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Development of Oil and Gas Exports from Northern Russia

Anders Backlund

INSROP International Northern Sea Route Programme

Central Marine Research & Design Institute, Russia

The Fridtjof Nansen Institute, Norway

Ship and Ocean Foundation, Japan

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Sub-programme III: Trade and Commercial Shipping Aspects.

Project III.01.3: Development of Oil and Gas Exports from Northern Russia.

By Anders Backlund, M.Sc.

Address:
Kværner Masa-Yards Technology Inc.
Kaanaantie 3 A
FIN-00100 Helsinki
FINLAND

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Reviewed by:
Nathan Mulherin, Research Physical Scientist, US Army Cold Regions Research and Engineering Laboratory, USA.

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

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 efficiency of shipping. Russia, being 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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PROGRAMME COORDINATORS

- **Yuri Ivanov, CNIIMF**
  Kavalergardskaya Str.6
  St. Petersburg 193015, Russia
  Tel: 7 812 271 5633
  Fax: 7 812 274 3864
  Telex: 12 14 58 CNIMF SU
- **Willy Østreng, FNI**
  P.O. Box 326
  N-1324 Lysaker, Norway
  Tel: 47 67 53 89 12
  Fax: 47 67 12 50 47
  Telex: 79 965 nanse n
  E-mail: Elin.Dragland @fni.
  wpoffice.telemax.no
- **Masaru Sakuma, SOF**
  Senpaku Shinko Building
  15-16 Toranomon 1-chome
  Minato-ku, Tokyo 105, Japan
  Tel: 81 3 3502 2371
  Fax: 81 3 3502 2033
  Telex: J 23704

INSROP PROJECT III.1.3

DEVELOPMENT OF OIL AND GAS EXPORTS FROM NORTHERN RUSSIA

Anders Backlund
Kværner Masa-Yards Technology

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1. INTRODUCTION

As part of INSROP Subprogram III, Trade and commercial shipping, a study has been prepared concerning the exportation of oil and gas from Northern Russia. The main purpose of this study is to compare the transportation costs from Northern Russia to market with costs from competing areas. This study concentrates on LNG-transportation, but some comments are also given on oil transportation. The study tries to include most cost factors that can differ compared to present transportation, the greatest emphasis being placed on the actual sea transportation costs.

A separate discussion on the differences caused by operating mode (assisted vs. independent) is also included to give a view of the effect of operating mode on total costs.

The results are supposed to give a starting point for more detailed comparisons about the effects of different solutions on total costs.

2. GENERAL

When discussing the use of the Northern Sea Route for international traffic, one important aspect is the export and import of goods to the Northern areas of Russia. The imports are mostly based on goods for the communities and some raw material for the local industry. Present exports are concentrated on the combinates in the Yenisey-region, but the greatest potential for future exports lie in the 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 is decreasing.

The economic feasibility study is made on LNG-transportation from the Kharasevey area on the Yamal peninsula to Rotterdam. This westbound route is selected because of its more natural suitability compared to various competitors. Rotterdam is selected to be the market, because of its central location. On the basis of this calculation, other markets can be compared with little extra work.

One of the main topics when comparing different solutions for Arctic transportation is to evaluate vessels of different ice breaking capability, the range being from vessels needing assistance by icebreakers in all ice conditions to vessels capable of year-round independent operation. Such a comparison is very complex in nature, as it includes the evaluation of pricing politics regarding the use of icebreaker assistance.

3. TECHNICAL FEASIBILITY OF THE OPERATION OF LARGE LNG-CARRIERS IN THE WESTERN RUSSIAN ARCTIC

3.1 HISTORY

The western part of the Northern Sea Route has quite an extensive history of vessels operating in different conditions. Especially on the route Murmansk - Dudinka there has been year-round operation already since the 70's. Thus a large amount of experience is available of operating vessels in the areas of greater interest.

The traffic on the route Murmansk - Dudinka has mostly been transportation of copper and nickel 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 a 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 ship hull today the ice breaking capability is about 0.8 m. Because of the changes in Russia and the need of 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 operated 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 the 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.

3.2 TECHNICAL TOPICS /1,2,3/

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 found on this route. Only large icebergs are extremely seldom seen.

For vessels operating in the area, this places extensive requirements on their performance.

Operation in first-year level ice is a topic that is of less interest, as the solution is well known and as this condition is more seldom encountered.

The dominant feature, in terms of ship design, is the ridging, especially the repetitive ridging that occurs in the Kara Sea. Vessel performance in ridges is not known to the same extent as for level ice, and especially in operation of large vessels with long parallel midbodies, there is a lack of experience. However, tests in model scale have given some data about this. The problem can be solved by the use of inclined ship sides, air bubbling and by installing a belt of stainless steel in the waterline area. All these solutions reduce the added resistance caused by the compressive force in the ridges, which is acting on the parallel midbody.

One feature that occurs more seldom but with an even greater influence on ship performance is compressive ice. The same solutions as above can be used to overcome this problem.

When operating in the northern part of the Kara Sea and eastwards from this area, the existence of multi-year ice must also be taken into account. This has a major impact on the design of the ship's hull and appendages, and must also be considered when determining the safe speed of a vessel in any prevailing ice condition. It thus influences the overall economy of the transportation.

When ranking the different operating conditions according to their influence on the economic feasibility of operation, the order is approximately the following

1) multi-year ice
2) compressive ice
3) ridges
4) level ice

State-of-the-art knowledge in ship design today allows us to build vessels to operate in a specified ice condition in the Western Russian Arctic. The most dominant problem is the definition of the prevailing conditions, mostly because of the limited data access to previous measurements. The Russian data collecting system, based on relative descriptions of ice conditions (on the scale 1 to 10 or 1 to 5) instead of physical parameters, cause extra problems in using existing data.

4. ECONOMIC FEASIBILITY OF LNG-TRANSPORTATION FROM THE KHARASEVEY AREA TO ROTTERDAM

4.0 GENERAL /4/

Large gas reserves are known to exist on the Yamal Peninsula. The main focus has been on the fields at Kharasevey, located in the middle of the western coast of Yamal. This study evaluates the economic feasibility of seaborne transportation from a terminal at Kharasevey, across the Kara Sea, through the Kara Gate and further on to Rotterdam.

4.1 VESSELS

In the design of vessels for traffic from Yamal to open water harbours, operations in both ice covered conditions and open water must be considered. The main topics to be considered in the traffic to Yamal are the relatively thick level ice, the great number of ridges and the existence of compressive ice. The large open water part of portion of routes to the Continent and further affects the bow shape that can be used.

Two separate modes of operation in ice must be considered: operation by assistance of icebreakers and independent operation. This study is done for an independently operating vessel. A discussion of the two modes of operation is presented later in the report.

To improve the operation of large vessels in the ice conditions of the Kara Sea, some special ice breaking technical features can be recommended. Great benefits can be achieved by the application of stainless steel in the ice contact area close to the waterline and by the use of an air-bubbling system in the bow area. These measures increase operating speed especially in compressive ice. In addition to this, the ship sides can be inclined, at least for a limited part of the ship side.

The basic criterion, when determining the propulsion power for the vessels, is that the vessels should be capable of operating in a continuous mode in most conditions in a normal year. Operation in conditions occurring in a limited area of the route and in other extreme conditions is allowed to take place in a ramming mode.

The vessels considered in this study are off-the-shelf-version suitable for Arctic operation. The cargo capacity is 135.000 m^3, which is a standard size LNG-carrier with four cargo tanks.

The main dimensions of the vessels are

Length	300.0 m
Breadth	48.0 m
Draught	11.3 m

The total propulsion power (on the propeller shaft) has been determined to be 48 MW, giving an engine power of approximately 53.5 MW. The propulsion machinery is diesel-electric, as this is most commonly used in Arctic vessels. A consideration of the effects of gas-turbine-electric machineries (the possible use of boil-off as fuel) is done in the economic evaluation.

The vessel has an ice breaking capability of 1.8 m at 2 kn.

4.2 ENVIRONMENTAL CONDITIONS /5,6,7,8,9,15,16/

The environmental conditions along the route from Kharasevey to Rotterdam include almost all possible variations. The ice conditions in the Kara Sea include level ice, heavy ridging and compressive ice. The open water section, especially the North Sea, represents severe open water conditions with heavy storms.

The route is totally free of ice for two months a year. The maximum extent of the ice cover is about 420 nm of the total 2300 nm (thus representing about 18%). In a normal year the maximum extent is about 300 nm (approx. 13%).

Considering only the ice conditions, the route from Kharasevey to Rotterdam can be divided in three major parts: the Kara Sea, the Kara Strait and the Pechora/Barents Sea.

The ice conditions in the southern Barents Sea (including the northern Pechora Sea) are similar to the conditions in the northern Baltic. Maximum ice thickness is 1.5 m. A special feature is the heavy ridging. The number of ridges can increase to 9 per km, with ridges up to 13 m in height (sail to keel).

The ice conditions are heavy in the Kara Strait. This is mostly because of the shallow waters and the compressive force of the ice in the Kara Sea, which causes heavy ridging. The number of ridges can be 21 per km (maximum sail to keel heights 18 m). These ice conditions have been the reason why ships choose the Jugorsky Strait and its lighter ridging.

The ice conditions in the Kara Sea are dominated by the ridges. A striking feature is the so called Novosemelsky massive, built up in the middle of the Kara Sea. This massive area moves with the wind, which in wintertime is mainly from the north-west and the south-east. This movement opens up leads along the coasts, but also causes heavy compression along the other coast. Because of this movement, which with today's knowledge cannot be predicted, the route has been selected to go the shortest way across the Kara Sea. On this route, the maximum ice thickness is 1.4 m and the number of ridges 17 per km.

In the transit time calculations, the ice conditions have been described on a monthly basis. The level ice thicknesses published are mostly maximum number in the area. The actual level ice varies in thickness and this variation has been considered by implementing a standard variation in level ice thickness. The variation is based on measurements done in parts of the route.

4.3 TRANSIT TIME CALCULATIONS

The transit time calculation for the vessel has for the ice going part been done using KMY's computer program, which calculates the speed of different vessels in varying ice conditions. Appendix 2 shows a principal diagram of the program. This program has been developed since the 70's and continuously checked against full scale measurements.

The time in open water has been calculated assuming constant open water speed. The effect of heavy weather on the transit speed has not been included, as the vessel has enough power to keep constant speed. The additional fuel consumption due to the higher power can be neglected.

Transit times have been calculated for three different types of winters: mild winters (20 % of the winters are milder than this), normal winters (50 % milder) and severe winters (80 % milder). Figure 4.1 shows the variation in transit times (time at sea only). The round-trip time varies between 240 h and 660 h.

It can be noted, that the variation in transit time is greatly influenced by the fact that the distance in ice represents only a minor part of the total distance. In cases where the ice conditions have caused delays, this gives a possibility to gain time by using the available power for speeding up the open water transit.

4.4 COSTS OF SEA TRANSPORTATION

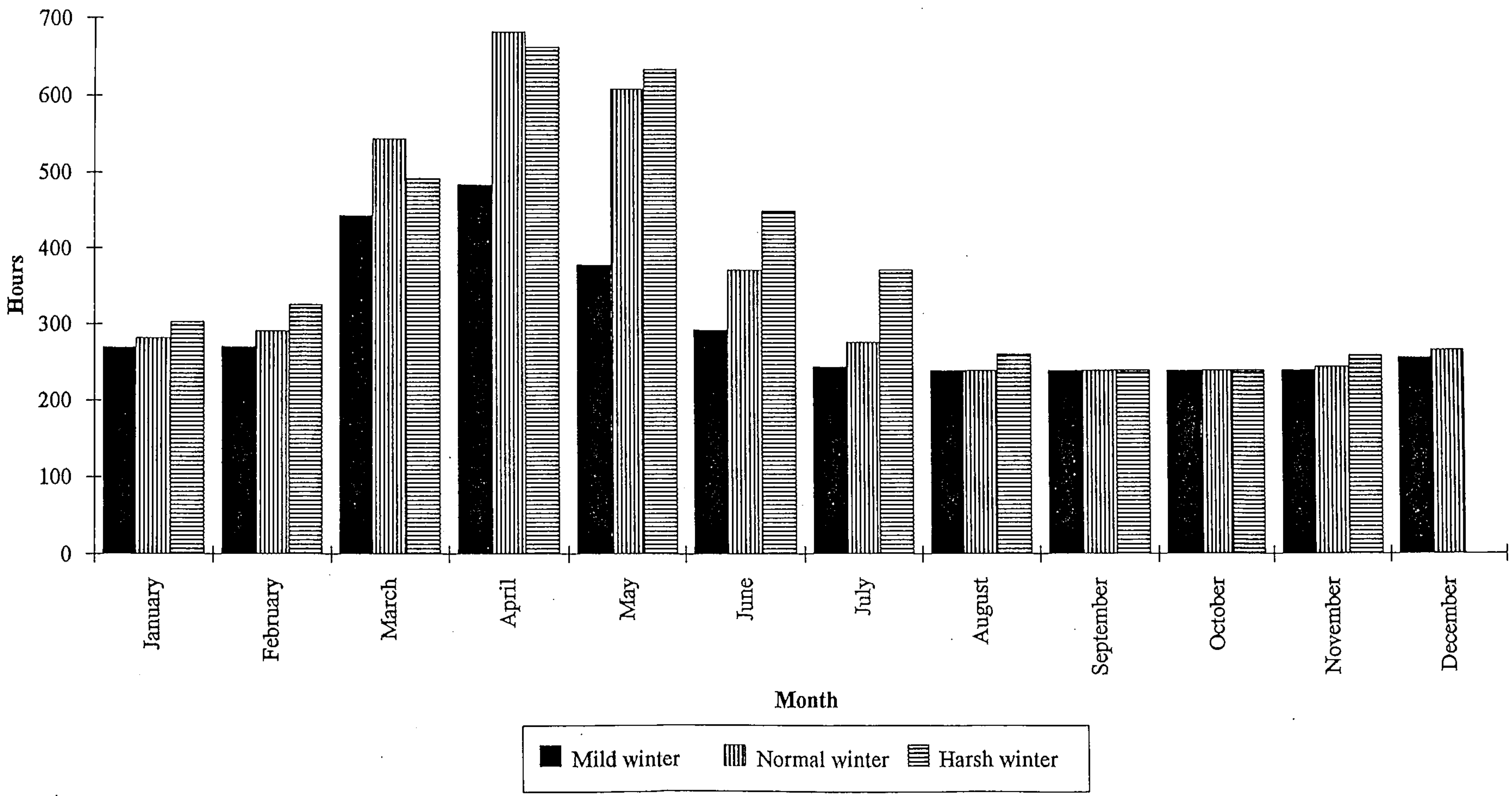
The cost calculations are based on published data concerning operating costs. The ship price (310 MUSD) is based on European building costs, with delivery in 1997. No inflation is included.
Appendix 1 shows the transportation economy calculation. The input data is based on:

- total production: production is selected to fit the number of vessels without extra transportation capacity on a yearly basis
- manning costs are of European standard
- shore side costs are for a small group handling the whole fleet
- fuel cost 100 USD/ton
- no insurance costs are included because no reliable data are available (a discussion on insurance fees is included later)
- interest rate 6.5 % for the total sum for 15 years
- lifetime of vessel 20 years
- total loading + discharging time 40 hours
- 365 operating days per 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 daily production.

The transit calculations show that three vessels are needed to transport the required amount of LNG. This means that a total investment of 930 MUSD must be done. With the above defined financial terms, this causes a yearly capital cost of about 74 MUSD. The total operating costs are about 27 MUSD per year, of which the fuel costs are approximately 15 MUSD.

The total transportation costs, when adding all the above and assuming 9.9 million cu.m. cargo, are 10.3 USD/cu.m. This figure includes all costs related to the operation of the vessels. Excluded are costs for the land-based facilities, storage, loading, LNG-plant, etc.

Figure 4.1 Roundtrip time (at sea only)
Rotterdam - Yamal - Rotterdam



As the capital costs represent such a large part of the total costs (somewhat more than 75%), it is obvious that differences in the financial terms influence the total cost figure remarkably.

The vessel price has been estimated for European construction costs. There may be political and other interests in maximising the Russian input. This can be done by subcontracting parts of the construction to Russia. Costwise, it can be noted that every change by 10% in the ship price changes the total transportation costs by about 7%.
In present LNG-carriers, the fuel used for propulsion is mainly boil-off LNG. If the calculations are done without including costs for propulsion fuel (and assuming the same amount of LNG transported), the costs are 9.1 USD/cu.m..

The LNG-storage volume required because of the variations in transit speed is 1 346 000 cu.m. This is the storage required in a severe winter. If the storage is dimensioned according to requirements in a normal winter, it is limited to 1 165 000 cu.m.

4.5 COSTS OF LAND-BASED FACILITIES

When estimating the total economic feasibility of LNG-production in Northern Russia, the costs for the shore based activities must also be included. The major cost factors are the gas production facilities, the LNG plant and the storage and loading facilities.

According to investigations done by CNIIMF, the costs for an LNG-plant, built in 1985, consisting of two units with a capacity of 1.525 Mton/year each (3.05 Mton/year = 6.1 million cu.m. in total) was about 500 MUSD. Assuming 8% inflation gives a 930 MUSD cost in 1993.

The costs for a plant consisting of two units of 2.6 Mton/year can be estimated on the basis of another plant, according to the formula

$$I_1 = I_0 \times \left(\frac{C_1}{C_0} \right)^n ,$$

where

$I_{1,0}$ = Investment cost for units
$C_{1,0}$ = Capacity of unit
n = index, which for similar projects is between 0.7 and 0.8
(subscripts 1 refer to the new plant, 0 to the known plant)

Assuming n = 0.75 gives a unit cost of 0.7 billion USD and a total cost of 1.4 billion USD.

On the basis of experience from other similar projects, the cost for the storage facilities is estimated to be 710 USD/cu.m. This gives a total investment cost in the shore-based facilities of 956 MUSD. When assuming the same financial terms as for the vessels (6.5% interest over 15 years, equal annual payments, lifetime 20 years) we get an annual cost of 76.2 MUSD. Assuming an annual production of 9.9 million cu.m., the costs will be 7.8 USD/cu.m. In the same way the costs of the production facilities can be determined to be 11.4 USD/cu.m.

Figure 4.2 shows the cost breakdown of the total supply chain excluding only the loading terminal.

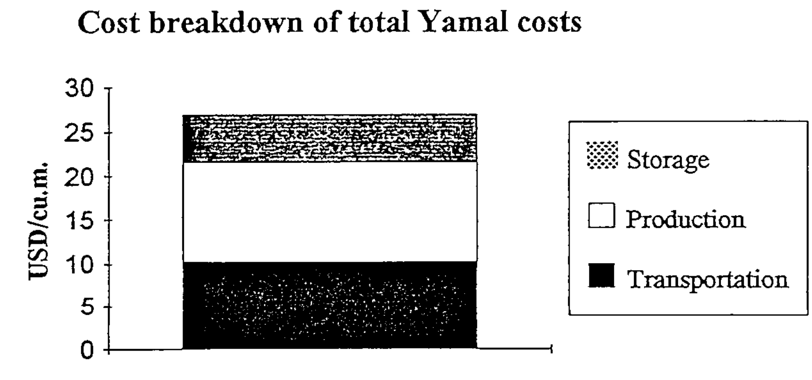


Figure 4.2 Cost breakdown of supply of LNG from Yamal to Rotterdam

4.6 POSSIBLE RISKS AND THEIR EFFECT ON FEASIBILITY

As can be seen from the above calculations, the investment costs play a major role in the economic feasibility. This also implies that the greatest risks lie in the need for additional investments.

The calculation is based on available data about the ice conditions in the area. The uncertainty in this data influences the reliability of the cost calculations. However, it should be noted that the route has been selected to represent an area where the reliability is higher. A possible error in ice conditions will affect the required propulsion power and to some extent the hull strengthening. As the machinery costs, which are directly proportional to the installed power, represent about 30 % of the total vessel costs, a 10 % increase in power will increase the vessel price by 3 %. Adding the possible extra steel, the cost increase is around 5 % for an additional power requirement of 10 %.

The calculations have not included the existence of compressive ice. Compressive ice would in most cases lead to a total stop of the vessel, thus causing a reduction in the amount of cargo transported. The influence on the total costs will be remarkable, when the need for an additional vessel arises.

5. COMPARISON WITH PRESENT TRANSPORTATION / COMPETITORS

This study concentrates on the transportation of LNG to Europe, even though there are much larger markets elsewhere, for example Japan. To evaluate the competitiveness of LNG from Yamal, a comparison is done with the costs for present transportation.

The comparison is made with transportation from Aden through the Suez Canal to Rotterdam. The vessels used are newbuildings of the same size as the Arctic vessels (135.000 cu.m.). The vessels operate at a speed of 19.5 knots and are assumed to use heavy oil fuel. This selection is done to set the compared alternatives in an equal position. The effect of "free" fuel for propulsion is also studied.

The amount of LNG transported is determined to be close to 5 million ton per year, however, so that the transportation capacity is fully used. All basic costs (manning, fuel costs, insurance, etc.) are assumed to be the same in both compared alternatives. The question of insurance costs can be discussed, as it is expected that insurance for Arctic operations will be higher. However, as there are very limited, scarcely any, data on insurance costs in Arctic operations, and as the insurance costs represent a minor part of the total costs, the insurance costs are assumed equal (in relation to the ship price).

Significant extra costs compared to the Yamal-route are the Suez Canal fees, which are one of the largest single cost components in the transportation. As the basis for the Suez Canal fees is very complicated, the estimation of the Canal fees will be rough. On the basis of the 1994 rates, and an assumption of 1.4 USD/SDR, would give an approximate canal fee for a round-trip close to 400.000 USD.

The calculations show that the total transportation cost for the Aden - Rotterdam route is 14.19 USD/cu.m., when assuming an LNG production of 30.000 cu.m per day. This cost is about 38 % more than for the compared Yamal transportation. If the fuel costs are excluded, which could represent the case of using boil-off LNG, the total costs are 12.99 USD/cu.m.

This difference puts the emphasis on the production costs in the different areas. This comparison will not be done due to lack of data.

It can be noted however, that the total costs for the Yamal alternative, including production, storage and transportation, are about 29 .5 USD/cu.m. The only component missing is the loading terminal. The market price for natural gas is about 3.5 USD/1000 cu. ft. (as 1 cu.m. is about 35 cu.ft, this is equivalent to 120 USD/1000 cu.m.). If we assume, that one cubic meter gas gives 0.0012 cu.m LNG, we get a price of about 100 USD/cu.m. LNG. This indicates that the Yamal LNG could be supplied at market price. This comparison is of somewhat less interest, as the market price would change in case of additional supply.

Figure 5.1 shows the cost breakdown for sea transportation in the two compared alternatives. It can be seen that the capital costs play a major part in both cases, and larger in the Yamal alternative. The differences are relatively small, mainly due to the high price of ordinary LNG-vessels. Thus the additional costs caused by ice breaking capability are smaller in proportion than they are for ordinary vessels like tankers.

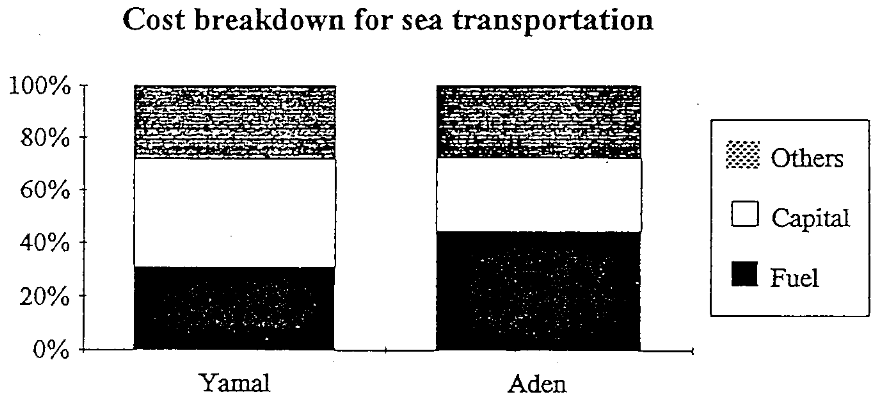


Figure 5.1 Cost breakdown of the two compared transportation alternatives

6. A COMPARISON OF ASSISTED AND INDEPENDENT OPERATION

6.1 DESCRIPTION OF DIFFERENT OPERATING MODES

Two main modes of operating vessels in ice covered waters can be distinguished:

1) cargo vessels operate with the assistance of one or more icebreakers
2) cargo vessels operate independently

The first mode is the most common in all ice covered areas (at least for the most severe parts of the year), but the second mode has also been used in many cases. The selected mode is of course dependent on the capabilities of each vessel.

In most areas with regular icebreaker assistance, one icebreaker assists each vessel group. This is possible because the maximum width of the cargo vessels is close to the width of the assisting icebreaker. In the case of large-scale transportation of oil and gas from Northwest Russia, however, the cargo vessels will be very much wider than the icebreakers. This will lead to a requirement of two assisting icebreakers for these larger vessels, which probably would lead to a significantly higher fee.

When designing a vessel for operation in ice-covered waters, a decision of operating mode must be made. For instance in the Baltic, the owner has to evaluate the extra costs of a higher ice class vessel against lower rates for port visits (called fairway fees). This evaluation is rather straightforward. The more complicated subject to evaluate is the reliability of traffic, what is the risk of experiencing delays due to the icebreaker assistance. These delays are caused by the fact that vessels are assisted in groups, not separately. If one vessel in the group gets stuck, the whole group must wait for the icebreaker releasing the jammed vessel. This is a risk, which to a large extent is out of the control of the single owner.

The above is valid for the Baltic. When discussing the Russian Arctic, one must bear in mind that for instance the tariff structure in undeveloped. There is very little tariff differentiation (only Russian ice class and ship size) and the tariff is a general one for transiting through the Northern Sea Route. No intermediate routes have been included or distinguished in the 1993 fees, which have been available (changes to these have been done, but the fees have not been available). The ship size is also limited to ships suitable for transiting through the whole NSR (upper limit 30.000 dwt). In 1993 the rates for transiting the NSR were for a vessel with 30.000 ton displacement and Russian ice class ULA 3.26 USD/ton (97 800 USD totally). For an ice class UL vessel of the same size it was 3.91 USD/ton (117 300). This fee secures icebreaker assistance along the total NSR and is not dependent on an actual need of assistance. The fees for a 15 000 ton vessel are 3.82 USD/ton (57 300 USD) and 4.59 USD/ton (68 850 USD) respectively.

If we assume a constant traffic with the above mentioned 30.000 displacement ton tankers and assume one trip per month through the NSR it leads to a yearly cost of 1 173 600 USD (ULA) and 1 407 600 USD (UL). On the basis of the same financial terms as for the LNG-vessel, this would allow an additional cost for the ULA vessel of about 2.2 MUSD. This should cover the extra power required and the extra steel. If we assume the same displacement, this leads to a smaller deadweight. It seems as if the higher ice class cannot be justified with the current rates.

For the LNG-carrier studied earlier, the costs would be (class ULA) 3.26 USD/displacement ton (displacement about 125 000 ton), giving a total fee of about 408.000 USD/trip. This would give an additional cost of about 3 USD/cu.m. LNG (an additional cost of about 30 % to the sea transportation costs). If we restrict the fees to be paid for only 10 trips/year (as in the Baltic) this reduces the cost to 1.25 USD/cu.m LNG.

Because of the so far limited traffic along the NSR, which in addition has been totally in control of the Russians, independent operation in wintertime has not been included in the tariff structure. This makes an evaluation very difficult.

The traditional way of transiting through the NSR has been by one or two large nuclear icebreakers assisting a group of cargo vessels. The size of the groups has varied from one single vessel to about 10 vessels. As the whole transportation system has been controlled by a single system, co-ordination of the different transport tasks has been possible.

Let us now do an extrapolation of this traffic to larger volumes, comprising vessels operated by different parties, en route to different harbours and various size and ice class. To be competitive, lead times have to be minimised. These lead times can be caused by vessels waiting for the assisting icebreaker, heavy ice conditions causing the vessel to a halt, other vessels in the same escort group causing delays. To avoid these delays, the following must be ensured:

- the number of assisting icebreakers is large enough for securing short lead time for a vessel arriving at any time.
- all vessels assisted must have sufficient capabilities to avoid stops along the route
- the icebreakers must have a sufficient capability for an uninterrupted transit along the route

This is the case when operating with the assistance of icebreakers.

When operating independently, the risk for lead time depends only on the single vessel's performance. This performance must of course be much higher than for the assisted vessels.

6.2 DIFFERENT RATE STRUCTURES

The assistance of icebreakers in most concerned countries is considered part of the infrastructure services provided to the shipping companies with a notable subsidy from the state. By securing stable transportation systems, the state guarantees good operating conditions for the industry and thus it is motivated to subsidise the assistance. Private icebreaker services are not available, although the Swedish icebreaker Oden is privately owned (but operated by the Swedish Maritime Board). Fees for icebreaking assistance are mostly based on ship size and level of ice strengthening. Not all countries carry any specified extra fee for icebreaker assistance, but include this service into general governmental fees. For instance in Finland, only one "fairway fee" is carried. This fee is based on the Net Register Tonnes of the vessel and the fee per ton is dependent on the ice class. The fee is carried for 10 port calls per year, and covers 65% of all costs related to fairways and vessel assistance. The aim is to increase this coverage to 75 %.

As the icebreakers are operated by state organisations, they do not function by normal business principles of total cost coverage. Fees are more based on political reasons and "reasonable cost"-thinking. Because of this, it is difficult to foresee what the assistance costs for an NSR-operation will be. Today, Russian icebreakers of Kapitan Dranitsyn-class can be chartered for about 20.000 USD/day. Assuming necessary assistance for 270 days per year, the total cost is 5.4 MUSD per year. These icebreakers can be used in the conditions of the Pechora Sea. If we assume that the icebreaker assists one 40.000 dwt vessel per day (about the maximum size of vessel that one single icebreaker can assist), we get a total transported cargo of 365*40.000 dwt =14.6 million dwt. This gives us a cost of 0.4 USD per ton deadweight.

If two such icebreakers would assist the 135.000 cu.m. LNG -vessels, it would give an extra cost of about 1.1 USD/cu.m. LNG (10.8 MUSD for the assumed 9.9 million cu.m. LNG).

Logically thinking, basing the costs on pricing principles, there are two different alternatives of pricing the service:

- total costs
- marginal costs

The first is obviously quite simple, but for the above mentioned reasons not in use, as it would lead to unacceptable rates.

The marginal cost principle is probably closer to the practice today. This would mean that the vessels pay for the extra cost they cause the icebreaker when they are assisted, in fact only the fuel costs. It may, however, be difficult to calculate the actual marginal costs, because the fuel costs per mile (or per hour) depend on the ice conditions in which the icebreaker operates. Thus, the fees must be based on a long-term average, probably not differentiating the time of year.

7. SOME VIEWS ON THE EXPORT OF OIL FROM NORTHWEST RUSSIA

The evaluations made above concern the transportation of LNG from the Kharasevey area on the Yamal Peninsula.

Major areas for transport of oil are the Timan-Pechora region at the Pechora Sea and the Yamburg area at the Ob Gulf. These areas have their own characteristics concerning both ice conditions and the environment in general.

The ice conditions in the Pechora Sea are less severe than those on the route to Kharasevey. The major obstacles are the heavy ridging and the moving ice, however, in a technical sense, these questions do not limit the feasibility of seaborne transportation. The coast along the Pechora Sea is quite shallow, which is why loading terminals have to be located quite far from the coast, requiring extensive sub-sea pipelines. This pipeline distance is the only limiting factor for the vessel draught. Vessels of 120.000 dwt, with a draught of about 15 m, can be used for the transportation.

As the ice conditions at the Pechora Sea vary greatly, the level of required ice strengthening and ice breaking capability of vessels to be used will also depend on the terminal location. The final selection of terminal location will be based on total costs of onshore and offshore piping in combination with terminal and vessel costs.

The environmental conditions encountered on the route to the Ob Gulf are different. In the northernmost parts of the Kara Sea multi-year ice can be met. As mentioned earlier, ridging is heavy in the Kara Sea.

The Ob Gulf is a relatively sheltered area and ridging is of less severity. The most limiting factors are the thick level ice and the shallow waters. Already at the mouth of the Ob Bay there is a very shallow section, restricting the draught of all vessels entering the Bay. On some parts of the route the area of deeper water is very narrow, which can cause problems when there is a need for widening an old channel or when opening a new channel. The maximum draught to the area of main interest, (the Novy Port area) is about 9 m, which limits the ship to a size of about 40.000 dwt.

8. CONCLUSIONS AND RECOMMENDATIONS

In the development of transportation along the NSR, one of the most interesting subjects is transportation of oil and gas from Northwest Russia. Presently a large number of projects are underway to determine the feasibility of producing oil and gas in the Ob, Yamal and Timan-Pechora areas. Seaborne transportation of the products is also being considered.

This study has investigated the different subjects influencing the selection of a transportation system. A more detailed calculation has been done regarding the costs for seaborne transportation.

The technical feasibility of seaborne transportation of LNG from the Kharasevey area across the Kara Sea 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 concerning the performance of various ship in such ice conditions. Both powerful icebreakers and cargo vessels of 15.000 dwt have been transiting the sea for 20 years which gives useful information for the design of tankers and LNG-carriers for the above mentioned route. It must, however, be noted that the amount of published data on the prevailing conditions is still limited, and in many cases the data is in a form not suitable for use in the design of vessels. It is essential that an extensive data collection and formation process be started. The most critical subject is the existence of compressive ice and its influence on the performance of different vessels.

This economic calculation shows a cost of 10.3 USD/m^3 for the transportation of LNG from the Kharasevey area to Rotterdam by 135.000 m^3 carriers. When including the production and storage costs, the total cost for delivering LNG to Rotterdam is 29.5 USD/m^3. This calculation is based on independent year-round operation. The transportation cost level can be compared with the present level of 12.1 USD/m^3 for transportation of LNG from Aden to Rotterdam.

The possible extra costs for navigating in the Northern Sea Route vary from 1.1 USD/cu.m. to about 3 USD/cu.m., where the cheapest alternative is for chartering two Kapitan Dranitsyn-class icebreakers for 270 days/year, and the most expensive alternative being the full Northern Sea Route fee for all visits. These costs represent 10 - 30 % of the sea transportation costs, but only 3 - 10 % of the total costs.

If we take into consideration that the market price for LNG today is about 100 USD/cu.m, this means that there are potentials in the supply of LNG from Yamal to the

European market. The components lacking in this comparison are the loading terminal in the Arctic alternative and production, storage and loading in the Aden option.

It should also be noted, that the Arctic alternative is expected to include some extra costs due to uncertainty of design data. Thus, from the transportation point of view, the LNG-supply from Yamal to the European market can be competitive.

The detailed calculation was done for 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 frequency of assistance that lead to significant 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 the case of traffic along the NSR increasing significantly, the effect of assistance may change. If the number of icebreakers grows and/or a constant lead is created, the need for independently operating vessels may change. However, this would require large constant traffic, which is not expected in the near future.

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APPENDIX 1
ECONOMY CALCULATIONS

SEAKEY ICEGOING SHIP ECONOMICS

User: AB
Date: 10.3.95

SHIP IDENTIFICATION

Project: 135 000 CU.M. LNG-carrier, Aden - Rotterdam (via Suez)
Name:
Owner: INSROP
Operator:

MAIN PARTICULARS

Deadweight:	68 500 ton	Propulsion Power:	29000 kW
Cargo Payload:	67500 ton	Trial Speed:	19.5 knots
Gross tonnage:	117000 tonnes	Auxilliary Power:	4000 kW
Length OA:	289.0 m	Currency:	USD
Beam:	48.1 m	Building Price:	230 Millions
Draught:	11.3 m	Start of Operation:	1997
		Operating days/year	365 days
		Production	30000 cu.m/day
		Required transportation	10.95 M cu.m/ye

CARGO PAYLOAD

Type of Cargo: LNG

Cargo Unit: cu.m.

CARGO CAPACITY

Cargo Category	Name	No of Units	Unit volume	Unit weight	Cargo volume	Cargo weight
Cargo 1:	LNG	135000	1.00	0.50	135000	67500
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		135000			135000	67500

ROUTE & SCHEDULE			
Route	Aden - Rotterdam - Aden		
Distance	9226 nm (roundtrip)		
Schedule	Mild	Normal	Strong
Months : September - October	61 days	61 days	61 days
Number of trips	2.85 per year	2.85 per year	2.85 per year
Time per Leg:	21.4 days	21.4 days	21.4 days
Time at Sea:	19.7 days	19.7 days	19.7 days
Average Speed:	19.5 knots	19.5 knots	19.5 knots
Month : November	30 days	30 days	30 days
Number of trips	1.40 per year	1.40 per year	1.40 per year
Time per Leg:	21.4 days	21.4 days	21.4 days
Time at Sea:	19.7 days	19.7 days	19.7 days
Average Speed:	19.5 knots	19.5 knots	19.5 knots
Month : December	31 days	31 days	31 days
Number of trips	1.45 per year	1.45 per year	1.45 per year
Time per Leg:	21.4 days	21.4 days	21.4 days
Time at Sea:	19.7 days	19.7 days	19.7 days
Average Speed:	19.5 knots	19.5 knots	19.5 knots
Month : January	31 days	31 days	31 days
Number of trips	1.45 per year	1.45 per year	1.45 per year
Time per Leg:	21.4 days	21.4 days	21.4 days
Time at Sea:	19.7 days	19.7 days	19.7 days
Average Speed:	19.5 knots	19.5 knots	19.5 knots
Month : February	28 days	28 days	28 days
Number of trips	1.31 per year	1.31 per year	1.31 per year
Time per Leg:	21.4 days	21.4 days	21.4 days
Time at Sea:	19.7 days	19.7 days	19.7 days
Average Speed:	19.5 knots	19.5 knots	19.5 knots
Month : March	31 days	31 days	31 days
Number of trips	1.45 per year	1.45 per year	1.45 per year
Time per Leg:	21.4 days	21.4 days	21.4 days
Time at Sea:	19.7 days	19.7 days	19.7 days
Average Speed:	19.5 knots	19.5 knots	19.5 knots
Month : April	30 days	30 days	30 days
Number of trips	1.40 per year	1.40 per year	1.40 per year
Time per Leg:	21.4 days	21.4 days	21.4 days
Time at Sea:	19.7 days	19.7 days	19.7 days
Average Speed:	19.5 knots	19.5 knots	19.5 knots
Month : May	31 days	31 days	31 days
Number of trips	1.45 per year	1.45 per year	1.45 per year
Time per Leg:	21.4 days	21.4 days	21.4 days
Time at Sea:	19.7 days	19.7 days	19.7 days
Average Speed:	19.5 knots	19.5 knots	19.5 knots
Month : June	30 days	30 days	30 days
Number of trips	1.40 per year	1.40 per year	1.40 per year
Time per Leg:	21.4 days	21.4 days	21.4 days
Time at Sea:	19.7 days	19.7 days	19.7 days
Average Speed:	19.5 knots	19.5 knots	19.5 knots
Month : July	31 days	31 days	31 days
Number of trips	1.45 per year	1.45 per year	1.45 per year
Time per Leg:	21.4 days	21.4 days	21.4 days
Time at Sea:	19.7 days	19.7 days	19.7 days
Average Speed:	19.5 knots	19.5 knots	19.5 knots

Month : August	31 days	31 days	31 days
Number of trips	1.45 per year	1.45 per year	1.45 per year
Time per Leg:	21.4 days	21.4 days	21.4 days
Time at Sea:	19.7 days	19.7 days	19.7 days
Average Speed:	19.5 knots	19.5 knots	19.5 knots
Total number of Trips	17.1	17.1	17.1
Operating Days:	365 days	365 days	365 days

Corrected schedule (acc. to production capacity)

Month: January			
Production	0.93 M cu.m.	0.93 M cu.m.	0.93 M cu.m.
Acc. Prod.	0.93 M cu.m.	0.93 M cu.m.	0.93 M cu.m.
Transp. cap.	0.96 M cu.m.	0.96 M cu.m.	0.96 M cu.m.
Transp.	0.93 M cu.m.	0.93 M cu.m.	0.93 M cu.m.
Number of trips/ship	1.41	1.41	1.41
Tot. transp.	0.93 M cu.m.	0.93 M cu.m.	0.93 M cu.m.
Month: February			
Production	0.84 M cu.m.	0.84 M cu.m.	0.84 M cu.m.
Acc. Prod.	1.77 M cu.m.	1.77 M cu.m.	1.77 M cu.m.
Transp. cap.	0.87 M cu.m.	0.87 M cu.m.	0.87 M cu.m.
Transp.	0.84 M cu.m.	0.84 M cu.m.	0.84 M cu.m.
Number of trips/ship	1.27	1.27	1.27
Tot. transp.	1.77 M cu.m.	1.77 M cu.m.	1.77 M cu.m.
Month: March			
Production	0.93 M cu.m.	0.93 M cu.m.	0.93 M cu.m.
Acc. Prod.	2.70 M cu.m.	2.70 M cu.m.	2.70 M cu.m.
Transp. cap.	0.96 M cu.m.	0.96 M cu.m.	0.96 M cu.m.
Transp.	0.93 M cu.m.	0.93 M cu.m.	0.93 M cu.m.
Number of trips/ship	1.41	1.41	1.41
Tot. transp.	2.70 M cu.m.	2.70 M cu.m.	2.70 M cu.m.
Month: April			
Production	0.90 M cu.m.	0.90 M cu.m.	0.90 M cu.m.
Acc. Prod.	3.60 M cu.m.	3.60 M cu.m.	3.60 M cu.m.
Transp. cap.	0.93 M cu.m.	0.93 M cu.m.	0.93 M cu.m.
Transp.	0.90 M cu.m.	0.90 M cu.m.	0.90 M cu.m.
Number of trips/ship	1.36	1.36	1.36
Tot. transp.	3.60 M cu.m.	3.60 M cu.m.	3.60 M cu.m.
Month: May			
Production	0.93 M cu.m.	0.93 M cu.m.	0.93 M cu.m.
Acc. Prod.	4.53 M cu.m.	4.53 M cu.m.	4.53 M cu.m.
Transp. cap.	0.96 M cu.m.	0.96 M cu.m.	0.96 M cu.m.
Transp.	0.93 M cu.m.	0.93 M cu.m.	0.93 M cu.m.
Number of trips/ship	1.41	1.41	1.41
Tot. transp.	4.53 M cu.m.	4.53 M cu.m.	4.53 M cu.m.
Month: June			
Production	0.90 M cu.m.	0.90 M cu.m.	0.90 M cu.m.
Acc. Prod.	5.43 M cu.m.	5.43 M cu.m.	5.43 M cu.m.
Transp. cap.	0.93 M cu.m.	0.93 M cu.m.	0.93 M cu.m.
Transp.	0.90 M cu.m.	0.90 M cu.m.	0.90 M cu.m.
Number of trips/ship	1.36	1.36	1.36
Tot. transp.	5.43 M cu.m.	5.43 M cu.m.	5.43 M cu.m.
Month: July			
Production	0.93 M cu.m.	0.93 M cu.m.	0.93 M cu.m.
Acc. Prod.	6.36 M cu.m.	6.36 M cu.m.	6.36 M cu.m.
Transp. cap.	0.96 M cu.m.	0.96 M cu.m.	0.96 M cu.m.
Transp.	0.93 M cu.m.	0.93 M cu.m.	0.93 M cu.m.
Number of trips/ship	1.41	1.41	1.41
Tot. transp.	6.36 M cu.m.	6.36 M cu.m.	6.36 M cu.m.

Month: August			
Production	0.93 M cu.m.	0.93 M cu.m.	0.93 M cu.m.
Acc. Prod.	7.29 M cu.m.	7.29 M cu.m.	7.29 M cu.m.
Transp. cap.	0.96 M cu.m.	0.96 M cu.m.	0.96 M cu.m.
Transp.	0.93 M cu.m.	0.93 M cu.m.	0.93 M cu.m.
Number of trips/ship	1.41	1.41	1.41
Tot. transp.	7.29 M cu.m.	7.29 M cu.m.	7.29 M cu.m.
Month: September - October			
Production	1.83 M cu.m.	1.83 M cu.m.	1.83 M cu.m.
Acc. Prod.	9.12 M cu.m.	9.12 M cu.m.	9.12 M cu.m.
Transp. cap.	1.89 M cu.m.	1.89 M cu.m.	1.89 M cu.m.
Transp.	1.83 M cu.m.	1.83 M cu.m.	1.83 M cu.m.
Number of trips/ship	2.77	2.77	2.77
Tot. transp.	9.12 M cu.m.	9.12 M cu.m.	9.12 M cu.m.
Month: November			
Production	0.90 M cu.m.	0.90 M cu.m.	0.90 M cu.m.
Acc. Prod.	10.02 M cu.m.	10.02 M cu.m.	10.02 M cu.m.
Transp. cap.	0.93 M cu.m.	0.93 M cu.m.	0.93 M cu.m.
Transp.	0.90 M cu.m.	0.90 M cu.m.	0.90 M cu.m.
Number of trips/ship	1.36	1.36	1.36
Tot. transp.	10.02 M cu.m.	10.02 M cu.m.	10.02 M cu.m.
Month: December			
Production	0.93 M cu.m.	0.93 M cu.m.	0.93 M cu.m.
Acc. Prod.	10.95 M cu.m.	10.95 M cu.m.	10.95 M cu.m.
Transp. cap.	0.96 M cu.m.	0.96 M cu.m.	0.96 M cu.m.
Transp.	0.93 M cu.m.	0.93 M cu.m.	0.93 M cu.m.
Number of trips/ship	1.41	1.41	1.41
Tot. transp.	10.95 M cu.m.	10.95 M cu.m.	10.95 M cu.m.
Total number of trips	16.6	16.6	16.6

Maximum transported cargo	12 M cu.m.	12 M cu.m.	12 M cu.m.
Excess capacity	1 M cu.m.	1 M cu.m.	1 M cu.m.

SEAKEY ICEGOING SHIP ECONOMICS: Route & Schedule

OPERATION PROFILE

Route Aden - Rotterdam - Aden
Distance 9226 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	9226	19.5	473.1				
Open water, normal	9226			19.5	473.1		
Open water, strong	9226					19.5	473.1
Ice, mild	0	0	0				
Ice, normal	0			0	0		
Ice strong	0					0	0
Total	9226	19.5	513.1	19.5	513.1	19.5	513.1

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	9226	19.5	473.1				
Open water, normal	9226			19.5	473.1		
Open water, strong	9226					19.5	473.1
Ice, mild	0	0	0				
Ice, normal	0			0	0		
Ice strong	0					0	0
Total	9226	19.5	513.1	19.5	513.1	19.5	513.1

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	9226	19.5	473.1				
Open water, normal	9226			19.5	473.1		
Open water, strong	9226					19.5	473.1
Ice, mild	0	0	0				
Ice, normal	0			0	0		
Ice strong	0					0	0
Total	9226	19.5	513.1	19.5	513.1	19.5	513.1

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	9226	19.5	473.1				
Open water, normal	9226			19.5	473.1		
Open water, strong	9226					19.5	473.1
Ice, mild	0	0	0				
Ice, normal	0			0	0		
Ice strong	0					0	0
Total	9226	19.5	513.1	19.5	513.1	19.5	513.1

Operation Season February	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	19.5	473.1				
Open water, normal	9226			19.5	473.1		
Open water, strong	9226					19.5	473.1
Ice, mild	0	0	0				
Ice, normal	0			0	0		
Ice strong	0					0	0
Total	9226	19.5	513.1	19.5	513.1	19.5	513.1

Operation Season March	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	19.5	473.1				
Open water, normal	9226			19.5	473.1		
Open water, strong	9226					19.5	473.1
Ice, mild	0	0	0				
Ice, normal	0			0	0		
Ice strong	0					0	0
Total	9226	19.5	513.1	19.5	513.1	19.5	513.1

Operation Season April	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	19.5	473.1				
Open water, normal	9226			19.5	473.1		
Open water, strong	9226					19.5	473.1
Ice, mild	0	0	0				
Ice, normal	0			0	0		
Ice strong	0					0	0
Total	9226	19.5	513.1	19.5	513.1	19.5	513.1

Operation Season May	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	19.5	473.1				
Open water, normal	9226			19.5	473.1		
Open water, strong	9226					19.5	473.1
Ice, mild	0	0	0				
Ice, normal	0			0	0		
Ice strong	0					0	0
Total	9226	19.5	513.1	19.5	513.1	19.5	513.1

Operation Season June	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	19.5	473.1				
Open water, normal	9226			19.5	473.1		
Open water, strong	9226					19.5	473.1
Ice, mild	0	0	0				
Ice, normal	0			0	0		
Ice strong	0					0	0
Total	9226	19.5	513.1	19.5	513.1	19.5	513.1

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	19.5	473.1				
Open water, normal	9226			19.5	473.1		
Open water, strong	9226					19.5	473.1
Ice, mild	0	0	0				
Ice, normal	0			0	0		
Ice strong	0					0	0
Total	9226	19.5	513.1	19.5	513.1	19.5	513.1

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	19.5	473.1				
Open water, normal	9226			19.5	473.1		
Open water, strong	9226					19.5	473.1
Ice, mild	0	0	0				
Ice, normal	0			0	0		
Ice strong	0					0	0
Total	9226	19.5	513.1	19.5	513.1	19.5	513.1

SEAKEY ICEGOING SHIP ECONOMICS: Cargo Revenue

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

CARGO CARRYING CAPACITY PER YEAR						
	Mild		Normal		Strong	
Cargo Category	Per Trip	Total	Per Trip	Total	Per Trip	Total
LNG	132300	2258593	132300	2258593	132300	2258593
Total Cargo	132300	2258593	132300	2258593	132300	2258593

AVERAGE LOAD FACTORS FOR THE WHOLE YEAR	Cargo LF:	49 %

CARGO FREIGHT INCOME			*1000
Cargo Category	Out	Back	Total
LNG	0	0	0
CARGO GROSS REVENUE	0	0	0

COST OF SALES				*1000
Reduction of Full Fare Prices		Out	Back	Total
Fare Dilution	0 %	0	0	0
Commissions	0 %	0	0	0
Advertising	0 %	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	4	5	17000	50	230
Additional Crew	Repaire	0	0	17000	50	0
Total Payroll		10	12			815

CONSUMABLES AND SUPPLIES	Crewday USD / per	*1000
Provision	7.0	26
Hotelsupply	1.5	5
Other	0	0
Total Consumables and Supplies	8.5	31

PORT CHARGES, CANAL FEES	Ports/trip	USD/GRT	USD/Trip	*1000
Dues and Charges	1	0.2		291
Canal fees			400000.0	6400
Towing & Mooring	1	0.1		194
Total Port and Cargo Handling Costs				6884

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	2300
Insurance	0.0	0
Other	0.0	0
Total Ship Expences		2300

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 Hours	MWh	Normal winter Hours	MWh	Strong winter Hours	MWh
FO							
Harbour	0	662.1	0	662.1	0	662.1	0
Open water	100	7831.8	227 123	7831.8	227 123	7831.8	227 123
Ice	0	0	0	0	0	0	0
Total	92	8494.0	227 123	8494.0	227 123	8494.0	227 123
g/kWh	185						
ton			42 018		42 018		42 018
LO							
g/kWh	2						
ton			454		454		454

Auxiliary Machinery	Load %	Mild winter Hours	MWh	Normal winter Hours	MWh	Strong winter Hours	MWh
Aux. power, at sea	20	7831.8	6 265	7831.8	6 265	7831.8	6 265
Aux. power, loading	70.0	662	1 854	662	1 854	662	1 854
Aux. power, waiting	20.0	266	213	266	213	266	213
Total			8 332		8 332		8 332
FO							
g/kWh	185.0						
ton			1 541		1 541		1 541
LO							
g/kWh	2						
ton			17		17		17

Total Consumption	Price / ton	Mild winter ton	USD	Normal winter ton	USD	Strong winter ton	USD
Propulsion	100	42018	4201775	42018	4201775	42 018	4201775
Aux Power	100	1541	154147	1541	154146.9	1541	154146.9
Boilers	100	700	70000	700	70000	700	70000
Lub.Oil	1500	471	706366	471	706365.8	471	706365.8
Total Bunker and Lubricating Oil Cost * 1000			5132		5132		5132

SEAKEY ICEGOING SHIP ECONOMICS: Profitability of Operation

SUMMARY OF OPERATING INCOME AND COSTS

Evaluated Year: 1997
Cargo carried: 2190000 cu.m.

CARGO REVENUE		*1000
	Freigth Rate	Total Income
Cargo Gross Revenue	0.00	0
Cost of Sales	0.00	0
CARGO NET REVENUE	0.00	0

OPERATING EXPENSES / SHIP		*1000
	Per Cargo Unit	Total Costs
Daily Running Costs:		
Payroll	0.37	815
Ship Expences	1.05	2300
Total Daily Running Costs	1.42	3115
Voyage Costs:		
Bunker and Lub Oil		
Mild winter	2.34	5132
Normal winter	2.34	5132
Strong winter	2.34	5132
Consumables and Supplies	0.01	31
Port and Canal Charges	3.14	6884
Icebreaker Assistance	0.00	0
Total Voyage Costs Mild winter	5.50	12047
Normal winter	5.50	12047
Strong winter	5.50	12047
Total Shore Side Expence	0.05	119
TOTAL OPERATING EXPENSES Mild winter	6.98	15281
Normal winter	6.98	15281
Strong winter	6.98	15281
OPERATING INCOME Mild winter	-6.98	-15300
Normal winter	-6.98	-15300
Strong winter	-6.98	-15300

CAPITAL COST ESTIMATE							*1000
Newbuilding Price:	230	Million USD					
	Amount	Interest		Depreciation			First Year
Financing:	% of price	%	First year	Years	Cost/year		cost
Loan 1	100	6.5	14950	15.0	15333		30280
Loan 2	0	0.0	0	0.0	0		0
CAPITAL COST	100		14950		15333		30300

FIRST YEAR CASH BALANCE	Per Cargo Unit	*1000
Operating Income	-6.98	-15300
First Year Capital Cost	13.84	30300
NET CASH FLOW (First Year)	-20.81	-45600

FLEET SIZE			
Amount to be transported	10.95 M cu.m.		
Required number of ships	5 (mild)		
	5 (normal)		
	5 (strong)		
AVERAGE COST /TON		USD	14.91 per cubic meter
TIME CHARTER RATE		USD	92000 per operating day

SEAKEY ICEGOING SHIP ECONOMICS:
Cash Flow Calculation

ANNUAL INFLATION RATES		AVERAGE LOAD FACTOR	
Income:	0 %	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
Operating Expense:	-	-	15	15	15	15
Operating Income:	0	0	-15	-15	-15	-15
Capital Costs						
Loan 1 Amount	0	0	230	215	199	184
Loan 1 Interest	0	0	15	14	13	12
Loan 1 Depreciation	0	0	15	15	15	15
Loan 2 Amount	0	0	0	0	0	0
Loan 2 Interest	0	0	0	0	0	0
Loan 2 Depreciation	0	0	0	0	0	0
Prepayments						
Amount	23	23				
Interest	1	1				
Total Capital Cost	1	1	30	29	28	27
Start Up Cost, etc.	2	3	5	0	0	0
Net Cash Flow	-3	-4	-51	-45	-44	-43
ACCUMULATED CF	-3	-8	-59	-103	-147	-189

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	15	15	15	15	15	15
Operating Income	-15	-15	-15	-15	-15	-15
Capital Costs						
Loan 1 Amount	169	153	138	123	107	92
Loan 1 Interest	11	10	9	8	7	6
Loan 1 Depreciation	15	15	15	15	15	15
Loan 2 Amount	0	0	0	0	0	0
Loan 2 Interest	0	0	0	0	0	0
Loan 2 Depreciation	0	0	0	0	0	0
Total Capital Cost	26	25	24	23	22	21
Start Up Cost, etc.	0	0	0	0	0	0
Net Cash Flow	-42	-41	-40	-39	-38	-37
ACCUMULATED CF	-231	-271	-311	-350	-387	-424

SEAKEY ICEGOING SHIP ECONOMICS: MUSD

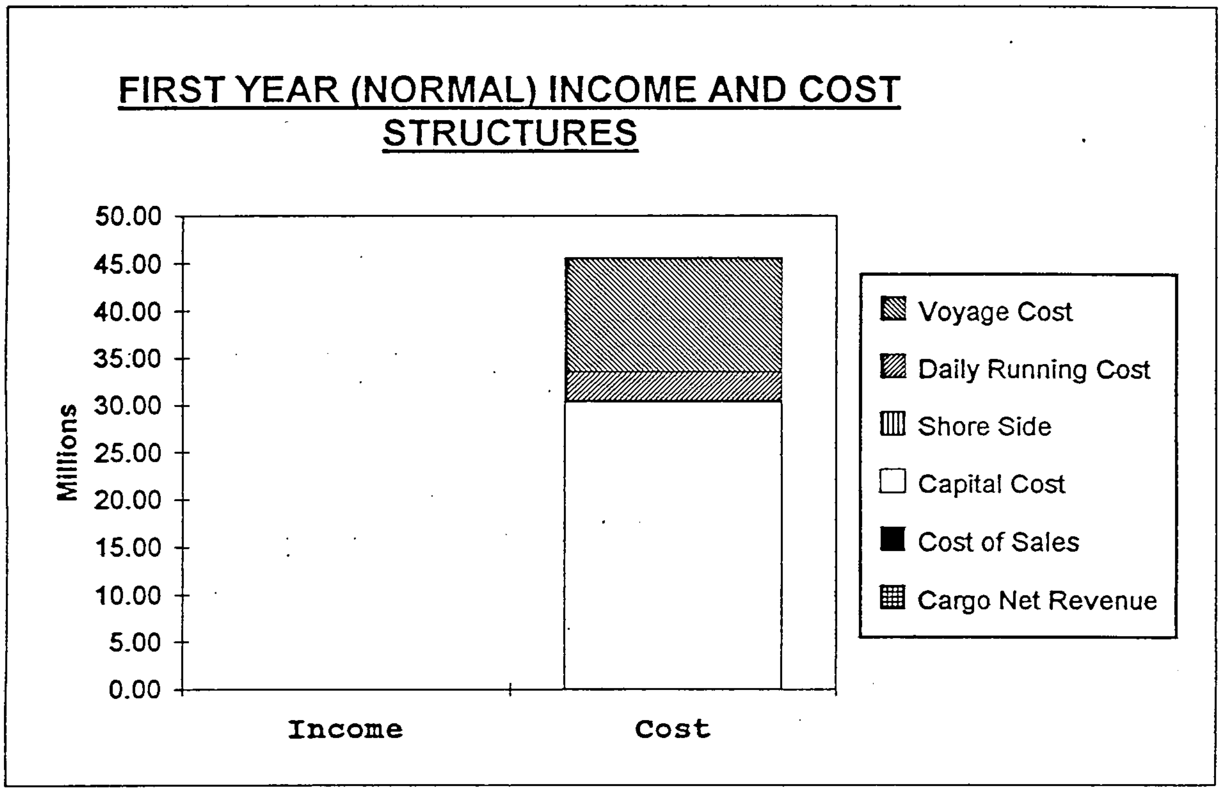
Cash Flow Calculation
contin.

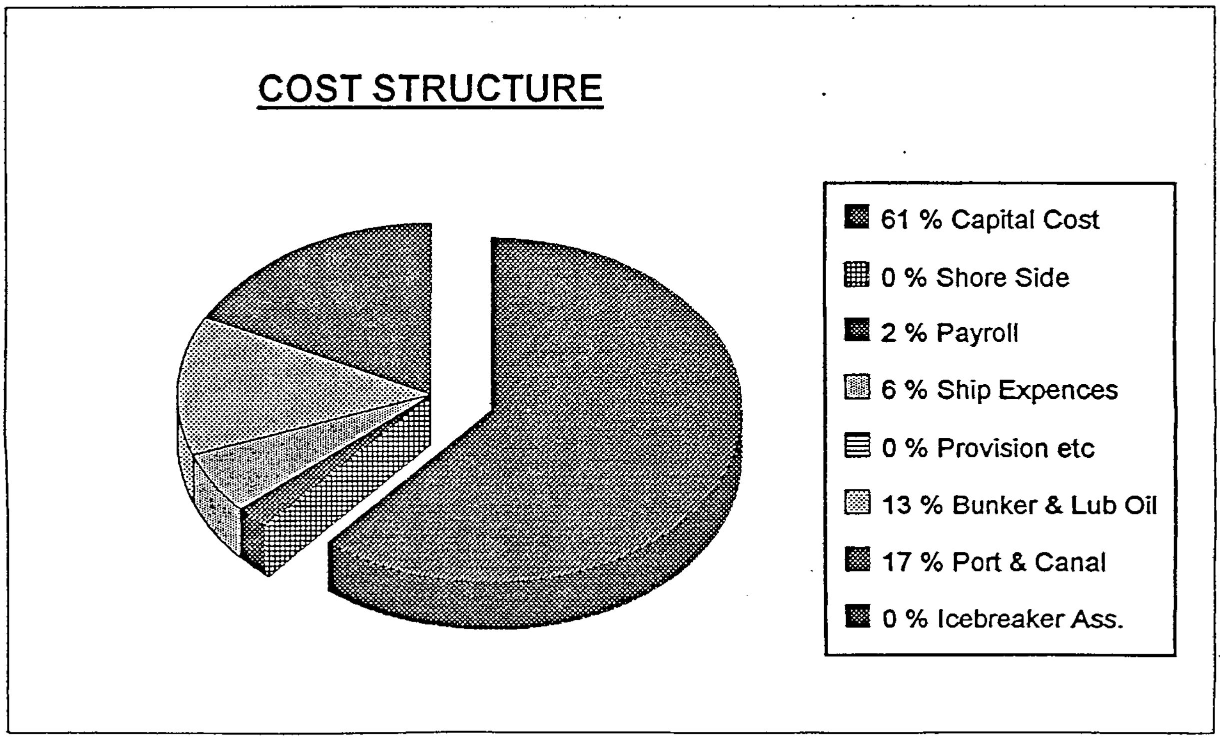
Year	2007N	2008N	2009S	2010N	2010M	2011N
Income escalation:	1.00	1.00	1.00	1.00	1.00	1.00
Cost escalation:	1.00	1.00	1.00	1.00	1.00	1.00
Operating Revenue	0	0	0	0	0	0
Operating Expense	15	15	15	15	15	15
Operating Income	-15	-15	-15	-15	-15	-15
Capital Costs						
Loan 1 Amount	77	61	46	31	15	0
Loan 1 Interest	5	4	3	2	1	0
Loan 1 Depreciation	15	15	15	15	15	0
Loan 2 Amount	0	0	0	0	0	0
Loan 2 Interest	0	0	0	0	0	0
Loan 2 Depreciation	0	0	0	0	0	0
Total Capital Cost	20	19	18	17	16	0
Start Up Cost, etc.	0	0	0	0	0	0
Net Cash Flow	-36	-35	-34	-33	-32	-15
ACCUMULATED CF	-459	-494	-528	-560	-592	-607

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:	15	15	15	0	0	0
Operating Income:	-15	-15	-15	0	0	0
Capital Costs						
Loan 1 Amount	0	0	0	0	0	0
Loan 1 Interest	0	0	0	0	0	0
Loan 1 Depreciation	0	0	0	0	0	0
Loan 2 Amount	0	0	0	0	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	0	0	0	0	0	0
Start Up Cost, etc.	0	0	0	0	0	0
Net Cash Flow	-15	-15	-15	0	0	0
ACCUMULATED CF	-622	-638	-653	-653	-653	-653

SEAKEY ICEGOING SHIP ECONOMICS

Project: 135 000 CU.M. LNG-carrier, Aden - Rotterdam (via
Name: 0
Currency USD





SEAKEY ICEGOING SHIP ECONOMICS

User: AB
Date: 10.3.95

SHIP IDENTIFICATION	
Project:	135 000 cu.m. ib LNG-carrier, Yamal - Rotterdam -Yamal
Name:	
Owner:	INSROP
Operator:	

MAIN PARTICULARS			
Deadweight:	70 000 ton	Propulsion Power:	53000 kW
Cargo Payload:	67500 ton	Trial Speed:	16.0 knots
Gross tonnage:	120000 tonnes	Auxilliary Power:	4000 kW
Length OA:	300.0 m	Currency:	USD
Beam:	48.0 m	Building Price:	310 Millions
Draught:	11.3 m	Start of Operation:	1997
		Operating days/year	365 days
		Production	27000 cu.m/day
		Required transportation	9.855 M cu.m/ye

CARGO PAYLOAD	
Type of Cargo: LNG	Cargo Unit: cu.m.

CARGO CAPACITY

Cargo Category	Name	No of Units	Unit volume	Unit weight	Cargo volume	Cargo weight
Cargo 1:	LNG	135000	1.00	0.50	135000	67500
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		135000			135000	67500

ROUTE & SCHEDULE			
Route	Yamal - Rotterdam - Yamal		
Distance	4600 nm (roundtrip)		
Schedule	Mild	Normal	Strong
Months : September - October	61 days	61 days	61 days
Number of trips	5.31 per year	5.31 per year	5.31 per year
Time per Leg:	11.5 days	11.5 days	11.5 days
Time at Sea:	9.8 days	9.8 days	9.8 days
Average Speed:	19.5 knots	19.5 knots	19.5 knots
Month : November	30 days	30 days	30 days
Number of trips	2.60 per year	2.57 per year	2.43 per year
Time per Leg:	11.5 days	11.7 days	12.4 days
Time at Sea:	9.9 days	10.0 days	10.7 days
Average Speed:	19.4 knots	19.2 knots	17.9 knots
Month : December	31 days	31 days	31 days
Number of trips	2.54 per year	2.45 per year	2.29 per year
Time per Leg:	12.2 days	12.6 days	13.6 days
Time at Sea:	10.5 days	11.0 days	11.9 days
Average Speed:	18.2 knots	17.5 knots	16.1 knots
Month : January	31 days	31 days	31 days
Number of trips	2.41 per year	2.34 per year	2.18 per year
Time per Leg:	12.9 days	13.3 days	14.2 days
Time at Sea:	11.2 days	11.6 days	12.6 days
Average Speed:	17.1 knots	16.5 knots	15.3 knots
Month : February	28 days	28 days	28 days
Number of trips	2.17 per year	2.05 per year	1.84 per year
Time per Leg:	12.9 days	13.6 days	15.3 days
Time at Sea:	11.2 days	12.0 days	13.6 days
Average Speed:	17.1 knots	16.0 knots	14.1 knots
Month : March	31 days	31 days	31 days
Number of trips	1.56 per year	1.27 per year	1.41 per year
Time per Leg:	19.9 days	24.4 days	22.0 days
Time at Sea:	18.2 days	22.7 days	20.3 days
Average Speed:	10.5 knots	8.4 knots	9.4 knots
Month : April	30 days	30 days	30 days
Number of trips	1.39 per year	1.00 per year	1.02 per year
Time per Leg:	21.6 days	29.9 days	29.3 days
Time at Sea:	19.9 days	28.2 days	27.6 days
Average Speed:	9.6 knots	6.8 knots	6.9 knots
Month : May	31 days	31 days	31 days
Number of trips	1.78 per year	1.14 per year	1.10 per year
Time per Leg:	17.4 days	27.1 days	28.2 days
Time at Sea:	15.7 days	25.5 days	26.5 days
Average Speed:	12.2 knots	7.5 knots	7.2 knots
Month : June	30 days	30 days	30 days
Number of trips	2.18 per year	1.77 per year	1.49 per year
Time per Leg:	13.7 days	16.9 days	20.1 days
Time at Sea:	12.1 days	15.3 days	18.4 days
Average Speed:	15.9 knots	12.5 knots	10.4 knots
Month : July	31 days	31 days	31 days
Number of trips	2.65 per year	2.38 per year	1.84 per year
Time per Leg:	11.7 days	13.0 days	16.9 days
Time at Sea:	10.0 days	11.4 days	15.2 days
Average Speed:	19.1 knots	16.9 knots	12.6 knots

Month : August	31 days	31 days	31 days
Number of trips	2.70 per year	2.70 per year	2.50 per year
Time per Leg:	11.5 days	11.5 days	12.4 days
Time at Sea:	9.8 days	9.8 days	10.7 days
Average Speed:	19.5 knots	19.5 knots	17.9 knots
Total number of Trips	27.3	25.0	23.4
Operating Days:	365 days	365 days	365 days

Corrected schedule (acc. to production capacity)

Month: January			
Production	0.84 M cu.m.	0.84 M cu.m.	0.84 M cu.m.
Acc. Prod.	0.84 M cu.m.	0.84 M cu.m.	0.84 M cu.m.
Transp. cap.	0.96 M cu.m.	0.93 M cu.m.	0.86 M cu.m.
Transp.	0.84 M cu.m.	0.84 M cu.m.	0.84 M cu.m.
Number of trips/ship	2.11	2.11	2.11
Tot. transp.	0.84 M cu.m.	0.84 M cu.m.	0.84 M cu.m.
Month: February			
Production	0.76 M cu.m.	0.76 M cu.m.	0.76 M cu.m.
Acc. Prod.	1.59 M cu.m.	1.59 M cu.m.	1.59 M cu.m.
Transp. cap.	0.86 M cu.m.	0.82 M cu.m.	0.73 M cu.m.
Transp.	0.76 M cu.m.	0.76 M cu.m.	0.73 M cu.m.
Number of trips/ship	1.90	1.90	1.84
Tot. transp.	1.59 M cu.m.	1.59 M cu.m.	1.57 M cu.m.
Month: March			
Production	0.84 M cu.m.	0.84 M cu.m.	0.84 M cu.m.
Acc. Prod.	2.43 M cu.m.	2.43 M cu.m.	2.43 M cu.m.
Transp. cap.	0.62 M cu.m.	0.51 M cu.m.	0.56 M cu.m.
Transp.	0.62 M cu.m.	0.51 M cu.m.	0.56 M cu.m.
Number of trips/ship	1.56	1.27	1.41
Tot. transp.	2.21 M cu.m.	2.10 M cu.m.	2.12 M cu.m.
Month: April			
Production	0.81 M cu.m.	0.81 M cu.m.	0.81 M cu.m.
Acc. Prod.	3.24 M cu.m.	3.24 M cu.m.	3.24 M cu.m.
Transp. cap.	0.55 M cu.m.	0.40 M cu.m.	0.41 M cu.m.
Transp.	0.55 M cu.m.	0.40 M cu.m.	0.41 M cu.m.
Number of trips/ship	1.39	1.00	1.02
Tot. transp.	2.76 M cu.m.	2.50 M cu.m.	2.53 M cu.m.
Month: May			
Production	0.84 M cu.m.	0.84 M cu.m.	0.84 M cu.m.
Acc. Prod.	4.08 M cu.m.	4.08 M cu.m.	4.08 M cu.m.
Transp. cap.	0.71 M cu.m.	0.45 M cu.m.	0.44 M cu.m.
Transp.	0.71 M cu.m.	0.45 M cu.m.	0.44 M cu.m.
Number of trips/ship	1.78	1.14	1.10
Tot. transp.	3.47 M cu.m.	2.95 M cu.m.	2.97 M cu.m.
Month: June			
Production	0.81 M cu.m.	0.81 M cu.m.	0.81 M cu.m.
Acc. Prod.	4.89 M cu.m.	4.89 M cu.m.	4.89 M cu.m.
Transp. cap.	0.87 M cu.m.	0.70 M cu.m.	0.59 M cu.m.
Transp.	0.87 M cu.m.	0.70 M cu.m.	0.59 M cu.m.
Number of trips/ship	2.18	1.77	1.49
Tot. transp.	4.34 M cu.m.	3.65 M cu.m.	3.56 M cu.m.
Month: July			
Production	0.84 M cu.m.	0.84 M cu.m.	0.84 M cu.m.
Acc. Prod.	5.72 M cu.m.	5.72 M cu.m.	5.72 M cu.m.
Transp. cap.	1.05 M cu.m.	0.94 M cu.m.	0.73 M cu.m.
Transp.	1.05 M cu.m.	0.94 M cu.m.	0.73 M cu.m.
Number of trips/ship	2.65	2.38	1.84
Tot. transp.	5.39 M cu.m.	4.60 M cu.m.	4.29 M cu.m.

Month: August			
Production	0.84 M cu.m.	0.84 M cu.m.	0.84 M cu.m.
Acc. Prod.	6.56 M cu.m.	6.56 M cu.m.	6.56 M cu.m.
Transp. cap.	1.07 M cu.m.	1.07 M cu.m.	0.99 M cu.m.
Transp.	1.07 M cu.m.	1.07 M cu.m.	0.99 M cu.m.
Number of trips/ship	2.70	2.70	2.50
Tot. transp.	6.46 M cu.m.	5.67 M cu.m.	5.28 M cu.m.
Month: September - October			
Production	1.65 M cu.m.	1.65 M cu.m.	1.65 M cu.m.
Acc. Prod.	8.21 M cu.m.	8.21 M cu.m.	8.21 M cu.m.
Transp. cap.	2.11 M cu.m.	2.11 M cu.m.	2.11 M cu.m.
Transp.	1.75 M cu.m.	2.11 M cu.m.	2.11 M cu.m.
Number of trips/ship	4.41	5.31	5.31
Tot. transp.	8.21 M cu.m.	7.77 M cu.m.	7.39 M cu.m.
Month: November			
Production	0.81 M cu.m.	0.81 M cu.m.	0.81 M cu.m.
Acc. Prod.	9.02 M cu.m.	9.02 M cu.m.	9.02 M cu.m.
Transp. cap.	1.03 M cu.m.	1.02 M cu.m.	0.96 M cu.m.
Transp.	0.81 M cu.m.	1.02 M cu.m.	0.96 M cu.m.
Number of trips/ship	2.04	2.57	2.43
Tot. transp.	9.02 M cu.m.	8.79 M cu.m.	8.35 M cu.m.
Month: December			
Production	0.84 M cu.m.	0.84 M cu.m.	0.84 M cu.m.
Acc. Prod.	9.86 M cu.m.	9.86 M cu.m.	9.86 M cu.m.
Transp. cap.	1.01 M cu.m.	0.97 M cu.m.	0.91 M cu.m.
Transp.	0.84 M cu.m.	0.97 M cu.m.	0.91 M cu.m.
Number of trips/ship	2.11	2.45	2.29
Tot. transp.	9.86 M cu.m.	9.77 M cu.m.	9.26 M cu.m.
Total number of trips	24.8	24.6	23.3

Maximum transported cargo	11 M cu.m.	10 M cu.m.	9 M cu.m.
Excess capacity	1 M cu.m.	0 M cu.m.	0 M cu.m.

SEAKEY ICEGOING SHIP ECONOMICS: Route & Schedule

OPERATION PROFILE

Route Yamal - Rotterdam - Yamal
Distance 4600 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	4600	19.5	235.9				
Open water, normal	4600			19.5	235.9		
Open water, strong	4600					19.5	235.9
Ice, mild	0	0	0				
Ice, normal	0			0	0		
Ice strong	0					0	0
Total	4600	19.5	275.9	19.5	275.9	19.5	275.9

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	4572	19.5	234.5				
Open water, normal	4460			19.5	228.7		
Open water, strong	4236					19.5	217.2
Ice, mild	28	13.6	2.1				
Ice, normal	140			12.2	11.5		
Ice strong	364					9.2	39.6
Total	4600	19.4	276.5	19.2	280.2	17.9	296.8

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	4269	19.5	218.9				
Open water, normal	4196			19.5	215.2		
Open water, strong	4072					19.5	208.8
Ice, mild	331	9.7	34.1				
Ice, normal	404			8.4	48.1		
Ice strong	528					6.9	76.5
Total	4600	18.2	293.0	17.5	303.3	16.1	325.3

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	4116	19.5	211.1				
Open water, normal	4034			19.5	206.9		
Open water, strong	3974					19.5	203.8
Ice, mild	484	8.4	57.6				
Ice, normal	566			7.9	71.6		
Ice strong	626					6.4	97.8
Total	4600	17.1	308.7	16.5	318.5	15.3	341.6

Operation Season February	Logged	Mild winter		Normal winter		Strong winter	
	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	4076	19.5	209.0				
Open water, normal	3994			19.5	204.8		
Open water, strong	3760					19.5	192.8
Ice, mild	524	8.7	60.2				
Ice, normal	609			7.4	82.3		
Ice strong	840					6.3	133.3
Total	4600	17.1	309.3	16.0	327.1	14.1	366.2

Operation Season March	Logged	Mild winter		Normal winter		Strong winter	
	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	4074	19.5	208.9				
Open water, normal	4025			19.5	206.4		
Open water, strong	3876					19.5	198.8
Ice, mild	526	2.3	228.7				
Ice, normal	575			1.7	338.2		
Ice strong	724					2.5	289.6
Total	4600	10.5	477.6	8.4	584.6	9.4	528.4

Operation Season April	Logged	Mild winter		Normal winter		Strong winter	
	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	4031	19.5	206.7				
Open water, normal	3986			19.5	204.4		
Open water, strong	3804					19.5	195.1
Ice, mild	569	2.1	271.0				
Ice, normal	614			1.3	472.3		
Ice strong	796					1.7	468.2
Total	4600	9.6	517.7	6.8	716.7	6.9	703.3

Operation Season May	Logged	Mild winter		Normal winter		Strong winter	
	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	4155	19.5	213.1				
Open water, normal	4034			19.5	206.9		
Open water, strong	3965					19.5	203.3
Ice, mild	445	2.7	164.8				
Ice, normal	566			1.4	404.3		
Ice strong	735					1.7	432.4
Total	4600	12.2	417.9	7.5	651.2	7.2	675.7

Operation Season June	Logged	Mild winter		Normal winter		Strong winter	
	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	4329	19.5	222.0				
Open water, normal	4242			19.5	217.5		
Open water, strong	3953					19.5	202.7
Ice, mild	271	4.0	67.8				
Ice, normal	358			2.4	149.2		
Ice strong	647					2.7	239.6
Total	4600	15.9	329.8	12.5	406.7	10.4	482.3

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	4529	19.5	232.3				
Open water, normal	4432			19.5	227.3		
Open water, strong	4194					19.5	215.1
Ice, mild	71	8.3	8.6				
Ice, normal	168			3.7	45.4		
Ice strong	406					2.7	150.4
Total	4600	19.1	280.8	16.9	312.7	12.6	405.4

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	4600	19.5	235.9				
Open water, normal	4600			19.5	235.9		
Open water, strong	4359					19.5	223.5
Ice, mild	0	0	0				
Ice, normal	0			0	0		
Ice strong	241					7.1	33.9
Total	4600	19.5	275.9	19.5	275.9	17.9	297.5

SEAKEY ICEGOING SHIP ECONOMICS: Cargo Revenue

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

CARGO CARRYING CAPACITY PER YEAR						
	Mild		Normal		Strong	
Cargo Category	Per Trip	Total	Per Trip	Total	Per Trip	Total
LNG	132300	3610545	132300	3305568	132300	3095016
Total Cargo	132300	3610545	132300	3305568	132300	3095016

AVERAGE LOAD FACTORS FOR THE WHOLE YEAR	Cargo LF:	49 %

CARGO FREIGHT INCOME			*1000
Cargo Category	Out	Back	Total
LNG	0	0	0
CARGO GROSS REVENUE	0	0	0

COST OF SALES				*1000
Reduction of Full Fare Prices		Out	Back	Total
Fare Dilution	0 %	0	0	0
Commissions	0 %	0	0	0
Advertising	0 %	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	4	5	17000	50	230
Additional Crew	Repaire	0	0	17000	50	0
Total Payroll		10	12			815

CONSUMABLES AND SUPPLIES	Crewday	*1000
	USD / per	
Provision	7.0	26
Hotelsupply	1.5	5
Other	0	0
Total Consumables and Supplies	8.5	31

PORT CHARGES AND CARGO HANDLING				*1000
	Ports/trip	USD/GRT	USD/Unit	
Dues and Charges	1	0.2		443
Cargo Handling	2		0.0	0
Towing & Mooring	1	0.1		295
Total Port and Cargo Handling Costs				738

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	3100
Insurance	0.0	0
Other	0.0	0
Total Ship Expences		3100

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		Mild winter		Normal winter		Strong winter	
Machinery	Load %	Hours	MWh	Hours	MWh	Hours	MWh
FO							
Harbour	0	993.2	0	984.4	0	933.0	0
Open water	40	5551.8	117 699	5460.2	115 756	4999.7	105 994
Ice	100	1509.5	80 005	2194.3	116 296	2803.7	148 594
Total	46	8054.6	197 704	8638.8	232 051	8736.4	254 589
g/kWh	185						
ton			36 575		42 929		47 099
LO							
g/kWh	2						
ton			395		464		509

Auxiliary		Mild winter		Normal winter		Strong winter	
Machinery	Load %	Hours	MWh	Hours	MWh	Hours	MWh
Aux. power, at sea	20	7061.4	5 649	7654.4	6 124	7803.4	6 243
Aux. power, loading	70.0	993	2 781	984	2 756	933	2 612
Aux. power, waiting	20.0	705	564	121	97	24	19
Total			8 994		8 977		8 874
FO							
g/kWh	185.0						
ton			1 664		1 661		1 642
LO							
g/kWh	2						
ton			18		18		18

Total Consumption	Price / ton	Mild winter		Normal winter		Strong winter	
		ton	USD	ton	USD	ton	USD
Propulsion	100	36575	3657516	42929	4292949	47 099	4709892
Aux Power	100	1664	166396	1661	166069.1	1642	164168.7
Boilers	100	700	70000	800	80000	900	90000
Lub.Oil	1500	413	620094	482	723084.1	527	790388.3
Total Bunker and Lubricating Oil Cost * 1000			4514		5262		5754

SEAKEY ICEGOING SHIP ECONOMICS:
Profitability of Operation

SUMMARY OF OPERATING INCOME AND COSTS

Evaluated Year: 1997
Cargo carried: 3285000 cu.m.

CARGO REVENUE	Freigth Rate	*1000 Total Income
Cargo Gross Revenue	0.00	0
Cost of Sales	0.00	0
CARGO NET REVENUE	0.00	0

OPERATING EXPENSES / SHIP	Per Cargo Unit	*1000 Total Costs
Daily Running Costs:		
Payroll	0.25	815
Ship Expences	0.94	3100
Total Daily Running Costs	1.19	3915
Voyage Costs:		
Bunker and Lub Oil		
Mild winter	1.37	4514
Normal winter	1.60	5262
Strong winter	1.75	5754
Consumables and Supplies	0.01	31
Port and Cargo Handling	0.22	738
Icebreaker Assistance	0.00	0
Total Voyage Costs Mild winter	1.61	5283
Normal winter	1.84	6031
Strong winter	1.99	6524
Total Shore Side Expence	0.06	198
TOTAL OPERATING EXPENSES Mild winter	2.86	9396
Normal winter	3.09	10144
Strong winter	3.24	10637

OPERATING INCOME Mild winter	-2.86	-9400
Normal winter	-3.09	-10100
Strong winter	-3.24	-10600

CAPITAL COST ESTIMATE							*1000
Newbuilding Price:	310	Million USD					
	Amount	Interest		Depreciation			First Year
Financing:	% of price	%	First year	Years	Cost/year		cost
Loan 1	100	6.5	20150	15.0	20667		40820
Loan 2	0	0.0	0	0.0	0		0
CAPITAL COST	100		20150		20667		40800

FIRST YEAR CASH BALANCE	Per Cargo Unit	*1000
Operating Income	-3.09	-10100
First Year Capital Cost	12.42	40800
NET CASH FLOW (First Year)	-15.51	-50900

FLEET SIZE			
Amount to be transported	9.855 M cu.m.		
Required number of ships	3 (mild)		
	3 (normal)		
	4 (strong)		
AVERAGE COST /TON		USD	10.30 per cubic meter
TIME CHARTER RATE		USD	123000 per operating day

SEAKEY ICEGOING SHIP ECONOMICS:
Cash Flow Calculation

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

ANNUAL CASH FLOW						MUSD
			Start Up			
Year	1995	1996	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
Operating Expense:	-	-	10	10	11	10
Operating Income:	0	0	-10	-10	-11	-10
Capital Costs						
Loan 1 Amount	0	0	310	289	269	248
Loan 1 Interest	0	0	20	19	17	16
Loan 1 Depreciation	0	0	21	21	21	21
Loan 2 Amount	0	0	0	0	0	0
Loan 2 Interest	0	0	0	0	0	0
Loan 2 Depreciation	0	0	0	0	0	0
Prepayments						
Amount	31	31				
Interest	2	2				
Total Capital Cost	2	2	41	39	38	37
Start Up Cost, etc.	2	3	5	0	0	0
Net Cash Flow	-4	-5	-56	-50	-49	-47
ACCUMULATED CF	-4	-9	-65	-115	-163	-210

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	11	10	9	10
Operating Income	-9	-10	-11	-10	-9	-10
Capital Costs						
Loan 1 Amount	227	207	186	165	145	124
Loan 1 Interest	15	13	12	11	9	8
Loan 1 Depreciation	21	21	21	21	21	21
Loan 2 Amount	0	0	0	0	0	0
Loan 2 Interest	0	0	0	0	0	0
Loan 2 Depreciation	0	0	0	0	0	0
Total Capital Cost	35	34	33	31	30	29
Start Up Cost, etc.	0	0	0	0	0	0
Net Cash Flow	-45	-44	-43	-42	-39	-39
ACCUMULATED CF	-255	-299	-343	-384	-424	-463

SEAKEY ICEGOING SHIP ECONOMICS: MUSD

Cash Flow Calculation

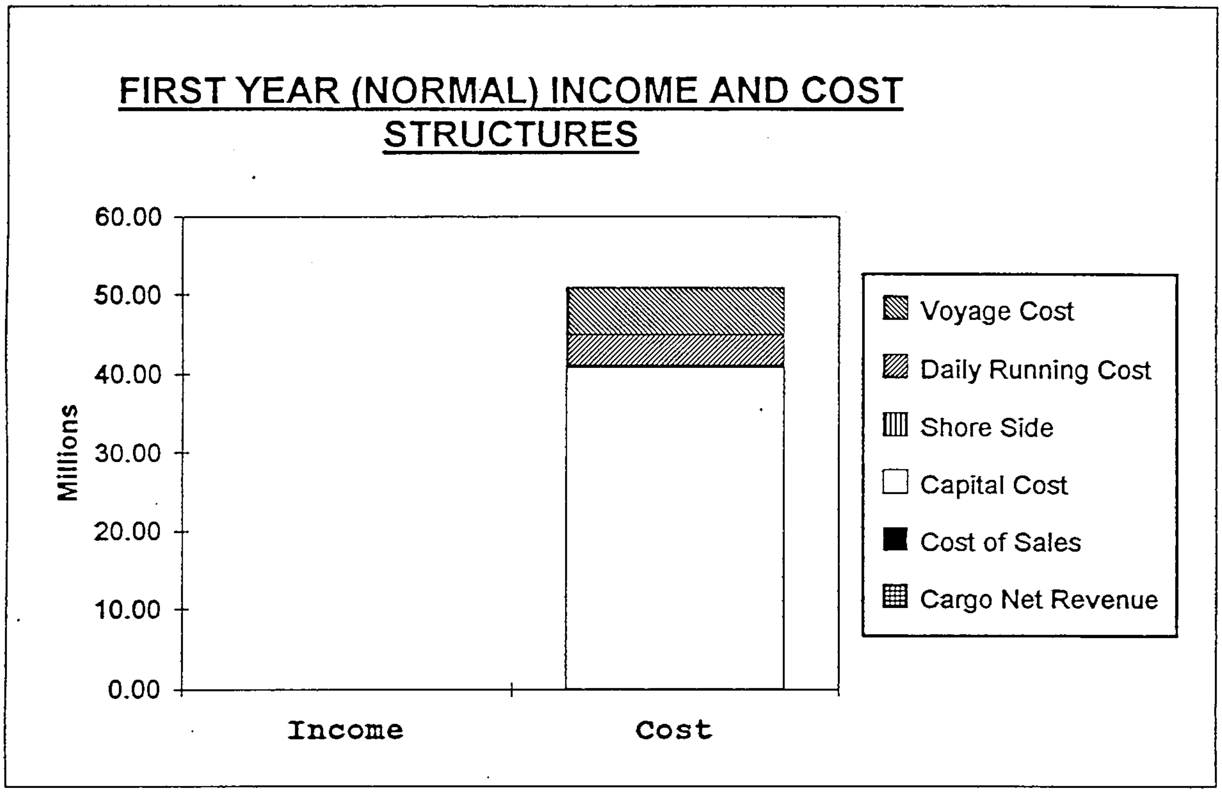
contin.

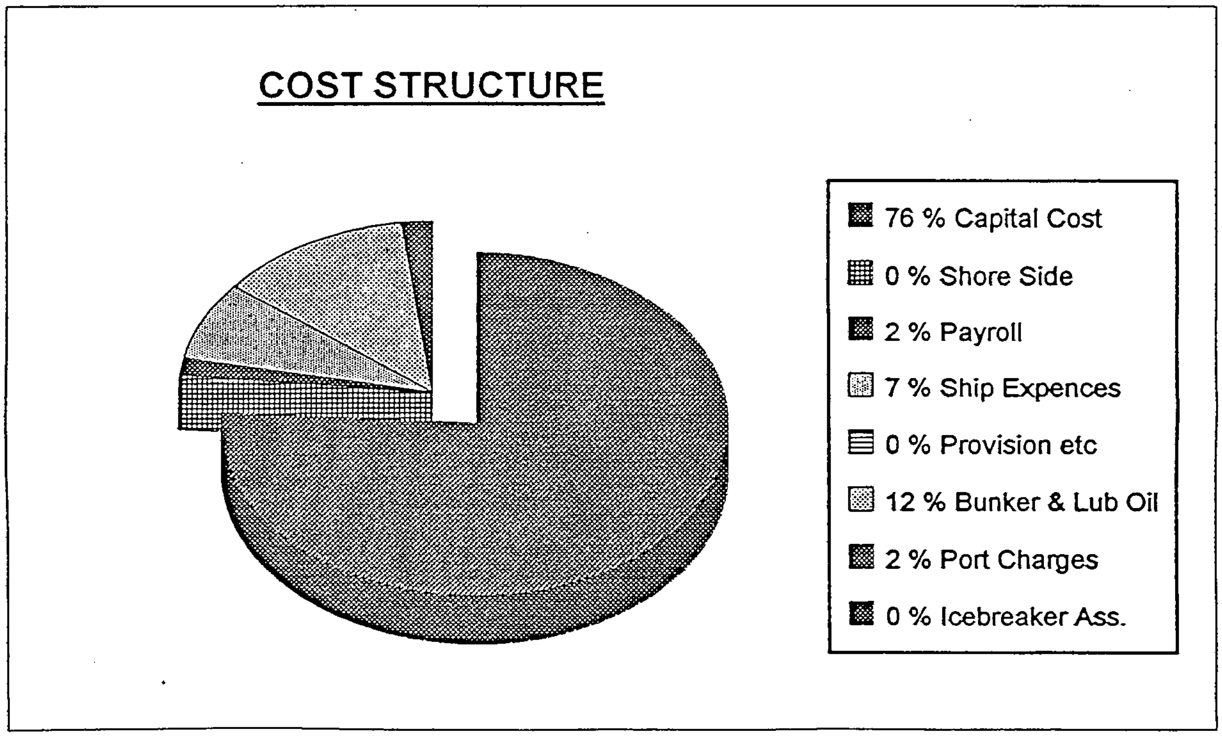
Year	2007N	2008N	2009S	2010N	2010M	2011N
Income escalation:	1.00	1.00	1.00	1.00	1.00	1.00
Cost escalation:	1.00	1.00	1.00	1.00	1.00	1.00
Operating Revenue	0	0	0	0	0	0
Operating Expense	10	10	11	10	9	10
Operating Income	-10	-10	-11	-10	-9	-10
Capital Costs						
Loan 1 Amount	103	83	62	41	21	0
Loan 1 Interest	7	5	4	3	1	0
Loan 1 Depreciation	21	21	21	21	21	0
Loan 2 Amount	0	0	0	0	0	0
Loan 2 Interest	0	0	0	0	0	0
Loan 2 Depreciation	0	0	0	0	0	0
Total Capital Cost	27	26	25	23	22	0
Start Up Cost, etc.	0	0	0	0	0	0
Net Cash Flow	-38	-36	-35	-33	-31	-10
ACCUMULATED CF	-500	-536	-572	-605	-637	-647

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:	11	10	9	0	0	0
Operating Income:	-11	-10	-9	0	0	0
Capital Costs						
Loan 1 Amount	0	0	0	0	0	0
Loan 1 Interest	0	0	0	0	0	0
Loan 1 Depreciation	0	0	0	0	0	0
Loan 2 Amount	0	0	0	0	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	0	0	0	0	0	0
Start Up Cost, etc.	0	0	0	0	0	0
Net Cash Flow	-11	-10	-9	0	0	0
ACCUMULATED CF	-657	-668	-677	-677	-677	-677

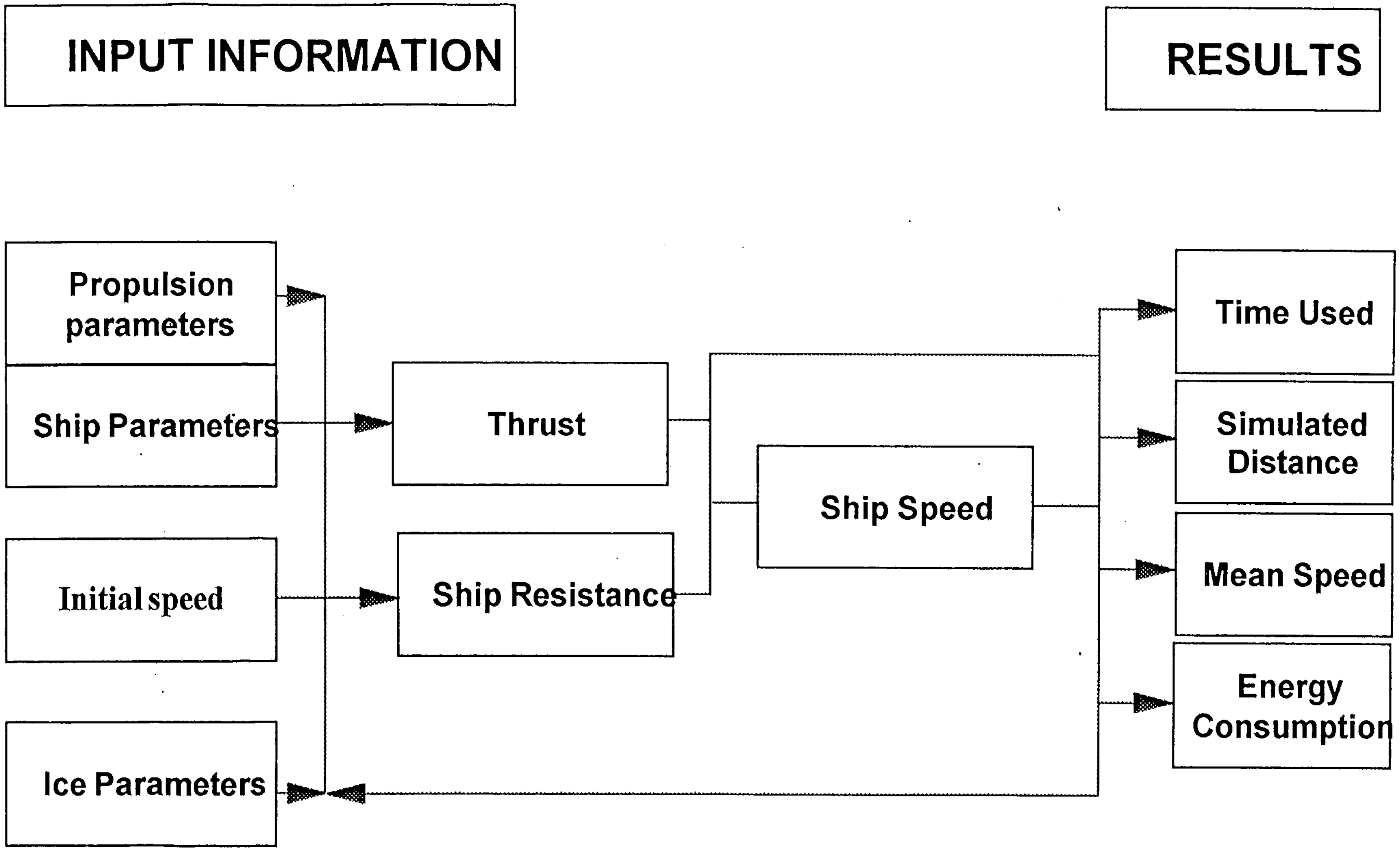
SEAKEY ICEGOING SHIP ECONOMICS

Project: 135 000 cu.m. ib LNG-carrier, Yamal - Rotterdam
Name: 0
Currency USD





APPENDIX 2
TRANSIT CALCULATION PROGRAM DIAGRAM


INPUT INFORMATION
RESULTS
Propulsion parameters
Ship Parameters
Initial speed
Ice Parameters
Thrust
Ship Resistance
Ship Speed
Time Used
Simulated Distance
Mean Speed
Energy Consumption

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.