Influence of technologies on LNG market development

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Abstract. The article is devoted to the issues of influence of liquid natural gas (LNG) technologies on transformation of LNG market. The relevance of the article is determined by several factors: growth in demand of LNG, development of gas liquefaction technologies, necessity of CO\textsubscript{2} emissions reduction and diversification of gas supply. All these factors contribute to development of gas liquefaction technologies and regasification LNG and also to assuming importance of companies that provide such technologies. Consequently, the article reveals competitive position which means possession of technologies but not only fossil fuels. The article presents evolution of technologies of gas liquefaction. In addition, the article shows advantages of LNG in comparison to other energy sources. Also in the article the analysis of the LNG service market is conducted. The article reveals advantages and disadvantages of the companies that offer services on researching gas fields, industry engineering and gas supply. Moreover, the article presents advantages and disadvantages of gas liquefaction methods. What is more, the article highlights the importance of not only gas liquefaction but also of transportation, storage and regasification of LNG. Furthermore, the article reveals consequences of LNG technologies development for energy field. The article concludes importance of technologies on LNG market and presents trends in LNG market development.

1. Introduction
Development of technologies of gas liquefaction started in 1823 when M.Faradey made experiments on ammonia liquefaction. In 1873 C.Linde designed a refrigeration unit using counter-steaming heat-exchange unit for oxygen liquefaction. In 1877 two physicists a Frenchman L.P. Cailletet and a Swiss R. Pictet separately using methods of compression and freezing and Joule-Thompson effect got some drops of liquid oxygen. In 1883 scientists S. Vrublevskiy and K.Olshevskiy using boiling under low pressure reached the temperature of 150°C. Such temperature let the scientists liquate such gases as methane, nitrogen and oxygen. Scientific discoveries of the 19th century guaranteed development technologies in the 21st century and contributed to the creation of the international market of liquid gas. For creating fully-factional international market it is necessary to increase the number of participants. Consequently, technologies of gas liquefaction are the factor that can allow to expand the number of market participants.

The international market of liquid natural gas (LNG) is developing dynamically. In 2017 import of LNG has increased by 11% in comparison to 2016. Owing to Asian countries consuming has increased by 29 million tones and equals 293 MT. Global LNG demand is supposed to be growing till 2030 by at least 4% every year. Nowadays current LNG capacity is not enough for supplying the demand. Excess of demand over supply will form 196 MT market [1].
Different countries are developing technologies of LNG producing.

2. Advantages of LNG in comparison to other energy sources

There are several advantages of LNG:

- High heating value, which equals 45.26 MJ/kilo in comparison to other fuels (oil, natural gas, coal, paraffin oil) makes LNG the most power-efficient.
- High level of boil units’ efficiency is maximum ratio of useful heat to total heat put into the combustor while burning fuel. Burning fuel comes with vast heat loosing with emerged gases because of chemical incompleteness of combustion, mechanical incompleteness of combustion and convection and radiation looses. Taking everything into consideration we can claim that LNG has a lot of benefits because the fuel burns completely without any residues and air emission.
- Environmental disposal and nontoxicity of LNG. LNG has low percentage of toxic substances of combustion products. In comparison to liquid and solid fossils the content is several times lower that can lessen the impact of pollution. There is no ash and necessity of removing it while burning LNG, and there is also no carbon and sulfur compound emission. It can help to increase durability of boil units.
- Efficiency, storage, transporting and consume convenience. For using liquid gas there is no necessity to build vast gas pipe lines which tie countries for a long time. Supply can be done to any destination and in any quantity.

3. LNG production

For gas liquefaction the temperature should be 160°C. There are two processes used in production:

- Condensation at constant pressure – using of Joule-Thompson effect.
- Heat-exchange process such as a refrigerating process while using aftercooler and the process of adiabatical abrupt gas enlargement in the special pressure reducer valve.

The second method is more preferable nowadays because the process of gas liquefaction is energy-consuming. Therefore, initial process of liquefaction using Joule-Thompson method is not so popular now.

Nowadays compression and expander scheme is widely used. It makes the process of gas liquefaction more energy efficient.

For reaching maximum efficiency of gas liquefaction thermodynamic schemes of cascade cycle are used. The cycle can use different number of refrigerants. For example, there is a cycle with three refrigerants which boiling temperatures consequentially decrease. This process requires a lot of expenses but benefits from low operating costs. There are also cycles with two refrigerants, for instance, a cycle with double refrigerant – the mixture of ethane and methane. Nowadays there is a new self-refrigerated scheme which uses a mixture of refrigerants such as ethane and propane. Such cascade schemes make use of displacement compressors which CAPEX and OPEX are very high.

Expansive liquefaction cycles. Such cycles are very beneficial nowadays. They use centrifugal machines which are more economical. Refrigerating occurs due to isentropic methane expansion in the turbo-expander. The consequence of actions includes purifying gas from water, carbon dioxide and other inclusions. Then the flow of pure gas is liquated under the pressure due to heat exchange with cool expansive gas flow.

Apart from processes and scheme of liquefaction there are different technologies. Such technologies are services provided by company including research of all steps of gas liquefaction project. There are several companies in the world that supply technologies of LNG. They study gas field, gas quality, its structure. They also design equipment according to capacity utilization. Moreover, the company analyses the most efficient process of liquefaction and its scheme on the basis of advantages of the gas
field region. Furthermore, the company controls forming of production-consumer marketing. There are six companies that provide such service:

Air Products & Chemicals, Inc. (APCI) - technologies AP-C3MR, AP-X, AP-SM (Single Mixed Refrigerant):

- ConocoPhillips - technologies Optimized Cascade.
- Linde – technologies MFC (mixed fluid cascade).
- Black & Veatch - technologies PRICO(SMR).
- Shell - technologies DMR (Dual Mixed Refrigerant).
- Air Liquide - technologies Liquefin.

The main differences are in capacity of equipment, mixtures of refrigerants and its concentration in liquefaction schemes, concepts of cascade options and consequently in its cost. Taking everything into consideration exporting countries choose the company with the most acceptable and beneficial technologies.

Figure 1 depicts percentage rating of companies market share. According to the data the leader is the American company Air Products & Chemicals which offers three different technologies of gas liquefaction. Popularity of this company is determined by the policy of the company that supplies equipment and technologies not only for large-capacity plants but also for the plant that produces 0.25-2 MT LNG a year. Such equipment is of high demand in home market. Small capacity equipment is also provided by the company ConocoPhillips. The company Shell provides technologies of Floating liquefied natural gas. They make it possible to get gas on subsea field, make it liquid, load tankers and transport it.

![Figure 1. Market share in technologies of gas liquefaction.](image)

Transportation of LNG has several steps:

- Loading tankers.
- Transporting by sea.
- Transporting by cryogenic tank cars.
- Transporting by railcars.
• Unloading liquid gas from tankers, tank cars into regasified LNG terminal.
• Delivery to the consumers.

This is the final step made by the company-seller. After that the buyer should regasify the gas. This process has its peculiarities. The regasified terminal consists of several parts:

• port;
• tank car loading and receiving rack;
• gas storage tank;
• evaporative system;
• odorization unit;
• gas-regulation station;
• unit for processing evaporating gases from the tanks.

After tankers berth liquid gas is pumped over from the tankers or tank cars to gas storage tanks using special receiving equipment. Next, liquid gas is sent to the evaporative system with the help of block valves. In the evaporative system gas is transformed into steam, is heated, odorized and finally sent to consumers though gas-regulation station.

LNG may become the most wide-spread fuel in the world. Consumption increase forces development and launch of LNG projects. Importers are searching for fuel of high quality and reliable suppliers, exporters are searching for new marker outlets and long-lasting relationship with buyers.

The diagram in the figure 2 depicts the structure of modern LNG market. World regasification capacity is constantly increasing. The biggest growth for the last four years was in 2017 and equaled 850 MT a year. Overall volume of LNG trade in 2017 reached 300 MT a year. There is a tendency of increasing number of LNG importers. By 2017 there have been 36 countries whereas the number of exporters has not changed.

![Figure 2. International overall production of LNG [2].](image)

4. Conclusions

• Volume of LNG consumption is expected to grow due to increasing of volume of energy consumption. It is caused by growth of population and by increasing capacity and production.
• The number of importers is going to increase. More and more countries stop using coal and oil and start using LNG due to its environmental disposal, heating capacity, convenient transportation and liquefaction technologies development.
• The number of exporters will not change dramatically. The reasons are the uneven distribution of gas fields and high cost of LNG projects development and launch. Apart from gas reserve
geographical position and cost of terminal building should be taken into consideration. The aim of gas liquefaction ought to be to reduce CAPEX and OPEX.

- CAPEX reduce can be reached due to the “brownfield” expansion instead of constructing new “greenfield”. In the USA constructing gas liquefaction plants on the place of non-demanded regasification terminals allows to save because there is no necessity to make storage, ports and other units.

- Floating LNG plants cannot be considered as the way to reduce CAPEX. However, A floating plant has its perspectives for it can be assumed as movable property that can allow to get financial bank support. Moreover, nowadays floating plants are of low capacity that leads to low total investment.

- In the future when demand of liquid gas is not so high medium capacity plants will be more profitable than high capacity plants as it will help companies to be more flexible and change according to the situation on the market. Such approach of increasing capacity can make getting financial support and LNG marketing easier.

- Cooperation with companies whose market share is not big enables technologies transfer and cooperative projects.

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