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GLOBAL LNG MARKET TRANSFORMATION: WAYS NOT TO MISS THE WINDOW OF OPPORTUNITIES FOR RUSSIA

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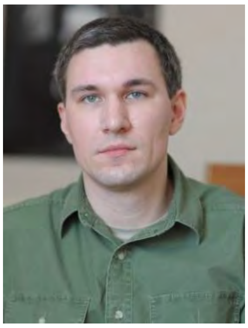

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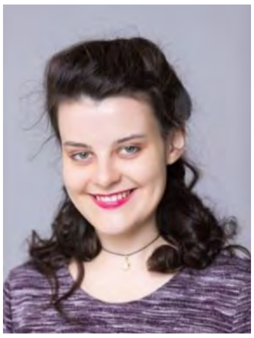

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SUMMARY: MARKET TRANSFORMATION – KEEP PACE OR DIE

Global liquefied natural gas (LNG) trade dates back more than half a century ago, but it is not until recently that the market has truly globalized, by undergoing a profound transformation of all of its fundamentals.

Global LNG industry goes through the times of uncertainty, the key word that describes various aspects of this market now. High price volatility, demand and supply uncertainty become usual.

But most importantly, the growing competition triggers vigorous changes in the 'rules of the game': adapting to new conditions, the market gains flexibility; parallel changes in LNG supply contracts are four-dimensional:

- Shortening of contractual terms
- Cutting of contractual scopes
- Cancellation of the destination clause
- Shifting from the exclusively oil-based pricing to the mixed gas/gas pricing that, in turn, may be expressed in referring to Henry Hub, European exchange prices and to price indicators on the Asian LNG market.

To withstand the competition, companies initiate a real cost cutting battle – the lowest-cost manufacturers only may feel confident on this extremely volatile market.

LNG market companies seek for new risk mitigation approaches, which results in new business models. Development of portfolio players building up flexible global chains becomes by far one of the focus areas. Market participants with a diversified upstream project portfolio and opportunities to expand to different downstream markets not only achieve diversification of both their supply and demand risks but also may curtail their global transportation costs.

Russia's statements of its plans to become the market leader grow stronger and stronger in the last few years. The huge and cheap resource base, the great technological potential and the strong governmental support make these ambitions quite realistic. A visible outcome of the efforts taken is commissioning of the Yamal LNG Project in the Arctic.

However, there is some way for Russia to go in the shaping intense competitive environment to secure and gain a foothold on this market: looking for new opportunities of sweeping efficiency enhancement; curtailing costs; introducing new technologies and streamlining logistics; creating new markets; and building up unique relations with importers.

Russia also faces some domestic challenges: the need to develop its own large-scale liquefaction technology independently and to commercialize cryogenic heat exchangers and the necessary auxiliary equipment. As the first step, the companies plan to design their own medium-tonnage liquefaction technologies.

A lot is at stake; many companies target this market, but only those who will demonstrate the highest performance and offer buyers the most attractive terms will be successful. Versatility, creativity, and speed are key to success in this market evolution. Will Russia be able to take advantage of the opening window of opportunities?

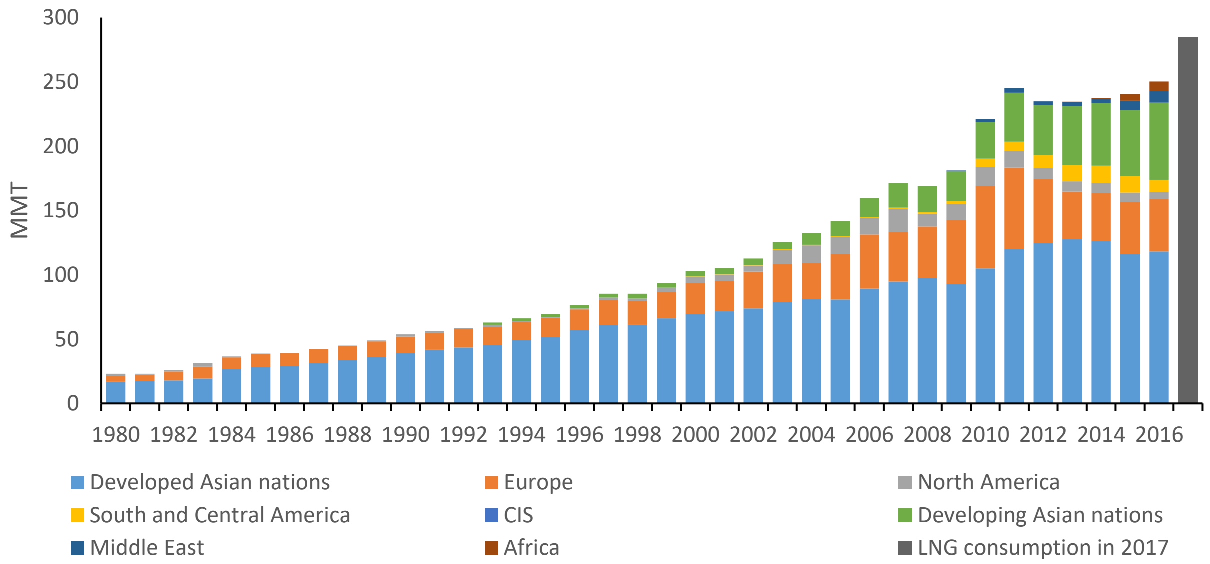
LOOKING FOR DEMAND AND SUPPLY BALANCE ON LNG MARKET

Significant periodicity has been inherent in the global LNG industry from the outset, the late 1950's, though the 'roller coaster' of recent years seems unprecedented. 2018 began with extremely high LNG market uncertainty, the prevailing feature of this market now.

High price volatility complicates the long-term price benchmark forecasting, which, in turn, leads to difficulties in making project investment decisions.

High LNG demand uncertainty: the market drops most observers short all the time: LNG demand had been sluggish for several years (while global annual LNG consumption was increasing almost 8% on average in 1980/2011, the annual average growth rate fell to 0.4% in 2012/2016) and, against the background of boosting liquefaction capacities, everybody expected a 'gas bubble' by 2017/2018, but it has never happened. 2017 saw a sudden explosive 11% growth in global LNG consumption (Fig. 1). It is accounted for, first of all, China's drastic increase in LNG import (46% y-o-y), triggered by the government's effort to shift from coal to gas in heat supply.

Fig. 1. LNG consumption in 1980/2017



Sources: Energy Centre, Moscow School of Management SKOLKOVO, IEA Natural Gas Information 2017, Enerdata World LNG Database 2017

High supply uncertainty. By 2020, the new liquefaction facilities under construction are expected to expand global LNG supply by 50% on 2015. These developments have been recently believed to entail the excess LNG market supply, but the growing demand in China and other developing markets shows that, eventually, the misbalance may be insignificant.

Lots of potential projects are under discussion. In the circumstances, even if the market is to absorb the current excess, will we not face another LNG market supply wave?

On the other hand, with the competitors' high demand and supply uncertainty, the manufacturers seem to 'dread the fire': almost no final investment decisions to build new LNG plants have been made in recent years. The only investment decision (a small floating plant, Coral FLNG, in Mozambique with 3.4 mtpa capacity) was made in 2017, plus a decision to construct Line 3 of Corpus Christi LNG in the U.S.A. (4.5 mtpa) in May 2018. Cf: FIDs for approx. 29.1 mtpa on average were made in 2011/2015. If the market does not reverse, we will not be able to witness LNG glut but rather will observe a new LNG market shortage curve by 2023 (maybe even earlier, depending on demand).

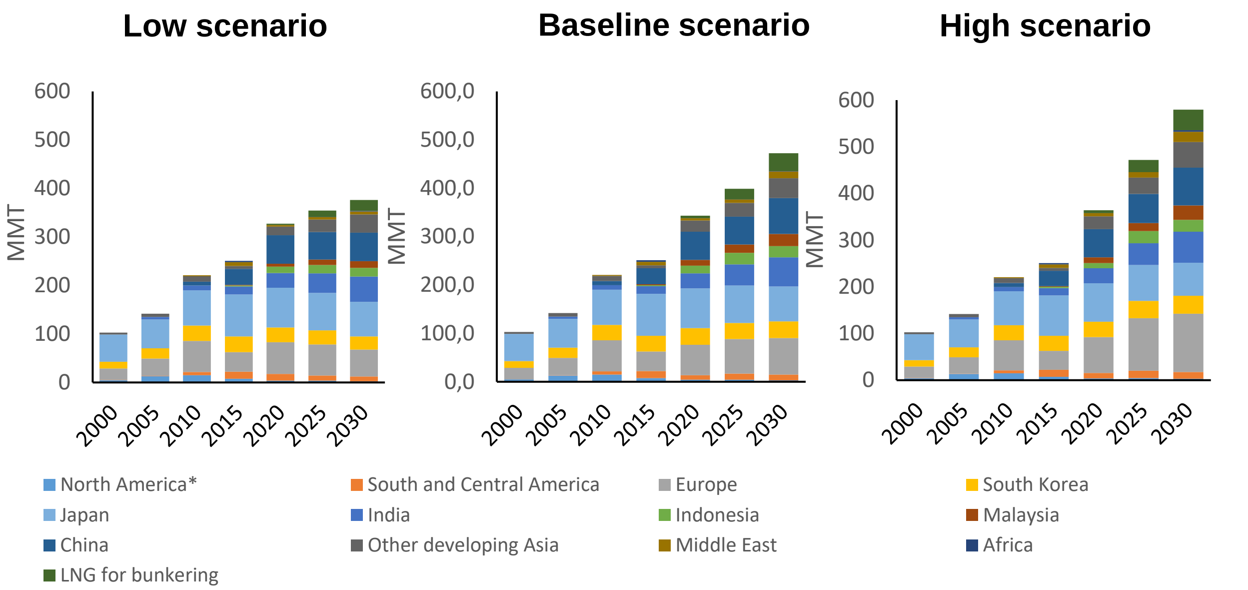
Demand: From Exclusivity to Mass Market

The wealthiest countries used to buy LNG for a long time. However, the last five years demonstrated a major breakthrough: the share of developing countries in global LNG consumption doubled from 2010 to 2015, from 17% to 33%, and it is expected to reach a half of the global LNG demand by 2022/2025.

The Energy Centre of the Moscow School of Management SKOLKOVO has simulated LNG demand scenarios forecast for the biggest countries and regions of the world (Fig. 2). It is noteworthy that LNG demand is a result of the complex interplay of a series of factors:

- Macro-economic growth/ population increase rates and the trends in energy intensity of the economy are the determinants of aggregate energy demand.
- Gas positions in the competition of fuels, as determined by new technology development and the changing prices for different energy sources as well as by the public energy and environmental policy in certain countries; these factors influence the role of gas in the fuel basket.
- In many cases, the competition between pipeline gas and LNG (driven by both price and energy security considerations as well as by importers' varied preferences in the gas market deregulation context); this group of factors determines the imported LNG share in a country's energy mix.

Fig. 2. LNG demand scenario by regions and biggest countries up to 2030



*Note: *including Puerto Rico.*
Source: Energy Centre, Moscow School of Management SKOLKOVO

The major groups of LNG importing countries are described below.

Japan and South Korea have jointly accounted for about 70% of global LNG demand for many decades. The power industry public policy regarding the fuel mix – the decisions as to NPP commissioning or decommissioning and coal-based generation – is the main uncertainty that will influence these countries' LNG demand. By 2030, as the energy savings increase and NPPs are launched, approx. 14-16 mtpa LNG demand decline is expected in Japan (down to 70-72 mtpa), whereas the Korean case is less certain: LNG import will either stabilize/ slightly drop (by 5 mtpa) by 2030 or grow by 5 mtpa.

Europe is the oldest LNG importing region that showed an explosive growth in demand for LNG in the early 2000's (up to 82 mtpa in 2011), though it is very price sensitive due to fierce competition between LNG and pipeline gas (by 2017, demand for LNG had declined to 45.5 mtpa). Depending on the scenario, its LNG demand growth will range very broadly, from 15 to 65 mtpa (up to 55-125 mtpa), by 2030. In other words, the uncertainty range is 70 mtpa. For its 'balancing' function, this LNG market is the most difficult to forecast and has the widest dispersion of potential demand volumes.

In ***China,*** demand for gas in general, and for LNG in particular, is mostly a function of its public policy. Announced by the government, the 'blue skies' policy (fighting smog in mega-cities), through shifting from coal to gas-fueled heating, boosted the demand in 2017. However, any further gas prospects in the power industry and other sectors are still highly uncertain. As a result, China's LNG demand may go up by 22-40 mtpa (to 46-62 mtpa) by 2030.

Following China, the ***Indian*** government announces the 'blue skies' policy, the plans to increase the gas share from 6.5% to 15% by 2022, and the electrification for millions of households. The country's demand potential is indeed strong, though there are some major infrastructure limitations and the high price sensitivity of the demand. India's LNG demand projected for 2030 even exceeds that of China: the increment may range from 35 to 50 mtpa (up to 52-67 mtpa in 2030).

New small consumers. Besides China, the rapid growth in demand from brand new consumers whose joint import was comparable to that of China came in as a big surprise for the global LNG market in 2016/2017. The list comprises countries with the entirely different demand drivers: Pakistan, Bangladesh, Thailand, Kuwait, UAE, Singapore, Indonesia, Lithuania, Poland, Egypt, Jordan, etc.

The aggregate demand of Pakistan, Bangladesh, Taiwan, Philippines, Singapore, Thailand and Viet Nam, as low as 18 mtpa in 2015, may keep pace with the demand of Japan, China or India, reaching 51-74 mtpa by 2030.

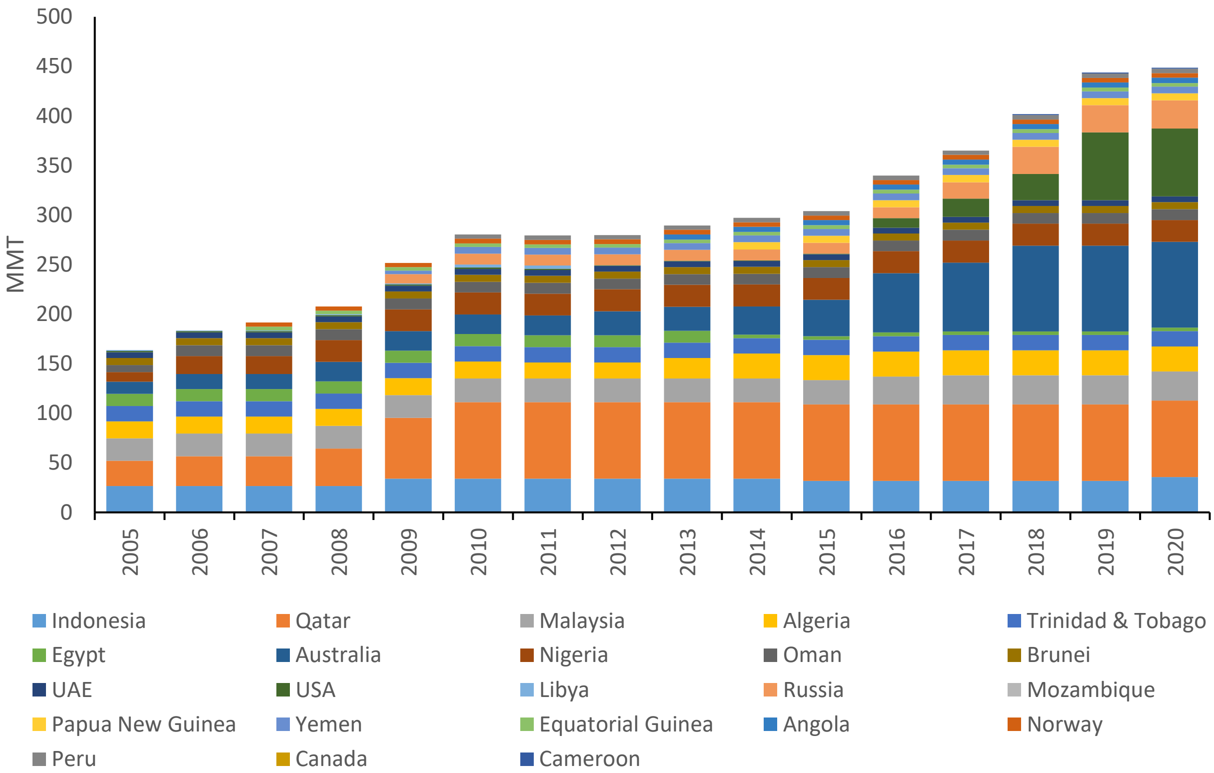
Moreover, there are a number of countries not importing LNG now but either seriously considering this option for the future or even building re-gasification terminals, namely: Bahrain, Cuba, Ecuador, Jamaica, Salvador, Gibraltar, Guadalupe, Malta, Martinique, Panama, South Africa, etc. Their aggregate demand may add 21-33 mtpa by 2030.

One more important demand segment that has recently come into focus oftener and cannot be statistically attributed to some particular country is LNG use for ***sea bunkering***. Limitations on emissions in a number of water areas are the key driver for LNG development as fuel for marine transport – for instance, IMO planned limitations on emissions may facilitate LNG demand for bunkering from the current 1.5 mtpa to 30-80 mtpa, depending on the oil and gas price ratios and the introduced environmental standards severity.

Global Supply: 'Fab Four and Co.'

LNG manufacturers' club was extremely narrow for many decades, with just 13 manufacturing countries present on the market before 2005, namely: Qatar, Algeria, Indonesia and Malaysia, Trinidad and Tobago, Nigeria, Libya, Oman, Brunei, Egypt, U.S.A., UAE and Australia, the first five listed countries accounting for 66% of global LNG production in 2005.

Fig. 3. Trends for installed liquefaction capacities by countries, 2005/2020

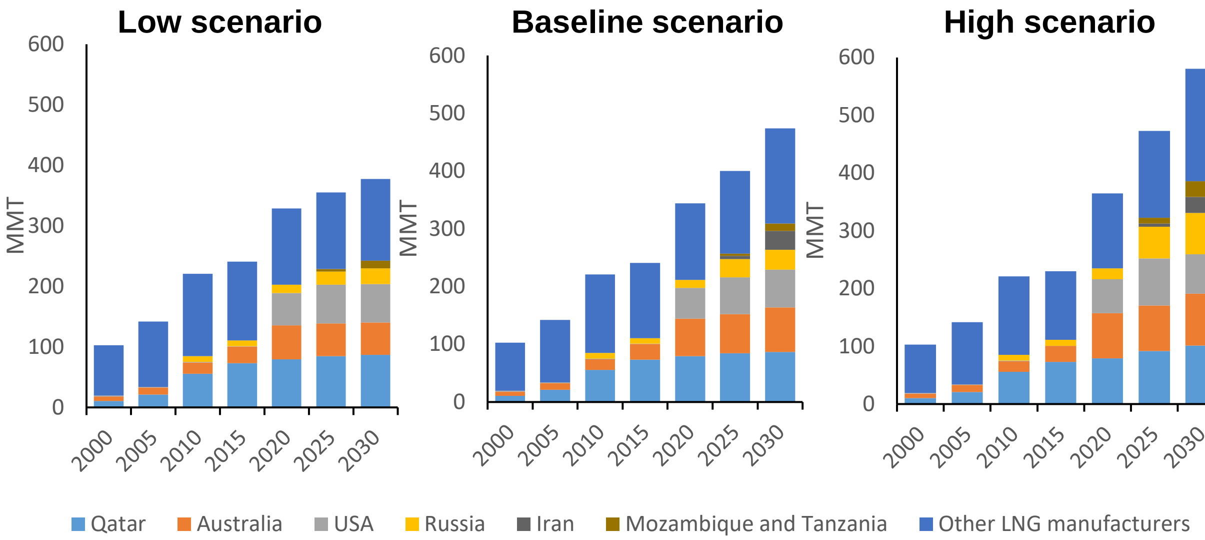


Sources: Energy Centre, Moscow School of Management SKOLKOVO, Nexant WGM Database 2018

The first wave of LNG capacity increase, 2005 through 2010, triggered its 117 mtpa growth (by 72%) and was primarily marked with a triple capacity increase in Qatar (Fig. 3). However, consumers' growing interest in LNG and high LNG prices, against the background of high oil prices and LNG shortage after Fukushima NPP accident in 2011, forced companies to make investment decisions entailing the second wave of LNG capacity increase. 145 mtpa (48%) growth is expected in the period from 2015 to 2020. This time, it will be due to LNG capacity multiplication in the U.S.A. and more than doubling Australian and Russian capacities. All these projects are at the construction stage and are very likely to go to the market.

More distant future, in 2020/2030, is obviously much less certain. The LNG production scenario drafted by the Energy Centre of the Moscow School of Management SKOLKOVO (Fig. 4) shows high uncertainty of supply: the future output will be the outcome of not only demand and prices but also domestic demand for gas in manufacturing countries, their resource base development and the geopolitical environment (in particular, persistence or lifting of sanctions). In adverse circumstances, some of the currently announced capacity construction plans will not be implemented after 2020, and the constructed liquefaction facilities may be underutilized due to the unfavorable market environment. This will lead to a very broad range of global LNG supply: from 377 mtpa to 580 mtpa by 2030.

Fig. 4. LNG production scenario up to 2030, by major producing countries



Source: Energy Centre, Moscow School of Management SKOLKOVO

Let's look at the four major manufacturers of 'new LNG' – the United States, Australia, Qatar and Russia – that are expected to account for more than a half of the entire supply in any of the scenarios.

United States. The U.S. transformation into LNG net exporter is the most significant and discussed change on the global LNG market in recent years. Plants with total capacity of 70 mtpa have been launched or are under construction in the United States (see Table 1).

Table 1. Existing LNG facilities and those under construction in the U.S.A.

Plant, number of lines	Capacity, mtpa	Key shareholder	Status	Launch years
Sabine Pass LNG T1-T5	5x4.5	Cheniere Energy	T1-T4 launched	2016/2018
Corpus Christi LNG T1-T2	2x4.5	Cheniere Energy	under construction	2019
Corpus Christi LNG T3	4.5	Cheniere Energy	FID: May 2018	?
Freeport LNGT1-T3	3x4.4	Freeport LNG	under construction	2019
Cameron LNGT1-T3	3x4.5	Sempra	under construction	2019
Cove Point LNG	5.25	Dominion	launched	2018
Elba Island LNG T1-T10	10x0.25	Kinder Morgan	under construction	2018/2019
Total:	**70.45**			

Source: Energy Centre, Moscow School of Management SKOLKOVO, based on mass media and corporate data

Besides these plants, a whole number of projects with capacity of hundreds of million tonnes are negotiated in the U.S.A., of which over 100 mtpa are likely to be implemented.

High flexibility of the American LNG production model itself suggests that the prospective export from this country will be sensitive to market changes: the high scenario of LNG export from the U.S.A. implies construction of new LNG plants and, on the contrary, the low scenario means that even existing facilities and those under construction will not be fully utilized; as a result, the export is forecast at 63-70 mtpa by 2030.

By the end of 2018, as soon as all facilities under construction are launched, there will be 10 LNG plants with the aggregate 88 mtpa capacity in ***Australia,*** making it the leading supplier on the global LNG market. Three out of these ten plants are relatively old North West Shelf and Darwin plants as well as Pluto LNG launched in 2012. Seven more plants were commissioned as part of the new construction wave (Table 2).

All Australia-based LNG plants can be divided into two groups: West Australian plants (the above-mentioned 'old' production facilities as well as Gorgon, Wheatstone, Ichthys, and Prelude plants) using offshore gas reserves as raw materials, and three LNG plants in the east of the country (Gladstone, Queensland Curtis, Australia Pacific), where coal bed methane (CBM) is used as raw material.

Table 2. Existing LNG facilities and those under construction in Australia

Plant, number of lines	Capacity, mtpa	Key shareholder	Status	Launch years
Withnell Bay (North West Shelf), T1-T5	16.7	Woodside	Functioning	1989/2008
Darwin	3.7	ConocoPhillips	Functioning	2006
Pluto	4.9	Woodside	Functioning	2012
Curtis Island, T1-T2 (МУП)	8.5	Shell	Functioning	2015
GLNG, T1-T2 (CBM)	7.8	Santos	Functioning	2015/2016
Australia Pacific, T1-T2 (CBM)	9	ConocoPhillips	Functioning	2015/2016
Gorgon, T1-T3	15.6	Chevron	Functioning	2016/2017
Wheatstone, T1-T2	9	Chevron	T1 launched	2017/2018
Prelude FLNG	3.6	Shell	under construction	2018
Ichthys, T1-T2	8.9	Inpex	under construction	2018
TOTAL:	87.7			by the end of 2018

Source: Energy Centre, Moscow School of Management SKOLKOVO, based on mass media and corporate data

The key difference of the East Australian production facilities is the shortage of raw materials: in fact, well delivery has proved to be lower than expected. The plants started using not only CBM but also the gas purchased on the domestic spot market to utilize their capacities, which resulted in the East Australian gas shortage. Eventually, there is a significant risk that actual LNG production in and export from East Australia will be below the plants' nominal capacity. Australia's export potential will range from 54 to 90 mtpa a year by 2030.

In July 2017, ***Qatar****, the world's biggest LNG manufacturer,* joined the 'project race' after the 10-year moratorium and announced the 23 mtpa expansion of its production capacities – from 77 to 100 mtpa. In March 2018, Qatar Petroleum was announced to have selected Japan's Chiyoda for FEED in the three new mega-lines (of 7.8 mtpa each), with an option to build the fourth line in the future [1]. Contrary to the expectations, there was no information on plans to upgrade the existing lines, which might increase plants' productivity at minimum costs.

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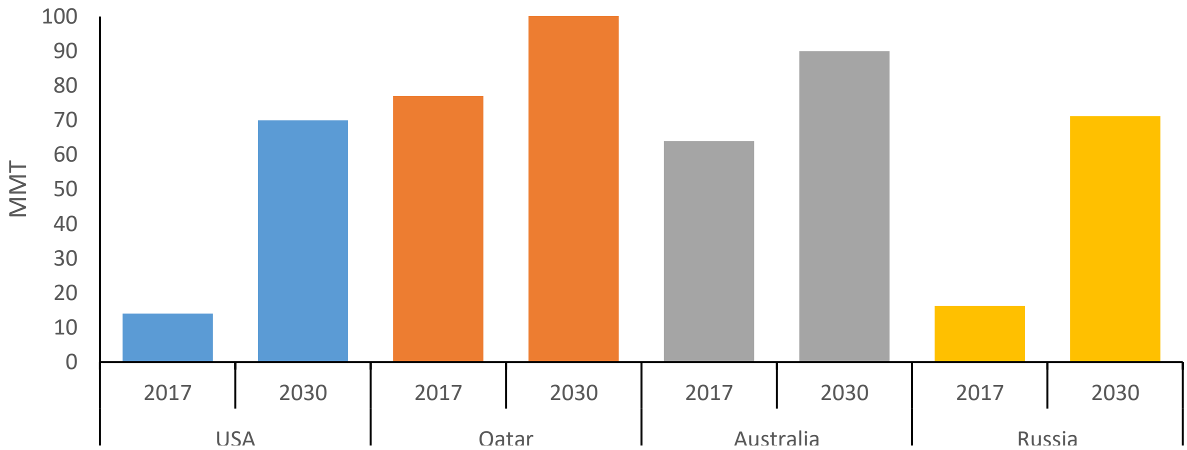
Besides the above three major LNG manufacturers, the United States, Qatar and Australia that target 80-100 mtpa annually (Fig. 5), Russia, with its announced plans to expand production capacities to 70-80 mtpa, may be classified in this 'Fab Four' group of major market players.

Fig. 5. LNG production forecast, by major manufacturing countries



Source: Energy Centre, Moscow School of Management SKOLKOVO

In addition to the four major market players, there are two regions – East Africa and Iran – that may enter the market with new noticeable LNG supply volumes, if the environment is favorable.

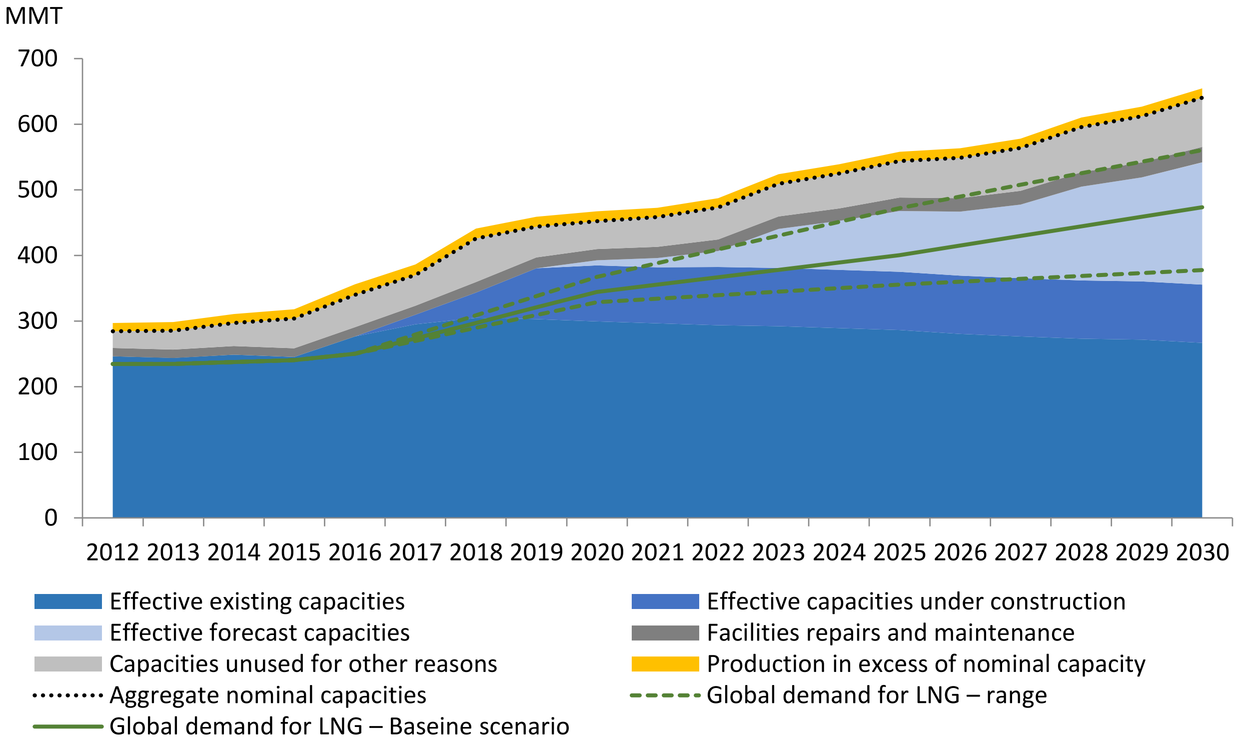
The region does not produce LNG now but large ***East African*** (Mozambique and Tanzania) fields discovered off-shore make it one of the most promising new centers. Estimated export from the region may amount to 13-27 mtpa annually (depending on the scenario) by 2030. Mozambique comes well ahead of Tanzania in terms of project implementation. So far, the final investment decision has been made on a small 3.4 mtpa floating plant, Coral FLNG (operated by Eni). Anadarko, the second active participant in Mozambique offshore development, has made a good progress in the project to construct a fixed-site onshore plant, Mozambique LNG, with two lines of 6 mtpa each.

The uncertainty related to ***Iran*** is worth a separate mention. In the long run, if the country's political relations with the West improve, Iran may become a strong player on the LNG market: we estimate that Iranian LNG export may reach 33 mtpa by 2030 in the best-case scenario and may remain at the current zero level in the worst-case scenario.

Global Balance: Between Scylla and Charybdis

The forecast demand and supply balance on the LNG market is shown in Fig. 6. The market will be obviously balanced by price changes at each particular point in time. In case of LNG market oversupply, spot prices are normally lower than the full cost of liquefied gas production. However, with capital construction costs incurred earlier, in many cases LNG may be produced even if the prices cover the current, operating, costs only. A low LNG price then pushes up LNG demand, while the excess supply is absorbed by the market, with losses of LNG manufacturers though. Alternatively, LNG shortage triggers higher prices, cutting off some consumers and thus reducing effective demand.

Fig. 6. LNG market demand and supply balance forecast



Sources: Energy Centre, Moscow School of Management SKOLKOVO, Nexant WGM Database 2017, IEA Global Gas Security Review 2017

It is worth noting here that actual global LNG output is usually lower than the existing production capacities, for several reasons. Firstly, LNG plants are shut down for scheduled preventive maintenance from time to time, which reduces the annual production capacity by an average of 5%. Moreover, unscheduled, emergency production halting or force majeure events (such as in Yemen now, with suspended LNG production) and domestic gas shortage may occur resulting in underutilization of LNG capacities (such as in Egypt). On the other hand, plants may operate with higher than their nominal capacity in some cases.

HOW DO DEVELOP LNG BUSINESS AMID UNCERTAINTY?

Cost-cutting battle. Fearful of large investments, LNG oversupply and the next potential market price downturn (as soon as by 2025) or cases similar to the Australian LNG projects, companies are extremely cautious about new investment decisions and do their utmost to reduce unit costs. The following approaches are the most popular ways out in the liquefaction plant construction sector:

- Curtailing capital costs. Expansion of the existing production facilities (brownfield), rather than construction of new ones (greenfield), is the most appropriate trend. In particular, in the U.S.A., liquefaction plant construction on the sites of unused regasification terminals, helps save on warehouses, berths and other infrastructure.

- Floating LNG plants (FLNG) are still a nontrivial capital-cost saving solution. However, a FLNG can be regarded as a movable asset, which facilitates obtaining bank funding. Moreover, the FLNG under construction and the completed ones have small capacity, which makes aggregate investments relatively insignificant.

- Decisions to create large-scale production facilities by gradually increasing the number of medium-tonnage lines instead of one-off construction of a large line. Such gradual capacity increase approach makes both raising finance and LNG marketing easier.

The approach involving establishment of large export production facilities based on medium-tonnage lines may be suitable for Russia (for more details please see below). This issue is discussed in detail below. The 2.5 mtpa Elba Island project under construction in the U.S.A. will comprise ten 25,000-ton installations to be launched gradually.

Another sector project in the United States, Calcasieu Pass LNG (operated by Venture Global Partners), envisages the use of lines of 1 mtpa each (up to 10 lines). The agreement of intent was signed with Shell; the liquefaction fee is expected to amount to as low as $2.5/MMBTU, but no project FIDs have been made yet.

Tellurian's Driftwood LNG project, whereby twenty lines of relatively small capacity, of 1.38 mtpa each, are to be built (the project FID has not yet been made either), is worth noting separately. In November 2017, Tellurian signed an EPC contract with Bechtel. The plant plus warehouses and berths are estimated at $15.2 billion [2] (approx. $550/ton, a record low indicator per liquefaction capacity unit). Significantly, Driftwood LNG plant is a greenfield project, and even though the projects with comparable investments per capacity unit ($800/ton) have already been launched in the United Stated, they rely on the use of the existing LNG regasification terminals. This figure can be currently used as the minimum estimate of investments into liquefaction, though one should bear in mind it is only a project now.

How to retain a buyer: new pricing. The LNG price under a classic long-term (20 to 25-year) LNG supply contract depends on global oil prices and is calculated by the S-formula named for the shape of the respective curve. LNG value grows pro rata oil quotations but the slope becomes less steep, if oil prices are extremely low or extremely high. The central section of the curve is described by the formula:

(LNG price, $/ MMBTU) =k (oil price, $/ bbl) + b*

The slope ratio is one of the key aspects in price negotiations. Ratio b ($0.5/$1/ MMBTU) is believed to reflect LNG transportation cost. In previous years, k=0.1485 was used as the ratio for the main part of the curve. However, for contracts concluded in recent years, k ratio has become much lower, dropping to 0.11-0.115, with contract revision precedents.

Provided that the oil price is $60/bbl, k=0.115 and b=0.5-1, the ratio of oil-indexed LNG in Asia Pacific will come to $**7.4-$7.9** / MMBTU.

Having published its LNG price formula for its buyers (FOB Gulf of Mexico), Cheniere Energy is often taken as a benchmark for **U.S. LNG** prices, and the U.S. LNG price has traditionally been estimated by this formula:

*LNG price ($/MMBTU) = U.S. gas price (Henry Hub) * 1.15 + k,*

where k=2.25-3.5 (more beneficial conditions were provided under earlier contracts). k is believed to reflect capital liquefaction costs (so the buyer may refuse to buy real LNG, by paying for liquefaction of contractual volumes ($2.25-$3.5/ MMBTU). At the same time, 1.15 ratio linked to the U.S. gas price and real liquefied gas volumes reflects the operating (in particular, energy) liquefaction costs.

Where Henry Hub gas price stands at $ 3/ MMBTU, the U.S. LNG price in Asia Pacific (using Cheniere Energy formula and taking into account the transportation price of $2/ MMBTU) will amount to $**7.7/ $8.95** /MMBTU.

Finally, the **spot-market** linked prices gain significance. Short-term contracts with prices linked to the spot market indicator [3] Platts JKM have already been observed. The Sling North Asia spot market index for the last year (from April 2017 to March 2018) (the equivalent of Platts JKM but from the Singapore exchange) averaged $7.68/ MMBTU.

All pricing methods limit LNG prices in the mid-term to $7.5-$8.5 / MMBTU. These are the values most market players target now. It is interesting to note in this context that Tellurian has already offered LNG at the fixed price of $8/ MMBTU (DES) to Japanese buyers, but this offer has not attracted market participants yet [4].

The growing **supply flexibility** in its broadest sense has become another key factor of change on LNG market. As Poten estimates, the average **term of a contract** concluded in 2017 shortened to 6.7 years vs 11.5 years as early as in 2016. At the same time, the share of **spot sales** increased year by year: in 2017, according to GIIGNL estimates, it came to 20% of the total LNG trade volume.

The average **contract volume** is decreasing, too. The average volume of a contract concluded before 2009 amounted to 1.3 mtpa, with gradual reduction in subsequent years, according to the International Energy Agency. In 2017, the average contract volume was as low as 0.67 mtpa, according to Poten.

Another drastic change in LNG trade understanding is systematic non-inclusion of the so-called **destination clause** – the provision that prohibits LNG resale to other markets.

Development of independent LNG spot trade indicators. The LNG market development logic follows that of the oil market development, which ended with independent oil pricing centres. In view of particular features of LNG storage and transportation, making LNG a stock exchange commodity is not so easy. However, attempts at creating independent pricing for LNG have been undertaken in recent years.

Platts-published JKM (Japan/Korea Marker) index launched in February 2009 has become the most common indicator in such trade. It reflects LNG spot transactions under DES in the ports of Korea and Japan. At present, Platts JKM index is the most representative indicator of LNG spot trade, which is promoted by the active development of the financial structure over physical trade: trade in Platts JKM swaps (i.e. futures contracts) on ICE and CME exchanges. Trade in Platts JKM swap contracts develops very rapidly: in 2017, the index swap trade proved 4 times higher than in 2016. Nonetheless, the entire annual trade amounts to as low as ~4% of total LNG trade worldwide.

At the same time, a number of Asia Pacific countries would like to create their own stock exchanges with their own indicators for LNG trade.

Singapore was the first to announce its plans to establish an LNG exchange; however, the full-fledged implementation is still a remote prospect. To address this objective, the Singapore exchange has launched LNG price indices (somewhat similar to Platts JKM). Financial derivatives for Sling indices have been met with market players' limited interest.

In 2014, **Japanese's** Tokyo commodity exchange launched an OTC trade system for purchasing LNG (Japan OTC Exchange), which also offered LNG forward contracts without physical delivery (Japan DES), but market players have not demonstrated great interest in them so far.

China is still focused on creating stock exchange trade in pipeline gas, even though LNG exchange trade facilitated by country-wide distribution of some LNG in tank cars also exists. If a liquid pipeline gas market is created, China will be able to use this price benchmark in the future when trading on LNG spot market; that is to say, actually the market model is the European one. There are all pre-requisites to go along the European path. The following three sources feed the large and ever growing domestic market simultaneously: own production, pipeline gas import, and LNG import. In 2015, the Chinese Government launched the Shanghai oil and gas exchange that became fully functional in autumn

2016 [5]. In January 2018, the plans were announced to launch one more Chongqing gas exchange early in 2018.

Finally, as LNG export from **the United States** increases, the price index of this country may become another prospective indicator of LNG spot market, which is fostered by the absence of the destination clause (the destination point obligation) requirement to contracts for LNG supply from the United States. In June 2016, four months after the first LNG export tanker shipment, Platts agency announced the launch of a new index, Gulf Coast Marker (GCM), reflecting FOB prices in the Gulf of Mexico. And in May 2017, ICE launched trade in futures contracts linked to Platts GCM.

Moreover, **online LNG trade** may become another independent pricing method. The launch of LNG online exchange, GLX, was announced for 2017, but the first transaction was made public late in May 2018 only.

Market participant transformations and new business models. Growth in flexible volumes on the market resulted in the various gas, and related oil, market participants engaging in LNG trade: traditional traders (Trafigura, Vitol, Gunvor and other companies) and traditional LNG importers (CNOOC, JERA, PGNIG etc.) entered the LNG market. The oil and gas majors that have traded in LNG and even grow this business are active, too. Shell became the LNG major trader after consolidation with BG. National LNG manufacturers begin to deal with trading, too. In January 2018, Qatar gas announced its merger with Rasgas, and Qatar Petroleum (the main shareholder of these companies) has a trading JV with ExxonMobil for sale of LNG manufactured outside Qatar.

The market development encourages investments of LNG sellers, LNG traders and importers (that become traders) into development of the downstream infrastructure on the new markets (the so-called ‘demand creation’ strategy). For instance, Mitsui and Trafigura invest into FSRU in Pakistan [6], [7]. Japan plans to invest $10 billion in LNG infrastructure development in Asia [8]. Such investments help attaining two objectives at once. Firstly, they create demand for LNG by building infrastructure on new markets, which is often too expensive for a buyer to build on its own. Secondly, ‘special relations’ between an LNG seller and an LNG buyer are thus established, which enables to obtain a guaranteed sales market in possible LNG market oversupply circumstances.

RUSSIA'S POSSIBLE FUTURE POSITION ON THE GLOBAL LNG MARKET

What is at stake?

Russia built the first large-scale gas liquefaction plant in 2009, under the Sakhalin II project operating in line with the Product Sharing Agreement. Its initial capacity stood at 9.6 mtpa (two lines of 4.8 mtpa) and was increased to 10.8 mtpa upon upgrading.

The second project was launched 8 years later. In December 2013, FID on the Yamal LNG project was adopted, and in December 2017, the first 5.5 mtpa line of the plant was commissioned (see Table 3). Thus, Russian capacities amount to 16.3 mtpa now.

Table 3. Main Russian LNG projects (large-scale production)

Plant	Capacity, mtpa	Year of commissioning	Status	Shareholders
Sakhalin II T1, T2	10.8 (post-upgrading)	2009	Functioning	Gazprom (50%), Shell (27.5%), Mitsui (12.5%), Mitsubishi (10%)
Sakhalin II, T3	5.4	after 2023	project	Gazprom (50%), Shell (27.5%), Mitsui (12.5%), Mitsubishi (10%)
Yamal LNG, T1	5.5	2017	Functioning	Novatek (50.1%), Total (20%), CNPC (20%), Silk Way Fund (9.9%)
Yamal LNG T2, T3 + T4	5.5*2 + 0.9	2018, 2019	under construction	Novatek (50.1%), Total (20%), CNPC (20%), Silk Way Fund (9.9%)
Arctic LNG-2» T1-T3	6.6*3	after 2023	project	Novatek and partners (Total 10%)
Baltic LNG	10	after 2023	project	Gazprom, Shell
Far East LNG	5	after 2030?	project	Rosneft, ExxonMobil
Pechora LNG	up to 10	after 2030?	project	Rosneft, Alltech

Source: Energy Centre, Moscow School of Management SKOLKOVO, based on corporate and mass media data

What's next? After the launch of the second, third and fourth Yamal LNG lines (approx. by the end of 2019), the aggregate capacity of Russian large-scale LNG production facilities will come to 28.2 mtpa – it is comparable to Malaysian or Indonesian active capacities.

However, the companies' further plans to expand capacities are highly uncertain. Gazprom plans two large-scale projects: as part of Sakhalin II, the project expansion by building the third 5.4 mtpa line has been negotiated for many years already. Being a brownfield project, this is the lowest-cost production site among Russia's new LNG plants. However, the unresolved resource base problem hinders its implementation. In addition, the Baltic LNG project envisaging the Unified Gas Supply System (UGSS) raw materials as the gas source is under discussion.

Rosneft still plans to build its own LNG production facilities (Far East LNG), but it is unlikely to be implemented in the current price conditions: it is a relatively small (5 mtpa) greenfield project, which makes LNG output of the potential plant rather expensive. Nonetheless, in May 2018, mass media (referring to persons familiar with the matter) [9] announced

Rosneft and ExxonMobil plans to expand the project, and the final decision on the scope of investments is to be made in 2019.

The company also considers Pechora LNG project based on the Kumzhino and Korovino fields, and there is not much certainty about this project, either.

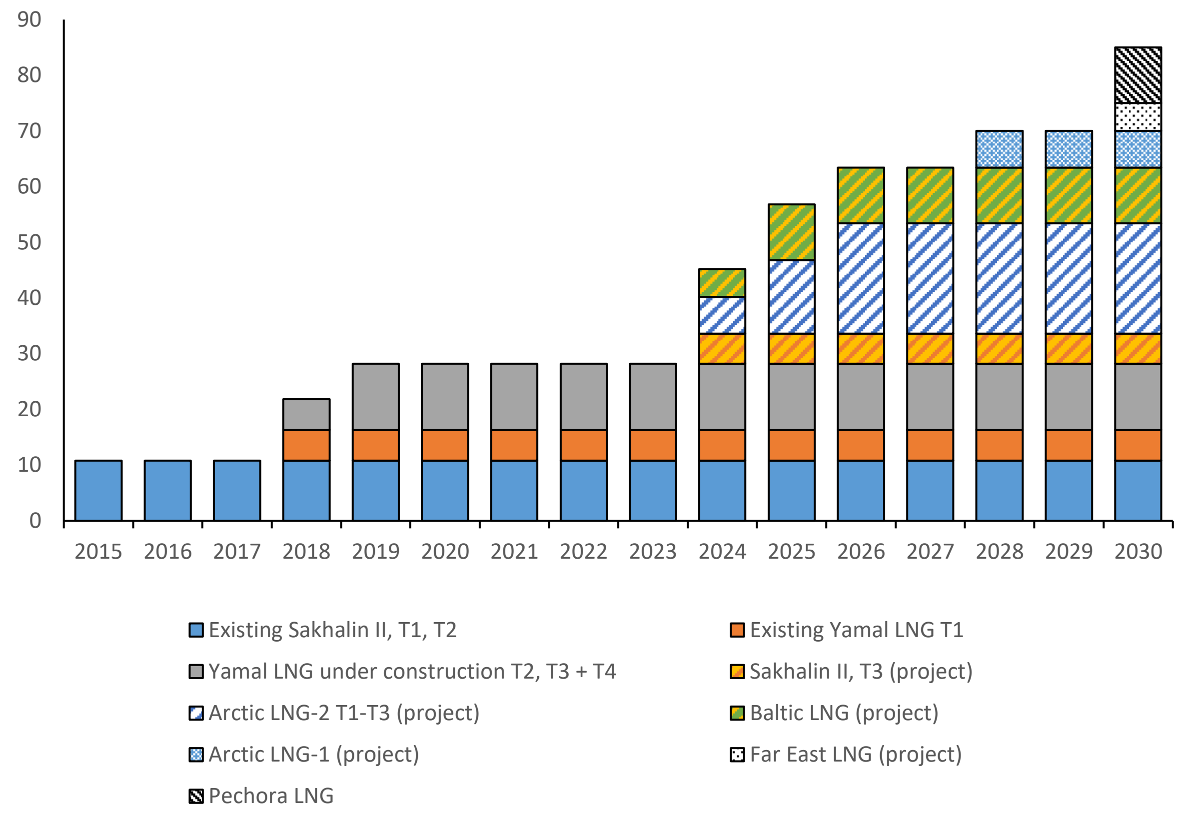
The most probable new production facilities include: Arctic LNG 2 Project (Novatek) – three lines of 6.6 mtpa each, with the resource base of the Utrennee field, in the Gydan Peninsula.

The Arctic LNG 2 project envisages LNG plant construction offshore, on the gravity-type platform (300 meters long and 150 meters wide), with the expected 30% capital cost curtailment. The project's FEED will be finalized at the end of 2018. The targeted capacity unit cost ranges from $650 to $750 /ton. LNG plant construction on platforms would enable to cut the cost of logistics and to install the capital equipment 'remotely' - LNG lines will be built in the Large-Scale Marine Facilities Construction Centre in Murmansk.

Moreover, based on the available resource base in the Yamal and Gydan peninsulas, Novatek considers implementation of Arctic LNG 1 and Arctic LNG 3 projects, of 19.8 mtpa each. This means growth in the aggregate capacity of the company's plants in the region up to 76.8 mtpa (taking into account the facilities under construction and the existing ones), which is comparable to Qatar's effective capacities. Clearly, there is a long way to go to implement these ambitious plans though.

In the current environment and given the statements of the companies' representatives, possible overall LNG capacities in Russia may reach 60 mtpa / 80 mtpa by the 2030's (Fig. 7), though this is just an estimate. Some of the most complex projects may not be implemented, while new, not yet announced, production capacities may appear (firstly, as part of monetization of Novatek gas reserves in the Yamal and Gydan peninsulas).

Fig. 7. Possible large-scale liquefaction capacity trends in Russia



Source: Energy Centre, Moscow School of Management SKOLKOVO

Several medium-tonnage LNG liquefaction production facilities are built/ discussed in Russia (Table 4). In this paper, we do not go into details of medium- and small-tonnage projects to be outlined in a separate study; main projects only are listed here.

Besides the above-mentioned fourth Yamal LNG line, the plant is under construction at Portovaya CP (1.5 mtpa) and also Cryogas Vysotsk (2 lines of 0.33 mtpa each), where the output may double in future.

The Gorskaya LNG project is pending agreement now: it comprises three lines of 0.42 mtpa LNG each. All the three medium-tonnage production facilities are located onshore the Baltic Sea and largely focus on bunkering. And in June 2017, Gazprom announced it was revising the Vladivostok LNG project towards medium-tonnage production (probably, with bunkering plans but in Asia Pacific countries this time).

Table 4. Russian Main LNG Projects (Medium-Tonnage Production Facilities)

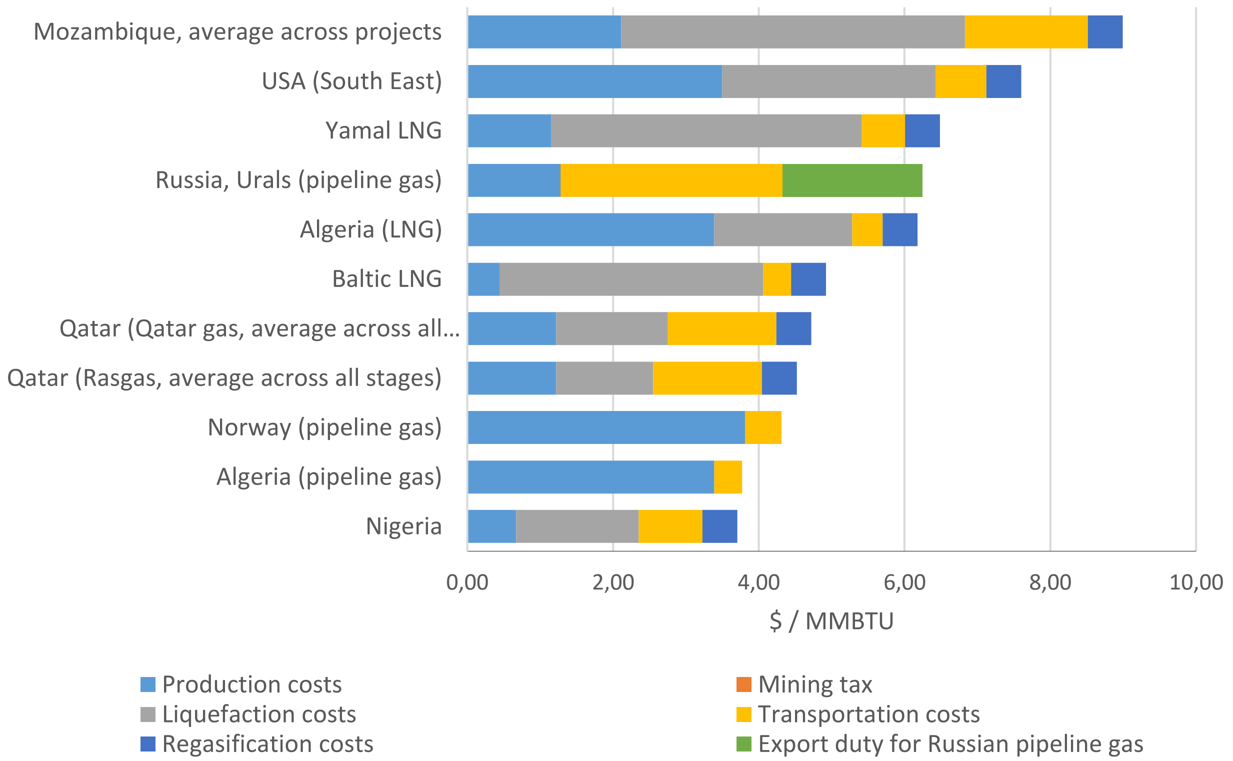
Plant	Capacity, mtpa	Year of commissioning	Status	Shareholders
Cryogas Vysotsk	0.33*2 (possible 0.33*2 expansion)	2018	under construction	Gazprombank (49%), Novatek (51%)
Plant at Portovaya CP	1.5	2019	under construction	Gazprom
Vladivostok LNG	1.5	?	project	Gazprom and partners
Gorskaya LNG T1-T3	0.42*3	?	project	Gorskaya LNG

Source: Energy Centre, Moscow School of Management SKOLKOVO, based on corporate and mass media data

Russian LNG Competitiveness

New Russian LNG projects go to global markets in a tough pricing environment. Analysis of our LNG competitiveness suggests that Russian LNG is a strong 'mediocrity' among competitors.

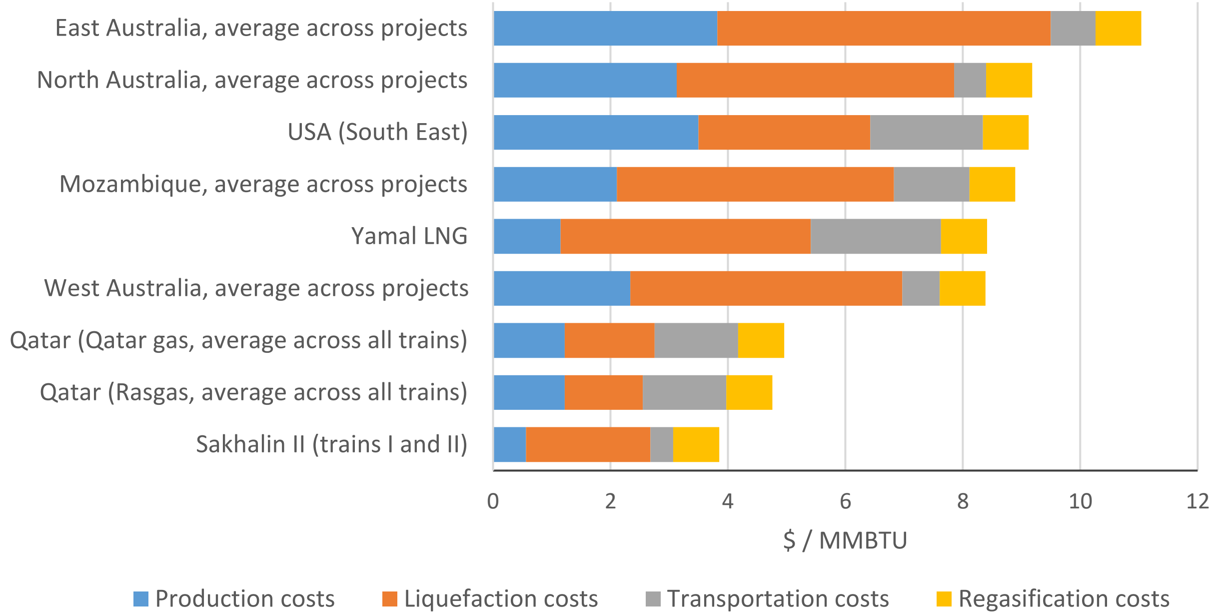
Fig. 8. Full Costs of LNG and Pipeline Gas Supplies to North West Europe (Belgium) in 2025



Source: Energy Centre, SKOLKOVO Business School

As concerns full production and delivery costs, we believe Russian LNG is not the last resort: new Australian projects are much costlier.

Fig. 9. Full Costs of LNG Supplies to Asia Pacific (Shanghai, China) in 2025



Source: Energy Centre, SKOLKOVO Business School

The Russian LNG industry SWOT analysis (Table 5) emphasizes strengths and weaknesses of Russian LNG, which are largely balanced.

Table 5. Russian LNG Industry SWOT Analysis

Strengths	**Weaknesses**
- Good resource base, low production cost across all projects - Proximity of a number of projects to the markets (Sakhalin II to Asia Pacific, Baltic LNG to Europe) - Opportunities to expand the existing projects and those under construction (third line Sakhalin II, new lines in Yamal and Gydan) - Favorable tax regulation - Long-term contracts in place for the existing facilities and those under construction - Major companies' interest in cooperation: participation of a broad range of foreign companies in the existing plants, willingness to participate in new liquefaction projects. Experience of cooperation with China	- Geography (for Arctic projects), which makes transportation more expensive and influences the construction cost - Lack of own technological base for large-scale liquefaction and LNG transportation - High country and sanction risks - High cost of capital - Inadequate workforce qualification
Opportunities	**Threats**
- Growing global LNG market - The market niche to emerge in Asia Pacific in the early 2020's - The market niche opens in the segment of new buyers and small-tonnage LNG - Possibility to sell 'turnkey solutions', not only LNG	- Slowdown of global and regional demand for LNG - High probability of excess capacities, high competition - Declining global LNG prices - Possible toughening of sanctions against Russia and certain companies

Source: Energy Centre, SKOLKOVO Business School

Cheap-to-produce gas is the key advantage and the competitiveness factor of Russian gas. The weaknesses are high costs of delivery to Asia Pacific markets (for projects in the Baltics and mainly in the Arctic where the highest capacity gain is expected) and the lack of own liquefaction technologies and facilities for production of the necessary auxiliary equipment. In addition, with transportation costs accounting for a significant share in the ultimate product cost, establishment of own gas carrier production facilities is an urgent task.

The calculations suggest that, against the background of competition with other projects, overall LNG export from Russia is estimated from 26 mtpa to 71 mtpa by 2030, depending on the scenario, even though, as shown in Fig. 7, the overall potential reaches 85 mtpa and certain Russian officials mention even 100-120 mtpa by 2035. Our results are derived from NEXANT WGM simulation and may be adjusted upwards, in case of a noticeable reduction in liquefaction and transportation costs, which has been announced by Novatek recently.

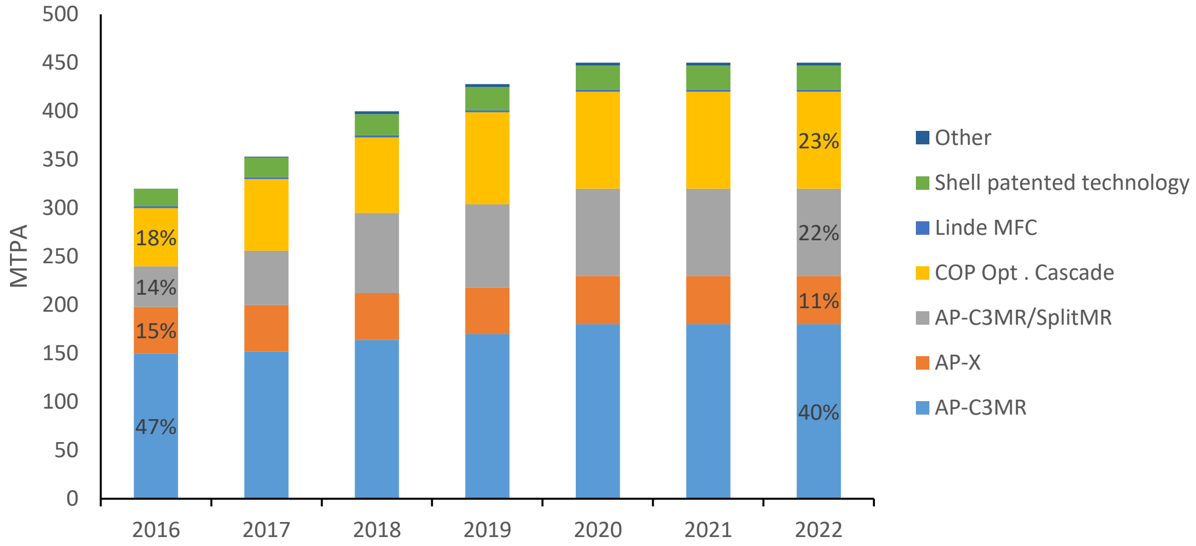
How to reduce costs and technological dependence?

As noted above, average LNG price on Asian markets will be $8/ MMBTU in the mid-term. At the same time, the liquefaction cost (mostly capital costs) of Russian projects is $3.5-$4 / MMBTU, and over $2/MMBTU is the cost of transportation to Asia. Moreover, liquefaction plants' reliance on imported components is extremely high, and Russia has to order gas carriers from South Korean wharves. If and when LNG price is $15/ MMBTU (as the case was several years ago), one can disregard the high share of foreign components, but now a logical question arises: does it make sense for Russia to export LNG if a great part of its price returns to foreign markets as payment for LNG production equipment. Letting alone that new potential sanctions may question even the purchase of necessary equipment. All this makes it topical to develop own LNG liquefaction technologies or localize foreign solutions.

In general, the global large-scale liquefaction technology market is highly concentrated: 76% facilities are built using Air Products (U.S.A.) technologies, and the two U.S.-based companies (Air Products и ConocoPhillips) have over 90% of the technology market (Fig. 10). The remaining market share is occupied by Shell and Linde technologies, which partner with Novatek and Gazprom, respectively. Shell used its own DMR technology at the Sakhalin II plant and, perhaps, the same technology will be applied when expanding Sakhalin II and building the Baltic LNG plant.

Yamal LNG used C3MR technology from Air Products, but the plan is to use Linde technology, for which Novatek has already signed a strategic cooperation agreement, for the Arctic LNG 2 project.

Fig. 10. Types of Technologies Used for Large-Scale Liquefaction



Source: IGU World LNG Report 2017

It is unclear now, to what extent the use of foreign liquefaction technologies will be accompanied with equipment localization or license transfer. However, it is noteworthy that both foreign partners Gazprom and Novatek plan to cooperate with have a minor share of the global liquefaction market and, thus, interested in increasing their share and creating new reference production facilities. In these circumstances, it is reasonable to hope that Russian and foreign companies will manage to agree upon establishment of joint ventures on win-win conditions, yet foreign partners are also interested in elaborating their technologies by analyzing the specific features of their technologies at Russia's new LNG plants. It is of particular importance for Linde because the company has not got many reference large-scale projects: in fact, it has the operating liquefaction plant in Norway only. The incomplete LNG plant in Iran was to be built on the use of Linde technology, too.

The second way to overcome the technological dependence is large-scale export production based on medium-tonnage liquefaction lines (as demonstrated by Elba Island LNG plant (under construction), Driftwood LNG and Calcasieu Pass LNG projects in the United States).

Developing own small-scale liquefaction technology is simpler than developing a large-scale one (and much more companies own such technology worldwide). Moreover, our country manufactures small-tonnage LNG plants of up to 50,000 ton capacity, in particular, for export to China.

As became known in December 2017, the fourth line of Yamal LNG plant (0.9 mtpa) will be fully based on the Russian liquefaction technology, Arctic Cascade, which enables to benefit from the region's cold climate. In March 2018, Novatek patented this technology [10], [11]. This 'pilot' will be tested as part of the fourth line of Yamal LNG plant and will become available for Novatek new Arctic projects in the future. There are two areas of possible efforts: firstly, an attempt at increasing the single line capacity by shifting to full-fledged large-scale liquefaction, and secondly, creation of a large-scale LNG plant based on a series of medium-tonnage lines.

At the same time, in November 2017, Gazprom placed an order with Cryogenmash to design the Russian gas liquefaction technology with approx. 0.87 mtpa single unit capacity.

Medium-tonnage LNG production at Cryogas Vysotsk relies on Air Liquide technology (mixed refrigerants), and the company has partially supplied cryogenic equipment. Russian enterprises have also made their contribution: some equipment has been provided by Izhora Plants, and REP Holding manufactured Russia's first LNG plant compressor for mixed refrigerants [12].

The Gorskaya LNG project history is illustrative, too: its representatives said at the outset they would mostly use Russian equipment. However, when working on the project, they found out no suitable equipment available on the Russian market. As a result, the main process equipment is said to have been ordered from General Electric [13].

It is worth noting one more problem: besides the liquefaction technology itself and its key component, a cryogenic heat exchanger, an array of auxiliary equipment is necessary, such as gas turbines, compressors, pumps etc. Russia has to import this equipment to a significant extent.

Here is one more aspect: equipment import substitution should not be accompanied with its cost escalation.

Costs of Yamal LNG came to $27 bln ($1,740/ ton under the integrated project, i.e. including mining costs); Arctic LNG 2 capital costs are expected to be lower by a third (per capacity unit). Savings are expected, in particular, from building up a floating LNG plant platform, meaning that the capital equipment may be installed remotely (Kola wharf in Murmansk). In both cases, it is still about the use of foreign technologies and, at least, some auxiliary equipment. However, domestic equipment may well be used for subsequent projects, Arctic LNG and Arctic LNG-3, based on the company's patented technology.

What about medium-tonnage production?

Cryogas Vysotsk LNG plant proves to be rather expensive: according to mass media, two lines of 330,000 tons and the accompanying infrastructure (including the bypass gas pipeline construction) will cost RUB 54 billion. That is to say, costs per capacity ton ($1 = RUB 59) will amount to $1,380, which is rather high. Anyway, as long as there is no large-scale liquefaction in Russia, Vysotsk-based medium-tonnage plant leverages the foreign technology and key equipment.

The first estimates of the Russian medium-tonnage LNG production technology costs are available from the forecast for the Yamal LNG fourth line estimated at $450/ $500 per ton of capacity. However, the plan is to make the most of all auxiliary infrastructure of the Yamal LNG plant, i.e. this cost refers to the liquefaction line only.

New Marketing Approaches

Following the analysis of global LNG market transformation, three key marketing developments can be distinguished on the LNG market. Исходя из анализа трансформаций мирового рынка СПГ можно Russia in general, and Russian companies in particular, are expected to be involved in each of these developments:

- creation of own active LNG trading

- 'demand creation' and development of 'special relations' with consumers

- development of an LNG hub and, ideally, an independent LNG price indicator.

Trading. Gazprom is the most active among Russian companies in LNG trading. This is not directly related to the Sakhalin II plant though. Gazprom's Marketing & Trading (GM&T) portfolio contains just approx. 1 mtpa LNG from the Sakhalin II plant as the bulk of the plant's LNG is purchased under direct contracts with Japan and South Korea. In 2017, the company (GM&T) sold 4,456 bcm LNG (approx. 3.3 mtpa). The volumes will scale up. Firstly, the company will repurchase the entire LNG volume of the Cameroon FLNG project (1.2 mtpa, launched in March 2018) during 8 years, and as early as in 2018, will repurchase Yamal LNG liquefied gas (2.5 mtpa) to secure Gazprom's obligations to supply to India.

Rosneft launched its LNG trading in spring 2016, having supplied an LNG consignment to Egypt, and in February 2017, a new contract for new supplies was concluded. The company's trading intensity is expected to increase as soon as LNG export begins from Zohr field offshore Egypt where the company holds a 35% stake. Late in May 2018, it became known Rosneft had agreed upon LNG supplies to Ghana for 12 years.

Novatek, represented by its trading business unit Novatek Gas & Power, carried out the first supply of 'third party' LNG in summer 2016 – the cargo was delivered from Trinidad and Tobago to Chile. With Yamal LNG launch, the company acquired certain volumes of own LNG, though most of gas from the production facilities was allocated under long-term contracts.

Creating demand. No doubt, the flexibility of contracts – first of all, in terms of non-inclusion of a particular cargo destination, to a lesser extent, in terms of volume and other conditions – is already a necessary competitive advantage of new LNG supply contracts, and all new LNG exporters will accept this approach to some extent.

Speaking about the most recent market trends related to LNG demand creation, i.e. investments of LNG exporters and sellers into re-gasification terminals and power plants in consumer countries, it will obviously be facilitated by extensive infrastructure investments. Besides additional debt burden, there are risks that can be, however, mitigated by investing into floating facilities. FSRU floating terminals are not a novelty, and floating power plants may be very promising in the near future.

In any event, such projects may generally be implemented jointly with foreign partners. In December 2017, Novatek signed a memorandum of understanding with Total and Siemens to cooperate in LNG supplies in Viet Nam and in the infrastructure development for newly created power generation capacities for the Viet Nam market. One should bear in mind that Total representatives were proponents of investments into the gas downstream as early as in summer 2017 [14]. And before that, Siemens announced its plans to invest into Bangladesh gas TPP [15].

Gas hub development. Finally, one more trend is LNG hub establishment, which is an especially complicated task for Russia due to limited access to seas. Creation of a Baltic full-fledged LNG hub is unlikely because LNG plant capacities will be relatively small in the long-term for the remoteness of gas fields.

Russian liquefaction capacities are most likely to be scaled up in the Arctic, but transportation difficulties prevent consumers from direct gas offtake from the region of production.

As is known, Novatek has already announced its plans to invest into a transshipment point in the Kamchatka peninsula. Total investments will reach $1.5 billion, and the 20 mtpa facility may be launched by 2023 [16].

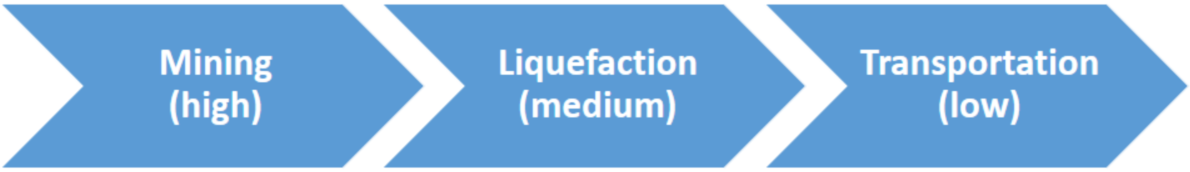
At present, the main transshipment point objective is to cut costs of LNG transportation to Asia (transshipment from ice-class gas carriers to conventional tankers). At the same time, the gas shortage problem will be resolved by transferring the boil off gas to the network. A similar point may be created in Murmansk, which will also help to supply gas throughout the region.

Will Kamchatka become a true LNG hub, and in the future, an alternative to other independent LNG pricing centres? It is too early to conclude; the answer to this question depends on many factors (e.g. warehouse volumes, 'free' LNG availability), but most importantly, on the opportunity to establish all-year-round cargo supplies via the Northern Sea Route. In any event, while the rest of world LNG hubs do not develop actively, Russia has a window of opportunities.

RECOMMENDATIONS

Russian LNG market players face a difficult task: entering the market at the time of strengthening competition, to improve supplies competitiveness. For this purpose, efforts should be taken along the entire supply chain (Fig. 11).

Fig. 11. Ways to improve competitiveness: cutting costs and lifting barriers



ACCESS TO CHEAP FINANCING

Mining:
- Access to licenses
- Lowering the tax burden (MRET, property tax, equipment import duties)
- PPP for creating basic infrastructure

Liquefaction:
- Own technology development (will entail cost cutting if there is economy of scale, so the volume growth in the sector is necessary)
- Lowering the tax burden (property tax, equipment import duties)

Transportation:
- Route improvement, swap transactions, own LNG trading and portfolio creation
- New logistic solutions: creation of terminals for transshipments from ice-class tankers (North West Europe, Kamchatka)
- Development of the nuclear fleet of ice breakers and the Northern Sea Route infrastructure (however, it necessitates the economy of scale and the flow of cargo)
- Own ship-building development

Source: Energy Centre, Moscow School of Management SKOLKOVO

Perhaps, the key efforts should focus on liquefaction and transportation stages. Theoretically, domestic developments can be cheaper than foreign equivalents, but the economy of scale is the main prerequisite. Obviously, it will not be cost-effective to elaborate a new technology for 2-3 new lines and, therefore, mass construction of new liquefaction lines (or expansion to export markets with the equipment, which is possible as soon as several reference production facilities are established in Russia) is needed. To this end, the planned large-scale growth in Russia's share on global LNG markets becomes not only an ambitious goal but also the required key to success.

Moreover, the 'effect of scale' is necessary in related sectors. Growth in the Arctic LNG production will enable the cost-effective Northern Sea Route utilization, which will attract other Asia-to-Europe cargo flows to this route. In the future, large transportation volumes will help to reduce the cost of passage via the Northern Sea Route using ice-breakers (in case of caravan passage) and, thus, to solve the problem of NSR use in winter.

Meanwhile, the thesis that the effect of scale is extremely important for the Russian LNG industry contradicts the competition in the Russian 'Big Gas 3' (Gazprom, Novatek, Rosneft). As early as in May 2016, the Energy Ministry suggested that the single engineering centre be created in Russia to develop domestic natural gas liquefaction technologies. However, Russian gas majors were unable to agree upon creation of such centre, because each player had its own strategic goals and corporate interests. Nonetheless, cooperation between the companies would be preferable, e.g. in case of swap (exchange) transactions from the three Russian companies' portfolio. At present, swap transactions are still insufficiently common worldwide: preferring their own geographically balanced portfolio, the competing companies are reluctant to carry out such transactions. Finally, even if the companies develop liquefaction technologies independently, coordination is possible in manufacturing auxiliary equipment (turbines, compressors etc.).

Understandably, the range of equipment for an LNG plant is very broad. Even having embarked on import substitution, it is necessary to focus on development of some equipment, realizing that all and at once cannot be substituted. It is also important in the context of the state support to the industry: it would be wrong to spread the state support 'evenly' in all directions – rather, it would be better to concentrate on the key industry sectors. In this case, when business and the state cooperate, one can create a competitive product that may be supplied to external markets in the future.

In any event, it is not an easy objective. According to all forecasts, the global LNG market will boom in the next few decades. Yet, the duration of processes launched in Russia in the field of own LNG industry formation is also counted by decades.

On the contrary, in the most long-term forecasts, the uncertainties increase. If the 'gas era' in general, and the LNG era in particular, lasts for additional, say, 30 to 40 years, then Russia's emerging LNG industry will have every chance to end up with the ultimate 'surplus' even in this scenario. And if it concerns the full-fledged gas era or at least gas century, then opportunities lost for having given up the industry's dynamic development will be extremely sizable in our country.

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The partners of the SKOLKOVO Energy Centre are leading Russian and international oil & gas, coal and heat & power companies. Center as well works with global energy expertise centers such as: International Energy Agency, Oxford Institute for Energy Studies (OIES), King's Abdulla Petroleum Research Center (KAPSARC), Center for Global Energy Policy (University of Columbia), Energy Academy Europe (EAE), University of Singapore, Institute of Energy Economics of Japan (IEEJ) and others.

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