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Financial Sensitivity Assessment On Different Approaches Toward LNG Transportation Means

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Abstracts:
LNG chain value consists of gas exploration, gas liquefaction, transportation, Re-gasification and finally gas distribution to the end user network. Transportation part of this chain normally consists of 25 to 30% of the total vale and is the most lucrative part of it. As proved Iranian gas reserves is about 29 trillions cubic meter and nearly half of it is South PARS gas field shared between Iran and Qatar ,there is an increasing concern on entering into gas export market in near future.

This enthusiasm enquires a thorough financial study on economical feasibility study on this industry. In this study by emphasizing on key parameters of LNG shipping industry like, technical vessel specification distance between exporting and importing terminals, cost of LNG carriers , boil of ratio of vessels, oil and gas future price prediction vessels heeling portions and most importantly the difference between vessel purchase and hiring daily rate of vessels.

We are to model this industry economically and by doing an economical sensitivity analysis on the model some economical indexes are extracted which are of most benefit for countries decision makers.

Two scenarios of purchasing and renting vessel have been investigated and it is shown than in different financial condition and oil and gas market there are at least minimum internal rate of return of 4 to 18% and at last these finding have been demonstrated in a 3D diagram showing net in come oil price (as an important parameters) and rent daily rate of vessels to show the profitability of this industry to the reader.

Key words:
Economical Sensitivity Analysis, shipping coast, LNG carriers, financial feasibility

1. Introduction

Liquefied Natural Gas, or LNG, is a means of transportation of natural gas. Cryogenically treated natural gas turn into a liquid (LNG), which represents 1/600th of the volume of natural gas, and it is therefore significantly more practical to transport. The natural gas is therefore liquefied at the exporting terminal, transported in special vessels and then re-gasified at the receiving terminal before injected into domestic pipelines and consumed.

Since LNG is no fixed substance which can be traded, is therefore no commodity and demand for LNG is derived from demand for natural gas. It thereby follows that the natural gas market is the underlying market for the LNG market**(Kjersti Hegde)**. The traditional LNG market is the foundation of the market, creating security for both sellers and buyers, while the spot market constitutes a possibility for flexibility and speculation. The traditional market will constitute a large portion of the market, as it constitutes a lower risk profile than the spot market. This is also reflected in the forecasted market share of the spot market, so in our study we have based our assumption on traditional LNG market and spot market opportunity is not considered. **(SIMMONS)**

The natural gas market is growing, driven by environmental concerns, the development of combined cycle power generators and embrace of previously "gas poor" countries. Natural gas is the cleanest burning fossil fuel, and is therefore preferred due to new emission policies. The demand if further enhanced by the fact that combined cycle power generators are much more inexpensive than the equivalent coal fired power plant. The embrace of previously gas poor countries has the most direct impact on the future of the LNG market, as the transportation distances are increasing, thereby increasing the volume traded as LNG.

Shipping is an important variable in the LNG value chain Liquefied natural gas (LNG) is expected to play an increasing role in the natural gas industry and global energy markets in the next several years. The combination of higher natural gas prices, lower LNG costs, rising gas imports demand, and the desire of gas producers to monetize their gas reserves is setting the stage for increased global LNG trade.

In this study we asses financial feasibility between purchasing and hiring LNG carriers In Iranian LNG industry which is to be built in Northern shore of Persian Gulf, liquefying natural gas from south pars gas field. **(SIMMONS)**

2. LNG Shipping market

Historically, LNG shipping was covered with long term LNG contracts, typically 20-25 years i.e., basically project financing. Short to medium term markets are dependent on the availability of extra gas which may result in a reduction in liftings under existing contracts, or built-in spare capacity. Availability of spot tonnage today is slowly gaining ground from being virtually non-existent. The year 2008, after a long hiatus, saw 'speculative' ordering of tonnage. Speculative ordering in the next 10 years is expected to give rise to an active spot market, as well as softening of long term shipping rates. Historically, average long term t/c rates have been around US$63-65,000 per day.

LNG shipping plays a critical role in the ongoing expansion of the global LNG industry, especially with the continuing growth of the spot/short-term market and the dynamic expansion of markets and supply sources. The LNG shipping sector is blossoming as it matures: more players, with more ships, mean that more flexible transport contracts can be arranged rather than the traditional long-term commitment of a 'floating pipeline' formed by a fleet that had to be purpose-built for a particular project. ***(*FACTS Global Energy)**

The rapid growth in spot movements is evidence of increased flexibility, and of the attraction for new investors. Although no other shipping sector shows such promise, the whole subject of transporting LNG by sea either through conventional mode or by means of LNG re-gasification vessels which processes the LNG cargo through on board re-gasification plant, delivers natural gas directly from the LNG tanker to the grid was not, until now at such world attention. For LNG shipping ventures to be viable on long term basis, the ultimate buyer's credibility and the financial strength of all the partners in the supply chain are crucial. In LNG shipping, ships are primarily dedicated to particular projects and these trades between two dedicated terminals almost throughout their life-span. However, spot trading is assuming more significance in the recent years.
By 2009 there were 281 vessels in service with 95 numbers on order. As the global LNG fleet expands and new players enter the market, experience in LNG shipping will be a must to harness opportunities for own requirements, customers and co-ventures.

Table1: Number of delivered and ordered available ships in LNG market

Type	Delivered	On order	Total
Ship	281	95	376
FSRU	1	1	2
FPSO	0	4	4
RV	4	6	10
TOTAL	286	106	392

In the Figure 1 you can see the current and forecasted LNG carrier fleet number till 2020. The forecast of ship demand in standard size units has been derived from a bottom-up estimate of project development over the next 5 years and a top-down appraisal of growth in global consumption and transport capacity requirements .This figure clearly shows the need for more Tankers to be constructed, otherwise the market shall face scarcity in near future and a jump in LNG ships charter rates.

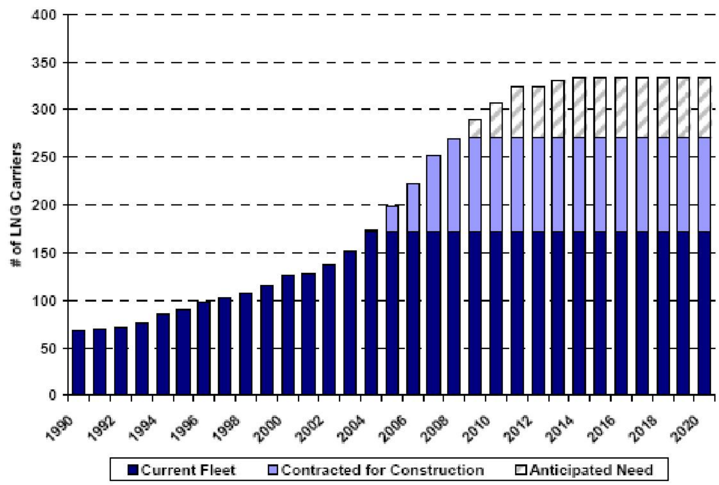


Figure 1: Current and forecasted LNG Carrier Fleet

Anyway spot LNG market's growth is considered to be a lucrative opportunity for LNG Tanker industry and in case of market's shifting from traditional contracts to more liberalized ones, the economy of LNG shipping will be more justified. But to be conservative in our study we haven't considered such opportunities. **(SIMMONS)**

3. Investment costs

According to Andy Flower LNG Associates, there are four main price components to an LNG project: gas production (15-20%), LNG plant (30-45%), LNG shipping (10-30%) and receiving terminal (15-25%).

1.3 LNG cost components

Production cost of LNG has been reduced drastically over the period where it has been traded. Soaring demand for gas initiated the innovation and investments needed to bring down the capital cost. Optimization of design parameters, improved reliability, closed-loop cooling system, exploration of cold-recovery and new heat-exchanger design have all helped reduce the production costs of liquefaction terminals. According to IEA, the average unit investment for a liquefaction plant was \$550 per ton per year capacity in 1960s, \$350 in 1970s and 1980s, \$250 in the late 1990s and slightly below \$200 in 2002 and by now it is around \$500 per ton per year capacity. **(Saleem Alavi)**

Cost reductions for shipping costs are mainly limited to increasing vessel size. Potentially, an increase in size from 140.000 m3, to 200.000 m3 could decrease shipping costs up to ten percent. Andy Flower estimated that using six 250,000 m3 vessels rather than eleven vessels of 145,000 m3 reduces cost per MMBtu from \$0.97 to \$0.73.

Building costs for LNG tankers have decreased from about $280 million in the mid1980s to about $155 million in late 2003 and in our study for today's LNG tankers we have assumed $170 million. ***(*FACTS Global Energy)**

2.3 LNG Ship Prices

The prices of LNG ships have varied considerably over time, driven to a large extent by competition for orders amongst the shipyards. The following figure shows the average cost of new ships of between 125,000 m3 and 145,000 m3 capacity, ordered over the last 34 years, and compares it with movements in the cost of very large crude oil carriers (VLCCs). VLCCs are often built in the same construction docks as LNG ships, so the demand for this type of vessel can influence the price of LNG carriers. The prices are the estimated average price of ships ordered in the given year in nominal US dollars. In the late 1980s and early 1990s, the cost of a 135,000 m3 ship (the largest ships in operation at that time) reached over $250 million. Costs fell steadily during the 1990s and by 2003, the cost of a 145,000 m3 ship (typical of the size of ships being ordered at that time) was between $150 and $160 million. However, price has risen again since, partly as a result of the increasing price of steel and other equipment. In 2006, the shipyards are reporting prices of around $220 million for a 155,000 m3 ship**(The World of Energy)**. The prices of the ships over 200,000 m3 ordered for the Qatargas and RasGas projects in Qatar are reported to range from $230 million for the orders for ships around 210,000 m3 placed in 2004 to $290 million for the most recent 270,000 m3 ships. ***(*FACTS Global Energy)**

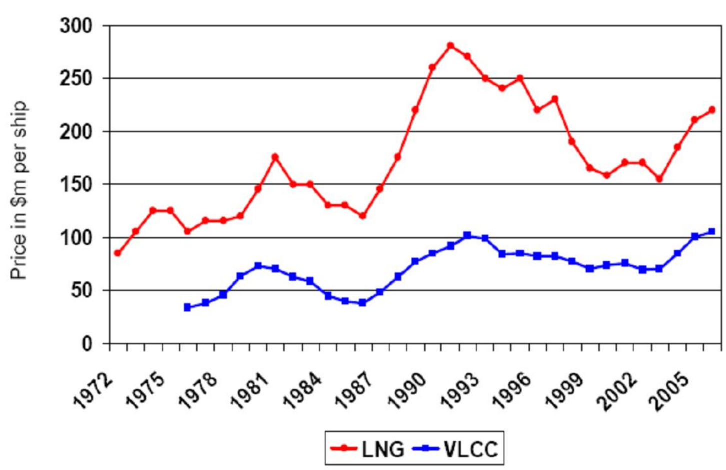


Figure 2: Average LNG Ship (125000 -145000m3) and VLCC Prices

In US dollar of the Day

3.3 Operating Costs

There are two main elements in the operating costs of an LNG ship: fixed costs, which are incurred irrespective of the employment of the ship, and voyage costs. The fixed costs include crew, maintenance, administration, and insurance, while the voyage costs include fuel used (bunkers and boil-off), port charges, The fixed costs vary considerably between operators. Crew costs make up a large proportion of the fixed costs and the way in which the ship is crewed. The cost of operating an LNG ship is estimated between $9,000 and $16,000/day. Fuel costs depend on the round voyage distance. Boil-off gas typically provides around 50% of the fuel needs of steam-engine ships, with the remaining fuel being bunker fuel oil. **(Saleem Alavi)**

4.3 LNG Ship Charter Rates

The number of ships in the LNG fleet is a small fraction of the number, for example, of crude oil carriers. Most of the LNG ships in operation are committed to a project or to an LNG buyer. The result is that there are too few charters (short-, medium-, or long-term) arranged for a market index of LNG charter rates to have been developed, The owner of a ship of between 135,000 m3 and 145,000 m3, costing $200 to $220 million is estimated to require a payment of between $45,000/day and $55,000/day to cover the capital cost of the vessel (interest payments, repayment of capital, and return on the equity part of the total capital cost), with the actual rate depending on such factors as interest rates, the share of the investment in the ship covered by loans, and the period over which the cost of the ship is amortized. Adding the $9,000/day to $16,000/day needed to cover fixed operating costs, gives a total charter rate of between $54,000/day and $71,000/day. ***(*FACTS Global Energy)**

A number of LNG projects particularly Iran LNG on South Pars are likely to come up in the near future establishing Iran as one of the important LNG exporting countries in the next decade or so. The strategic location of the country being surrounded by other gas-producing countries in the Persian Gulf Region and The Caspian, would require an advanced strategy not only to find a competitive transportation cost but creation of an own fleet of LNG carriers, to guarantee security of exports, independence and the access to the prime markets for the sales of LNG at more interesting pricing as well as a reasonable LNG price for the long term commitments, taking into account the current uncertain situation faced by the world economical crisis.

Considering these points and the above concepts we have investigated a feasibility study on LNG shipping industry.

4. Financial calculation of an LNG Plant owner’s entrance into LNG shipping industry

In this part we evaluate if it is profitable and feasible for an LNG plant of 10.5 Million ton LNG per annual to order and purchase LNG tankers or not.

To study this issue we assume that at first the liquefaction plant possesses no ship and during the plant operation it will purchase one tanker each year and as the ship comes into operation the cost of transportation by charter tanker fleet will be reduced annually till the plant owns all its required fleet. By shifting from charter tankers to purchased tanker not only the plant will gain more control over its product and its desired destination and arbitrage opportunity but also there is a good opportunity to get a reasonable net profit. By ordering a new ship the plant will burden an initial capital cost of approximately $170 million and after two years it won't pay for charter.

By obtaining the relative cash flow, which shall be the difference of this expenditure and income obtained from not paying the charter rate we will show the profitability of this cash flow**(Saleem Alavi)**.

The variables to be assessed in this study are as below:

1. Initial required capital cost for a tanker is assumed to be $170 million and each year only one ship is ordered
2. Liquefaction Plant capacity which for IRAN LNG is about 10.5 MTPA of LNG
3. Plant and ships lifecycle is assumed t be 25 year
4. The distance between loading and unloading terminals is assumed to be 5000 mile
5. Charter rate of a ship is the source of UNCERTAITY in the study and has a high volatility, so this parameter is assumed to be from 50000 to 130000 dollar per day
6. Ships construction duration is assumed to be 2 year
7. Each ship capacity is around 135000 cubic meter
8. Ship's speed is 19 knot
9. Boil off ratio is 0.15% per day for each ship
10. 2 days is assumed for loading, unloading, berthing and delays
11. Ships and plants overhaul is assumed to be at the same time and once upon 5 year

These parameters have significant effect in LNG transportation industry and any change in one of them will affect decision makers mind and we have been conservative on these assumptions.

The first parameter to calculate financial feasibility for entering into shipping industry for an LNG Plant is to know how many ships are required to transport its product.

Number of required ships is obtained by **Eq. 1**:

$$\text{Number of ships} = \frac{\text{Plant Capacity(Based on Million Ton Per Year)} * \text{Plant Utilization Factor} * \text{Heat capacity of each ton of LNG based on MMBTU}}{\text{Each tanker's Capacity(Cubic Meter)} * \text{Heat capacity of each cubic meter}} \quad \text{Eq. 1}$$

$$\frac{\text{Distance between Ports} * 2}{\text{Ship speed} * 24} + \text{loading, unloading Duration}$$

By considering all previous assumptions at least 13 ships are required to transport the product.

Now we shall calculate cost of transportation based on each MMBTU of the product export. In this calculation we consider boil off loss and heeling loss. As in our calculation we are considering LNG losses during transportation and its consequent expense, we need to have LNG price.

Cost of transportation is obtained by **Eq.2**:

$$\text{Cost of Transportation per MMBTU} = \frac{\dfrac{\text{Distance between terminal ports} * 2}{\text{Ship Speed} * 24} \text{ Charter Daily Rate}}{\left(1 - \dfrac{\text{Distance between Ports} * 2}{\text{Ship speed} * 24}\right) * \text{Ship Capacity} * \text{Heating Capacity}} \qquad \text{Eq.2}$$

LNG price is related to oil price and as we are considering a 25 year cash flow we have to have a prediction for oil price for next 25 year. This prediction is shown in Figure 3.

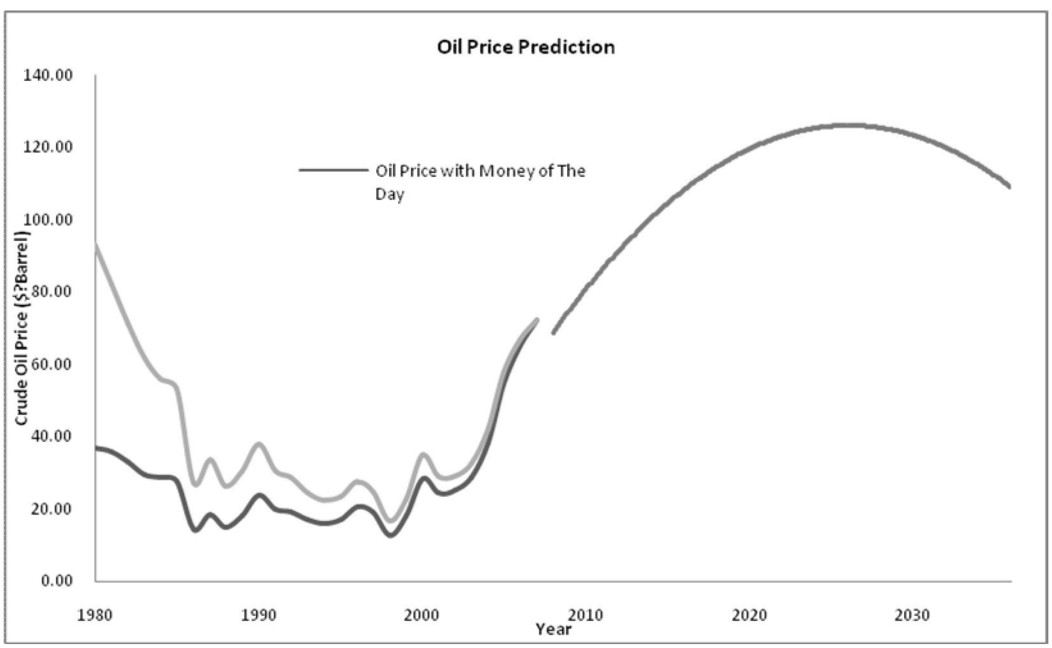


Figure 3: Oil prediction Diagram to obtain LNG Price for boil-off and heeling portion

LNG Price formula is the traditional Japanese formula which is: 0.12 * Oil Price +1.5

The price of boil off and heeling will be obtained by the above formula and is added to the charter rate cost as calculated from above formula and then multiplied by the export volume.

Net difference transportation expense calculation:

- Transportation Cost in case of chartering the fleet:
  In this case the cost of boil-off, heeling and charter rate per MMBTU is calculated and multiplied by product volume
- Transportation Cost in case of chartering and then buying 1 ship annually
  In this case we have to add the cost of each ship annually and after 2 years which is the construction period; we can reduce the cost of relevant charter expense which could be transported by the new ship capacity.

By having these two cash flows, now we can subtract ship purchasing case scenario from chartering scenario. The difference gained from this two expense is the net profit and we can evaluate the Internal Rate of Return of the liquefaction plants entering into shipping industry and owning the tanker fleet.

These calculations are shown in table.2 and table.3 .

Table2: Transportation expenses of a 10.5 MTPA LNG plant using charter to export its product

Daily Charter Rate($/Day)	Ave Expense	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036
50000	188	190	190	190	190	190	175	190	190	190	190	175	190	190	190	190	175	190	190	190	190	175	190	190	190	190
60000	225	228	228	228	228	228	210	228	228	228	228	210	228	228	228	228	210	228	228	228	228	210	228	228	228	228
70000	263	267	267	267	267	267	245	267	267	267	267	245	267	267	267	267	245	267	267	267	267	245	267	267	267	267
80000	300	305	305	305	305	305	280	305	305	305	305	280	305	305	305	305	280	305	305	305	305	280	305	305	305	305
90000	338	343	343	343	343	343	315	343	343	343	343	315	343	343	343	343	315	343	343	343	343	315	343	343	343	343
100000	376	381	381	381	381	381	349	381	381	381	381	349	381	381	381	381	349	381	381	381	381	349	381	381	381	381
110000	413	419	419	419	419	419	384	419	419	419	419	384	419	419	419	419	384	419	419	419	419	384	419	419	419	419
120000	451	457	457	457	457	457	419	457	457	457	457	419	457	457	457	457	419	457	457	457	457	419	457	457	457	457
130000	488	495	495	495	495	495	454	495	495	495	495	454	495	495	495	495	454	495	495	495	495	454	495	495	495	495

Note: All expenses are in Million $, Each five year the plant and tankers go under Overhaul, No inflation is assumed for Charter Daily Rate

Table3: Transportation expenses of a 10.5 MTPA LNG plant using charter and then purchasing ships to replace the charter fleet to export its product

Daily Charter Rate($/Day)	IRR	AVE Annual Profit	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036
50000	4%	33	-170	-170	-155	-141	-126	-116	-97	-82	-67	-53	-49	-24	-9	176	190	175	190	190	190	190	175	190	190	190	190
60000	6%	58	-170	-170	-152	-135	-117	-105	-82	-65	-47	-29	-25	6	23	211	228	210	228	228	228	228	210	228	228	228	228
70000	8%	83	-170	-170	-150	-129	-109	-95	-67	-47	-26	-6	-1	35	56	246	267	245	267	267	267	267	245	267	267	267	267
80000	10%	108	-170	-170	-147	-123	-100	-84	-53	-29	-6	17	24	64	88	281	305	280	305	305	305	305	280	305	305	305	305
90000	12%	133	-170	-170	-144	-117	-91	-73	-38	-12	15	41	48	94	120	316	343	315	343	343	343	343	315	343	343	343	343
100000	13%	158	-170	-170	-141	-111	-82	-62	-24	6	35	64	72	123	152	351	381	349	381	381	381	381	349	381	381	381	381
110000	15%	183	-170	-170	-138	-106	-73	-52	-9	23	56	88	96	152	184	387	419	384	419	419	419	419	384	419	419	419	419
120000	16%	208	-170	-170	-135	-100	-65	-41	6	41	76	111	120	181	217	422	457	419	457	457	457	457	419	457	457	457	457
130000	18%	233	-170	-170	-132	-94	-56	-30	20	58	97	135	145	211	249	457	495	454	495	495	495	495	454	495	495	495	495

Note: All expenses are in Million $, Each five year the plant and tankers go under Overhaul, No inflation is assumed for Charter Daily Rate

Figure 4 shows the cash flow for plant's lifecycle and as it is obvious if charter rate is high enough the plant owners can enter into shipping industry.

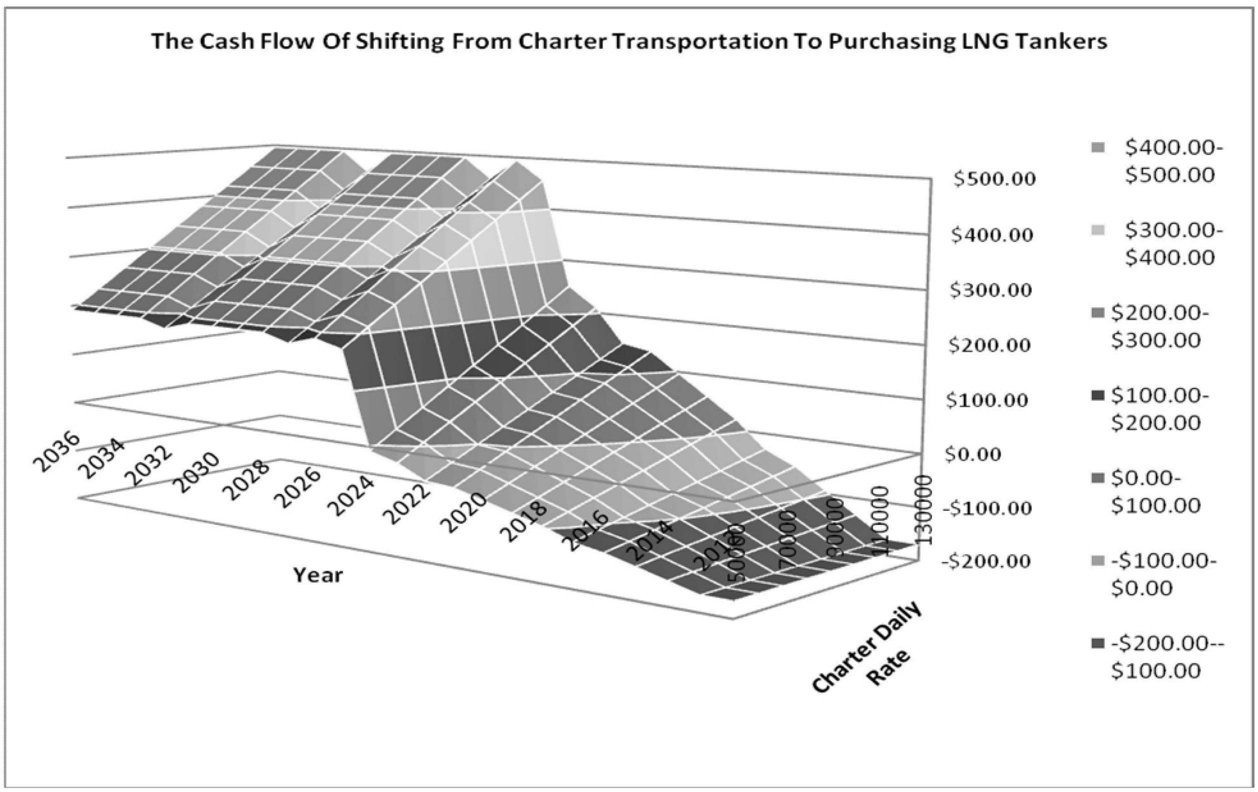
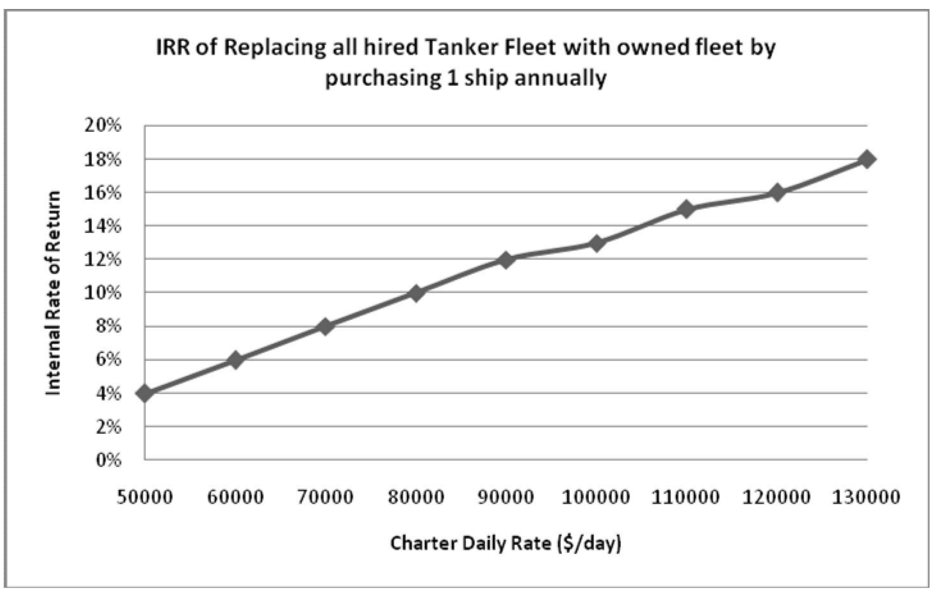


Figure 4: Cash flow sensitivity on charter daily rate between hiring or constructing LNG plant's Private fleet

5. Conclusion

Shipping is an important variable in the LNG value chain Liquefied natural gas (LNG) and is expected to play an increasing role in the natural gas industry and global energy markets in the next several years. LNG shipping plays a critical role in the ongoing expansion of the global LNG industry. A number of LNG projects particularly Iran LNG on South Pars (10.5 MTPA Capacity) are likely to come up in the near future establishing Iran as one of the important LNG exporting countries in the next decade or so. The strategic location of the country being surrounded by other gas-producing countries in the Persian Gulf Region and The Caspian, would require a progressive strategy not only to find a competitive transportation cost fleet but also creation of its own fleet of LNG carriers, to guarantee security of exports, independence and the access to the prime markets for the sales of LNG at more interesting pricing as well as a reasonable LNG price for the long term commitments. In this study by emphasizing on key parameters of LNG shipping industry like, technical vessel specification distance between exporting and importing terminals, cost of LNG carriers , boil of ratio of vessels, oil and gas future price prediction vessels heeling portions and most importantly the difference between vessel purchase and hiring daily rate of vessels. We have modeled this industry economically and by doing an economical sensitivity analysis on the model some economical indexes are extracted which are of most benefit for country's decision makers. Two scenarios of purchasing and renting vessel have been investigated, below figure represents this industry's internal rate of return versus daily charter rate.



Plant owner's based on their long term policies and favourable independence from charter fleet and the financial indexes shown can decide the entrance into this market.

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