Natural Gas Utilization Plan for Sri Lanka

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Abstract

Natural gas is finding its place at the heart of the energy discussion all over the world. It is being a cheap and relatively environmentally friendly alternative energy. The recent emergence of this discussion is due to substantial new discovery of natural gas in Sri Lanka. As a developing country, Sri Lanka spends an excessive amount of money for energy. The new discovery of natural gas deposits may be able to raise the Sri Lankan economy in next decades. To start gas production in the country should have a plan to consume the gas within the country to gain the best use of its research. Under the topic of natural gas utilization system for Sri Lanka the research is carried out to find the best way or the most economical way of utilizing the natural gas in Sri Lanka comparing scale and the economic factors. The research is focused on five special areas :Distribution of NG within the country :Public and private transportation :Power generation: Domestic and industrial use of NG: Fertilizer manufacturing

Study area of this research on scientific and economic comparisons of above processes to address this important problem in the presence of uncertainty. This work presents such a method based on decision analysis of gas prices as well. It includes the entire well-to-market supply chain, from extraction, conversion, and transportation, to reconversion at the target market. Finally, it identifies the best gas transporting method according to the current situation, daily production, how these effects to the power generation sector in Sri Lanka, propose the most economical and safe method of using NG for domestic use which suitable for Sri Lankan context with analyzed data with evidence.

Key words: Natural Gas(NG), Liquefied Natural Gas(LNG), Compressed Natural Gas(CNG), Liquified Petroleum Gas(Lpg), Billion Cubic Feets(bcf), Trillion Cubic Feets(tcf)

1. Introduction

The world's primary energy demand is increasing at an accelerating rate. This has motivated extensive research on finding and developing new and better energy sources. Although the unconventional energy sources such as renewable will help in gradually shaking the world's reliance on fossil fuels; oil, gas, and coal will continue to dominate as the main energy

The economic advantage is growing as policies and/or mechanisms for carbon taxes/credits/ penalties are being implemented by several developed countries[1]. These factors have led to a faster growth of natural gas exploration, processing, and consumption. In fact, they have made it feasible to exploit even the high cost unconventional NG resources Natural gas is a more powerful energy source, which can definitely develop the Sri Lankan economy in few years. From the exploration in northwestern sea of Sri Lanka, the exploration company has found adequate reservoirs, which is planned to start production in 2020. At this stage, Sri Lanka is planning to conduct more gas or oil exploration in possible areas and planning to take the optimum benefit from the natural gas.

The main task in this research project is downstream planning of natural gas production in Sri Lanka in which expected demand in the starting stage will be calculated and mainly an economical natural gas utilization plan is being proposing to the country with help of Petroleum resources development secretariat of Sri Lanka. In other countries, they already utilize natural gas in a very large scale. Sri Lanka cannot implement all those systems without a proper study on it. In addition, an economic analysis should be done to check whether what methods are feasible to implement in consideration of utilizing natural gas in Sri Lanka. Comparing available gas distribution methods in terms of technology, cost, available infrastructure facilities and safety the most suitable method can be suggested. The plan is highly concern about four special areas which are public and private transportation, power generation, domestic use and fertilizer manufacturing.And finally make the decision of the daily natural gas demand after implementing natural gas to mentioned four sectors. Through the research, the research supposes to give most suitable natural gas utilization methods for Sri Lanka. In this section selection of most economic gas transportation system among pipe line and storage as compressed natural gas (CNG) or liquefied natural gas (LNG) is done.

Currently, Mannar basin proven gas reserves are comparatively small. So at the very beginning it is not preferable to invest much capital for gas transportation. So, main objective is currently gasoline operated thermal power plants convert into gas operated plants and reduce the production cost of electricity. Considering cost of the pipe line network materials, Cost for labor as well as Miscellaneous and Investigation cost, when pipe line network use for the gas transportation to thermal power plants. Most probably more gas reservoirs would be found in future.

2. Problem statement

Sri Lanka discovered a natural gas reservoir in northwestern ocean basin, which has around 2tcf [3] of NG in two wells and there is a high possibility of discovering more reservoirs in the same area according to the seismic survey data in the area. Though Sri Lanka has enough Natural gas production can be done because Sri Lanka has no plan to use natural gas within the country. So the research is to find the possible and economical ways of using natural gas in the country to gain the maximum benefit of the resources as well as to give the responsible authorities an idea about the daily production of NG requied for different sectors according to the current demand.

3. OBJECTIVE

The main objective of this research is to study about the current energy requirement which can be replaced by NG and finding the daily requirement of natural gas to replace the identified energy demand.

-To identify different possible sectors that can effectively use natural gas while contributing to the Sri Lankan economy in a significant scale.

-To identify the feasibility of gas utilization for different sectors by conducting an economic analysis of different possible areas of natural gas utilization.

-To identify the daily natural gas production required for the proposed plan of natural gas utilization plan.

-To identify the most economical method of natural gas transportation from well head to the consumer.

-To understand the feasibility of the proposed plan of natural gas utilization comparing all the analysis conducted separately.

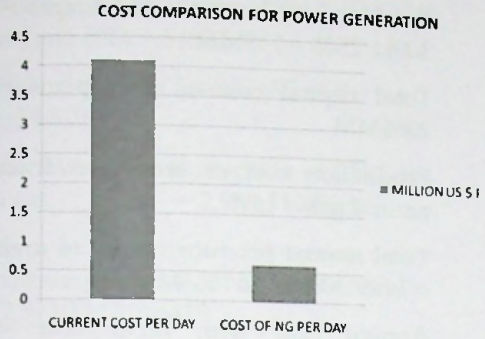
4. Evaluation of utilization options

4.1. Power generation

Only few power plants are available in Sri Lanka which are possible to convert to run with NG.But those 3 plants can be used to contribute to around 84% of the total production if they are run in full capacity[4]. Kelanitissa Power Stationcan be operated already by bothoil and gas because it has been constructed to run with both oil and gas.

Power Plant	Capacity	Average Production (Per day)	Cost (million rupees per day)
Norochcholai	900MW	18.7GWh	$(18.7*10^6)*6.39 = 119.5$
Kelanithissa	500MW	10.5GWh	$(10.5*10^6)*21.46 = 225.3$
Kerawalapitiya	300MW	6.3GWh	$(6.3*10^6)*29.97 = 188.8$
Total		=35.5GWh	=533.6million

To produce the same amount of energy produce by those three power plants amount of natural gas required is $3.7*10^6$ m^3 or **0.13066bcf/ day.** as the exploration company is unable to publish the NG price they are planning to sell, the price of natural gas is assumed as the current market price and according to the daily requirement cost of natural gas per day is 0.626 million US $ [5]. the current cost of oil and coal to produce electricity from those plants is around 4.1 million US $[6].



4.2.Indusrial and Domestic use

When considering global natural gas utilization 46% of total production of natural gas is used for industrial and domestic purposes[7]. Sri Lanka spends a considerable amount of money on importing Liquefied petroleum gas (Lpg). So natural gas would be a good alternative to the mentioned problem. Annually 0.23 Million tones ofLpg is imported [8] from Oman spending a lot of money. Method of transportation of natural gas should be a major concern because according to the transportation method gas price changes. CNG is generally cheaper than LPG. However, propane produces over twice the amount of energy than natural gas. So LPG could be more cost effective than natural gas depending upon local prices (which tend to fluctuate). So the next alternatives are LNG or the Natural gas distributed through pipe lines. LNG is also an expensive method of transportation for short distances. The remaining economical method was distribution of natural gas by pipelines.

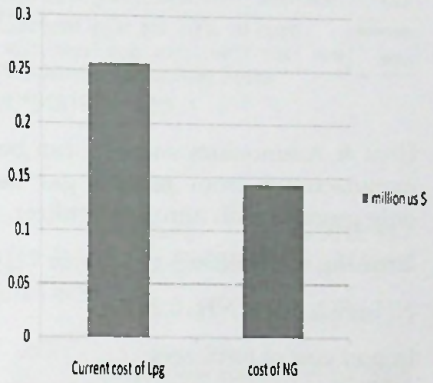
Annual requirement of Lpg= 230000000kg

Daily requirement of Lpg= 630.1369863ton

Amount of NG required =30.024million ft^3/day

The cost of LPG per day = 0.257 million US $

Cost of NG per day= 0.1438 million US $



4.3.Fertilizer Manufacturing

Sri Lanka spends an excessive amount of money for importing fertilizers. With the discovery of natural gas resources in Sri Lankan ocean,fertilizer manufacturing within Sri Lanka has come to discussion among leaders. Under this research, fertilizer manufacture from natural gas is also discussed as fertilizer is a widely used commodity used in agricultural activities in Sri Lanka. An effort is also made to study the feasibility of manufacturing fertilizer from natural gas in Sri Lanka using the available resources, in a bid to cut down the immense government expenditure on the import of nitrogen-containing fertilizer from foreign countries. Sri Lanka is a record holding country in annual fertilizer importing. Following table shows the amount of fertilizers

import to Sri Lanka. From these fertilizers only urea and ammonium sulphate can be made by ammonia which is made by natural gas.

Fertilizer type	2006	2007	2008	2009	2010	2011	2012
Urea	366.199	311.192	413.615	352.322	15.705	424.153	302.831
TripleSuper Phosphate	81.930	71.588	123.135	40.878	124.174	122.081	108.229
Muriate of Potash	159.908	98.096	149.749	62.692	168.021	303.756	111.855
ammonium sulpate	60681	50258	37860	17.926	46.505	65.982	77.199

Urea & Ammonium sulphate can be manufactured from natural gas as only produce with nitrogen fertilizer.

Urea 1kg - NH_3 0.567kg

$NH_4)_2SO_4$ 1kg - NH_3 0.258kg

Import cost of fertilizers

urea fertilizer	US $230 - 400 / Ton
Ammonium Sulphate Fertilizer	US $250 - 280 / Metric Ton

Required amount of NH_3 per year (urea) = 170100 ton

Required amount of NH_3 per day = 466 ton

Required amount of natural gas for 1ton of NH_3 =33MBtu

Required amount of natural gas per day = 466* 33MBtu

(1MBtu = 0.00000098 bcf) [15]

Required amount of natural gas per day

=

0.015bcf

Total annual Import cost of urea = 300kt*250$ = 75$MM

Total capital cost of urea plant = 236$MM

Production cost of urea 1ton from natural gas = 149$

Total annual production cost of urea = 149$*300kt= 44.7$MM

Annual cost with other cost = 44.7+10+5 = 59.3$MM

Annual amount of saving = 75$ - 59.3$ = 15.7$MM

Time to recover capital cost = 236/15.7 = 15 years

4.4.public and private transportation

Sri Lanka spent a big portion of its energy consumption for the transportation sector. If natural gas can be introduce to the public and private transportation it would be significantly economical as a country. The suggestion of the research is to promote natural gas to the transportation sector and provide required infrastructure so that more people will use natural gas to run their vehicles. According to the data gathered from department of motor traffic of Sri Lanka there are 548,183 of cars and 94,940 buses in Sri Lanka when it was June 2014. In this research it is planned to find the economic feasibility If 10% of these two types of vehicles converted to run with natural gas because converting all vehicles to run with natural gas may not be practical due to lack of infrastructure facilities for rural areas. A rough estimation can be made as follows

Total number of cars in Sri Lanka up to June 2014 = 548,183

10% of the cars (uses CNG as the fuel) = 54,819

The average consumption of CNG by a car = 2.9Kg/100Km

If a car travels 20km/day, the consumption of CNG by a car = (2.9/100)*20*54819

=1.25 million cubic foot per day

Total number of buses in Sri Lanka up to June 2014 = 94,940

10% of the buses (use CNG as the fuel) =9494

The average consumption of CNG by a bus = 6.2Kg/100Km

If a bus travels 80Km/day, the consumption of CNG by a bus = (6.2/100)*80*9494kg/day

=1.85 million cubic foot per day

Total requirement of natural gas per day =1.85+1.25 = 3.1 million ft^3

Special problem in this sector is CNG has to be provided as the energy input to the vehicles. CNG production plant is to be established which accounts for a big capital investment. But still it is economical and if Sri Lanka is able to produce CNG with available natural gas to a cost less than market price of CNG rough economic analysis can be done as follows.

Average market price of CNG [Jan 2015] = 2.17 $ per gallon [16]

Average consumption of CNG per day

=47090.25kg/day+31795.02 kg/day

=78885.27kg/day

=41099.2256 gallon

The daily cost of CNG for transportation 10% of all cars and buses = 89185.3$/day

If an assumption is made that average car runs 15km/L and a bus runs 6km/L.

Current cost for 10% of cars

Amount of gasoline liters = 20*54819km /15

=73092L

Total cost =73092*117 (117 rupees per gasoline liter in April 2015 in SL)

=8551764 rupees = 65782.8 US dollars

Current cost for 10% of buses

Amount of diesel liters = 80*9494km/(6km/L)

=759520L

Total cost =759520*95 (price of diesel liter in April 2015)

=72154400 = 555033 US dollars

Therefore current cost of transportation of considered 10% = 65782.8+555033.8

=620816.65 $ per day

5. Methodology

Following methodology steps were followed in this research to reach objectives.

- Learning background about research project and the necessity of research was identified
- Literature review was done to accumulate relevant knowledge of this research
- Collection of data required for the research
- Analysis of data and economic analysis is done on different options of NG utilization.
- Analysis of results

6. Results

6.1. Natural Gas Transportation

Total costs for pipe line establish and LNG process calculated at the methodology process. According to calculations, total cost or capital cost for established of pipe line can be shown as follow.

Table 6.1-total capital cost of pipe lining

Description	Cost ($)
Material cost	36,937,834
Compressors cost	1,113.550
Labor cost	59,105,573
Miscellaneous and Investigation cost	26,696,851
Total capital cost	124,967,358

This capital represent if pipe line produce at 2004. As it converts into current value, total capital cost equal to $ 356,546,457. And the total cost of LNG process is equal to $ 21.0 billion.

The cost variation proportions of LNG and pipe line network can be graphically represented as follow.

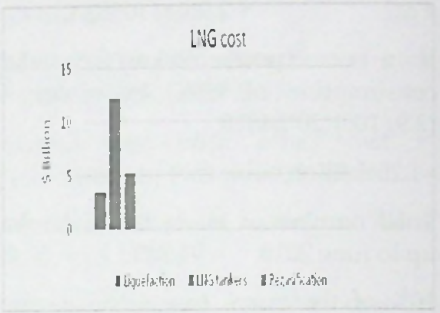


Figure 6.1- bar chart of LNG cost proportions

6.2. Natural gas utilization options

The results obtained by each sector can be summarize as follows.

Use	Current cost per day (million US$)	Cost when using NG per day (million US$)	Daily requirement of NG (million ft^3)
Electricity Generation	4.105	0.626	130.7
Industrial and Domestic use	0.257	0.144	30.02
Transporta-tion	0.621	0.892	3.1

Fertilizer Manufacturing	0.206	0.163	15.07
Total			178.9

According to the results which have been obtained by the project Total daily requirement of natural gas is 178.854million cubic foots. Which leads to consume the deposit for 30.64 years as the total discovered recoverable amount of the deposit contains around 2tcf.

The obtained results are showing that using natural gas is more economical which can directly affect the Sri Lankan economy. In this project capital cost of each sector is also roughly estimated which is around 615 million US dollars which can be varying in a significant amount.

7. Discussion

According to the results of the project the daily production required to suggest plan has been found which is going to be useful in deciding the production rates of natural gas. Moreover, it is so useful to adjust the utilization rate according to the changes of the production rate is occurred when production is done. All the suggested options are profitable than current status when implementing natural gas as an alternative energy source. The most economical method of natural gas transportation has been found as transportation through pipelines rejecting all other methods such as CNG, LNG etc.

In the power generation section the cost of power generation from natural gas is lower than the current cost of power generation by coal and fuel oil. 84% of total electricity production can be generated by natural gas according to the suggested plan saving 3.4787 million US Dollars per day which is a huge effect to the country's economy.

By using NG as an alternative to LPG Sri Lanka can save 0.1132 million US Dollars per day this may take some time to change from LPG to NG because people are not used to it. But people may adjust to use NG because it is going to be much cheaper than LPG. The capital cost of laying pipe lines for Colombo district is being calculated and found to be around 220 million US Dollars which can be recovered less than 19 years considering Colombo district uses 30% of total NG. Though this option is economical, it takes more time to recover the capital cost, which is a big investment to be made with a risk. Though the investment is risky from this project Sri Lanka may find a lot of job opportunities as well which returns some of the expenditure to Sri Lanka.

As an agricultural country Sri Lanka uses a lot of fertilizers during a year which is around 300000 metric tons[18]. From the suggested option Sri Lanka can save 15.5million dollars per annum. Considerable amount of money have to be invested to construct the fertilizer manufacturing plant, which can be recovered in 15 years.

The other interested area of study is supplying natural gas to the public and private transportation which can save around 100 million Dollars per annum. If the required infrastructure

can be installed in the country NG driven vehicles will be more popular due to less cost of travelling.

8. References

BP statistical review of world energy; 2008.

US-DOE. The global liquefied natural gas market: status & outlook. Washington:Energy Information Administration; 2003.

IEA, World Energy Outlook. Are we entering a golden age of gas? International Energy Agency; 2011.

Khalilpour R, Karimi IA.Optimal LNG contract selection using mixed integer linear programming. Nashville, TN: American Institute of Chemical Engineering (AICHE); 2009.

Khalilpour R, Karimi IA. Selection of liquefied natural gas (LNG) contracts for minimizing procurement cost. Industrial & Engineering Chemistry Research 2011;50(17):10298e312.

Coyle D, Durr C, Shah P. LNG: a proven stranded gas monetization option. In:SPE annual technical conference and exhibition. Denver (Colorado).

Thackeray F, Leckie G. Stranded gas: a vital resource. Petroleum Economist 2002;69(5):10.

Sri Lanka energy balance 2014

Holditch SA. Turning natural gas to liquid. Oilfield Review 2003;15(3):32e7.

Khalilpour R, Karimi IA. Evaluation of LNG, CNG, GTL and NGH for monetization of stranded associated gas with incentive of carbon credit. In: International petroleum technology conference (IPTC). Doha (Qatar): 2009.

Thomas S, Dawe RA. Review of ways to transport natural gas energy fromcountries which do not need the gas for domestic use. Energy 2003;28(14):1461e77.

Deshpande A, Economides MJ. CNG: an alternative transport for natural gas instead of LNG; 2005.

Subero G, Sun K, Deshpande A, McLaughlin J, Economides MJ. A comparative study of sea-going natural gas transport. In: SPE annual technical conference and exhibition. Houston (Texas): 2004.

Sri Lanka energy balance 2014

Dong LC, Wei SA, Tan SY, Zhang HJ. GTL or LNG: which is the best way to monetize "stranded" natural gas? Petroleum Science 2008;5(4):388e94.

Al-Saadoon FT. Economics of GTL plants. SPE Projects Facilities & Constructions
2007;2(1):1e5.

Imperial-Ventrue. Natural gas utilization study: offshore Newfoundland;
1998. Newfoundland, Canada.

Ward EG, Wolford AJ, Mick MB, Hauser W, Verret AJ, Tapia L.

Alternatives for transporting associated gas from deepwater Gulf of Mexico developments.