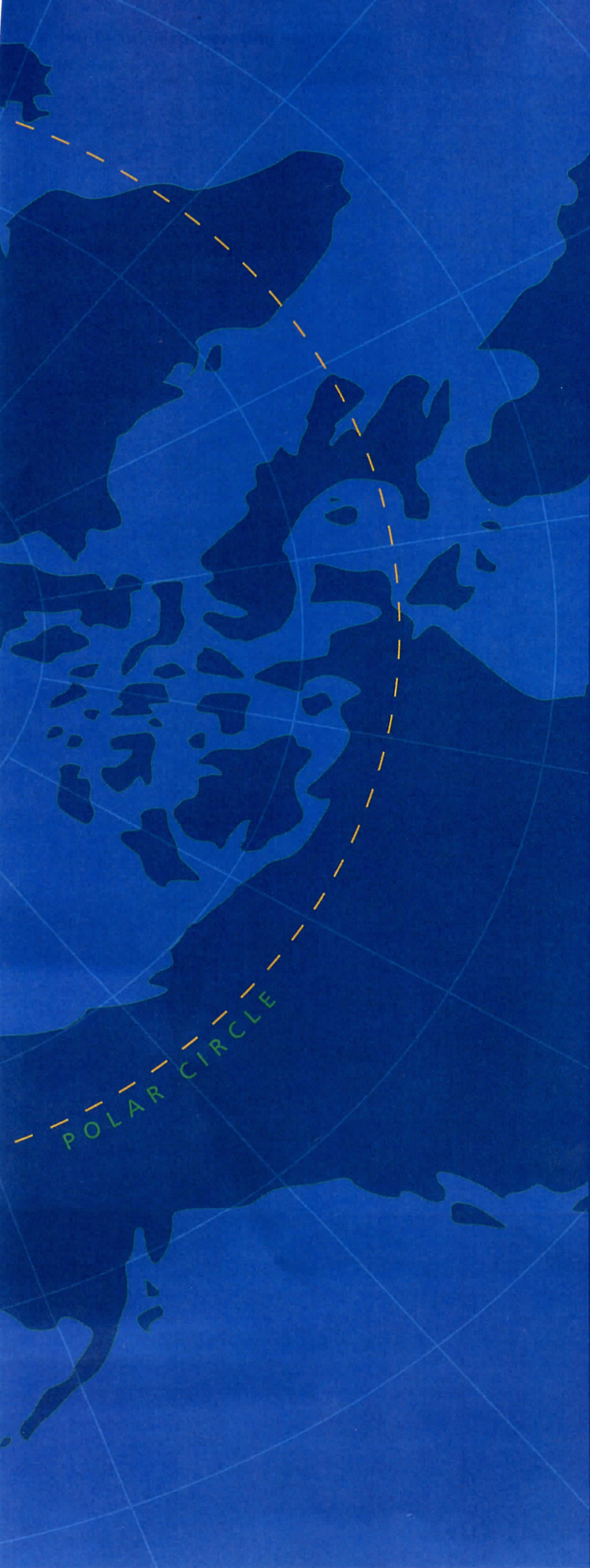
Answers to comments by reviewer Bjørn K. Markussen (M.Sc., MBA)

First of all I like to thank Mr. Markussen for reviewing the report. It is of utmost importance to get feedback on a report like this from the actual operators. It is also interesting to hear that you share the opinion that there is a good demand for LPG on the world market.

I fully agree that there will be no interest in investing in vessels causing higher costs, if there are no markets which can pay the higher price. This again is dependent on the cost level of the competing suppliers and in relation to the prevailing price level. As we do not have any detailed information about the price level of LPG at the plant in the Ob-Gulf area, this matter remains on a speculative level. Indications exist of low price levels, which would indicate a capability of paying higher charter rates. One must also remember that if there is no willingness for paying the higher rates, the LPG might remain unused in the Ob Gulf.

It is very valuable to receive comments on the existing price level for the vessels. The prices used in the study (73/88 MUSD) were based on statistics from 1994/95. The indicated 90/103 MUSD is almost 25% higher. In combination with the higher requirements for interest on equity (12% vs. 4.5%) this of course leads to a much higher T/C-requirement. Using the same criteria in our study would lead to the same result.
The interest rate for equity used in the study was fixed on a level which led to a T/C-rate for the Aden-case close to the market rates. The same rate was then used in the Ob-case. Using a higher rate would of course lead to less promising figures for the Ob-case as the vessel price is higher.

An alternative with a transhipment point in the Kola area is naturally interesting. Experiences from earlier projects have however indicated possible difficulties in transhipping and storing LPG and it has therefore not been seen as a too promising alternative. We have also wanted to limit the compared alternatives to be able to concentrate our effort. Such a comparison could be done in a possible continuation of the INSROP-project.



The three main cooperating institutions of INSROP

Ship & Ocean Foundation (SOF), Tokyo, Japan.
SOF was established in 1975 as a non-profit organization to advance modernization and rationalization of Japan's shipbuilding and related industries, and to give assistance to non-profit organizations associated with these industries. SOF is provided with operation funds by the Sasakawa Foundation, the world's largest foundation operated with revenue from motorboat racing. An integral part of SOF, the Tsukuba Institute, carries out experimental research into ocean environment protection and ocean development.

Central Marine Research & Design Institute (CNIIMF), St. Petersburg, Russia.
CNIIMF was founded in 1929. The institute's research focus is applied and technological with four main goals: the improvment of merchant fleet efficiency; shipping safety; technical development of the merchant fleet; and design support for future fleet development. CNIIMF was a Russian state institution up to 1993, when it was converted into a stockholding company.

The Fridtjof Nansen Institute (FNI), Lysaker, Norway.
FNI was founded in 1958 and is based at Polhøgda, the home of Fridtjof Nansen, famous Norwegian polar explorer, scientist, humanist and statesman. The institute spesializes in applied social science research, with special focus on international resource and environmental management. In addition to INSROP, the research is organized in six integrated programmes. Typical of FNI research is a multidisciplinary approach, entailing extensive cooperation with other *research institutions* both at home and abroad. The INSROP Secretariat is located at FNI.