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The "keep in the ground future" of Arctic fossil fuel resources

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Abstract. It is extremely important to understand which role Arctic fossil fuel resources will play in the development and geopolitics of the Arctic region. The article analyses the recent trends in the world energy supply with special focus on renewable energy and future demand for fossil fuels. Focusing on the Arctic LNG projects it comes to the conclusion that there is a growing possibility that the majority of Arctic oil and natural gas will be kept in the ground. Such an outcome would strongly influence the sustainable development and geopolitics of the region.

Keywords: *Arctic fossil fuels, renewable energy, carbon budget, oil and gas demand, transport electrification, Yamal LNG, International cooperation*

The increased international and media focus on the Arctic region has been until recently highly influenced by its estimated reserves of natural resources, especially oil and gas. The vast majority of actual publications cite the famous 2008 US geological survey [1]. It has increasingly become one of the strongest arguments in favour of the resource exploitation Arctic paradigm due to its high estimates of undiscovered Arctic fossil fuel reserves. There are, however, a series of reasons to believe, as some authors have already extensively discussed this issue [2, pp. 169-193; 3, pp. 103-133; 4, pp. 45-55], that the offshore Arctic oil and gas will not play a crucial role in the economy and geopolitics of the Arctic and in the world energy supply. This, undoubtedly, would lower the economical and geopolitical importance of the region. Some northern areas have been and could be strongly impacted by the developments in the oil and gas sector, but on the wider regional scale, the Arctic oil and gas intensive exploitation has not materialized yet. This is especially true for the offshore sector which could also have the strongest impact on the region's ecosystem and regional relations due to the harsh environmental conditions and possible border issues which will not be addressed here.

The major transformations in the energy market

This article will analyze some recent developments especially in the gas sector and propose some additional reasons which would suggest that the Arctic is far from being a place of an energy resources race among the Arctic and adjacent countries. The oil and gas markets have become incredibly flexible with many analysts speaking about a new oil order referring to the fast cycle of

shale oil[1]. Similarly, the increasing liquefied natural gas technology adoption has disrupted the long-term pipeline planning system and the bargaining power especially on the side of the suppliers. The remoteness of the North pole region, the difficulties in building infrastructure there and the two more recent step downturns in energy prices, with the last still ongoing in May of 2016, are strong arguments against widespread Arctic resource extraction. The pick oil arguments, which dominated the debate for many years, have been sided by a fierce price competition and rising non conventional supply which does not allow a dynamic of ever increasing oil prices to dominate the energy market. In addition, the advanced economies have undergone a significant reduction in the energy intensity with China increasingly catching up. The energy intensity of the global economy dropped by 2.3% in 2014, more than double the average rate of fall over the last decade [2]. This will also limit future oil and gas demand. Furthermore the energy intensity and energy efficiency improvements are being followed by a booming and rapidly evolving renewable energy sector which is already playing, and will have, a crucial role in the global energy planning and future capacity building. There is also an oncoming revolution in the transportation sector with the electrification of the transport vehicles, the sharing economy and improving energy storage which will gradually start reducing the demand for fossil fuels in the near future.

Renewable energy, innovations and climate change

The world has entered an energy revolution which will completely change the way we produce and use energy. Renewable energy brings many benefits since it has been becoming cost effective and competitive already reaching grid parity with the fossil fuels in many parts of the world. In countries like Germany and the UK, onshore wind is the cheapest electricity to produce[3] and according to the Bloomberg 2015 Energy outlook: “By 2040, the world’s power-generating capacity mix will have transformed: from today’s system composed of two-thirds fossil fuels to one with 60% from zero-emission energy sources. Renewables will command just under 60% of the 9,786GW of new generating capacity and two-thirds of the $12.2 trillion of investment.[4]” Renewable energy is also one of the key elements in the countries’ struggle to limit climate change. The recent COP21 Paris agreement in December 2015 will probably give a further boost to

[1] From the horse’s mouth: The new oil order is radically different from the old one URL: http://www.energypost.eu/horses-mouth-new-oil-world-radically-different-old-one/ (Accessed 5th May 2016). The New Oil Order URL: http://www.bloomberg.com/news/videos/2015-08-25/the-new-oil-order (Accessed 5th May 2016)

[2] IEA Special Report Energy and Climate Change. 2015. P. 11. URL: www.iea.org/publica-tions/freepublica-tions/publication/WEO2015SpecialReportonEnergyandClimateChange.pdf (дата обращения 06.05.2016)

[3] Solar and Wind Just Passed Another Turning Point URL: http://www.bloomberg.com/news/articles/2015-10-06/solar-wind-reach-a-big-renewables-turning-point-bnef (Accessed 6th May 2016)

[4] Bloomberg New Energy Outlook 2015 URL: http://www.bloomberg.com/company/new-energy-outlook/ (Accessed 6th May 2016)

clean and renewable energy in order to limit the greenhouse gases emissions. Not less important is the carbon budget and the required 450-500 ppm CO_2 concentration limit[5] in order to keep the temperature below the two degree target, which implies that a certain amount of discovered fossil fuels reserves will and should be kept in the ground. This is also recognized by major oil companies like the recent French Total decision to invest in renewables and its growth strategies based on the 2 C° scenario[6].

The keep in the ground future

The Arctic offshore oil and gas estimated recoverable resources, for all the above mentioned reasons, do not represent such a value that would force countries into conflict to control and exploit them. The megaprojects which characterize the activity in the Arctic region are indeed becoming less and less attractive[7]

Resources are also expensive to extract and the vast majority of them is also found inside already established national borders or in the special economic zones. Further evidence against a massive oil and gas exploitation, is undoubtedly provided by the recent decision of several major oil companies to abandon the U.S. Arctic and relinquish their drilling rights there[8]. Moreover, the US president Obama, after seven years of strong fight, due to climate and environmental concerns, just put an end to the XL Keystone pipeline extension which would bring the Canadian tar sands oil to the US market[9]. The Arctic is also a frontier environment where the human knowledge and technologies are tested to the limit so some countries and especially Russia, which is also the major Arctic player, do not have the technology and financial resources to individually

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[5] According to the 2014 IPCC report the increase of global mean surface temperature by the end of the 21st century (2081–2100) relative to 1986–2005 is likely to be 0.3°C to 1.7°C under RCP2.6 (430-480ppm of CO2) and 1.1°C to 2.6°C under RCP4.5 (480-530ppm) URL: https://www.ipcc.ch/pdf/assessment-report/ar5/syr/AR5_SYR_FINAL_SPM.pdf pp.9 (Accessed 6th May 2016)

[6] Calcuttawala, Z. Total Jumps On Renewables Bandwagon, Announces Ambitious Goals. URL: http://oilprice.com/Latest-Energy-News/World-News/Total-Jumps-On-Renewables-Bandwagon-Announces-Ambitious-Goals.html (Accessed 25th May 2016)

[7] Oil Producers Curb Megaprojects Ambitions to Focus on U.S. Shale URL: http://www.bloomberg.com/news/articles/2015-10-29/oil-producers-curb-megaproject-ambitions-to-focus-on-u-s-shale (Accessed 6th May 2016). Oil Megaprojects Won't Stay On The Shelf For Long URL: http://oilprice.com/Energy/Energy-General/Oil-Megaprojects-Wont-Stay-On-The-Shelf-For-Long.html (Accessed 6th May).

[8] Dlouhy, J.A. Big Oil Abandons $2.5 Billion in U.S. Arctic Drilling Rights URL: http://www.bloomberg.com/news/articles/2016-05-10/big-oil-abandons-2-5-billion-in-u-s-arctic-drilling-rights (Accessed 10th May 2016)

[9] Eilperin, J. and Mufson, S. Obama rejects Keystone XL project, citing U.S. climate leadership. URL: https://www.washingtonpost.com/news/post-politics/wp/2015/11/06/obama-set-to-reject-keystone-xl-project-citing-climate-concerns/?hpid=hp_hp-top-table-main_keystone-1120am%3Ahomepage%2Fstory URL: (Accessed 6th May 2016). Dorning, M. and Drajem, M. Obama's Keystone Rejection Strengthens His Hand at Climate Talks. URL: http://www.bloomberg.com/politics/articles/2015-11-06/obama-said-to-reject-keystone-project-win-for-environmentalists (Accessed 6th May 2016)

and competitively develop the huge Arctic projects on a large scale[10] [5, pp. 22-39]. The recent international sanctions against Russia were focused also on the Arctic offshore operations banning western companies any participation or technology transfer linked to this sector[11]. There is an increasing possibility that the Arctic region will see a continuation of cooperation on environmental and other issues and that its estimated energy resources will not generate increased geopolitical tensions. The vast majority of the region's oil and gas will be kept in the ground.

The Arctic gas sector

Although oil could still be seen as more attractive in the near term, it is natural gas that dominates the energy reserves of the region. Natural gas has lower CO_2 emissions per unit of energy[12] and is therefore seen by many as the transitional fuel to the future zero emissions economy. The growing LNG market and its transportation flexibility could also sustain natural gas demand in the future. The American Arctic is richer in oil and the onshore Prudhoe bay field, for instance, is still operating almost 40 years after its development and the Trans-Alaska Pipeline System construction in 1977 following the 1973 oil crisis. Analyzing the USGS report, Philip Budzik provides the following conclusion: "Arctic oil and natural gas resources are not evenly distributed among the Eurasian and North American continents. Eurasia is estimated to hold about 63 percent of the total Arctic resource base, while North America holds about 36 percent. The Eurasian resource base is predominantly natural gas and NGL, which account for about 88 percent of the total Eurasian resource base. The North American side of the Arctic is estimated to have about 65 percent of the undiscovered Arctic oil, but only 26 percent of the undiscovered Arctic natural gas". 43 of 61 significant deposits were in Russia. Of 18 deposits outside Russia, 6 were in Alaska, 11 in

[10] Mordushenko O. Burovaja ugroza. URL: http://kommersant.ru/doc/2811635 (Accessed 6th May 2016)

[11] New Directive 4 issued pursuant to E.O. 13662 prohibits the provision, exportation, or reexportation of goods, services (except for financial services), or technology by U.S. persons or from the United States in support of exploration or production for deepwater, Arctic offshore, or shale projects that have the potential to produce oil in the Russian Federation, or in maritime area claimed by the Russian Federation and extending from its territory, and that involve five listed Russian energy companies: Gazprom, Gazprom Neft, Lukoil, Surgutneftegas, and Rosneft. Treasury initially imposed sanctions against Rosneft, Russia's largest petroleum company and third-largest gas producer, pursuant to E.O. 13662 on July 17, 2014. Today's step, which complements Commerce Department restrictions and is similar to new EU measures published today, will impede Russia's ability to develop so-called frontier or unconventional oil resources, areas in which Russian firms are heavily dependent on U.S. and western technology. While these sanctions do not target or interfere with the current supply of energy from Russia or prevent Russian companies from selling oil and gas to any country, they make it difficult for Russia to develop long-term, technically challenging future projects. URL: http://www.treasury.gov/press-center/press-releases/Pages/jl2629.aspx (Accessed 6th May 2016)

[12] 117 Pounds of CO2 emitted per million British thermal units (Btu) of energy compared to 157.2 for gasoline, 161,3 for diesel fuel and about 215 for coal URL: https://www.eia.gov/tools/faqs/faq.cfm?id=73&t=11 (Accessed 6th May 2016)

Canada and 1 in Norway [6]. According to the data of S.E. Donskoy, in 2016 340 oil and gas deposits were found in the Russian Arctic, including 33 in the Arctic shelf [13].

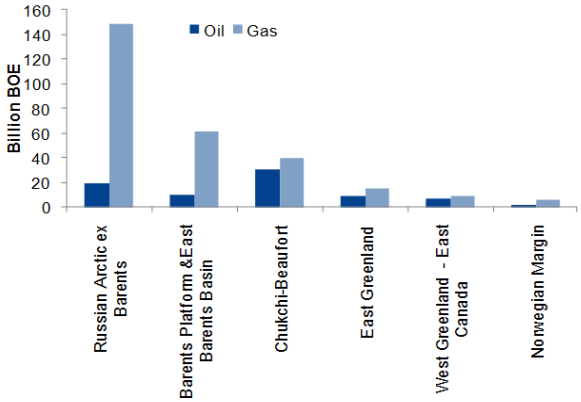

Figure 1. Source USGS from The Prospects and Challenges for Arctic Oil Development [14]

The Russian data from the Ministry of energy (Minenergo) is of 13 bln tones of oil and 87 tln cubic meters of natural gas[15], while other sources put the oil reserves higher as can be seen from the graph below:

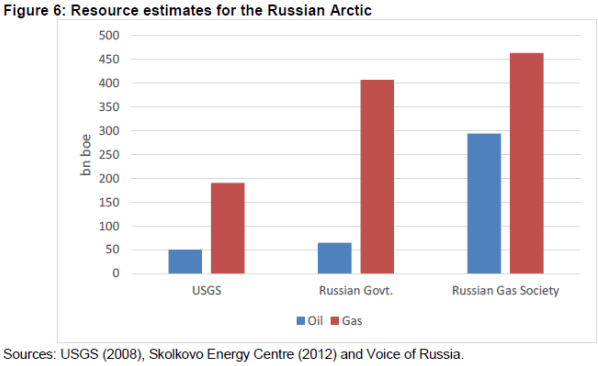

Figure 2. Source USGS from The Prospects and Challenges for Arctic Oil Development

In this context, the Obama administration decision to review plans for Arctic drilling, while refusing to extent also already approved leases[16], is critical for the oil sector, although market factors largely anticipated this move and made Arctic drilling uneconomical under current oil prices. Because of its predominance and economic and geopolitical value, the huge Arctic Eurasian

[13] Soveschanie s chlenami Pravitelstva. 07.09.2016. http://www.kremlin.ru/events/president/transcripts/deliberations/52843 (Accessed 14th October 2016)

[14] Source: USGS 2008, taken from The Prospects and Challenges for Arctic Oil Development, The Oxford Institute for Energy Studies written by James Henderso and Julia Loe, November 2014 p.5.
It should be taken into account that the assessment methods are based on geological presumptions, which implies a large degree of uncertainty.

[15] Rossiya budet dobyvat bolshe poloviny arkticheskoy nefti I gaza. URL: http://izvestia.ru/news/588397 (Accessed 7th May 2016)

[16] URL: http://instituteforenergyresearch.org/analysis/obama-cancels-lease-sales-in-arctic-cedes-arctic-to-russias-vladimir-putin/ (Accessed 6th May 2016)

gas reserves will be addressed here. Norway for instance, in 2015, exported for the first time more natural gas than oil in value[17]

Arctic natural gas supply and projects

The Eurasian USGS estimates are of about 34500 bln cubic meters of natural gas[18]. To put this volume in context, this is equivalent to almost a century of the current EU annual gas consumption of about 450 bln cubic meters. A limited number of operating Arctic gas projects are located mostly in Norway and Russia.

Norway operates the Snøhvit LNG facility in the Arctic with a capacity of about 5 billion cubic meters annually and produces an additional 2.2 bcm of gas in the southern Norwegian waters[19]. The Statoil Norvegian company, with the state as the largest stakeholder, is also working on the Aasta Hansten gas field in the Norwegian sea in the Arctic circle. The field is estimated to contain 47 bcm of gas which will be connected through the 482 km Polarled 70 million standard cu m/day pipeline to the Norwegian gas grid[20]. The project is very complex and according to Statoil recovering the resources on Aasta Hansteen will be demanding since the discovery is located far from land and outside the established infrastructure. The water depth is significant and the weather conditions are challenging[21]. The project cost has risen by about 9% since its submission and amounts to $4.34 bln. Its conclusion has been delayed from 2017 to the middle of 2018[22].

Russian projects

The country which could have the biggest impact on the Arctic gas extraction is obviously the Russian Federation. Currently Russia is not exploiting any offshore Arctic gas field, while the onshore area is a very important region for its gas supplies. The Yamalo-Nenets region provides about 80% of Russian natural gas [23]. Half of the region is located inside the Arctic circle. The offshore natural gas could be exported to the world markets through the liquefaction process which provides export flexibility and lower transportation costs on longer distances compared to the pipeline system as can be seen from the graph below.

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[17] URL: http://barentsobserver.com/en/energy/2015/09/gas-bigger-oil-18-09 (Accessed 6th May 2016)
[18] 1219 trillion cubic feet
[19] In Arctic, Norway steps on the gas. URL: http://barentsobserver.com/en/energy/2015/03/arctic-norway-steps-gas-25-03 (Accessed 7th May 2016)
[20] Statoil: Polarled gas pipeline crosses Arctic Circle. URL: http://www.ogj.com/articles/2015/08/statoil-polarled-gas-pipeline-crosses-arctic-circle.html (Accessed 7th May 2016)
[21] Aasta Hansten. URL: http://www.statoil.com/en/ouroperations/futurevolumes/projectdevelopment/pages/aastahansteen.aspx (Accessed 7th May 2016)
[22] URL: http://www.offshore-mag.com/articles/2015/10/statoil-pushes-back-production-start-up-at-two-offshore-northwest-europe-projects.html (Accessed 7th May 2016)
[23] Soveschanie s chlenami Pravitelstva. 07.09.2016. http://www.kremlin.ru/events/president/transcripts/deliberations/52843 (Accessed 14th October 2016)

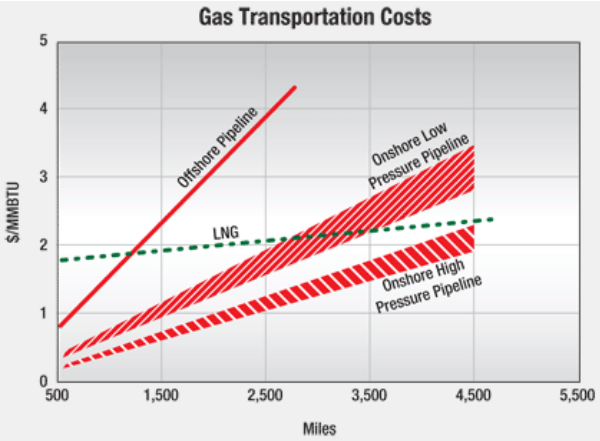

Figure 3. Pipeline vs LNG transportation cost[24]

Due to the permafrost conditions, the geographical limitations of a pipeline system, and long distances the Arctic offshore gas extraction is based on LNG technology. Yamal, the second LNG terminal in Russia, should be finished soon. Its three LNG trains, presumably operational in 2021, would provide a total liquefied gas production of 16.5 mmt of LNG or 23 bcm per year of natural gas.

The project is owned for 50.1% by Novatek with Total and CNPC having a 20% stake each and the Silk Road Fund a 9.9% participation. Total detains also a 18.9% stake in Novatek bringing its indirect involvement in the project to almost 30%. The Yamal LNG has involved the construction of a major new maritime route for transporting liquefied natural gas to Europe and Asia.

The $27 bln project has been experiencing financial problems due to the economic sanctions imposed on Russia and closed access to cheaper credit. A large part of the financial resources will be secured from Chinese investors through a $12 bln loan. The Chinese partners have also recently acquired an additional 9.9% stake in the project through the Silk Road Fund providing €1.09bln. The Russian government provided financing from the National Wealth Found of $2.8 bln and Russian banks recently agreed a further $3.6 bln loan[25].

With the exception of the Yamal project in active construction phase, Russia has recently delayed important Arctic projects. One of them is undoubtedly the Shtokman gas field which was discovered already in 1988. Gazprom, with its partners, in 2012 couldn't find a technologically and economically viable solution for the development of the 4 trillion cubic meters giant gas field. The field covers an area of 1,400 m² and lies inside the Arctic 600 km offshore in deep water. Successful development would require the construction of a long subsea pipeline in deep water in

[24] URL: http://www.energytribune.com/941/compressed-natural-gas-monetizing-stranded-gas#sthash.VROqacjV.dpbs (Accessed 8th May 2016)
[25] Russian banks sign loan deal with Yamal LNG worth 3.6 bln euros - Interfax cites sources. URL: http://www.reuters.com/article/russia-yamal-lng-loans-idUSR4N0ZC01I (Accessed 7th May 2016)

some of the harshest conditions on earth.[26] It is subject to icebergs weighing up to one million tonnes drifting at speeds of up to 0.25 m per second, and 1.2 m drift ice moving at up to 1m per second. Statoil left the project in 2012 and Total abandoned it in 2015 returning its 25% stake to Gazprom. Furthermore, the US, in the last several years, has drastically increased the production of natural gas following the shale oil boom. The country has even become a gas exporter which cut demand for Shtokman natural gas and lowered global natural gas prices. The development cost for the first phase of the Shtokman project was estimated at $12 bln to $25 bln ($50 bln overall investment). The project, after the completion of the third phase, would have produced up to an impressive 71.1 bcm of gas annually[27]. In February 2010, Gazprom postponed the phase I development of the project to 2016 from the original scheduled date of 2013. The field, according to those plans, should have started producing its first gas in 2016 and first LNG in 2017[28]. The project is currently frozen.

It is interesting to review the list of proposed LNG projects in Russia below, which if built, would bring the country's liquefied gas export capacity to about 117 bcm annually.

Table 1. Source: EIA International energy data and analysis[29]

Facility	Area	Status	Capacity (million Metric tons LNG/year)	Anounced Start year	Owners
Liquefaction projects					
Sakhalin LNG	Pacific coast	Operating	9.6	2009	Gazprom, Shell, Mitsui and Mitsubishi
Yamal LNG	Arctic coast	Construc.	16.5	2017	Novatek, Total and CNPC
Baltic LNG	Baltic coast	planning	10	2018	Gazprom
Valdivostok LNG	Pacific coast	planning	15	2018	Gazprom
Sakhalin LNG (expansion)	Pacific coast	planning	5	Post 2018	Gazprom, Shell, Mitsui and Mitsubishi
Far East LNG	Pacific coast	planning	5	2018-2019	ExxonMobil, Rosneft, ONGC Videsh and SODECO
Gaydan LNG	Arctic coast	planning	16	2018-22	Novatek
Pechora LNG	Arctic coast	delayed	10	NA	Rosneft
Shtokman LNG	Arctic coast	delayed	30	NA	Gazprom

[26] Is the time right for Arctic LNG? URL: http://mediaserver.dwpub.com/fjd-profile/30722/Arctic+LNG+November+2012.pdf (Accessed 7th May 2016)
[27] Shtokmanovskiy proekt. URL: http://www.gazprom.ru/about/production/projects/deposits/shp/ (Accessed 7th May 2016)
[28] Shtokman Gas Condensate Deposit, Russia URL: http://www.offshore-technology.com/projects/shtokman/ (Accessed 7th May 2016)
[29] Russia. URL: http://www.eia.gov/beta/international/analysis.cfm?iso=RUS (Accessed 7th May 2016)

The recent downturn in global energy prices, the Russian recession and the international sanctions will impact all those projects. It is very likely that until 2020 only the Yamal LNG will become partially operational. All the other projects in the Arctic are postponed or will never come online at all. In 2016 Russian government to decided to set up a temporary moratorium on licensing of shelf use [30].

The Yamal LNG project

In order to try to understand the future of the Russian Arctic LNG projects, which are crucial for the future gas extraction activity in the Arctic, the Yamal LNG development could provide some data and interesting insights. The project is the first of its kind and is not comparable to the Norwegian Snøhvit LNG facility which is located in southern waters where the Gulf Stream keeps the sea free of ice all year round. The Yamal field consists of five shallow gas horizons and 27 deeper gas condensate horizons, with depths varying from 900 to 2,850 meters. 208 wells will be drilled from 19 well pads. The Yamal LNG project is one of the largest industrial undertakings in the Arctic. It will eventually involve the drilling of more than 200 wells, the construction of 3 LNG trains, each with a capacity of 5.5 million tons per year, and a vast gas terminal, and the commissioning (a world first) of 16 icebreaker tankers, each able to transport 170,000 m³. [31]

A total of 188 kilometres (km) of gas gathering lines, 121 km of roads and 143 km of high voltage lines will be constructed[32]. It is very likely therefore that only after an initial evaluation and analysis of the Yamal operations additional similar projects could be approved. This will partially determine the development of the Novatek's Gydan project in Arctic waters with 16mmt LNG capacity which could become operational in 2023[33]. Shtokman LNG and the Pechora LNG projects are delayed. It is also important to consider that other reasons than economics could determine the development of important projects, especially in the Russian state, such as strategic planning or regional development plans. This was often the case for the Soviet Arctic projects, many of which were often not justified from a pure economic perspective but were indeed considered important for regional development or strategic interests.

The capital expenditures for Yamal LNG were assessed of being $26.9 bln in 2013 when the final investment decision was taken up from $20 bln initially estimated. The upstream accounts for

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[30] Soveschanie s chlenami Pravitelstva. 07.09.2016. http://www.kremlin.ru/events/president/transcripts/deliberations/52843 (Accessed 14th October 2016)

[31] Yamal LNG: The gas that came in from the cold. URL: http://www.total.com/en/energies-expertise/oilgas/exploration-production/projects-achievements/lng/ yamal-lng (Accessed 6th May 2016)

[32] Government Support to Upstream Oil & Gas in Russia URL: https://www.iisd.org/gsi/sites/default/files/ffs_awc_russia_yamalprirazlomnoe_en.pdf (Accessed 8th May 2016)

[33] Novatek presents plan for new Arctic LNG URL: http://www.thebarentsobserver.com/industry/2016/02/novatek-presents-new-plans-arctic-lng (Accessed 8th May 2016)

$4 bln, $4 bln goes to infrastructure, while the other $19 bln is attributable to the LNG liquefaction plant [34]. According to a recent analysis of the Moscow broker "Otkritie", the total capex can raise up to $33 due to the impact of the sanctions imposed on Russia and more expensive capital [35]. In addition, there are other indirect costs taken by the government like for instance, the building of three LK-60 nuclear ice breakers for about $2 bln which would be also partially used for the export and operation of the Yamal LNG.

It is also important to mention the unstable exchange rate of the ruble which has lost more than 50% in the last two years going from 33 rubles for $1 at the beginning of 2014 to 66 rubles for $1 in May of 2016[36]. The project in roubles would cost 1.27 trillion[37] which is $40 bln or $20 bln according to the two different exchange rates. If the expenditures or the financing are in euro or dollars the depreciation could have a negative impact and raise the financial burden for the companies involved.

According to two different sources, the Yamal LNG would break-even at a price of $8.2MMBtu[38], while a recent Gazprombank analysis reported a price of $6 MMBtu[39]. They write: "We estimate that Yamal-LNG will be breakeven and provide zero value to NOVATEK's target price at an LNG price of no more than $6 per MMBtu in 2017-20 and no more than $9 per MMBtu in 2021-24." Currently the European Russian gas prices at the German border are $4,02 MMBtu or $145 mcm and they still have not fully discounted the decline in oil prices[40] while in Asia the LNG stands at $4.24 MMBtu. Additional pressure on prices will come from American LNG exports to Europe and new Australian export terminals. At these prices the Yamal LNG in Europe in the short-term is uneconomical and would not guarantee an adequate return on the $27bln investment taking into consideration also the higher Russian interests rates.

The Gazprombank analysts point out the fact that the Asian spot LNG prices are not a good benchmark for Yamal future prices. The gas is also contracted for 90-95% and according to them it is not linked to LNG prices so they don't see possible impacts from LNG prices on Yamal. However, they are linked to crude oil prices benchmark [4]. On the other hand, a recent analysis of the

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[34] Gazprombank. Novatek, Pricing in sanctions and Yamal LNG // Gazprombank equity research 2014. P. 17. URL: http: //www.gazprombank.ru/upload/iblock/a1b/gpb_ novatek_ tp%20update_ 040814.pdf (Accessed 10th May 2016)

[35] Moscow gives a boost to Yamal LNG. URL: http://www.hellenicshippingnews.com/moscow-gives-a-boost-to-yamal-lng/ (Accessed 8th May 2016)

[36] Dinamika kursa valuty. Dollar SSha. URL: http://www.cbr.ru/currency_base/daily.aspx (Accessed 8th May 2016)

[37] Fadeeva A. "Yamal SPG" znachitelno prevyshaet planovye raskhody, soobschila Schetnaya Palata. URL: http://www.vedomosti.ru/business/articles/2015/08/13/604610-yamal-spg-previshaet-planovie-rashodi (Accessed 8th May 2016)

[38] BTU (British thermal unit) is an outdated measure unit used for thermal energy.

[39] URL: http://www.gazprombank.ru/upload/iblock/2f6/GPB_NVTK_TP_Update_230915.pdf (Accessed 8th May 2016)

[40] Gazprom Said to See Its Lowest Europe Gas Price in 11 Years. RL: http://www.bloomberg.com/news/articles/2015-10-23/gazprom-said-to-see-its-lowest-eu-gas-price-in-11-years -in-2016 (Accessed 8th May 2016)

International Institute for Sustainable Development/WWF points out that the project's Net Present Value (NPV) is positive only due to the Russian government's subsidies and that otherwise Yamal LNG would not be economically viable regardless of infrastructure costs. They also estimate the transportation cost for Yamal LNG from calculations made by Armstrong Atlantic State University. According to them costs are US$1.15/MMBtu to Europe, US$7.04/MMBtu to Asia via the Suez Canal and US $2.85/MMBtu to Asia via the NSR. Average transportation costs are thus US$3.7/MMBtu [7]. With current LNG prices in Europe and Asia of about $4MMBtu the capital return margins are really very slim.

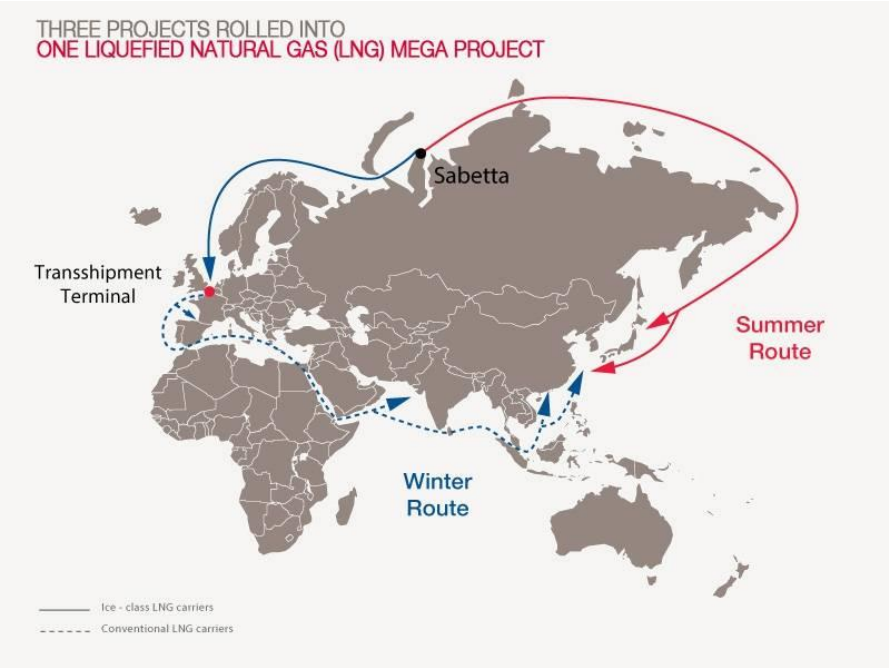

Figure 5. Yamal LNG transportation routes

The long horizon of such projects could partially offset current low LNG prices in the long-term. The Energy center of the Skolkovo business school in 2013 did a comparison of the LNG prices in Europe and Asia from different suppliers and it is interesting to see the competitiveness of the Yamal LNG in comparison to them [8, pp. 46-47].

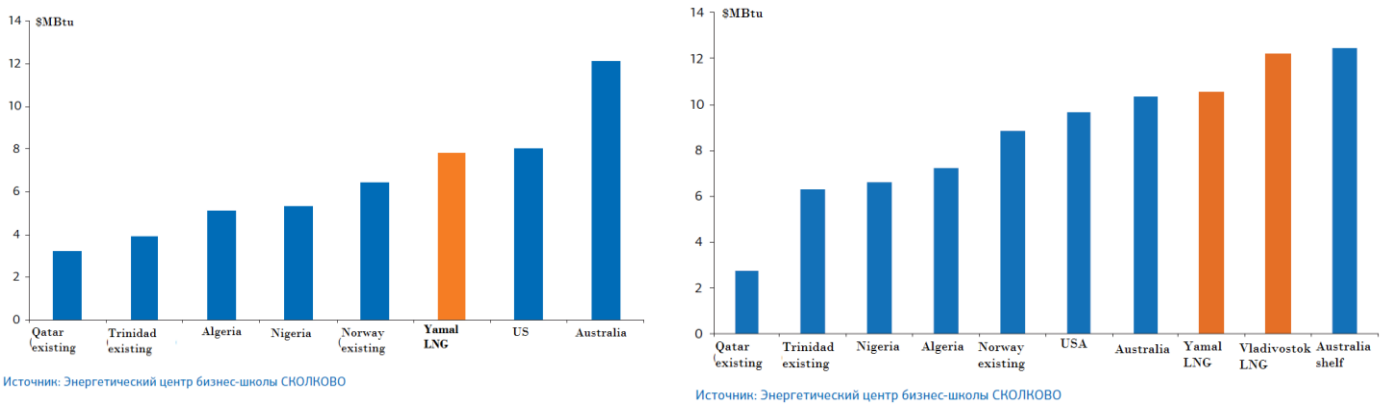

Figure 6. LNG delivered to Europe and LNG delivered to Asia: Skolkovo business school energy center

Gazprombank in its analysis of Novatek "Pricing sanctions and Yamal LNG" provides a different picture. They calculate that the Yamal LNG has the lowest capex per mln tonnes of LNG capacity of all the projects until 2020. They argue that even if the American projects like the Sabine Pass liquefaction facility has a capex of $0.74 per mln tonnes of LNG capacity this does not account for the upstream. The U.S. projects have to use outsourced gas from shale what, according to them, doubles the costs. Of course, also transportation costs have to be considered which are higher for Yamal LNG.

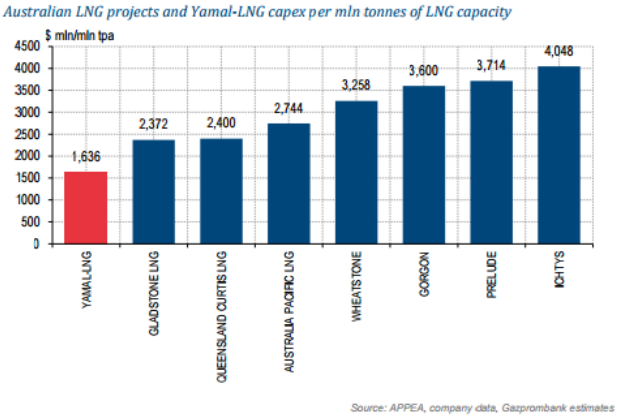

Figure 6. Comparison of projects' capex per mln tonnes of LNG: Gazprombank

Conclusions about Arctic gas

Arctic gas projects are very expensive long-term investments. The European market is already supplied by the existing pipeline system and the demand in Europe is flat and even declining after 2008. Similarly China will soon receive 61 billion cubic meters of Russian natural gas from the project Power of Siberia and Japan is restarting its nuclear reactors. In addition, the U.S. has become a natural gas exporter and the Chinese economy is slowing, switching also to less energy intense sectors following the advanced economies. Of course, there are other potential buyers, however, currently the global LNG market is oversupplied. The international energy consultancy Wood Mackenzie sees the window of opportunity closed for new projects at least until 2025[41]. The liquefaction capacity at the end of 2015 was about 301,5MTPA and additional 141,5MTPA of capacity will be added until the end of this decade especially in Australia and in the U.S.[42] In the best scenario until 2025, the Russian Arctic could see two operating LNG projects the Yamal LNG and the Gaydan LNG which would not drastically change the picture of the region considering also that this would be only about 5% of the Russian annual gas production. In

[41] Hussain, Y. 'Window of opportunity' for new LNG projects is gone because of supply glut, consultancy says. URL: http://business.financialpost.com/news/energy/window-of-opportunity-for-new-lng-projects-is-gone-because-of-supply-glut-consultancy-says?__lsa=94c1-5c19 (Accessed 9th May 2016)

[42] International Gas Union World LNG Report 2016. P. 17

addition, the Arctic projects would face strong competition from other LNG projects around the world especially in places with lower costs. In 2025 the world will presumably face a new energy reality and soon after natural gas will probably be already on the declining path in the world energy supply.

Growing alternatives to fossil fuels

In order to limit climate change and to use infinite renewable and sustainable resources for the world's energy needs, renewable energy will be crucial for our future. In the last several years many countries across Europe, and more recently other countries too, have seen an important shift in their energy mix with an exponential growth of wind and solar energy. For example, Italy and Germany, two important importers of energy, in particular of oil and natural gas, have seen in just a couple of years the combined share of solar and wind go up to 12,5% of total electricity generation in Italy and to almost 20% in Germany in 2015. In the EU28, for instance, renewable electricity generation grew from 678 TWh in 2011 to 923 in 2015 while natural gas electricity generation decreased from 705 to 485 in the same period[43]. China is installing photovoltaic and wind turbines systems at a record peace in the last several years and plans to reach 150GW of solar pv installed capacity until 2020. It has also 262 GW-thermal of solar heating capacity[44]. In the OECD countries solar and wind generation increased by 16% to 776 TWh in 2015 while fossil fuel generation decreased by 1%. Combustible fuels production was 6189 TWh [45]. The total world wind annual installations are already above 60GW in 2015 with solar catching up. According to the latest projections, they will already reach 100GW annual installations each in 2020.

In the automotive sector there is a growing trend towards the electrification of the transportation sector. In some advanced economies like Norway, electric and hybrid cars in 2015 have already reached a 23% market proportion of new vehicles sales. Tesla Motors, for instance, plans to produce 500000 electric vehicles annually from 2018-2020 and all the major auto companies are shifting to hybrid and electrical cars production. According to some calculations this should start the displacement of oil already beginning from 2022[46].

Another important factor to consider is the carbon budget. The world can emit at the current levels for another ten-twenty more years to reach the limit. There are some projects which

[43] URL: http://c1cleantechnicacom.wpengine.netdna-cdn.com/files/2016/05/europe-status-quo.jpg (Accessed 9th May 2016)

[44] URL: http://www.pv-magazine.com/news/details/beitrag/its-official--china-has-the-most-solar-pv-installed-globally_100022939/#axzz48Hm3q1Wf (Accessed 9th May 2016

[45] Wind & Solar OECD Electricity Generation Grew 16% in 2015 URL: http://cleantechnica.com/2016/04/05/wind-solar-oecd-electricity-generation-grew-16-2015/ (Accessed 9th May 2016)

[46] The Peak Oil Myth and the Rise of the Electric Car URL: http://www.bloomberg.com/news/videos/2016-02-24/the-peak-oil-myth-and-the-rise-of-the-electric-car (Accessed 9th May 2016)

started incorporating carbon sequestration but they are very expensive and can not compete with renewables. Additionally, many important international investors have already started the divestment process from fossil fuels. With the recent COP21 climate agreement the countries agreed to keep the temperature below 2 C° with the desire to keep it under 1.5 C° if possible. This will undoubtedly foster policies towards a renewable energy future.

Conclusions

In conclusion, the developments outside the Arctic region will largely determine the fate of its fossil fuel reserves. The latest advancements in the energy sector and the increased awareness about the climate risks have changed the world's attitude towards energy. Natural gas is still seen as the transitional fuel to the zero emissions economy but probably it will be overtaken by renewables soon. The global market is actually flooded by natural gas and especially LNG with prices slipping to historical lows. For all those reasons, it is difficult to expect that the Arctic will experience a fossil fuel extraction bonanza. Arctic projects require huge capital investments and do not provide flexibility in the long term due to the high initial investment requirements. It would be very risky to predict a fresh wave of Arctic extraction projects in ten years time following the rapid cost reductions and technological breakthroughs of other energy sources. This article clearly suggests that the timing for new Arctic oil and gas extraction projects is very limited and can be restricted to one or two more decades and that the majority of Arctic fossil fuels reserves will be kept in the ground.

In this scenario, it would be extremely important for Arctic countries to adapt and to plan for such a future and to consider alternative ways for their northern development. The low Arctic fossil energy resources potential could benefit the sustainable development of the entire Arctic region since huge extraction projects could have a negative impact on the environment and the society. The assumption that a large part of Arctic fossil fuels will be kept in the ground, could help to reframe the governments' attitude and plans towards the region and strengthen the spirit of cooperation. Artic transportation, Arctic tourism and sustainable development, for instance, contrary to huge extraction projects, require a continuous and ever improving forms of cooperation among the Arctic states, regions and communities.

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