

Factors influencing future oil and gas prospects in the Arctic

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ARTICLE INFO

Article history:

Received 21 June 2011

Accepted 26 September 2011

Available online 14 October 2011

Keywords:

Arctic

Oil

Gas

ABSTRACT

The article explores oil and natural gas development in the Arctic. While several commentators have argued that an increase in Arctic petroleum production in the years to come will follow directly from an increased demand for energy, our study finds that oil and natural gas production in the Arctic is dependent on a range of variables. By using climate-driven changes as a baseline, we examine spill-over effects and conditions that are important for further Arctic hydrocarbon production. Using the available literature from different scientific fields, this article provides a broad and nuanced perspective on the much debated question of whether or not the Arctic will become a region driven by oil and gas production.

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1. Introduction

From the start of 2007 until the end of 2008, important events made commentators and scientists predict a new intensified race for Arctic resources. First, as a result of decades of substantial ice melting, **the Northwest east passage can become a viable transportation route**. Second, in 2007 Russia planted a deep sea flag at the North Pole, a signal to the world of the importance of the Arctic region to the leadership in the Kremlin. Third, when the price of oil reached 147 US\$ per barrel in the summer of 2008, some feared that current oil and gas production would not be able to meet future oil demands from rising powers such as India, China, and Brazil, and that the prices would continue to soar if new sources were not be able to compensate for higher demands (Koivurova and Hossain, 2008). **Finally, in 2008 the US geological survey (USGS, 2008) estimated that nearly one quarter of the world's undiscovered oil and natural gas deposits is probably located in the Arctic**. Hence, the need for an increase in production, the high probability of finding vast resources, and the fact that the Arctic is more accessible following the decline in ice coverage since 1987 (Arctic Council, 2009), fuelled the race for Arctic resources. Some commentators have consequently come to the conclusion that we are “more than likely” to witness a substantial increase in oil and gas activities in the Arctic in the years to come (Howard, 2009).¹

Looking back, oil prices, from their record high level in July 2008, plummeted to a staggering 34 US\$ per barrel in December 2008.² **The lack of supply was replaced by an oversupply of oil and gas in the market, which partly contributed to Gazprom delaying**

production of natural gas at the Shtokman field on several occasions (Gazprom, 2010).³ In Alaska, the company Eni S.p.A. delayed work on a new field as it missed the opportunity in the summer season to ocean-barge the field's processing and operations modules (Budzik, 2009), and **in light of the Macondo oil spill disaster in the gulf of Mexico, the US government decided to review Shell's licence to drill in Alaska. The Macondo disaster paved the way for a “newfound” scepticism in the general public on the general safety of oil production, which in turn made the US drilling rules stricter. This new rule “increases the cost of operating in the Outer Continental Shelf (OCS) for each operator by an estimated \$184.3 million” (McAndrews, 2011), which in turn can have an effect on the attractiveness of future oil and gas prospects**. Thus, although major oil and gas companies are becoming increasingly interested and involved in the Arctic,⁴ there are several obstacles that have to be taken into consideration regarding the likelihood of increased oil and gas activities above the Arctic Circle. This paper reviews the on-going debate on future oil and gas production in the Arctic by providing an analysis of the anticipated development. It studies oil and gas development in the Arctic by analysing the combined effect of environmental and geological variables (below ground) and political and economic variables (above ground), which will provide a more nuanced picture of the oil and gas development in the Arctic.

In the following, we begin by briefly presenting the potential Arctic oil and gas resources. Then an analysis of possible environmental changes that may affect oil and gas development is provided, followed by a discussion of climate-driven economic effects and some considerations regarding political changes, before the final concluding remarks.

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¹ According to the Russian expert Professor Nikolay Dobretsov, the Arctic will become the centre for oil and gas between 2030–2050 (BarentsObserver, 2010).

² Even though the price of oil recovered, it has yet to reach 90 US\$ per barrel, less than two thirds of the price in the summer of 2008.

³ According to the latest news, Gazprom has delayed production until 2016 or 2017.

⁴ In Norway, the petroleum directorate received 47 applications in 2008 from different oil companies (Norwegian Petroleum Directorate, 2009).

2. Arctic oil and natural gas

At present there is considerable oil and gas activity in the Arctic being carried out in the Canada, the USA, Norway, and Russia, all of which are producers of oil and gas in this region. The areas of importance are indicated in Fig. 1.

The largest oil and gas reserves in the Arctic are found in Russia, where 43 large⁵ oil and gas fields have been identified. In Alaska there are six, in Canada 11, and finally in Norway there is one large discovered field (Budzik, 2009). It is important to note, however, that though many of the fields were discovered more than 30 years ago, the significant development costs have hampered production. Harsh winters with extreme temperatures and year-round ice, combined with long and (partly) limited supply lines to energy consumers and a lack of adequate infrastructure, do not provide ideal conditions for the private oil and gas industry (Budzik, 2009; Dell and Pasteris, 2010). As a result, only three fields in North America have been developed (Budzik, 2009). In contrast, oil and gas activity in Russia is much higher, which is mainly due to the fact that the Soviet Union, with a nationalised energy sector, had developed much of the existing Russian oil and gas fields.

Now, even though there is considerable activity in the Arctic, the region is, as mentioned previously, estimated to contain one of the world's largest undiscovered oil and gas reserves. According to the US Geological Survey (USGS), approximately 22% of the world's undiscovered resources are located in the Arctic.⁶ More specifically, the USGS estimates⁷ that the Arctic contains: "90 billion barrels of oil and 1669 trillion cubic feet of natural gas, and 44 billion barrels of natural gas liquids" (USGS, 2008).⁸ Furthermore, around 84% of the undiscovered resources are believed to be located offshore. Resources in the Arctic are dominated by natural gas, which is about 30% of the total undiscovered gas resources in the world. In comparison, Arctic oil resources account for approximately 13% of the undiscovered oil resources. Resources within the Arctic are scattered, with the largest ten provinces accounting for 93% of the total undiscovered resources. Furthermore, while the provinces around Alaska hold most of the Arctic's oil reserves, according to Budzik (2009) the provinces around Russia are dominated by natural gas.

While the four Arctic countries referred to are looking to expand their activities, Iceland and Greenland are looking to become oil and gas producers. Initially Iceland granted exploration licences to Aker Exploration and Sagex Petroleum & Lindir Exploration in 2008, both however withdrew their applications (National Energy Authority, 2009).⁹ The country has decided to launch a second licensing round for hydrocarbon exploration in 2011. Greenland's East Greenland Rift Basins, and the West Greenland–East Canada provinces are, according to the USGS, expected to have more than 50 trillion cubic feet of natural gas. Even though Cairn Energy Company has been carrying out exploratory drilling in Greenland since 2008, full-scale plans for production have yet to become a reality. Moreover, since ice-

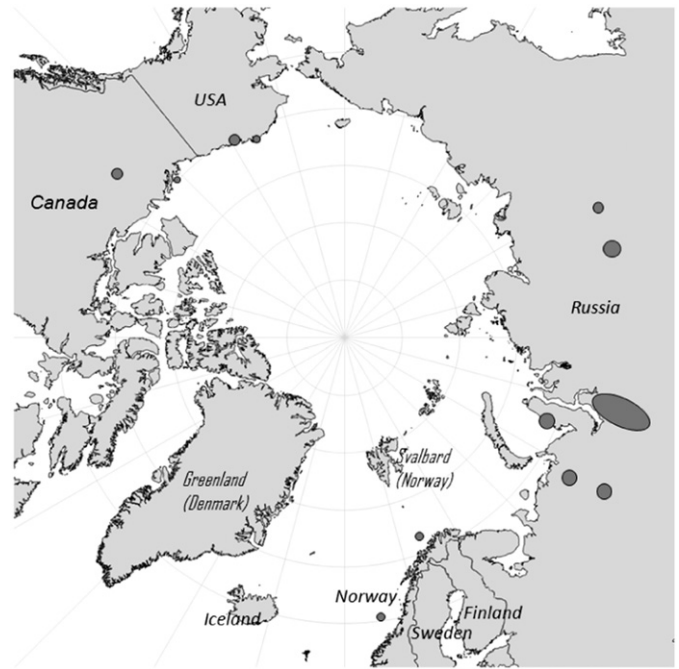


Fig. 1. Areas of major Arctic oil and gas activity. Known areas of ongoing gas or oil exploitation are indicated by the darker grey areas.

melting has been extensive over the last three decades, one could assume that conditions have improved, or at least made drilling easier. An interesting question is therefore why has not the development gone further, or faster? One answer is the extreme weather conditions, which makes exploratory drilling difficult and costly. Moreover, as a result of global warming the Arctic climate has, and will, become less predictable with an increase in storm frequency (Kolstad and Bracegirdle, 2008), among other things, making long term planning harder. Another crucial factor is that the demand for energy fell in 2008 as a result of the financial crisis (Stern, 2009). In addition, governments are not giving out drilling licences without careful consideration of the potential environmental impact of drilling in a highly sensitive environment.

To sum up, there are several factors that determine whether or not increased oil and gas development in the Arctic will happen in the foreseeable future. In the remainder of the present paper these obstacles will be discussed.

3. Climate change

The last fifty years have witnessed a significant increase in the earth's temperature. While the average global temperature has increased by 0.6° since the industrial revolution, the annual temperature rise in the Arctic has been twice as fast (Hassol, 2004). The temperature increase is more pronounced in the Arctic, partially due to the sharper angle at which the sun rays hit the polar region during the summer, and because the retreating sea ice is turning into open water, which in turn absorbs far more solar radiation (Borgerson, 2008). As a result, according to Richter-Menge (2009), Arctic ice has been reduced, the snow cover season is shorter, sea level is higher, permafrost has warmed by 2 °C, and land temperature has increased. Global warming is affecting oil and gas development in the Arctic as a changing Arctic environment can either make exploration, drilling, and production of hydrocarbon easier, or to the extent that it becomes impossible. In the following section some of the main

⁵ "Large" is defined as a field that exceeds 500 million barrels of recoverable oil and natural gas.

⁶ It is important to note that this is based on probabilistic methodology of geological analysis and analogue modelling, and not actual drilling.

⁷ The USGS estimate does not include non-conventional hydrocarbons, such as heavy oil and gas hydrates. It is estimated that the world's gas hydrate resources exceed conventional gas by 6–600 times, globally (Johnston, 2010).

⁸ According to the Icelandic National Energy Authority, several oil companies showed their interest during the first round, but did not apply because of the poor economic conditions at the time.

⁹ In a study of the Beaufort Sea Production System, it is shown that open water periods are not very predictable with regards to how heavy pack ice moves (Wright, 2005).

issues of the future production of hydrocarbon development in the Arctic will be discussed.

3.1. Ice structure and extent

According to the Arctic Climate Impact Assessment report (Hassol, 2004), the extent and thickness of the Arctic ice have been declining for the past five decades. Each decade has had an average decline of 3.7%. According to model simulations, presuming that the ice-melting continues in the same rate, the Arctic area will become ice free during the summer around the year 2040 (Hassol, 2004). Ice thickness is reduced from around 3.5 m to less than 2 m (Hammer, 2010). As no models predict ice-free winters, it is important to bear in mind that further oil and gas production in the Arctic must be able to tackle extreme winter conditions, with temperatures below -40°C in the foreseeable future. But on the other hand, a longer and wider ice-free period for exploration will also be available. Even though Arctic ice has been declining for almost 50 years, 2007 was a record year (NSIDC, 2010) in which the ice-extent was at a record minimum, with only 4.1 million km^2 of ice (Doble and Wadhams, 2010).

Data on ice thickness shows that we could have passed a critical value or *tipping point*, where the ice has been qualitatively altered in the way it responds to sea currents and wind (Doble and Wadhams, 2010). This implies that the ice has become more movable than in previous years, thus making it harder to predict how the ice will behave. Researchers from University of Manitoba reported that the ice in the Beaufort Sea is becoming rotten,¹⁰ which could make transportation through the ice easier, and is more evidence to suggest that the Arctic ice form is qualitatively altered (NSIDC, 2010). What caused such a record decline in 2007 in the Arctic ice is debateable, but research points to the fact that the ice-albedo feedback was particularly strong in 2007 (Lindsay et al., 2009), and that 2007 was a year with anomalous winds. Even though the following years did not surpass 2007 levels with respect to the summer sea ice level, 2009 was still the third lowest recorded ice level since 1979 (Richter-Menge, 2009). Also, early estimates from 2010 confirm the same trend, where the ice reduction in October/November surpassed even 2007 levels.

If the ice structure in the Arctic has passed a critical value, (which may possibly be a threshold value) the question is, what implications will this have on the oil and gas industry? Will an ice free summer make it harder or easier for oil companies in the years to come? According to Dell and Pasteris (2010), climate change will create both opportunities and risks for the industry. First, a continued ice reduction will naturally create possibilities of new shipping routes in the summer. However, as an ice-free Arctic is only likely to take place during the summer, pipelines are still the most likely solution in the foreseeable future for transporting oil and gas from offshore Arctic fields. Second, ice-free summers will create longer drilling seasons, which could increase the rate at which new fields become developed. In Greenland, due to fast ice melting, the shipping route called “Iceberg Alley” is now ice-free from May to September, and this ice-free period is expected to lengthen as the temperature rises, improving the conditions for oil and gas exploration in the area.

On the other hand, a different ice structure could prove to be more difficult to deal with for the oil companies than previously expected. Fragile Arctic ice (i.e., an increase in first and second year ice) has been shown to be more moveable by strong winds (Doble and Wadhams, 2010), and can therefore be expected to

move at a greater speed compared to the older, more stable ice.¹¹ This represents a potential risk for the oil and gas industry, as increased ice movement could interrupt drilling (Dell and Pasteris, 2010). In addition, greater movement of icebergs may damage rigs and vessels. According to the oil and gas companies, relatively new technology enables oil rigs and vessels to handle larger movements of ice (Ryerson, 2008).¹² The platform Hibernia is designed to withstand the impact of a one-million tonne iceberg without damage. The platform is also designed to manage contact with icebergs of up to 6 million tonnes, which are the largest icebergs that are able to drift, with repairable damage (Hibernia, 2010).

Experience from the oil industry in Newfoundland,¹³ an area south of the Arctic Circle, is also worth considering. Terra Nova, a large oil and gas field located about 350 km off the coast of Newfoundland, began production in 2002 and has had to face Arctic challenges such as icebergs, extreme winter temperature, and huge waves that can reach up to 30 m (Offshore Shipping Online, 2000). In order to deal with the extremely challenging environment, new technology was developed that may become useful for future development in the Arctic. First, the Terra Nova field has ice tracking radars that detect icebergs. Second, when an iceberg is detected, standby vessels are capable of towing them away. Finally, Terra Nova is a Floating Production Storage and Offloading (FPSO) vessel, which by definition has the ability to disconnect from its risers, and move away if potential icebergs are on collision course (Allen et al., 2001). This technology is naturally of great importance to increased offshore development in the Arctic, where ice movement is expected to increase in the years to come (Doble and Wadhams, 2010). Also worth mentioning is the new generation of cargo ships and oil tankers that have been developed by Aker (through Aker Arctic Technology) that have the ability to navigate through the polar region, and more importantly can break up ice (Hammer, 2010). Also, subsea installation (as in the case of the Snøhvit field), is a technology that will be of crucial importance, as it reduces production-related disruptions due to ice movement.

3.2. Extreme weather

Ice reduction is not the only by-product of climate change in the Arctic. Researchers also point to an increase in extreme weather conditions as a result of global warming. Extreme weather conditions such as hurricanes are most commonly found in warmer climates. A recent study suggests that polar storms and hurricanes are likely to increase in the years to come (Kolstad and Bracegirdle, 2008), which could potentially worsen the conditions for the oil industry. An increase in storm frequency could prove a serious risk to the oil industry, as it has the potential to disrupt drilling, production, and transportation (Dell and Pasteris, 2010). In addition it augments the risk of potential oil spills, which combined could make the cost of oil and gas development greater than expected. An increase in storm frequency in the Arctic is another potential tipping point worth considering. Scheffer et al. (2009) point out that over the last 10,000 years, the weather has been extremely stable, and that a qualitatively new system could therefore be a system of much greater instability. This implies that the Arctic climate could in the near future be a region with a

¹¹ It is also important to note that: “A search of major databases indicates that neither atmospheric nor superstructure icing has been a primary cause of the loss of any rigs globally” (Ryerson, 2008).

¹² Some of the companies that have been involved are: ExxonMobil, Statoil and Chevron.

¹³ For a detailed account of different possible Arctic hydrocarbon production facilities see Paulin and Kennedy (2010).

¹⁰ Rotten ice defined by the National Snow and Ice Data Center (NSIDC) as: “Floating ice which has become honeycombed in the course of melting, and which is in an advanced state of disintegration.”

higher degree of variation in its climate, which would make planning considerably more difficult. **Another factor which makes the Arctic more challenging is the fact that the water is relatively shallow, compared to larger oceans (Johnston, 2010). This represents a significant risk to the shipping industry as it may enlarge the already huge waves that may damage drilling and production facilities.**

When the Sakhalin-1 project (a field off the shore of eastern Russia) began production in 2005, field surveys and data gathering on ice movement, waves and earthquakes had been collected since 1995 in order to develop installations that would be able to tackle an environment with heavy ice and extreme weather conditions. **The concluding remarks from an industry report highlight the need for several years of reliable data collection: “Many years of ice data are needed to develop reliable design criteria based on meaningful statistics” (Hamilton and Jones, 2009).** In other words, in order to decide upon the right oil and gas production facilities,¹⁴ developers need reliable data on which to base cost effective solutions. **The need for, and thus potential lack of, reliable data is a problem for the ongoing development of offshore Liquefied Natural Gas production in the Russia's far north.** The need for reliable data has also been pointed out by representatives of Statoil, looking to expand its activity in the northern part of the Barents Sea. As global warming is potentially creating a more unstable climate, using historical weather data as a baseline for predicting ice movement and storm frequencies in the Arctic becomes problematic (Berg and Bakke, 2009).

Contrary to most research on the likelihood of increased storm frequency in the Arctic, a recent study (Zahn and von Storch, 2010) found that Arctic hurricanes are likely to decrease in the years to come. By using climate simulations from the Intergovernmental Panel on Climate Change (IPCC), they predicted that the annual number of Arctic hurricanes will decrease from a current annual average of 36 to about 20 by the end of this century. If this holds, we could be witnessing a different change in the Arctic, where Arctic storm frequency declines, providing a more predictable environment for the oil companies to operate in. In combination with summer seasons that are free from ice, a decrease in storm frequency could make exploratory drilling significantly more cost effective.

Finally, another factor worth taking into consideration is the potential risk of oil spills. An increase in movable ice and extreme weather would make an Arctic oil spill difficult to handle. In the Gulf of Mexico thousands of people were mobilised. In contrast, the Arctic region with poor infrastructure and limited manpower may not be capable of handling an oil spill on the scale of the Gulf of Mexico. This represents a potential extra cost to not only the industry, but also to governments when they are deciding upon whether or not new drilling licences will be granted in the Arctic.

3.3. Longer summer seasons and the Arctic tundra

Global warming may make offshore Arctic oil and gas development easier as the ice continues to melt, while onshore Arctic exploration may face new problems in a warmer environmental situation. A longer summer season, with a decline in ice and snow may have a positive effect on offshore drilling. It can reduce some production costs, as oil companies may be able to replace ice based construction with lower cost conventional construction equipment (Dell and Pasteris, 2010). On the other hand, a lengthy summer season will shorten exploration activities, since drilling in the marshy Arctic tundra is not desirable, nor politically acceptable (Budzik, 2009). Climate warming can, according to a

recent study by Kokelj et al. (2010), “...lead to the thawing of drilling-mud sumps and those situated in warm permafrost will thaw more quickly than those constructed in colder environments”. It is therefore paramount that the natural permafrost maintain its current level: if not, a milder climate will affect transportation equipment and infrastructure such as roads and pipelines. It is therefore in the oil companies' interest to be careful when drilling, as the Arctic tundra is vulnerable to drilling. As a result, the industry has improved over the years, making sure that seismic surveys and exploratory drilling take place during the winter. The marshy Arctic tundra makes it almost impossible to conduct large scale transportation during the summer months, as the tundra is not able to support motorised vehicles (Crandall et al., 2007).

4. Economic and market conditions

Oil and gas exploration and production are economic activities, which take place within natural, political, social, and market constraints. These constraints are dynamic and may display unpredicted and significant perturbations at any time. In the previous section a number of possible scenarios are presented, all affecting, in different ways, the constraints on economic activities related to oil and gas in the Arctic.

Climate changes may increase storm frequency and ice movement, causing increased costs in oil and gas exploration and extraction in the exposed areas. **Alternative energy sources may become more competitive if the costs reach the backstop prices of the oil and gas products (Heal, 1976, see also Fig. 2).** Further development of backstop technologies may enhance the effect of increased costs and potentially affect oil and gas production in areas not experiencing increased costs from global warming. **Increased concern and introduction of governmental actions aiming to mitigate and reduce the climate effects caused by human behaviour, as well as increasing taxes related to the use of fossil fuels, may significantly affect the demand for such products.** Hence both changes in the supply and the demand for fossil fuels may lead to reduced production and consumption of such products, while alternative sources of energy becomes more viable.

The continuously growing global demand for oil and gas products represents however a counteracting trend. Improved technology contributes by increasing the available amount of low cost deposits (by reducing costs and identifying new deposits), but also in reduced backstop price by making alternative sources of energy more competitive. Increased concern and consciousness may also increase the willingness to pay for such sources as well as reducing the willingness to pay for oil and gas resources in the long run.

The situation today does not, however, indicate that oil and gas resources will be less demanded in the near future. On the contrary, increased demand contributes in making previously marginal or unviable deposits competitive and of economic interest to exploit.

The growing demand for gas imports in Europe is one example, where the remote offshore field Shtokman¹⁵ was launched as part of the solution to Europe's increased need for energy supply. In combination with the new North stream pipeline it would ensure that Western Europe could be supplied with gas regardless of potential Russian–Ukrainian, Russian–Belarus gas conflicts.¹⁶

¹⁵ For more on the gas disputes see Pirani et al. (2009).

¹⁶ An additional factor which reduced the need for LNG in the Shtokman field is the American “gas revolution”, where the development of unconventional gas has dramatically altered the US need for increased imports of gas (Moe, 2010).

¹⁴ Matishov et al. (2009) outline the development of the Shtokman field.

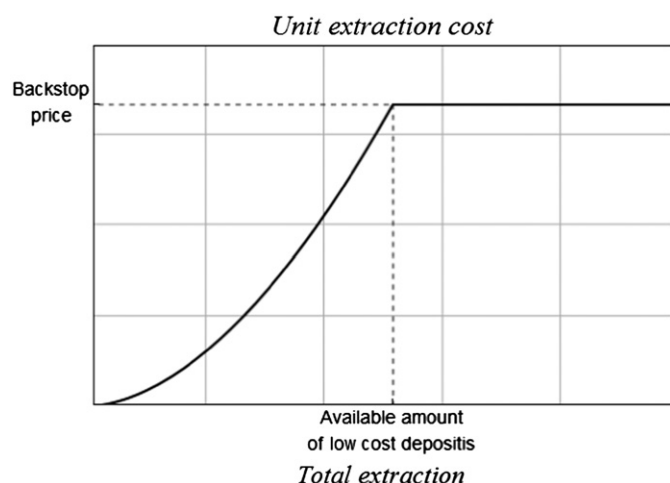


Fig. 2. Unit extraction costs as a function of total extraction, assuming an alternative available source of supply with high and constant unit cost, which are fully taken into use after passing the point of available low cost deposits. From Heal (1976).

Production from the Shtokman field was expected to begin in 2013, but final investment decisions on LNG production will take place by the end 2011, and production is now expected to start by 2016/17 (Gazprom.com). The decision to delay production illustrates how changes in demand affect the price of gas, determining whether marginal fields, such as in the Arctic, are opened or not. First, as a result of the financial crisis in 2008, the global demand for natural gas and oil declined in 2009 (IEA, 2010). Europe, in particular, was importing far less natural gas in 2009 (Stern, 2009) compared to 2008.¹⁷ The planned LNG export from Shtokman to the US market also has become superfluous as a result of the American gas revolution (Moe, 2010). Oil prices dropped to record lows, forcing developers to recalculate the cost of production (Moe, 2010).

Looking further ahead, towards 2030, Europe will, according to the European Commission and the US Energy Information Administration (EIA, 2010), increase its gas consumption substantially. Combined with the emerging powers of Brazil, India, and China (Brigham, 2010),¹⁸ the overall world consumption of natural gas is expected to increase by 50% in the next 25 years (EIA, 2010). Oil consumption is expected to increase at a lower rate, with a predicted increase of about 20% in the next 25 years. If these estimates are close to being correct, Arctic natural gas resources will become increasingly more important. Expanding oil and gas production in the Arctic will come at a relative high cost, however, making global energy demand, and consequently high prices, crucial to further development (Johnston, 2010).

A report from the Arctic Monitoring and Assessment Programme (AMAP) (Crandall et al., 2007) shows that, historically, increased development in the Arctic, that is, an increase in licences given by governments; seismic analysis; exploration and discovery wells; production wells; and finally production of oil and gas in the Arctic, is not closely correlated with high oil prices. The report also highlights an interesting, and often less regarded fact: high energy prices can increase overall Arctic oil and gas development costs, as transportation costs will increase.

It is important to bear in mind that oil is traded in a global commercial market, with common price setting and exchanges.

The potential customers and suppliers include almost all actors. In the international gas market, price setting is more complicated since the parties involved are for the most part tied together by pipelines, prohibiting an easy switch to other suppliers or customers. So far, gas prices have generally been tied to the price of oil. However, an increase in, among other things, LNG is likely to transform the gas market where hub based pricing will most likely replace the oil link (Stern and Rogers, 2011).

With regard to cost estimates, the available data is sparse, nevertheless there are a few studies worth mentioning. First, the IEA estimates that offshore Arctic production costs,¹⁹ including drilling, production facilities and operating and decommissioning components, are for the easiest exploitable resources around 35 US\$ to 40 US\$ per barrel (IEA, 2008). The more difficult resources to exploit could, on the other hand, cost as much as 100 US\$ per barrel. Second, Lindholt and Glomsrød (2008) model future oil and gas production under various oil price scenarios, finding that the price of oil needs to be around 80 US\$ per barrel in order to maintain current production levels in the Arctic. At oil prices of 120 US\$ per barrel and beyond, Arctic oil and gas production will increase significantly towards 2030, according to their model.

The EIA (2010) predicts an increasing trend in oil prices until 2035, with oil prices substantially higher than 80 US\$ per barrel. Currently the global production is about 85 million barrels of oil per day, and this number is expected to increase up to 100 million barrels per day by 2030 (Hughes and Rudolph, 2010). Exogenous shocks can however seriously affect production, as they did in 1973–74 and again in 1980, with extreme increases in oil prices and dramatic reductions in oil production.

Oil is traded in an imperfectly competitive market with few suppliers and many consumers. Expectations of future development, including external factors, also play a role both for the demand and supply of oil (Chevillon and Riffart, 2009). Expectations and knowledge about future investments, new fields, etc., may also cause business cycles in the oil prices (Jaimovich and Rebelo, 2009). When adding the technological development, which might influence the energy market and lead to a sudden drop in the back stop price on oil, we may conclude by stating that the future of oil prices is highly unpredictable both for consumers and producers.

A relatively long lasting steady oil price increase started in 2003 and continued until the financial crisis in 2008 (Kilian and Hicks, 2009). Hamilton (2009) points at three factors contributing to the increase in oil prices during the period up to the financial crisis. First of all, oil price elasticity was low during this period, meaning that changes in price had little effect on demand. Even though the price continued to rise, demand remained high. This was first of all explained by China's increasing imports of oil, a country which up to 1998 had been a net exporter of oil. Today China is the world's largest consumer of natural oil. The second factor, which Hamilton (2009) mentions, is the failure of physical production to increase. Finally, according to Hamilton, speculators partly contributed to the increase in price by miscalculations, which were influenced by the flow on investment dollars into future contracts. Also, Kilian (2009) shows that statistically the reserves of crude oil have a minimal effect on the price of oil.

The state of the global economy will be the most important factor for Arctic oil and gas development in the years to come. When the global economy was hit by the US banking crisis, which has had a worldwide spill-over effect, both the demand for and the price of oil plummeted. The financial crisis affected oil and gas drilling (as in the case of Iceland), and production (as in the case

¹⁷ Russia and China opened a new oil pipeline, which will supply China with 300,000 barrels of oil per day (Clover, 2010).

¹⁸ Offshore production price is crucial because about 80% of the undiscovered resources in the Arctic are located offshore (USGS, 2008).

¹⁹ Stern (2009) argues that the price of gas will most likely move away from its link to oil.

of the Shtokman field). Gas demand was equally affected by the recession. By 2009 the total reduction of gas demand was 5% (Pirani, 2009). As most natural gas is traded on long term contracts where prices (especially in Eurasia) are linked to the price of oil²⁰ (Stern, 2009), prices did not drop immediately. Gas contracts between European countries and Gazprom have in most cases been priced on the basis of oil prices that lag from six to nine months behind market prices (Pirani, 2009). This had a great effect on the long term gas contracts that were made in 2008 with a record high oil price. The financial crisis not only affected the demand for gas, but in addition, had serious implications for capital investment in new and on-going projects, as in the case of the **Yamal megaproject** (on the Yamal Peninsula in Russia). While most of the world's traded natural gas is transported by pipelines, Liquefied Natural Gas (LNG) is sold on market hubs and spot cargoes where prices are to a greater extent determined by current supply and demand in different regions (True, 2008). The LNG share of the total market has increased significantly over the last years, and increased production in the years to come is expected to reduce the current differences between the oil market and the gas market. As production in the Arctic is far away from the consumers, more LNG production is one of the more likely transportation scenarios. **The Statoils Snøhvit project was the first to produce LNG north of the Arctic Circle and others are expected to emerge in the future (particularly the Shtokman field and the Yamal project).**

The financial crisis not only influenced current gas demand, it is also affecting future supply. Gazprom has stated that it is expected to deliver 160 Bcm for 2010 and furthermore 168 Bcm per year for the period stretching from 2020 to 2025, which is substantially lower than the earlier estimates released (Pirani, 2009). Honore (2010) points out that European gas demand is constantly being revised downwards by the IEA (Pirani, 2009). **Russia, which is one of the countries that is expected to significantly increase its gas production, might lose its dominant position in Europe if increased LNG export from the US and Qatar becomes a reality (Pirani, 2009). This may have serious implications for the development of gas production in the Arctic.**

The financial crisis and how it has affected oil and gas demand and investments serves as an illustration to the argument made by Brigham (2010), in that the state of the global economy is the single most important driving factor for increased attention to the Arctic. Considering the counterfactual, even though ice melting continues and governments are handing out new drilling licences, a downturn in the global economy will make increased production in the Arctic less likely to occur. **Furthermore, as production cost is higher in the Arctic compared to other oil and gas producing regions, the region is even more vulnerable to changes in the global economy.**

5. Will governments encourage or block increased activity?

While all the Arctic countries are officially concerned about how climate change is affecting the Arctic, as has been stated in reports from the Arctic Council, no government has decided to dramatically reduce its Arctic oil and gas production. They ostensibly recognise that CO₂ emissions are more than likely to increase the already rapid changes in the Arctic climate, but there is nothing indicating that they have sought measures to significantly reduce ongoing production, for example by the use higher taxes on CO₂ emissions that would have serious effects on the willingness of oil companies to maintain current output, and furthermore invest in new projects. One could thus argue that the

need for energy supply and state revenues are valued above environmental concerns.

Young (2009) argues that, contrary to common perception, the Arctic region is not in need of a specific Arctic treaty. The Law of the Sea has been ratified by all the Arctic states except the United States, and even though there are legal disputes still to be resolved, a future military or hardened political confrontation between two or more Arctic states seems highly unlikely. More specifically, with regards to Arctic oil and gas development, various international agreements and conventions have also contributed to a stable and relatively friendly Arctic hydrocarbon development between the countries in question.²¹

On the other hand, there are notable differences between the Arctic states that are worth exploring. The Arctic countries vary in size, population and regime type, and it is therefore worthwhile thoroughly investigating the current oil and gas producers' Arctic policies.

5.1. Russia

Russia, since the beginning of the "Putin era", has nationalised most of its energy sector. **Gazprom, which handles 87 percent of Russian gas production (Moe and Rowe, 2009), became state owned in 2005, 12 years after Yeltsin had privatised the company. Putin's centralisation policies had serious implications for international companies such as Shell, which was forced to sell a majority of its share of the Yamal megaproject to Gazprom.** Nationalisation of the energy sector was needed, according to Putin and his governing elite, in order to strengthen the central government by among other things increasing state revenue (Light, 2008). **As soon as the energy sector was brought back under state control (as in the days of the Soviet Union) oil prices started to soar, and the Russian government (through Gazprom) decided that the country would heavily invest in new production facilities in the coming years. Russia, in order to continue being the world biggest supplier of oil natural gas, will eventually have to increase production from the Arctic.** The Russian government targeted specific oil and gas production levels in 2003, but due to the world economic crisis did not propose fixed production volumes up until 2030 (Bambulyak and Frantzen, 2009).

Furthermore, even though the Russian government has ratified the Kyoto treaty, **the governing elite is not, according to Baev (2007), particularly worried about global warming, and is therefore not likely to invest in new forms of energy.** In addition, offshore hydrocarbon resources are defined as "strategic natural resource assets" (Moe and Rowe, 2009). **One can thus conclude that the Russian government is not likely to put constraining measures on the Russian hydrocarbon industry. According to Baev (2009), Russia is not dependent on increased production from untapped offshore Arctic fields in the near future, and it is therefore not self evident when Russia will increase production and investment.** However, if one takes into account that Gazprom production is challenged, as the output of three of the four major fields may decline after 2010, one may see an increase in Arctic activity (Moe and Rowe, 2009). Russia has the most developed infrastructure of all the Arctic nations, with, among other things, 25 ice breakers, and has constructed pipelines of record-breaking lengths from the Yamal peninsula in Siberia (Hammer, 2010). Two major "Arctic projects" that are currently under development and production in Russia (and will represent a substantial part of the new Russian production) are the Shtokman project and the Yamal megaproject. **The former of these fields is estimated to contain 3.8 trillion m³ of gas, and the latter 16 trillion m³ of gas reserves**

²⁰ The AMAP report (2007) outlines the various international agreements relevant to Arctic oil and gas development.

²¹ For a more detailed account of Russian offshore strategy, see Moe (2010).

(Bambulyak and Frantzen, 2009). Russia's problem, however, lies in obtaining foreign investment and attracting the companies that possess the new technology that is required to increase production. **In recent months, for example, the BP-Rosneft Arctic offshore venture broke down, as Russian investors blocked it (Wall Street Journal May 24, 2011).** Russian legislation has, among other things, restricted foreign investors' ability to acquire stocks in Russian companies (Moe and Rowe, 2009). On the other hand, Moe and Rowe (2009) shows that Russia is, in order to attract offshore investment, willing to give the "finders" rights to production and development. The authors note that Russia lacks a coherent Arctic strategy. Furthermore, both Gazprom and Rosneft are in need of investment and capital. Gazprom is said to need an annual investment of around 18 billion US\$ until 2030 in order to maintain its output (Simmons and Murray, 2007). **The Russian government is thus on the one side encouraging increased Arctic oil and gas activity, and on the other side indirectly constraining development by pursuing policies that are hostile to the foreign direct investment on which increased development is, and will in the future, dependent.**

5.2. Canada

Canada has 40% of its land mass located in the Arctic, and has therefore considerable interests in the far north. In an Arctic strategy paper (2010), the Canadian government explicitly states that environmental changes are of great concern to Canada. This strategy paper points out that the Arctic Offshore Oil and Gas Guidelines from 2009 of the Arctic Council was with Canadian participation, and that Canada seeks to follow these guidelines. Furthermore, the country has decided that offshore drilling in the Beaufort Sea will not take place prior to 2014, and that a National Energy Board will review it (Government of Canada, 2010).

On the other hand, Canada, the world fifth largest energy producer, has considerable oil and gas interests in the Arctic, as it seeks to maintain its current production levels. **Although the Canadian government publicly states its concern for the environment, it has not sought measures that would stop, decrease or discourage oil and gas activity in the high north.** The following should be considered: first, in 2007, Imperial Oil and ExxonMobil won a 585 million US\$ bid for the Beaufort Sea. Second, in 2008, six companies were granted licences to explore for oil and gas in the Mackenzie Delta and Beaufort Sea. Finally, in 2008, the government itself announced that it would spend 100 million US\$ over the following five years in order to further discover and map out Canada's energy resources in the high north (Parliamentary Infoseries, 2008). One should nevertheless not forget that the Canadian environmental and regulatory process is complex and thorough, where both local and regional authorities are involved (Crandall et al., 2007). Looking further ahead, increased Canadian Arctic production is not only conditional on government regulations. As Canada is one of the main suppliers of oil and gas to the US, increased Canadian Arctic production will be co-determined by, among other things, the US demand for increased imports of hydrocarbons, and the relatively high energy prices. As such, the Mackenzie Gas Project, which includes a 1200 km pipeline from the Arctic to Alberta, may come to fruition in the near future (Crandall et al., 2007), a project which would make Canadian Arctic gas production more easily transported, and thus contribute to new drilling and production in the years ahead.

5.3. The USA

Contrary to common perceptions about US policies on climate change, the United States has been cautious about oil and gas development in the Arctic. Even when George W. Bush enjoyed a

majority in both houses, the US government did not allow full scale drilling, due to opposition from both parties in Congress (Rabinowitz, 2009). On other hand, the US refused to sign the Kyoto protocol, and has been reluctant to commit itself to substantial CO₂ cuts. For the last 50 years, US Arctic oil and gas development has been controlled by local, regional and global players. Furthermore, various departments and agencies have developed systematic leasing schedules (Crandall et al., 2007). **In 2009, US Arctic Policy was outlined in a National Security Presidential Directive.** The directive outlines US energy interests in the high north, and emphasises the need to protect US hydrocarbon reservoirs (NSPD-66, 2009). The directive also acknowledges the need for environmental protection, and the preservation of indigenous peoples' way of life.

The US is currently one of the world's largest importers of oil, and relies heavily upon imports from the Middle East. Further development of Arctic hydrocarbon resources is in that perspective very attractive to the US government as the reserves in Alaska are, according to the USGS (2008), estimated to be oil rich. As such, the US recently conducted exploratory missions to the Chukchi Plateau to investigate an undersea ridge in Alaska. However, the US lacks the icebreakers and other equipment needed to continue this work (Hammer, 2010).

Increased activity is not only focused on the need to be less dependent on oil imports, but is also conditioned on how the general public views climate change, and the risk of oil spills and their impact on the environment and people's lives. The oil spill in the Gulf of Mexico could thus have a serious impact on further development in Alaska. The fact that people lost their jobs as a result of the oil spill has arguably contributed to the fact that the US government decided to review Arctic drilling licences that were given to companies before the spill. On the other hand, an international conflict, a financial downturn or another form of exogenous shock that would limit the US access to oil imports will most likely significantly increase oil and gas activity in Alaska. (Rabinowitz, 2009).

5.4. Norway

Norway, as one of the world's largest exporters of natural gas, has genuine interests in oil and gas production in the Arctic. At present, Norway is the sole producer of LNG in the Arctic, with its production from the Snøhvit field. In addition, the Norwegian parliament approved the development of the Goliath oilfield outside Hammerfest in 2009. The need to maintain and increase Norway's current oil and gas production is important to Norwegian decision-makers. The country is heavily dependent on the oil and gas sector, as the industry accounts for more than 25 percent of the Norwegian GNP, and more than 50 percent of Norway's total exports (Arbo, 2010). Increased attention to the high north has come about partially as a result of the fact that Norwegian output has declined during the last few years (EIA, 2010). If Norway wants to continue its current output level, Arctic oil and gas activity must increase.

On the other hand, Norway being a strong supporter of the Kyoto agreement, and an advocate for a worldwide reduction of CO₂ emissions, has appeared to be somewhat reluctant in recent years to increase development in the Arctic. The government introduced a tax on CO₂ emissions in 1991, and has yet to approve development in Loosen, as it could potentially disrupt fishing and tourism. However, the government is also encouraging further development of the oil and gas sector, which is stated in the current administrations "high north" policies (Arbo and Hersoug, 2010). Increased development in the Norwegian Arctic area is therefore hard to predict. Arbo and Hersoug (2010) discuss the complexity of the Norwegian "oil and gas game", in which the oil

companies, government and environmental organisations all seek to influence decisions. In some areas, environmental concerns have so far triumphed (Lofoten and Vesterålen), while in others profit maximisation has been salient (Hammerfest). It is therefore safe to assume that increased development in the Arctic will vary from region to region. Overall the Norwegian government will take into consideration the need for increased income, environmental concerns, and, perhaps most importantly, public opinion.

5.5. Greenland/(Denmark)

If oil prices continue to soar, and if China and India continue to grow at a rapid rate, one of the most likely new oil and gas producing Arctic states over the next decades is Greenland. The country covers a vast area, and exploration drilling has been ongoing for a couple of years. **In 1992, the Geological Survey of Denmark and Greenland discovered oil seeps on the south west side of the Nuussuaq Peninsula, and Statoil gathered valuable information when they conducted exploratory drilling in 2000** (Crandall et al., 2007). Furthermore, there have been several licensing rounds going back to 2002. Both the industry and the USGS (2008) expect substantial discoveries in Greenland in the near future. As a result the licensing rounds in Greenland have attracted huge interest from the industry, especially the area covering the Baffin Bay off the west coast of Greenland. Moreover, Greenland is expected to launch new licensing rounds in 2012 and 2013, increasing the likelihood of significant findings.

As of today, several oil and gas companies are thought to be in dialogue with Greenland regarding exploration and drilling (Webb, 2010). **However, authorities in Greenland are stressing the need for an “oil spill” clause which would guarantee that the oil and gas companies will cover clean-up costs.** To that end, the Greenland authorities are said to be demanding that each company pays an upfront “clean-up bond”, thought to be valued at 2 billion US\$ (Webb, 2010). **Ever since 2009, Greenland has been in charge of its natural resources** (Government of Greenland, 2008), and therefore controls the rate and pace of oil and gas exploration. Negotiations are, however, complicated as Denmark is still responsible for Greenland's foreign policy, and must therefore sign off on any oil contracts made with foreign companies. On the other hand, Greenland, due to income from its natural resources, will become less reliant on subsidies from the Danish central authorities. Consequently Denmark's foreign policy control will gradually decline.

6. Conclusion

Predicting future oil and gas production levels in the Arctic will always be difficult. This study has shown that Arctic oil and gas production is dependent on a complex set of variables, which alone or combined will determine further development. First of all, the Arctic environment is extremely difficult to operate in. As the Arctic climate is changing (i.e., the temperature is increasing, the Arctic ice is declining, and so forth) it becomes increasingly difficult for the industry to make long term plans and predictions. It is also increasingly difficult to use long term historical data to make cost effective decisions regarding the use of the right production and transportation facilities. Second, as the Arctic region is “extreme”, development and production costs are high compared to other hydrocarbon rich regions. Thus, a sudden shift in demand or price could potentially have a great effect on future Arctic hydrocarbon production. Third, as the costs are high, governments have on several occasions taken the lead in developing Arctic oil and gas fields. Hence, one must consider the policies of the various Arctic oil and gas producing countries.

Development will not take place without approval and encouragement from government decision-makers seeking to boost state revenues.

On the other hand, even though the obstacles for the hydrocarbon producing industry are formidable in the Arctic, there are strong signs that new fields will be developed in the near future. In Russia, the world's largest exporter of oil and gas, Arctic development is going forward, although not at the pace some commentators predicted a few years ago. Nevertheless, since the Russian energy sector is mostly state owned, increased Russian Arctic activity is less sensitive to global economical changes. The Stokhman field will after countless delays most likely start production before 2020, and on the Yamal peninsula, offshore production will become a reality in the near future. Regardless of state owned energy companies (e.g., Statoil and Gazprom), the state of the global economy and specifically the demand for non-renewable energy will be crucial for further development. International and multinational companies are dependent on relatively stable and high energy prices in order to invest in new high cost activities in the Arctic. Lastly one should bear in mind that the industry has, historically, tackled the harsh arctic environment extremely well. In Newfoundland and Alaska platforms have been designed to be able to withstand floating icebergs, and in Norway (e.g. Snøhvit) subsea installations have made gas transportation safer.

Acknowledgement

This work has received funding from the European Union's Seventh Framework Programme under grant agreement number 226248 - ATP. We thank our colleagues at the ATP team and Ann-Sophie Crepin and Paul Renaud in particular for their support. We are also grateful for valuable comments from Peter Arbo.

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