Export Infrastructure and Monetizing Options for Lebanon’s Natural Gas

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Abstract—Lebanon stands to benefit significantly from extracting and monetizing its potential natural gas reserves. However, significant uncertainty has resulted in stakeholders adopting a wait-and-see approach in decision-making and investment in the hydrocarbon sector. This paper aims to address this uncertainty by providing a structured framework to determine the conditions that make various export options under consideration feasible and attractive. Our analysis particularly focuses on the LNG option that Lebanon could use to ship its gas to market. This option is broad and the alternatives range from building an LNG liquefaction plant in Lebanon, deploying floating LNG vessel, leasing an existing underutilized LNG plant, to a brownfield expansion of an existing LNG facility in Egypt.

Keywords—Lebanon; Eastern Mediterranean; export options; infrastructure; natural gas; LNG; discounted cash flow analysis

I. INTRODUCTION

The discovery of natural gas in the Levant basin and the recent success of natural gas exploration in Israel and Cyprus offshore fields raised expectations that Lebanon could also follow suit and potentially become a natural gas exporter. Seismic studies conducted in 2010 off the Lebanese coast suggest gas reserves could be in the range of 25 Tcf [1]. Choosing the appropriate export infrastructure is an important prerequisite for the success of Lebanon as a commodity producer. This paper aims to provide a structured framework to determine the conditions that make various export infrastructures under consideration feasible and attractive.

II. WHY FOCUS ON EXPORTS?

Naturally, Lebanon could use its natural gas to satisfy domestic demand for electricity generation. With the government’s plan to add another 800 MW of gas-fired capacity into the grid by 2017 [2] [3], 60% of the Lebanese installed capacity could be fueled by natural gas. With this, and assuming that domestic energy demand is growing at 4% annually, we projected that Lebanon’s natural gas consumption will reach 0.06 Tcf in 2025, and 0.16 Tcf in 2050. This paper assumes that the size of Lebanon’s gas reserves is much larger than domestic demand, and therefore, gas exports would be the better option for Lebanon.

Another potential development is for Lebanon to import LNG [4], as switching to gas immediately could save Lebanon $1.9 billion on its annual fuel bill [5]. If LNG import materializes, by the time Lebanon reaches production stage of its natural gas, it would not abrogate its existing gas contracts, making the domestic demand for the new offshore gas limited to a very small incremental demand. As a result, exports would still be the better option for Lebanon.

III. MONETIZATION OPTIONS FOR LEBANON’S GAS

Various monetization options that Lebanon can explore are: building a Liquefied Natural Gas (LNG) plant, expanding and use existing regional gas pipeline, building a transnational undersea pipeline, deploying a compressed natural gas (CNG) vessel, and developing a gas-to-chemical option.

LNG option could provide access to lucrative and growing Asian market and also more certainty of cash flow since most contracts are fixed-price long-term contracts. On the other hand, it has a high initial investment costs and requires a sizable coastal site in which Lebanon is currently lacking.

Exporting the gas through the existing Arab Gas Pipelines would lower down the capital costs significantly. However, this infrastructure does not provide export destination flexibility and by the time Lebanon reaches production stage, the regional demand may have been filled by supply from Israel [6].

Undersea pipeline could connect Lebanon to European gas market that seeks to diversify their gas supply away from Russia. Nevertheless, offshore pipelines between Lebanon and Europe continue to pose significant financing and engineering challenges [7].

Deployment of CNG vessel is an attractive option as it has lower capital costs compared to LNG option while at the same time offers market flexibility. Yet, while we have small-scale FCNG example from Indonesia [8], we are yet to see large scale deployment of FCNG. Furthermore, the economics of CNG vessel only work for markets in close proximity [9].

Gas-to-chemical option provides the highest jobs creation potential, with the additional upside from significant growth in the global demand for petrochemicals. On the downside, it is extremely capital intensive and there is no guarantee that Lebanese could compete with more established players.

IV. LNG OPTION ANALYSIS

Our analysis particularly explores the LNG option, which comprises a broad spectrum of alternatives, ranging from building a greenfield LNG liquefaction plant in Lebanon, deploying floating LNG vessel, leasing an underutilized LNG plant, to a brownfield expansion of an existing LNG facility.

At the highest level, LNG is connecting the upstream and the natural gas markets and it can be broken down into three sub-elements: liquefaction, shipping, and regasification. The focus of our analysis is limited to the liquefaction stage of the LNG value chain. Therefore, the price that we will use throughout this report is the free-on-board price (FOB), which excludes shipping and regasification costs.
A. Greenfield LNG (“LNG”)  

The first alternative is for Lebanon to build its own LNG liquefaction plant domestically. This option offers the greatest market flexibility and low geopolitical risks. However, learning from Cyprus’ experience, to be economically viable, Lebanon must have at least 12 Tcf of gas [10].

B. Floating LNG (“FLNG”)  

Floating LNG (FLNG) is a floating liquefaction plant that eliminates the need to have a separate offshore gas production facilities and transmission pipelines to onshore facilities. The current FLNG design would collect directly the natural gas from multiple subsea wells, liquefy, and store it before offloading it onto LNG tankers [11]. Therefore, production, treatment, and liquefaction are done in the same location.

C. Cooperation with Egypt  

We also consider the potential for Lebanon to take advantage of existing infrastructure, namely the Arab Gas Pipeline (AGP) and Egyptian LNG plants. The sub-options are:

1) Direct Sales: Sell the gas directly to Egypt through the Arab Gas Pipelines to serve the growing domestic Egyptian demand as the country now cannot reliably rely on its domestic gas supply. Despite new findings between 2010 and 2013 that drove up estimated reserves from 59 Tcf to 77 Tcf, Egypt’s annual production has declined, with low levels of investment to replace depleting gas fields [12]. This option would involve reversing the flow of the AGP.

2) Lease: Use underutilized Egypt’s LNG infrastructure by leasing liquefaction and storage through tolling. In the short term, the low utilization of the Idku plant due to lack of adequate supply [13], opens up an attractive option for Lebanon. Beside reversing the AGP, this option would involve the construction of an extension of the pipeline from Al-Arish to the LNG terminal at Idku.

3) Expand Idku: Expand the existing Egyptian LNG plant at Idku by adding more LNG trains. The facility currently has 2 trains, but it can be expanded for up to 6 trains [14].

V. METHODOLOGY

A. Economic Assessment with Discounted Cash Flow (DCF)

Economic analysis plays an important role in providing a degree of guidance to any decision-making process that is also contending with multiple non-economic considerations. The key features of DCF analysis is that it allows apple-to-apple comparison of projects with different CAPEX, risks, and timelines. In this paper, the output of the DCF analysis is the breakeven gas price (BEP), which represents the minimum gas price to ensure that a project is value neutral. If the actual gas price is above the BEP, the project will create value by having a positive Net Present Value (NPV).

The following assumptions are used throughout the DCF analysis: reserves size of 13-48 Tcf, corporate tax rate of 15-35%, export size of approximately 250-500 bcf annually, inflation rate of 1.8-3.2% annually, domestic energy demand is growing at 3-5% annually, and partial gasification of Lebanese power sector.

B. Risks Assessment  

On top of economic assessment with the DCF analysis, we also assessed each alternative on four risk criteria:

1) Institutional and Political Risks: These risks take into account historical and social environment of the country in which the project is being developed [15], which include: political instability, conflict and violence, corruption, social acceptability, political acceptability, and regulatory risks, such as the introduction of tariffs, deregulation, and expropriation.

2) Completion Risks: These risks include technical risks, construction risks, and operational risks [16].

3) Environmental Risks: These include potential outside problems such as pollution and hazards, the implementation of mechanisms that reduce contamination, and cleanup costs.

4) Geopolitical Risks: These risks refer to the potential problems that might arise due to the relationship between countries and region that will affect the project execution.

VI. EVALUATION

A. Economic Assessment

1) LNG Option

Fig. 2 shows various assumptions that we use to assess this option. Of a particular note is the CAPEX assumption; over the past decade or more, it has considerably increased and this upward trend is expected to continue.

### TABLE I. SENSITIVITY ANALYSIS FOR LNG OPTION

<table>
<thead>
<tr>
<th>Variables</th>
<th>Floor</th>
<th>Median</th>
<th>Ceiling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feedstock costs ($/MMBtu)</td>
<td>2.7</td>
<td>4.2</td>
<td>6.0</td>
</tr>
<tr>
<td>Plant CAPEX ($/tonne)</td>
<td>1,300</td>
<td>1,500</td>
<td>1,900</td>
</tr>
<tr>
<td>Utilization rate</td>
<td>90%</td>
<td>80%</td>
<td>70%</td>
</tr>
<tr>
<td>O&amp;M costs ($/MMBtu)</td>
<td>0.10</td>
<td>0.20</td>
<td>0.30</td>
</tr>
<tr>
<td>Loss factor</td>
<td>8%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corporate income tax (CIT)</td>
<td>15-35%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost of capital</td>
<td>14.16%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* CIT in Lebanon is 15%, but for oil & gas sector, CIT might be higher
  a. Assuming debt to equity ratio of 2:1, cost of capital varies depending on the CIT

Fig. 2. Various assumptions used in the DCF analysis of the LNG option

This option would be economically feasible if the prices of natural gas, excluding shipping and regasification, are between $9.92-$14/MMBtu. Variation in the gas feedstock costs has the most significant impact to the BEP.
The previous figure assumed that construction will be completed in year 0 and revenue generation begins in year 1. However, this is not always the case. Our analysis shows that delays add $0.65-$0.95/MMBtu per year in BEP.

Fig. 3 shows how Lebanon LNG could compete with recent LNG projects. LNG projects in Australia now have BEP between $11.1-19.8/MMBtu. Canadian projects now range around $12-13/MMBtu. African LNG projects in Mozambique need around $11.50/MMBtu to break even. The most competitive right now is the U.S. LNG projects such as Cheniere’s Sabine Pass, with BEP of $8.1/MMBtu.

![Figure 3. Competitiveness of Lebanon LNG](image)

2) FLNG Option

Fig. 4 shows various assumptions that we use to assess this option. The CAPEX for on-going FLNG projects varies from $600/tonne for Caribbean LNG, to $4,000/tonne for Abadi FLNG. For our analysis, we use $2,000/tonne as the lower bound as this figure has been adopted by some reports [17].

<table>
<thead>
<tr>
<th>Variables</th>
<th>Floor</th>
<th>Median</th>
<th>Ceiling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant CAPEX ($/tonne)</td>
<td>2,000</td>
<td>3,000</td>
<td>4,000</td>
</tr>
<tr>
<td>Utilization rate (%)</td>
<td>90%</td>
<td>80%</td>
<td>70%</td>
</tr>
<tr>
<td>O&amp;M costs ($/MMBtu)</td>
<td>0.10</td>
<td>0.20</td>
<td>0.30</td>
</tr>
<tr>
<td>Loss factor (%)</td>
<td>-</td>
<td>8%</td>
<td></td>
</tr>
<tr>
<td>Corporate income tax (CIT)</td>
<td>15-35%</td>
<td>9%</td>
<td></td>
</tr>
<tr>
<td>Cost of capital (%)</td>
<td>12.72-14.76%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\footnote{CIT in Lebanon is 15%, but for oil & gas sector, CIT might be higher.}

\footnote{Assuming debt to equity ratio of 7:3, cost of capital varies depending on the CIT.}

FLNG would be economically feasible if the prices of natural gas, excluding shipping and regasification, are between $9.07-$18.73/MMBtu. Variation in CAPEX has the most significant impact to the BEP.

Given this figure, Lebanese FLNG would be able to compete with current FLNG projects in the pipeline, such as Prelude FLNG (with BEP of $12/MMBtu), Greater Sunrise FLNG, Browse FLNG (both with BEP of $15/MMBtu), and Abadi FLNG (with BEP of $15.8/MMBtu).

3) Egypt: Direct Sales Option

The option to sale the gas directly to Egypt would be economically feasible if: lifting costs are lower than the contracted price with the Egyptian government, currently between $2.65 and $5.88/MMBtu and Lebanon could negotiate with the Arab Gas Pipeline (AGP) transit countries for favorable transit fees and regulations. From the CAPEX perspective, the cost of reversing the pipeline is $10-$20 million, much cheaper compared to other infrastructure we have explored.

4) Egypt: Lease Option

This option would be economically feasible if liquefaction tolls anchored around $3/MMBtu and are less than the feedstock costs. This would be an attractive option if there is a guarantee that liquefaction capacity at the Idku plant is available when Lebanon needs it.

5) Egypt: Expand Idku Option

This option would be economically feasible if the prices of natural gas, excluding shipping and regasification, are between $5.99-$10.22/MMBtu. The lower BEP compared to greenfield LNG and FLNG options make this option the most attractive economically.

B. Other Risks Assessment

Fig. 5 shows the risks assessment matrix of various alternatives. The fuller the circle is, the higher the risks are, with empty circle denotes the lowest risk. In summary, LNG option suffers from institutional and political risks, FLNG option suffers from completion risks, while Direct Sales, Lease, and Expand Idku option suffer from geopolitical risks.

![Figure 5. Risks assessment matrix of various alternatives](image)

<table>
<thead>
<tr>
<th>Risks assessment matrix of various alternatives</th>
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</thead>
<tbody>
<tr>
<td><strong>LNG</strong></td>
</tr>
<tr>
<td><strong>FLNG</strong></td>
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<tr>
<td><strong>Egypt</strong></td>
</tr>
<tr>
<td><strong>Direct Sales</strong></td>
</tr>
<tr>
<td><strong>Lease</strong></td>
</tr>
<tr>
<td><strong>Expand Idku</strong></td>
</tr>
<tr>
<td>Institutional and political risks</td>
</tr>
<tr>
<td>Completion risks</td>
</tr>
<tr>
<td>Environmental risks</td>
</tr>
<tr>
<td>Geopolitical risks</td>
</tr>
</tbody>
</table>

1) Institutional and political risks

LNG option suffers from medium-high institutional and political risks, with most of the risks coming from Lebanon’s unstable political situation, sectarian violence, and corruption. On the other hand, the option to cooperate with Egypt, in general, has lower institutional and political risks as we are dealing with existing infrastructure. However, building high cost LNG trains in foreign territory (Expand Idku option) would be a hard sell politically, even if it is economically viable. It also exposes Lebanon to expropriation risks which rise over time and with successive regime changes in Egypt.

2) Completion risks

FLNG option suffers the most from completion risks, particularly as it is an untested technology with high potential of cost overruns. However, if those risks could be mitigated, it could be more favorable than the LNG option as it doesn’t require large coastal site and has a lower construction risks [18]. For the Direct Sales, Lease, and Expand Idku options, completion risks seem to be minimal as we use existing
pipeline or lease liquefaction services. The risks escalate when we invest in capital intensive brownfield, exposing Lebanon to significant construction risks (Expand Idku option).

3) Environmental risks

FLNG option seems to have the lowest environmental risks as it does not require the construction of undersea pipelines, onshore infrastructures, and dredging for jetties [18]. FLNG vessel could also be easily removed and re-deployed.

4) Geopolitical risks

LNG option has medium geopolitical risks due to the fact that onshore fixed facilities like LNG plants are prone to internal conflict and geopolitical instability in the region. Direct Sales, Lease, and Expand Idku options suffer from higher geopolitical risks as the pipeline and infrastructures are located in another country which is politically unstable.

VII. CAUTIONARY TALE

In a volatile market such as natural gas market, every recommendation for future decision must be taken with a pinch of salt. Therefore, it is important to consider the following broader risks inherent in the LNG option.

A. LNG prices will continue on its weakening trend in the near future

This trend continues as the indexing of natural gas prices to oil continue outside the U.S. [19]. Into the next decade, we would expect also to see no prices convergence between the three major markets and the persistence of oil-linked contracts. The longer term prices are much harder to predict given the volatility of the market, and many projections by IEA or the U.S. based EIA have never been accurate.

B. The future demand for LNG may not be as big as many had thought, with the biggest competition likely to come from renewables.

Growing number of countries are now considering plan for renewables, even in oil and gas producing countries such as Algeria and Saudi Arabia. UAE is building a photovoltaic plant that has a lower price per MWh than the price of gas for electricity generation in the country [20]. Even in Brazil, the price per MWh from a photovoltaic plant is only a little higher than similar price in UAE [21].

C. European market may not be that attractive anymore.

The demand for gas from E.U. countries is dropping due to high energy prices in the last decade, increasing role of renewables, availability of cheap coal, lower carbon dioxide prices, environmental regulations, and economic crises. This was made complicated by potential Russian respond to any effort to reduce its market share in European gas market [22].

D. Demand from Asia could be big, but not without any complexities.

LNG demands from mature Asian economies such as Japan, S Korea, and Taiwan are stagnating. Chinese market has a potential for LNG to satisfy its growing domestic demands. However, the slowing down of Chinese economy might make some forecasts on the growing Chinese demand obsolescence.

VIII. DISCUSSION

We explored a broad spectrum of options involving LNG, ranging from building a greenfield LNG plant in Lebanon, using floating LNG, leasing an existing underutilized LNG plant to a brownfield expansion of an existing LNG liquefaction plant. However, our study does not presume that LNG would be the best option for Lebanon. Therefore, we are calling for more rigorous study on other options such as pipelines, and CNG marine transport, among others.

REFERENCES


