ENHANCING VIABILITY OF NEW LNG PROJECTS

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Summary

Cost reductions of LNG chains have been the target of the major companies from 1960s until the present time. LNG train construction is the highest cost element of LNG chain.

So far, increasing economy of scale and improving of technology, were the targets for the cost reduction in the world. Iran LNG has found a new way for LNG train cost reduction which is periodical segregation, producing and export of electricity and sweet gas during the construction. Geographically segregation of different parts of LNG train, as various packages, and awarding each package to a separate EPC (Engineering, Procurement and Construction) contractor is the other way for this cost reduction.

Background

Comparison of Pipeline and LNG Economy for Natural Gas Transportation

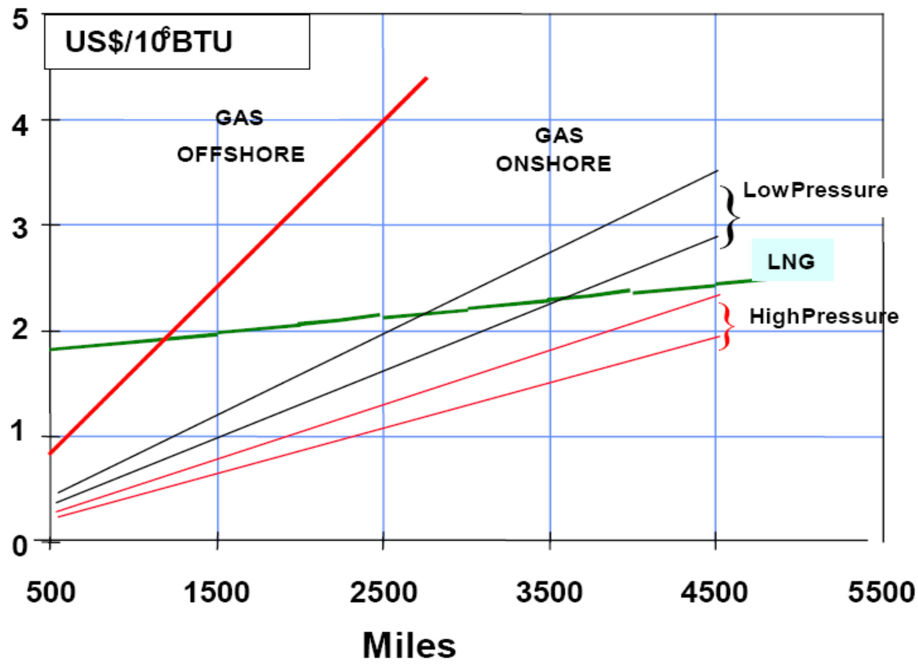
Economy of natural gas transportation by pipeline depends on the size, gas pressure and distance between supply location and destination. For short distances and involvement of one or two counties, pipeline is more economical way. But for longer distances more than 3000 km, LNG for carrying natural gas would be more economical (1).

In general, while comparison is made between pipeline and LNG for transportation, LNG option is preferred because of its flexibility for rate, destination and time schedule. Growing spot trades of LNG has also increased this flexibility. However, in case of small and medium amount of gas for transportation, LNG chain cost will be quite high (2 and3) .

The economics of production of GTL (gas to liquid) is high and NGH (natural gas hydrate) technology is in research study stage and not yet commercialised worldwide. Therefore, it takes some years that GTL and NGH development to compete and economy advantages over pipeline and LNG for transportation (2 and 4) .

The following figure shows the comparison cost between pipeline and LNG for transportation (5 and 6).

Pipes/LNG competition for 30 10^9 m^3/year capacity



LNG Chain costs

LNG chain costs consist of development of gas field, LNG train construction, LNG transportation and consumer storage and regasification facilities.

Cost estimation for LNG train is shown in the following table from early 1990s up to present years for Middle East export to Far East destination (5).

$/MM BTU

LNG chain activity	Cost estimation Early 1990s (5)	Cost estimation Early 2000s (5)	Cost estimation Present Date (ILC)	
			Rate	%
--Upstream development (well head and gas field)	0.5 – 0.8	0.5 – 0.8	1.7	27
--LNG production (treating and liquefaction)	**1.3 –1.4**	**1.0 –1.1**	**2.8**	**44**
--Shipping (LNG tankers)	1.2 –1.3	0.9 –1.0	1.2	19
--Consumer (storage and Regasification)	0.5 –0.6	0.4 –0.5	0.6	10
Total LNG chain	3.5 –4.1	2.8 –3.4	6.3	100

As it is noticed from the above table, LNG production cost was all the time the highest among the other elements of the chain and liquefaction part of LNG production is also the highest.

In spite of the above cost estimations, it is accepted that, the average unit investment cost for liquefaction plants has been reduced from 550 $/ton a year in 1960s, to approximately 350 $/ton in 1970s and 1980s and to 250 $/ton in late 1990s and for the projects starting operation recently the price is claimed slightly under 200 $/ton a year (5).

However, a quick review on several established LNG trains and LNG licenses reveals that the two following means were the target for cost reduction of LNG train construction:

--Increasing economy of scale (from 0.5 MMTPA in 1960s to 5 -- 8 MMTPA in 2010s)

--Improving technology

Iran LNG Co. (ILC) has found the other way of cost reduction for LNG train construction which is production and export of electricity and sweet gas during the construction period and also geographically segregation of the project.

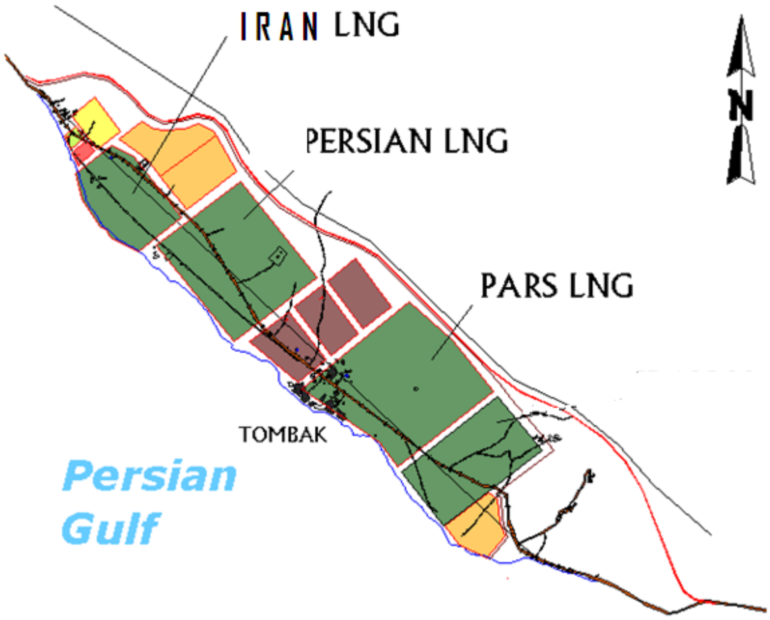
Iran LNG Project

Iran LNG Co. (ILC) is an Iranian private entity established since June 2006 and is conducting Iran LNG project during engineering, procurement, construction, commissioning and operation.

After completion of feasibility study of Iran LNG project, the front-end-end-engineering–design (FEED) was awarded to a joint-venture of JGC of Japan and Technip of France, on bid basis, for construction of two trains (Train1 and 2) with total capacity of 10.8 MM TPA at Tombak, 60 km west side of Assaluyeh, North of Persian Gulf.

After preparation of the preliminary data such as feed gas composition, LNG and other products composition, meteorological condition, consensus on basis of design, FEED was prepared and completed in Yokohama and Paris.

During FEED work progress, JGC/ Technip were receiving necessary basic design data from Lurgi, the licensor of Treating Units and from Linde, the licensor of Liquefaction Units.



Summary of feed gas composition is as follow:

	Mole%
--Methane	83.215
--Ethane	5.060
--C3+	3.483
--Carbon dioxide	2.530
--Nitrogen	4.560
--Hydrogen sulphide	1.100

--Water	0.052
Total	100.000

The rate of feed gas and products of each train are shown in the following:

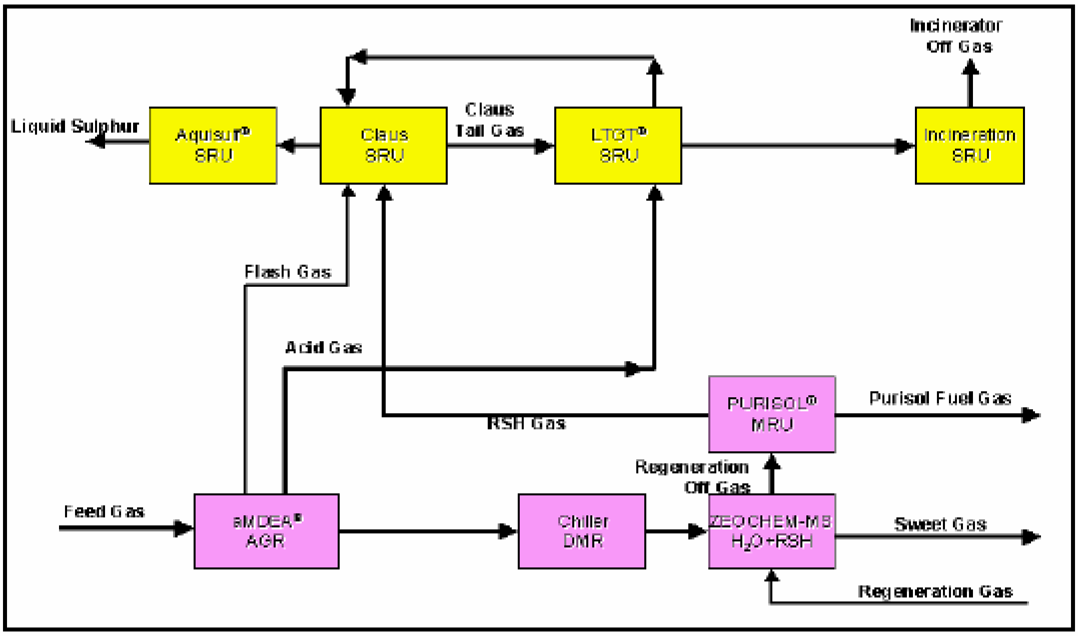
--Feed gas	955 MMSCFD
--LNG production	5.4 MMTPA
--LPG production	0.45 MMTPA
--Condensate production	0.21 MMTPA
-- Sulphur Production	0.136 MMTP A

Selection of technology

The first step for making a project viable is to select a right and proper technology.

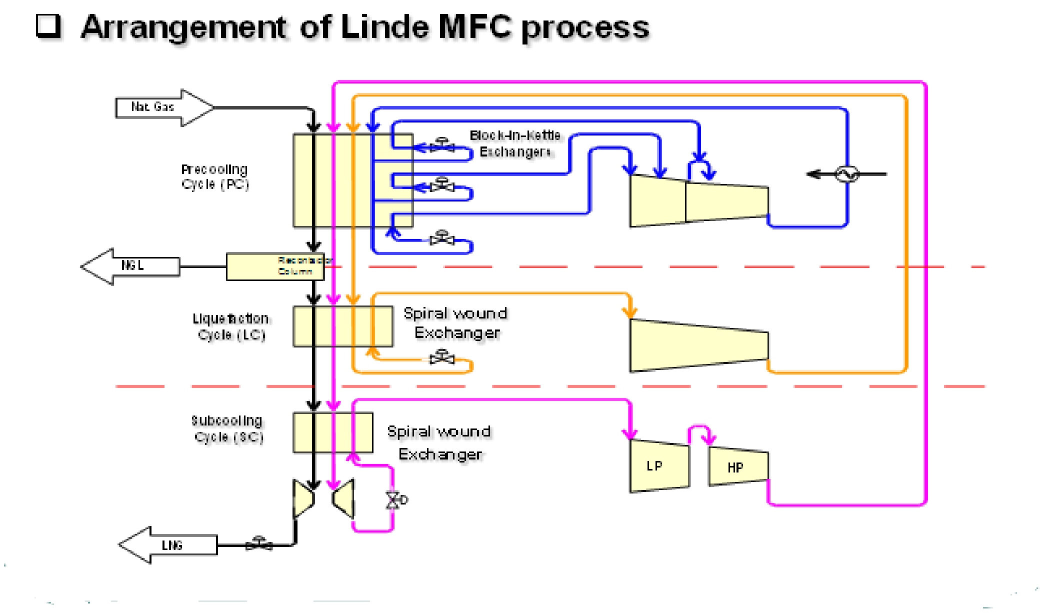
After profound study of available commercial licenses in the world, BASF technology for acid gas removal and Lurgi technology for other parts of gas Treating Units such as: Dehydration and Mercaptan Removal (DMR) and Sulphur Recovery Unit (SRU) were selected.

The following flow diagram shows Treating Units of Iran LNG project.



Five sets of Frame-6 of General Electric (GE) gas turbines (GTs) for refrigeration cycles of Liquefaction Units were chosen for each train.

Mixed Fluid Cascade (MFC) of Linde license was selected for Liquefaction Units as it is shown in the following diagram.



Plant Availability Study

On reviewing of the new LNG trains under construction and in consultation with JGC/Technip; the FEED Contractor, it was understood that if gas turbine (GT) drivers of Liquefaction Units being substituted by electric motors, the same as the most LNG trains under construction, the problems and failures of GTs will be shifted to power plant. As power plant has always some spare capacity, this problem can be ratified and availability of LNG plant shall be increased.

Therefore the plant availability study was performed in details by M.W.Kellogg Limited through FEED Contractor (7). In this study, several main cases and a number of sensitivities with and without planned maintenance were taken into consideration.

In different cases, the plant availability varies between 90 to 95% for Liquefaction Units. The compressor drivers are the main contributors for plant availability. If the drivers are changed from GTs to electric motors, the overall plant availability shall increase by about 3%, because the regular maintenance of GT drivers are diverted to Island Power Plant. If this 3% of higher availability is converted into number of days per year, that shall be around 10 days that LNG shall be producing more during the year.

It is interesting to note that, as part of Island Power Plant investment cost is compensated by eliminating the five steam boilers by installation of 5 Heat Recovery Steam Generators (HRSGs), the remaining costs of this installation shall be recovered by the longer plant availability within a short period.

ReFEED and Island Power plant Design

In order to substitute the GT drivers with electric motors in Liquefaction Units, the FEED was revised by a joint-venture of Linde/Snamprogetti under ReFEED study.

In the study of power plant optimisation by the said J.V., different scenarios of GTs, steam turbine (STs) and HRSGs were examined for optimisation and finally based on, fuel consumption, spare capacity (N+1) and investment cost; the case of combined cycle of power plant of 5 GTs (5X159 MW), two STs (2X122 MW) and 5 HRSGs were finally selected for supplying of power and steam to the two trains. (8 & 9). The iso rating of the Island Power Plant is 1020 MW.

In addition to provide necessary steam for steam turbines (STs), some more steam also being generated by HRSGs for heat-exchangers, reboilers and other parts of LNG trains.

ILC has awarded construction of Island Power Plant to MAPNA Co. which provides the major equipment from Siemens of Germany.

The fuel gas for Island Power Plant is supplied on temporary basis from a branch taken from IGAT-5, the trunk pipeline transporting sweet gas from Assaluyeh to Bid-Boland, within 2 km from north side of the plant site.

Train 3 and 4 of Iran LNG project

The FEED work for Train 3 and 4 of Iran LNG Project is in progress.

HSE (health, safety and environment) consideration of the project

The legal requirements for HSE which specified by Environment Protection Organisation of Iran shall be observed and followed at all stages of the progress and in all parts of the project.

The main effects of construction of the project on local environment are as follows (10):

- Solid wastes from water and sewage treating unit, sludge settled from pits, molecular sieve materials, mercury removal absorbent and spent Claus catalysts shall be segregated as hazardous and non-hazardous and disposed off.
- Sour water contaminated with H2S is stripped off and oil and water will be separated. The water will be treated and is used for irrigation.
- Continuous flue gas emission during operation are exhausted from combustion equipment such as: GTs, incinerator and flare under close control and observation.
- Noise level at any point along plant fence and boundary will be below 70 dB. Inside the fence, around the compressors and other plant area will be less than 85 dB.

The followings are major actions so far taken for HSE protection:

- Selection of the right technology and recovery of 99% of total sulphur and more than 80% of nitrogen of feed gas to prevent of emission of SO_2 and NOx to atmosphere.
- Providing 5 HRSGs for steam production and eliminating 5 steam boilers which were designed in FEED with total capacity of 400 ton/hour. This deletion of the boilers caused to remove CO2 emissions and also heat effect of global warming.
- All international standards (API, ASTM, NFPA, IP etc.) for HSE were closely observed and followed during FEED, ReFEED, procurement, and construction period of the project and all contractors, sub-contractors and vendors are instructed to do the same for HSE protection.

Methods

Construction Period

For execution of the construction works, the LNG trains have been divided into some smaller projects. These divisions have been made for two purposes: First, according to time completion of the small projects and second, with respecting to geographical spread of the equipment and facilities all over the site.

Therefore, the following arrangements are made for construction, erection, installation and commissioning of different parts of LNG Trains:

Package—I

This Package –I is divided into following Packages (11):

Package—IA: Liquefaction Units: consists of Refrigeration, Liquefaction, Fractionation, Nitrogen Removal and Purification Units.

Package—IB: Treating Units, including Feed Gas Metering, Acid Gas Removal (AGR), Dehydration and Mercaptan Removal (DMR) Sulphur Removal Unit (SRU), Mercury Removal, C3 and C4 Sweetening Units.

Package—IC: E-LNG, including Inland Power Plant, electric motors and compressors of Liquefaction Units.

Package—ID: Utilities and Offsite

Package—IE: Main Automation Contract (MAC)

Package—IF: Telecommunication

Package—II, LNG and LPG Storage Tanks and Loading Facilities (12).

This package is consists of three (3) full containment of LNG storage tanks with capacity of 140,000 M^3 each and two (2) LPG storage tanks with capacity of 30,000 M^3 each.

The overall progress of this package is about 75% (11).

Package—III, Harbour and jetties (excluding Loading Facilities) and Sulphur Loading (12)

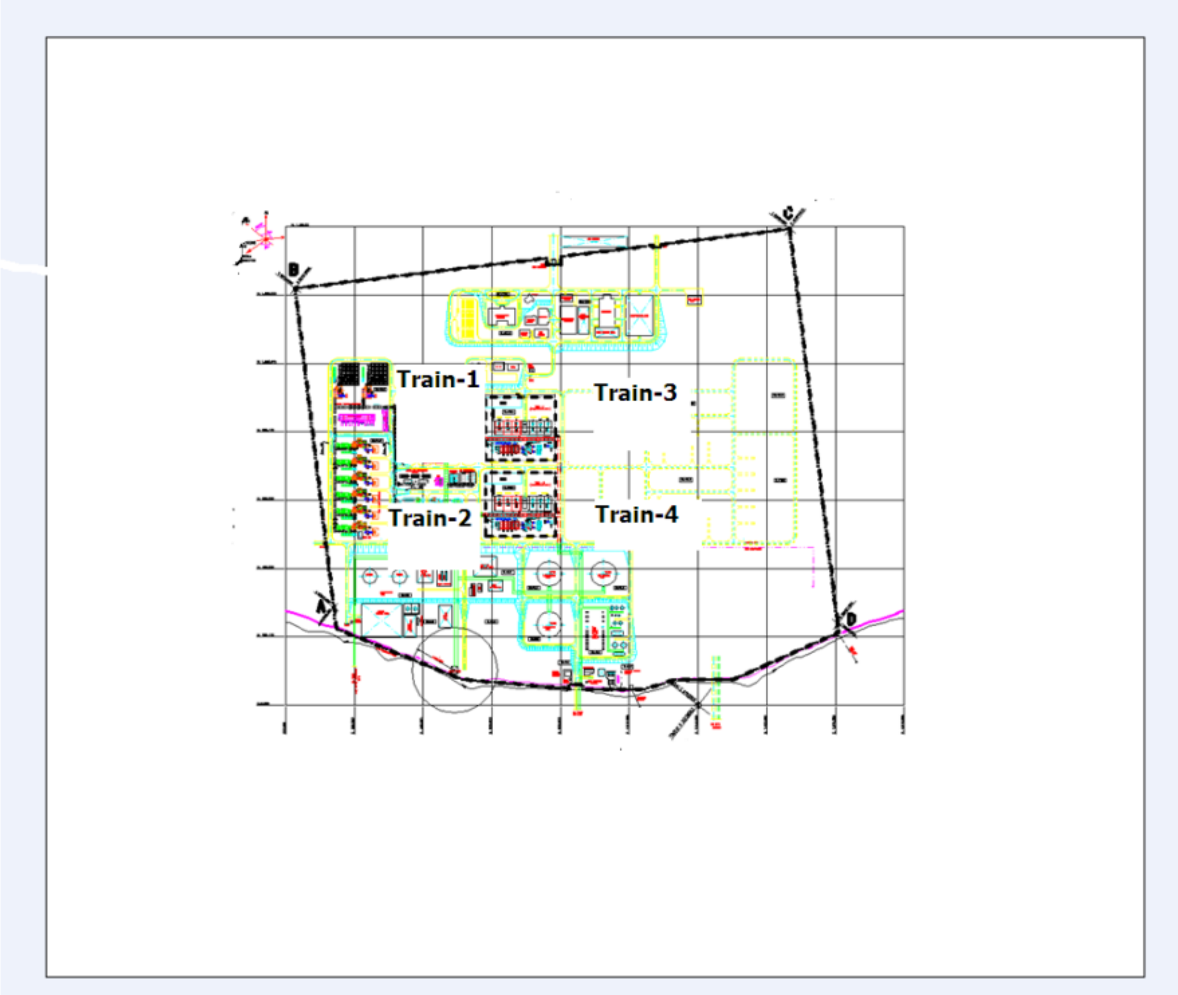
Installation of core and armour on breakwater and eastern dike is completed.

Pile driving and pile production on the LNG trestle is in progress.

The overall progress of this package is more than 80% (11).

All the said Packages have been contracted to foreign and Iranian contractors after bidding, short listing, selection and awarding of the contracts.

The following figure shows the plot-plan and location of the four Iran LNG Trains at Tombak site (12).



Periodical Segregation of Packages

The construction period of each Package was evaluated and assessed with time schedules of the overall project. Being aware of time schedule tightness of overall project and using critical path method, the decisions have been made according to the following three main stages of construction of the packages, as per their interval completion:

First Stage—Construction of the Island Power Plant (Package—IC) for early production of electricity and export of power to National Power Grid was the first step of construction. Therefore, the fabricated and assembled Gas Turbines (GT) were installed first.

Starting from rough grading and site preparation for Island Power Plant site only, until start-up of the first GT, it took less than18 months. At that time, more than 100 MW of electricity was exporting to National Grid. Therefore, the project had some income a fter a short period of time.

For the time being, only after less than one year from the first GT start-up, three GTs are running and exporting more than 400 MW of electricity to the Grid. Installations of two other GTs are in progress and export of electricity shall be raised to more than 600MW soon. Of course, seasonal fluctuation and periodical shortage and excess of National Power Grid shall have some effects on the export of the power. Construction of two steam turbines (STs), and five (5) HRSG which are in the scheme of Island Power Plant, are in progress. The overall progress of this package (E-LNG) is more than 75%.

Second Stage—Construction of Treating Units (Package-IB) for production and export of sweet gas is in the second phase of the schedule. It should be noted that along with this package, Utilities and Offsite Package (package-ID), such as: N2 gas system for purging, Instrument and plant air system, fresh water, steam and condensate etc. of Utilities Package and flare system, fire protection system, and effluent treatment etc. of Offsite Package should be ready in advance for operation of Treating Units.

It is interesting to note that, after commissioning and start-up of Liquefaction Units and export of sweet gas to National Gas Network , export of electricity shall also be be continued, because only some smaller power (around 20 MW) comparing with Liquefaction Units is consumed for Treating Units. The remainder of power is available for export and shall exceed of 600 MW when all GTs are running.

Therefore, at the end of this stage, the project shall have two sources of incomes:

- Export of electricity (around 600 MW)
- Export of sweet gas. The added value and price change of sour gas to sweet gas is the other source of income of the project during construction.

At the present time, Treating Units have about 50% progress and Utilities and Offsite around 40%.It is expected that sweet gas export be started in early year of 2013.

Third Stage—Start of Liquefaction Units and export of LNG

At this stage all Liquefaction Units (Package–IA) consisting of Refrigeration, Liquefaction, Fractionation, Nitrogen Removal and Purification Units, after mechanical completion, purging and cooling shall be commissioned and export of LNG shall be started. Before start-up of Liquefaction Units, export of electricity and sweet gas shall stopped.

The overall progress of Liquefaction Units is about 25%.

It is planned to produce and export LNG at the early season of 2014.

Geographical Segregation

Breaking down the project into some distinct geographical areas, the same as in the Packages as described before and contracting each part or Package to a smaller contractors, rather than having a main contractor was the essential part of efforts for enhancing viability of the LNG project.

Some Packages are also divided into Sub-Packages, for instance, Utilities and Offsite Package (Package—ID) is divided into sub-packages and Air Compressor, Nitrogen Production System, Fire Protection System, Flare System, Fuel Gas System, Administration and Other Buildings etc. were separately awarded to some smaller contractors.

This manner of segregation of the project and contracting caused to encourage some local and foreign manufacturers to be directly involved in contracting business; eliminate the intermediate contractors; reduce the cost of manufacturing the equipment; raise internal fabrication; increase the activity of client for execution of the project and finally expedite transfer of technology into the country.

However, the only disadvantage of this scheme is having many interfaces between contractors, sub-contractors, vendors, ILC organisations etc. which are being settled and eliminated by appointing a team of experienced experts from various disciplines according to the following task force activities:

- To develop interface management plan and procedure.
- To identify key interfaces on drawings and prepare necessary documentations.
- To prepare and execute interface agreements between involved parties.
- To develop schedules, monitor, tracking and reporting on the performance and progress.
- To organise interface coordination meetings to discuss and solve the interface problems.
- To prepare a detailed documentation and necessary references for settling the claims that may be arisen sometimes in the future.

Discussions

Due to some problems and constraints exist for implementation of this method of construction; it may not be possible to follow the same in every other LNG train's schedule and procedure during construction of a project. The major foreseen problems are as follows:

--Providing sweet gas for start-up and running gas turbines of power plant is the first constraint. For ILC case, sweet gas was provided from a pipeline branch of a trunk gas IGAT-5 passing from north side of Iran LNG site within 2km distance. After installation of gas pressure reducing system (GPRS), sweet gas to Island Power Plant was available within a short time. The other LNG trains in other places may not have the same kind of facility. But, as some of well head gas impurities are low, it is possible to design gas turbine to commission and run with this kind of natural gas feedstock.

--The other problem is to find a market for the produced electricity for a short period. Because of high consumption of electricity in industrial and domestic sectors and possible shotage of electricity for some period, it is possible to plan and find temporary market to export electricity.

-- Exporting of sweet gas and having a market to absorb such huge amount of gas for some Period of time would be another problem of this scheme.

Seasonal fluctuation of city gas consumption and also manipulating on utilization of liquid fuel with Natural gas in power plants and other industries, may be possible ways of finding temporary market for sweet natural gas.

However, with a very careful and accurate planning and attracting the cooperation of different energy organisations and industries, it might be possible to achieve similar mechanism such as ILC construction arrangement for other LNG trains.

Conclusions

The following conclusions are obtained from this experiment:

- In addition to higher economy of scale and technology improvement for enhancing viability of New LNG projects, there are some other ways that applied by Iran LNG during the construction.
- Dividing LNG project into different Packages by periodical and geographical segregation and having different productions such as: electricity and sweet gas during construction period is another way for cost reduction of LNG trains.
- Dividing of the main EPC contract of LNG train into some smaller contracts and sub-contracts, has a considerable effect on cost reduction for construction in execution of the project.
- Involvement of more local contractors and sub-contractors and raising their capabilities for performing high technique jobs, utilisation of more local fabrications are the other benefits of this arrangements.
- More involvement of client in the project, increasing its abilities for handling of large projects and finally transfer of technology into the county are also the advantage of the scheme.
- The only disadvantage of this schedule on construction of LNG train is, having many interfaces between contractors, sub-contractors and vendors which are being settled and eliminated by appointing of a team of experienced experts from various disciplines and effective decisions of the client management.

ILC strongly claims that, more than 50% of total costs of LNG train for construction would be saved by applying this plan, comparing with the whole lump sum contracts of similar large project which are normally being executed in the Middle East countries.

Therefore, enhancing viability of new LNG project has been fulfilled by utilising the above scheme.

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Construction Progress

The following photos are taken from Iran LNG Site in 2011, showing the progress of construction of Iran LNG project.