Analysis of world LNG production capacity

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Abstract. The article considers issues of global LNG production capacities. A brief description of the dynamics of global LNG trade is given and changing the structure of global energy consumption is considered. The analysis of the global dynamics of LNG production capacities is presented, as well as the regional structure of LNG capacities. Production capacities in the Asia-Pacific region, the Middle East, countries of Africa, America, as well as Russia and Norway are researched and analyzed in details. The paper also discusses the depreciation of LNG capacities, depletion of the resource base of LNG projects, development of floating LNG projects, geopolitical risks for LNG projects, the impact of environmental regulation, and changes in the capital costs structure of LNG projects.

1. Introduction

Currently, the global liquefied natural gas (LNG) market is one of the fastest growing. Global LNG trade has been growing for the sixth consecutive year, reaching 316.5 million tons in 2018. The average market growth over the past five years is about 5.7% per year.

The increasing role of LNG in the global energy market is primarily due to its transport flexibility compared to pipeline gas as well as there is no need for significant capital expenditures with a tight geographical attachment to the buyer location [1].

Secondly, one of the current trends is a substitution of coal and nuclear energy consumption with natural gas and correspondingly LNG due to implementation of strict ecological regulations [2]. We should also mention that LNG is more pure than pipeline gas due to its purification from impurities in the process of liquefaction [3]. In general, in recent years, the global LNG market has been characterized by the growth of all key parameters: an increase in LNG production capacity, an increase of the LNG carriers fleet, an increase in the capacity of LNG receiving terminals as well as promotion of natural gas liquefaction technologies [4]. The focus of this research is an analysis of global LNG production capacity.

The purpose of this research is to make a scope of global LNG facilities, to find out regional structure of LNG production and to summarize key influencing and risk factors of LNG production.

2. Data and methods

The research was based on statistic data and analytical reports from the International Gas Union, the International LNG Importers Group, the International Energy Agency, the Asia-Pacific Center for Energy Research, the Oxford Institute for Energy Research, materials from energy companies Shell, BP, Novatek, Gazprom, and information from corporate sites of LNG projects operators.
3. Results

3.1. Dynamics and regional structure of global LNG production capacities

Over last 20 years global LNG production capacities have grown more than eight times — from 52.3 MTPA (million tons per annum) in 1990 to 419 MTPA by the end of 2019. The oldest LNG plant was built in 1970 is Kenai LNG in Alaska, USA. Until 1997, only eight countries in the world produced LNG; they were Algeria, Australia, Brunei, Indonesia, Libya, Malaysia, United Arab Emirates and the United States. In 1997, they were joined by the future world LNG production leader — Qatar. By 2000, LNG production capacity were doubled compared to 1990 up to 109.3 MTPA. Further, such countries as Trinidad, Nigeria, Oman began to join to the club of LNG producers, Egypt in 2005 began to produce LNG, Norway in 2008, Russia in 2009. Global LNG production capacity in 2010 was 264.3 MTPA. At the end of 2019, LNG facilities are being allocated in 21 countries; the global capacity, as already mentioned is 419 MTPA [5]. The dynamics of the global production capacity of liquefied natural gas is presented in Figure 1.

In 2019, due to the launch of new LNG projects, Australia became the world leader in LNG production, having reached the level of 87.6 MTPA, and replacing Qatar, which still has only 77 MTPA capacities. Also nowadays liquefaction facilities are concentrated in the USA — 33.75 MTPA, in Malaysia — 30.5 MTPA, Russia — 28.9, Indonesia — 26.5, Algeria — 25.3, Nigeria — 21.9. In others countries the production level is less than 20 MTPA.

In terms of geographical structure, the Asia-Pacific region is the leader in LNG production with 38% of global production or 157.5 MTPA, then goes the Middle East, where 24% or 100.8 MTPA are concentrated, after Africa with 17% and 73.9 MTPA, America - 13% or 53.7 MTPA, and Europe and Russia close regional producers with 8% or 33.1 MTPA [6]. Graphically the data on shares of regions in the global production capacity of LNG in 2019 is presented in Figure 2.

3.2. LNG production in the Asia-Pacific region

3.2.1. LNG production facilities in Australia. Having commissioned two large gas liquefaction projects Wheatstone and Ichthys in 2018-2019, each project consists of two trains with a total capacity of 8.9 MTPA, as well as launching Prelude FLNG, Australia became the leader in the global LNG production with a production capacity of 87.6 MTPA [7].
Australian LNG projects can be divided into two groups. The first group is the projects North West Shelf, Darwin, Pluto, Gorgon, Wheatstone, Prelude FLNG, Ichthys the resource base for these projects is an offshore gas. The second group of LNG projects is located in the East of the country. Among them are Australia Pacific, Queensland Curtis and Gladstone for which coal bed methane is the resource base. These three projects are characterized by work in conditions of shortage of gas, as the actual production of coalbed methane wells turned out to be lower than the estimated one. Australian LNG production facilities are presented in Table 1.

### Table 1. LNG projects in Australia

| LNG project name                        | Start Year | Nameplate Capacity (MTPA) | Owners                                                                 |
|-----------------------------------------|------------|---------------------------|------------------------------------------------------------------------|
| Withnell Bay (North West Shelf), Trains 1-5 | 1989-2008  | 16.7                      | BHP Billiton, BP, Chevron, Shell, Woodside, Mitsubishi, Mitsui         |
| Darwin, Train 1                          | 2006       | 3.7                       | ConocoPhillips, Santos, INPEX, Eni, JERA, Tokyo Gas                    |
| Pluto, Train 1                           | 2012       | 4.9                       | Woodside, Kansai Electric, Tokyo Gas                                   |
| Queensland Curtis, Trains 1-2            | 2015       | 8.5                       | Shell, CNOOC, Tokyo Gas                                               |
| GLNG (Gladstone), Trains 1-2             | 2016       | 7.8                       | Santos, PETRONAS, TOTAL, KOGAS                                        |
| Australia Pacific                        | 2016-2017  | 9                         | ConocoPhillips, Origin Energy, Sinopec                                |
| Gorgon, Trains 1-3                       | 2016-2017  | 15.6                      | Chevron, ExxonMobil, Shell, Osaka Gas, Tokyo Gas, JERA                 |
| Wheatstone, Trains 1-2                   | 2018       | 8.9                       | Chevron, KUFPEC, Woodside, JOGMEC, Mitsubishi, Kyushu Electric, NYK, JERA |
| Ichthys, Trains 1-2                      | 2018-2019  | 8.9                       | INPEX, TOTAL, CPC, Tokyo Gas, Kansai Electric, Osaka Gas, JERA, Toho Gas |
| Prelude FLNG                             | 2019       | 3.6                       | Shell, INPEX, KOGAS, CPC                                               |

There is a significant risk that real LNG output and exports in eastern Australia may be below the nameplate capacity of the plants. This situation is especially likely if prices on the global market drop significantly.

3.2.2. **LNG production facilities in Malaysia.** Malaysia has the second largest production capacity in the Asia-Pacific region and the fourth in the world with 30.5 MTPA. Malaysia's LNG production is characterized by a low resource base with proven gas reserves of only 2.4 trillion cubic meters.

One of the largest LNG facilities of Petronas LNG Complex is located in the state of Sarawak and consists of nine trains with a total capacity of 29.3 MTPA. Also in 2019, the second in the world (after the Australian Prelude FLNG) LNG floating unit for liquefied natural gas called PFLNG SATU or PFLNG with one train and production capacity of 1.2 MTPA was commissioned. This floating plant was built at the Daewoo shipyard in Okpo, South Korea. In 2016, the PFLNG SATU was towed to its place 180 km off the coast of Bintulu, and in 2019 it was transferred to the Kebabangan field on the Sabah shelf, Malaysia.

3.2.3. **LNG production facilities in Indonesia.** Production at one of the first LNG projects in the world, the Arun LNG Plant with a total capacity of 12.5 MTPA, the production lines of which were
built from 1978 to 1986, was finished by the end of 2014. In 2015, part of the plant's capacity was converted to regasification terminal. There are currently only three operating LNG projects in Malaysia.

The largest project, Bontang LNG, out of the eight initial production lines with a total capacity of 22.5 MTPA operate only six with a total capacity of 16.9 MTPA. At the same time, the actual LNG production has declined significantly in recent years. The maximum amount of LNG was produced in 2001 — 21.3 MTPA, while in 2010 — 16.5, in 2015 — 10, and 2019 only — 6.2 MTPA. We can see a strong decrease in production of LNG.

Tangguh LNG Plant began operations in 2009, and consists of two production lines with a total capacity of 7.6 MTPA. The resource for this project is gas from the Wiriaagar, Berau and Muturi fields located in Bintuni Bay, Indonesia's West Papua.

The Donggi Senoro LNG (DSLNG) plant is located in the Province of Central Sulawesi, began its operations in 2015 and has a small capacity of only 2 MTPA.

In general, we can summarize that due to the deterioration of the resource base and a decrease in domestic electricity consumption, Indonesian LNG projects capacity utilization has been declining in recent years.

3.2.4. Other LNG production facilities in Asia-Pacific region. In addition to the above mentioned plants in the Asia-Pacific region there are also LNG plants in Brunei and Papua New Guinea.

The LNG plant in Brunei, the first in the Western Pacific, was completed in 1972. The project was a joint venture between the government of Sultan Brunei, Shell Overseas Holdings Limited and Mitsubishi Corporation. The project was successful, and it pioneered large-scale liquefaction and transportation of natural gas, helping to make LNG a global source of energy. Brunei LNG consists of five production lines with a total capacity of 7.2 MTPA.

The Papua New Guinea PNG LNG plant, worth of 19 billion USD, and managed by ExxonMobil, began producing LNG in 2014. The plant consists of two production lines with a total capacity of 6.9 MTPA [9].

3.3. LNG production in Middle East region
The Middle East holds a leading position in natural gas reserves — 38.4% of the world, in 2018 is was 75.5 trillion cubic meters, and the second place after the Asia-Pacific region for LNG supplies to the world market with a share of 29.2% of world exports that was about 125.8 million tons in 2018. The leading Middle Eastern regional and second global LNG producer is Qatar that exported about 77 million tons of LNG in 2018, that is 24.3% of world exports.

3.3.1. LNG production facilities in Qatar.
Qatar has significant proven gas reserves of 24.7 trillion cubic meters [10]. This is the third place in the world after Russia and Iran. Qatar's LNG production is located at Ras Laffan Industrial City.

Qatargas company, founded in 1984 as a joint venture between Qatar Petroleum, Exxon Mobil and other companies, is the world leader in LNG production. The headquarters of the company is located in Doha, the capital of Qatar. Qatargas, after merging with Rasgas in 2018, operates 14 LNG production lines with a total capacity of 77 MTPA. In addition to LNG, Qatargas also exports natural gas, gas condensate, helium and related products [11-12]. Company’s production facilities are presented in table 2.

| LNG project name | Start Year | Nameplate Capacity (MTPA) | Owners |
|------------------|------------|----------------------------|--------|
| Qatargas I, Trains | 1997- | 9,5 | Qatar Petroleum, ExxonMobil, TOTAL, Marubeni, |
3.3.2. Other Middle East LNG projects

LNG production in Oman started in 2000. Nowadays, after the merge in 2013 of Oman LNG with Qalhat LNG, company operates three trains with a total capacity of 10.7 MTPA.

In the United Arab Emirates, the Abu Dhabi Gas Liquefaction Company Ltd, currently known as the Abu Dhabi National Oil Company, is one of the world's oldest LNG producers. The first ADGAS project consisting of two LNG trains was launched in 1977. The third production line was put into operation only in 1994. The total LNG capacity in the UAE is 5.8 MTPA.

The LNG production in Yemen, which began in 2009-2010 with a total capacity of 7.2 MTPA, was suspended in 2015 due to the ongoing civil war.

3.4. LNG production in Africa

The African continent has a total proven gas reserves of 14.4 trillion cubic meters that is about 7.3% of global reserves. The main LNG producers in Africa are Algeria, Nigeria and Egypt. Altogether, Africa has LNG production facilities with a total capacity of 73.9 MTPA [13].

3.4.1. LNG production facilities in Algeria, Nigeria and Egypt. Algerian Sonatrach company is operating four major projects. First of all, these are two fairly old factories Arzew-GL1Z and Arzew-GL2Z, launched in 1978 and 1981. Each plant consists of six trains, the total capacity of the two plants is 16.1 MTPA. In 2013 was partially restored after the explosion in 2004 Skikda-GL1K factory with one 4.5 MTPA train. And in 2014, the third plant of the Arzew-GL3Z plant was launched with one production line of 4.7 MTPA.

In Nigeria, starting 2000 and 2008, six trains were commissioned with a total capacity of 21.9 MTPA at the NLNG plant, located on Bonny Island in Rivers State. The trains are managed by Nigeria LNG, which is owned by Nigerian National Petroleum Corporation — 49%, Shell — 25.6%, Total — 15%, ENI — 10.4%.

In Egypt, in 2005, two LNG projects were launched. The SEGAS LNG plant, located in the port city of Damietta, with a capacity of 5 MTPA worked for about eight years and in 2013 was suspended due to a shortage of reserve base, natural gas purposed for LNG project was sent for domestic consumption in the city of Cairo. Currently, in Egypt only two trains of the Idku project operate, with a total capacity of 7.2 MTPA [14].

3.4.2. LNG production facilities in other African countries. In Libya, the Marsa El Brega LNG project with a capacity of 3.2 MTPA, was the second LNG project in the world. Now it has almost stopped work due to obsolescence of equipment, depletion of the resource base and the ongoing civil war. In 2007 the EG LNG project was launched, located in Malabao, the capital of Equatorial Guinea. The capacity of one EG production line is 3.7 MTPA. Since 2014 Angola LNG project has been operating in Angola, consisting of a single train with a capacity of 5.2 MTPA. The project is owned by Qatar Petroleum, ExxomMobil, KOGAS, Itochu LNG.

| 1-3          | 1998         | Mitsui                  |
|--------------|--------------|-------------------------|
| RasGas I, Trains 1-2 | 1999-2000 | 6,6 | Qatar Petroleum, ExxomMobil, KOGAS, Itochu LNG |
| RasGas II, Trains 1-3 | 2004-2007 | 14,1 | Qatar Petroleum, ExxomMobil |
| Qatargas II, Trains 1-2 | 2009-2010 | 15,6 | Qatar Petroleum, ExxomMobil |
| RasGas III, Trains 1-2 | 2009-2010 | 15,6 | Qatar Petroleum, ExxomMobil |
| Qatargas III, Trains 1 | 2010   | 7,8 | Qatar Petroleum, ConocoPhillips, Mitsui |
| Qatargas IV Trains 1 | 2011 | 7,8 | Qatar Petroleum, Shell |
companies, Chevron 36.4%, Sonangol 22.8%, BP 13.6%, ENI 13.6%, Total 13.6%. And since 2018, Kribi FLNG floating platform with a capacity of 2.4 MTPA has been operating in Cameroon.

3.5. LNG production facilities in American countries

The technological revolution made it possible the cost-effective production of shale gas actually ensured the creation of a new industry in the United States — LNG export projects. Despite the fact that one of the first Kenai LNG plant with a capacity of 1.5 MTPA was built in the USA in 1970, for a long time it remained the only project in the United States, and in 2015 this plant was converted into a regasification terminal. However, shale gas production has transformed the United States from a gas importer to an exporter. Since 2016, several large LNG projects have been commissioned in the United States. Firstly, these are five trains of the Sabine Pass LNG project with 4.5 MTPA each. In total, the Cheniere operator plans to commission six trains of the same capacity. Cheniere also manages the Corpus Christi LNG project, in total it is planned to operate three production lines with a capacity of 4.5 MTPA, so far two only two with a total capacity of 9 MTPA have been commissioned yet [15].

There are also two other major LNG projects in the United States. Cove Point LNG operated by Dominion with one 5.25 MTPA train and Cameron LNG with one (of the three planned) 4 MTPA train managed by a consortium of companies led by Sempra. Summarizing — four projects with a total capacity of 36.75 MTPA were operating in the USA at the end of 2019.

Except US there are three other LNG projects in America. Trinidad and Tobago has a large Atlantic LNG manufacturing facility run by Shell and BP, which consists of four trains total of 15.5 MTPA. In addition, since 2010, Peru has been producing LNG at Peru LNG, with production capacity of 4.45 MTPA. We should also mention the Tango FLNG project launched in October 2019 in Argentina.

3.6. LNG production facilities in Russia and Europe

3.6.1. LNG production facilities in Russia. Russia has the world's largest proven reserves of natural gas in the world - 38.9 trillion cubic meters. However, in Russia now there are only two large-capacity LNG projects.

The first, Sakhalin-2 LNG, consisting of two trains with a total capacity of 10.8 MTPA, uses natural gas from the Lunskoye field of Sakhalin Island as a recourse base. The project operator is Sakhalin Energy, which is co-owned by Gazprom (50% plus one share), Shell (27.5% minus one share), Mitsui (12.5%) and Mitsubishi (10%).

Second project, Yamal LNG is a key project of NOVATEK for the production of liquefied natural gas, has four LNG trains with nameplate capacity of 17.4 MTPA. The resource base for Yamal LNG project is the South Tambeyskoye field of the Yamal Peninsula with reserves of 927 billion cubic meters. The project operator and owner of all assets is JSC Yamal LNG. Together with NOVATEK with a 50.1% ownership interest, the Yamal LNG project shareholders are French oil and gas company Total — 20%, China National Petroleum Corporation CNPC — 20%, and the Chinese Investment Silk Road Fund — 9.9% [16].

Also NOVATEK has a 51% participation interest in Cryogas-Vysotsk, medium-scale LNG project that located in the port of Vysotsk, the Leningrad Region (Baltic Sea). The project capacity is 0.66 MTPA and its infrastructure also includes a 42 000 cubic meters LNG storage tank and an offloading terminal designed to handle LNG carriers with a capacity of up to 30,000 cubic meters [17].

One of the Novatek project hat is currently under construction is Arctic LNG 2 that includes the construction of a gas liquefaction plant with resource base of the Utrennie field on the Gydan Peninsula in the Yamal-Nenets Autonomous District [18-20]. The total capacity of the plant, which consists of three production lines, is 19.8 MTPA. Shareholders of the project made a final investment decision for the project in September 2019.
3.6.2. LNG production facilities in Norwegia. The only European LNG export project is Snohvit LNG, located on Melkoya Island, Hammerfest, Norway. The production facilities of Snohvit LNG consist of a single train with a capacity of 4.3 MTPA.

The Snohvit LNG project was built to exploit the resources of three gas fields in the Barents Sea: Snohvit, Albatross and Askeladd, that lie about 140km northwest of Hammerfest in Norway.

The project was led by Statoil as part of a consortium of six companies. The consortium consists of Statoil (33.53%), Petoro (30%), TotalFinalElf (18.4%), Gaz de France (12%), Amerada Hess (3.26%) and RWE-DEA (2.81%).

4. Discussion

Based on the results of the study we can summarize the following.

1. One of the factors characterizing the global LNG production capacity is the amortization of LNG trains. By the end of 2020, more than 25% of global production capacity will be over 20 years old. This, in turn, affects LNG production volumes, an increase in maintenance costs, and an increase in the risk of accidents. First of all, this problem is relevant for Brunei, United Arab Emirates, Australia, Indonesia, Malaysia, Qatar.

2. A number of regions are characterized by depletion of the LNG resource base. First of all, this is typical for projects in Malaysia, North Africa and eastern projects in Australia for which coal bed methane is the resource base.

3. The answer to the depletion of the resource base of gas fields is the creation of floating platforms for LNG production. Four such platforms are already operational: Kribi FLNG in Cameroon, Prelude FLNG in Australia, PFLNG SATU in Malaysia and Tango FLNG in Argentina. Also in the coming years, it is planned to commission additional FLNG projects in Malaysia, Mozambique, Mauritania. FLNG projects typically have less capacity than onshore LNG, can liquefy gas from offshore fields. Barge-based FLNG projects are mainly installed in the coastal zone and supply gas from the coast.

4. LNG projects are subject to geopolitical risks. Since 2015, due to the civil war, LNG facilities has not been operating in Yemen. Partially Nigeria LNG was forced to close due to security reasons in 2017. Also the United States imposed sanctions against LNG projects in Russia and Iran.

5. LNG exports and related production are substantially dependent on the volatility of the oil market, with which LNG market correlates substantially. A drop in energy consumption and, as a consequence, a decrease in energy prices can lead to a significant decrease in the profitability of existing LNG projects, suspension of construction projects and cancellation of FID plans for a number of LNG projects. This is especially true for future projects in the USA, Canada and Indonesia. We also should mention the increase in the share of the spot market in the overall LNG trade.

6. A positive factor for the development of LNG projects is the tightening of environmental regulation in importing countries. More and more countries are abandoning the use of coal in favor of natural gas, including liquefied. However, LNG producers complying with environmental standards in their own countries could spend a lot of time and money. This is especially an issue for projects in the USA and Canada.

7. It is possible to predict an increase in the share of medium-tonnage LNG production due to extremely high capital costs of large-scale projects, as well as high risks of its implementation. In the period from 2019 to 2024, the average capacity of one commissioned train is projected to decrease from 4.3 MTPA to 2.8 MTPA.

8. In general, in the next decade Asia-Pacific region it will remain a global leader both in the production and export of LNG from Australia, Malaysia, Indonesia, and in LNG demand — import to Japan and China.

5. Conclusion

This paper has presented a current outlook of global LNG production facilities. Dynamics and regional structure of global LNG production capacities were analysis. We should keep in mind that the real world LNG output is usually less than the capacity of existing trains, due to several reasons.
First, from time to time, LNG plants stop for scheduled maintenance, that reduces the annual production capacity by an average of 5-10%. In addition, there are unplanned, emergency shutdowns, force majeure circumstances as, for example, now in Yemen due to the civil war, where LNG production is suspended or due to the explosion accident, as it was in case of Algerin Sonatrach project.

Also it can be country gas internal shortage, as a result of which the capacity of an LNG project is under loaded (as, for example, in Egypt) In addition, if we analyze the capacity at the end of the year, we need to understand that most of the new capacities of the current year were launched during the reporting period, and therefore the volume of production at them will be lower than the average annual. On the other hand, there are cases when plants operate with output higher than was initially engineered.

Anyway, the real LNG production will be always subject to changes in LNG demand, oil price, level of unit capital expenditures, environmental regulations and geopolitics risks that are the key influencing factors.

References
[1] Makarichev Y A, Anufriev A S, Zubkov Y V and Didenko N I 2019 Energy efficiency of the wind power generator IEEE Conference of Russian Young Researchers in Electrical and Electronic Engineering, ElConRus 2019 8657095 1011-1015
[2] Didenko N I, Skripnuk D F and Mirolyubova O V 2017 Urbanization and Greenhouse Gas Emissions from Industry IOP Conference Series: Earth and Environmental Science 72(1) 012014
[3] Dyatlov S A, Didenko N I, Ivanova E A, Soshneva E B and Kulik S V 2020 Prospects for Alternative Energy Sources in Global Energy Sector IOP Conference Series: Earth and Environmental Science 434(1) 012014
[4] Kikkas K N, Kulik S V, Krepkaia T N and Mokhorov D A 2019 Analysis of the economic relations of the circumpolar countries IOP Conference Series: Earth and Environmental Science 302(1) 012093
[5] Skripnuk D F, Kikkas K N, Safonova A S and Volodarskaya E B 2019 Comparison of international transport corridors in the Arctic based on the autoregressive distributed lag model IOP Conference Series: Earth and Environmental Science 302(1) 012096
[6] Didenko N I and Romashkina E S 2018 Assessment of the Influence of the Extraction of Energy Resources on the Environment IOP Conference Series: Earth and Environmental Science 180 (1) 012014
[7] Didenko N I and Cherenkov V I 2018 Economic and geopolitical aspects of developing the Northern Sea Route IOP Conference Series: Earth and Environmental Science 180 (1) 012012
[8] Dyatlov S A, Didenko N I, Lobanov O S and Kulik S V 2019 Digital transformation and convergence effect as factors of achieving sustainable development IOP Conference Series: Earth and Environmental Science 302(1) 012102
[9] Kikkas K N, Cherenkov V I, Berezovskaya I P and Anosova N E 2019 The application of the ARCH model for the assessment of transport routes in Northern Europe and Southeast Asia IOP Conference Series: Earth and Environmental Science 302(1) 012100
[10] Efremova I, Didenko N, Rudenko D and Skripnuk D 2017 Disparities in rural development of the Russian arctic zone regions Research for Rural Development 2 p 189-194
[11] Kikkas K and Romashkina E 2018 Potential Opportunities for the Arctic Transport Space IOP Conference Series: Earth and Environmental Science 180(1) 012016
[12] Kireev K V, Ermakov V V and Kikkas K 2017 Mathematical modeling of Arc extinction process in devices with liquid-metal contact International Conference on Reliability, Infocom Technologies and Optimization: Trends and Future Directions: ICRITO 273-277
[13] Gudkov A V, Dadonov D N and Krasulina O Y 2018 Research features of voltage static load
characteristics in the electric system of Russia International Conference on Reliability, Infocom Technologies and Optimization: Trends and Future Directions: ICRITO 295-300

[14] Gudkov A V, Dadonov D N, Krotkov E A, Didenko N I and Parkhomenko V 2018 Thermal wear of cable lines isolation research owing to current flow of the high harmonics at oil extraction electrical generating systems International Conference on Reliability, Infocom Technologies and Optimization: Trends and Future Directions: ICRITO 182-187

[15] Atroshenko S A, Korolyov I A and Didenko N 2016 Evaluation of physico-mechanical properties of high-chromium tool steels modified with Harrington method Materials Physics and Mechanics 26(1) 26-29

[16] International Gas Union 2019 World LNG Report Available from: https://www.igu.org/publication/302341/31 [Accessed 20 January 2020]

[17] BP Statistical Review of World Energy Available from: https://www.bp.com/ [Accessed 20 January 2020]

[18] International Group of Liquefied Natural Gas Importers 2019 GIIGNL Annual report

[19] Smith K 2018 The future of LNG Exports: How the Federal Government can promote U.S. LNG exports Southern California Interdisciplinary Law Jl. Winter2018 27 (2) 405-428

[20] Ritz R A 2019 A Strategic Perspective on Competition between Pipeline Gas and LNG Energy J. Sep2019 40(5) 95-220