Arctic Offshore Hydrocarbon Resource Development
Past, Present and Vision of the Future

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Abstract

Energy issues have always been on the global economics and geopolitics agenda, even though energy sources have been changing over time.

In recent years, the awareness of Arctic offshore oil and natural gas development has escalated, yielding economic opportunities and incurring risks. The offshore Arctic is one of ‘edges’ of the global petroleum industry. The importance of these oil and natural gas resources extends beyond regional and national boarders and local economies, as these activities have become a key geopolitical, economic, and social concern. In an attempt to shed light on this growing issue, this thesis outlines the Arctic is a link in the global energy system and shows how it plays a special role.

The aim of this research is to provide deeper insight into offshore hydrocarbon development activities in the Arctic. Historical approach is applied as a main conceptual framework to provide a critical link of past to the present in order to explore the origin and intensity of these activities in the Arctic.

This licentiate thesis presents the results of an ongoing doctoral research project. The study provides several insights into Arctic offshore oil and natural gas resources development in the global context via an analysis of the relevant investments and technology from a country-by-country and historical perspective in the maximum period time frame between 1920 and 2025. The two papers included in this thesis explore the impact of investment and technology. This research project illustrates the importance of several factors influencing the Arctic offshore oil and natural gas production and highlights the most promising areas for cooperation at the industrial and global level.

The implications of the study results can be useful for identifying and emphasizing the factors that influence offshore Arctic hydrocarbon resource development and investment trends, as well as making assumptions regarding future development. Topics for further research are discussed and refined relating to the ongoing study and the conceptual framework presented.

**Keywords:** Arctic, oil and natural gas, resource development, investment trends, offshore technology, production volume, projection, historical framework
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Stockholm, sunny 18th of March, 2015

Maria Morgunova
List of appended papers

This thesis is based on work presented in the following articles.

**Paper I**


**Paper II**

Morgunova, M. Role of technology in expanding accessible oil and natural gas resources in the offshore Arctic.
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Introduction

Energy issues have always been on the global economics and geopolitics agenda, even though energy sources have been changing over time. People’s inevitable need to cook and to heat their houses can drive the energy industry. In the reality of globalization and increasing world population - which in 2013 had reached 7.2 billion (UN, 2013) and is projected to reach 8.3 billion (BP, 2013a) - more people are becoming energy consumers.

Economic activity is a principal driver of energy demand, which has increased dramatically worldwide since 2000. According to BP Energy Outlook (BP, 2014a), 2002-2012 recorded the largest-ever growth in energy consumption (in volume terms). Most projections foresee an energy demand growth of up to 37% from today’s demand by 2040 (WEO, 2014). Although new concepts of sustainable living, energy efficiency and renewable energy technologies have become more real in the last two decades, the issue of energy sufficiency is pending. Due to energy efficiency, energy consumption can be decreased in Europe and the United States of America (the USA) but not in the developing world (SWP, 2014). Most projections predict that fossil fuels will dominate the global energy balance for the next two decades (WEO, 2013, 2014; BP 2014a, 2014b; Shell, 2008); neither technological change nor market conditions are likely to shift global fossil fuel consumption in the coming century.

Simultaneously, one of the most challenging trends in the oil and natural gas industry is the depletion of major traditional oil and gas reserves. Peak oil, or the time at which there is a conventional oil and gas shortage and a steep decrease in conventional production will be unavoidable (Bentley, 2002; Deffeyes, 2001), is a very negative view. Although it is necessary to pay attention to the challenging trends of traditional oil and gas reserve depletion, peak oil has ongoing relevance (Chapman, 2014); a less radical view is that peak oil means the end of the era of cheap oil (Hirsch, 2005; Owen et al., 2010; Robelius, 2007).

Powerful changes are occurring in the global energy system, in which energy is both "the answer to and the cause of" urgent issues (WEO, 2014:1). Sanctions against Russia and instability in traditional oil-producing regions are major short-term concerns faced by energy markets. Changing architectonics of global energy balance and production bring additional instability to the markets.
It is not easy to change the global energy trend (WEO, 2014:1). The depth of energy needs and emergent issues of energy supply security are the subjects of global energy concerns. The energy industry is searching for alternatives. Currently, world petroleum production is dependent on the Middle East and Northern Africa, other politically unstable suppliers and peak oil fears. The global community has already begun to prepare a transition to unconventional sources of oil and other alternatives (Greene et al., 2006). For example, the heavy-oil fields of Venezuela, the Athabascan oil sands in Canada and shale gas in the USA have already found their places in the global energy balance. The temporary solution lies in the world’s huge unconventional hydrocarbon resource potential: oil shales, coal bed methane, gas hydrates, shale gas, deep-water and ultra deep-water resources, etc., all of which are opened up by new technologies and market needs (Bardi, 2009; Chapman, 2014; Greene et al., 2006; Rogner, 1997). These unconventional resources are less attractive compared to conventional light crude oil because of their higher price and need for new technologies (Adelman, 2003; Greene et al., 2006). However, they are highly promising (IEA, 2008) and sometimes already considered by energy reviews as conventionals (Sorrell et al., 2010).

In an effort to guarantee energy independence and the reliability of energy supplies (for instance Bielecki, 2002; Correljé and van der Linde, 2006; Stern, 2002, Winzer, 2012 and others), both developed and developing countries continue to move forward in the search for new resources. Today, the above mentioned challenges - along with new exploration approaches and comprehensive technologies - have moved the energy frontier to distant, hard accessible and politically stable (Heininen, 2005) regions such as the Arctic (Zolotukhin et al., 2012).

The offshore Arctic is one of ‘edges’ of the global petroleum industry. Corporate and government interest in oil and natural gas activities in the Arctic region has recently occurred with renewed force and has become a key geopolitical, economic and social concern (ex. Palmer, 2009; Stokke, 2011; Blunden, 2012; and others). However, the origin and intensity of these activities in the Arctic have not been fully revealed. The Arctic is a link in the global energy system and plays a special role. It is an important region from the perspective of sovereignty, mineral resources extraction and transportation, and raises issues related to indigenous interests, involvement of other Arctic countries, and potential sources of economic advantage.
Why does the Arctic matter?

The Arctic covers as much as 11% of the world’s surface area. It is the region of spacious Northern territories and unbounded Arctic waters. This is only one reason that the Arctic receives so much attention. Many studies argue the importance, power and causal relationships of the factors that drive interest in the Arctic. The Arctic is “an emerging space of and for geopolitics” (Dittmer et al., 2011:202) and a region of the globalized world with a variety of intersecting economic and political interests.

Today, there is a wide-ranging debate on the Arctic. To address a variety of global challenges, more research is focused on regional socio-economic and geopolitical development, environmental issues, geopolitical claims, potential energy resource extraction and increasing competition for resources. The following literature review on Arctic issues serves a double purpose: it provides both a research background and a way to identify the forces that drive interest in the Arctic.

The reviewed literature addresses the social sciences (particularly economics) and energy issues. It consists of recently published books, reviews and academic papers. The targeted literature represents studies of aspects of geopolitics, economics and resource management; it also estimates and forecasts the Arctic’s future both qualitatively and quantitatively. The periodical literature that studies the Arctic and its potential resource utilization (e.g., hydrocarbons, other mineral resources, water, biological resources, transport routes, etc.) has significantly increased during the last decade, providing ample opportunities for exploration. The keywords for the literature search were the following: Arctic, shelf, offshore, development prospects, natural gas, oil, petroleum, hydrocarbon resources, natural resources, extraction, production, fields, Arctic future, development factor, factors influence, drivers, driving forces, history, historical study, and historical perspective.

Numerous recently published books research Arctic geopolitics, resource and sovereignty issues from a wider perspective. Charles Emmerson’s “Future History of the Arctic” (2011) explains the history of the Arctic in a globalized world, describes its contemporary state and aims to understand its future. Michael Byers’s (2009) book, “Who owns the Arctic? Understanding sovereignty disputes in the North”, is tightly focused on sovereignty issues. A more precise investigation of the Arctic’s place in international relations in a
historical, political, and legal context is conducted by David Fairhall (2011). The focus on resources is presented as the ‘Arctic gold rush’ by Roger Howard (2009). There is a broad discussion on hydrocarbon resources that might be offshore. The key issue of these studies is the Arctic as a region, which has become prominent in global politics and economy due to its re-evaluated importance. These studies are mostly qualitative. They are based on historical data and review the current legal framework, geopolitical and economic situation as described in both primary and secondary sources. Young (2011) characterizes these books on the Arctic as “explaining the ‘new’ Arctic in terms easily digestible for the wider public” with large-scale socioeconomic and geopolitical processes. To Young (2011), this literature provides the raw materials to construct answers to global questions: in most cases, geopolitics is taken as a starting point.

Reviewing the academic literature, the second-largest block of topical literature is dedicated to Arctic governance and changing management in the Arctic region (Holland, 2002). During the past twenty years, Arctic nations have formed “an initial framework for cooperation” (Huebert & Yeager, 2007:5) to address common challenges in the region, beginning with some environmental and nature-protection treaties. This is the example of the Arctic Council - the best-known institute of Arctic governance arrangement (Smits et al., 2014) - which was formed to address environmental issues and to promote both sustainable development and cooperation among governments, institutions and indigenous people. However, those same factors comprise the politics in the Arctic controversy (Emmerson and Lahn, 2012), including the high political tensions resulting from the opposing interests of the interested parties at different levels. Territorial claims by the five Arctic countries (Dodds, 2010) and other demarcations (Borgerson, 2008; Huebert, 2003) represent only a small portion of Arctic disputes. Ongoing Arctic territorial claims, climate changes and the accessibility of sea routes have resulted in considerable geopolitical speculation (Dodds, 2010:72). In the fields of diplomacy and international relations, some authors argue, the Arctic is a special region that consists of remote lands of several Northern states (Young, 2005) that are governed from faraway political centers. This makes Arctic governing and the Arctic region itself a special case. Others argue that there are no political structures to provide stable regional development (Borgerson, 2008). Some differences in regulatory regimes, standards and overall governance may be found among the Arctic states, thus causing international relations in the region to take on a more confrontational character. Military and sovereignty issues in the Arctic unfold in a more radical
way, including the possibility of military conflicts (Dittmer et al., 2011; Huebert, 2003; Jensen and Rottem, 2010); opposing opinions (Baev, 2007) target cooperation and stability. However, the Arctic is a truly important strategic (and military) region, especially for Russia and the USA (Heininen, 2005). Generally, the Arctic is a stable region with normalized political relationships among the Arctic states (Emmerson and Lahn, 2012:32).

The Arctic is at the centre of numerous climate studies and reports. This is because of the region’s natural vulnerability, and especially in the face of climate change (Arctic Climate Impact Assessment, 2004; IPCC, 2007; and others), due to dramatic recent changes and the speed with which those changes have occurred (Comiso et al., 2008). Sea ice is melting due to increasing temperatures (for instance, see Kattsov et al., 2011; Ridley et al., 2007), and many other events (Hinzman et al., 2005) create challenges for nature (Derocher et al., 2004), business and society. Climate change affects economic sectors and mining industries, along with both infrastructure and transportation (Prowse et al., 2009). Simultaneously, some authors argue that climate change is the primary cause of the ‘Arctic rush’ (Borgerson, 2008; Ebinger and Zambetakis, 2009; Peters et al., 2011) and the most suitable area to cooperate in the region (Numminen, 2010). From a global perspective, climate change in the Arctic is becoming a global environmental security issue (Dalby, 2002), which has implications for all of the Arctic’s activities.

Indigenous peoples’ rights (Nicol, 2010), recognition of their rights and protecting the security of their traditional lifestyles (Tennberg, 2010) are included among the Arctic’s important issues. Indigenous recognition and diplomacy are not new, but recently have been noticed (Beier, 2010). Indigenous people have become important political actors, raising their voices to communication about Arctic political and economic activities.

There are numerous economic opportunities in the Arctic region. Natural resource management is of a complex Arctic issue; sometimes, it is considered a separate factor in the international affairs context (Borgerson, 2008; Powell, 2008; and many others). The Arctic Seas are opening up for shipping because of melting ice. This creates legal issues (Jensen, 2008) and implicates social and economic interests for indigenous people, Arctic governments and non-Arctic states (like China). Shipping also provides new opportunities to explore the Arctic resources (Blunden, 2012; Brubaker, 2001). Use of the Northern Sea Route (NSR) and The Northwest Passage (NWP) increases possibilities both for national (Russian and Canadian, respectively) economic development and for
international transit (Granberg, 1998; Parker and Madjd-Sadjadi, 2010). Additional ice melting can improve local economies (Somanathan et al., 2009) if geopolitics (such as sovereignty claims and military issues) related to shipping routes remain stable and favor international transit.

Consequently, numerous factors make the Arctic a challenging and interesting issue to explore: geopolitics, governance, climate change, indigenous issues and economic opportunities. “Lawyers, energy economists and military strategists trained to envisage the northern regions in very different ways” (Powell, 2010:76) stressing their own interests. Most disciplines that address the Arctic have a clear perspective, but it is difficult to choose between “treating the Arctic as a suitable subject for an integrated [policy]” study or “a discipline-by-discipline functional basis” (Kildow, 1983:232). Arctic issues enter a whirligig in which the Arctic is presented as ‘bonanza’, a region with new strategic transport routes and immense biological resources (Dittmer et al., 2011; Powell, 2008) in which resource exploration requires further development of the region’s infrastructure (Heininen, 2005), and the prospects of Arctic offshore oil and gas exploration advance governmental development (Humrich, 2013:80; Huebert and Yeager, 2007:4). Again, the indigenous community participates in economic and industrial changes to secure their rights (Nuttall, 2006; Stern, 2006). Overall, the urgency of the delimitation issues, economic factors and technological possibilities motivates the international and business communities to elaborate further governance in the Arctic region, namely, offshore.

The study area is highly promising because “not all activities will be what they seem to be” (Avango et al., 2010:10). This study provides a space to explore these activities, particularly given the Arctic’s changing geopolitical and economic setting. Following the aspiration of Arctic pioneers, the study aims to discover the Arctic of economic opportunities and to obtain deeper insight into offshore hydrocarbon development activities. Lack of quantitative data on oil and natural gas fields’ exploration and development costs, oil and natural gas production costs and production volumes set according to commercial value limits most studies to qualitative estimations and forecasts, whereas empirical and historical data provides a variety of ways to untangle these issues. In this, the central issue is the gap in structured, longitudinal and consequential research into Arctic offshore hydrocarbon resources development. Aiming to provide deeper insight into Arctic offshore hydrocarbon development activities, several questions arise. The first question relates to a simple delimitation, because the Arctic is huge. What exactly is the Arctic and the offshore Arctic? The second
issue that must be clarified is the following: What is the Arctic offshore oil and gas experience? There are many oil and gas projects worldwide that can be called ‘Arctic’ or that at least are similar to ‘Arctic conditions’. Finally, we examine the primary question that targets our goals: What is the scope of Arctic offshore oil and natural gas development?
Oil and natural gas in a changing Arctic

Arctic regions are either northern regions or the five Arctic countries with sea outlets - Canada, Greenland (Denmark), Norway, Russia and the USA - and the three Arctic countries without sea outlets - Finland, Iceland and Sweden. Fewer than 4 million people permanently live in the Arctic (UNEP, 2008). At the circumpolar level, the Arctic region with 0.2% of the world’s population generated 0.5% of global gross domestic product in 2005 (Mäenpää, 2008). Today Arctic is a region in which economies are built on natural resources. These resources are used both for internal consumption and for exports. Following is some information about the population and GDP distribution of the Arctic economies. According to Duhaime and Caron (2008), the first group of Arctic regions is fully oriented towards large-scale extraction of non-renewable resources as fossil fuels and minerals (i.e., oil and natural gas on the North Slope of Alaska in the USA, the Khanty-Mansi Autonomous Area in Russia, nickel in Norilsk and the Kola Peninsula in Russia, diamonds in the Northwest Territories of Canada and gold in Chukotka in Russia). The second group uses natural renewable resources such as fish and wood. The Russian Arctic economy is the largest. It generates more than 10% of Russia’s GDP (approximately 70% of the Arctic’s total GDP) and more than 20% of its exports (oil, natural gas, minerals, fish). Canada and Denmark (Greenland and the Faeroe Islands) take second and third place after Russia by Arctic territory size, but both their populations and their economic activities are much lower. In other Arctic countries - Finland, Iceland, Norway and Sweden - population and industries are relatively large compared to national levels. In Canada and the USA, the Arctic population is approximately 1% of the country. Economic growth in the Arctic regions is double that of non-Arctic regions. Growth rates are very high in regions that recently have started to produce oil and natural gas (e.g., Russia’s Evenk Autonomous Area). At the same time, the spread between regions’ economic development and industrial distribution is relatively substantial. Four Arctic regions generate more than 60% of the Arctic’s total GDP (the Khanty-Mansi and Yamal-Nenets Autonomous Areas in Russia’s Republic of Sakha and Alaska in the USA). In addition to the Arctic’s substantial economic opportunities, the socio-ecological impact of extractive industries is significant and hydrocarbon resources play a substantial role.
The history of Arctic oil and gas exploration

The Arctic region was not always economically oriented toward resource extraction. Historically, the scope of human activity in the Arctic has significantly changed. Previously, people challenged the Arctic’s harsh climate conditions and remoteness; they strived for uncertainty and were willing to be the pioneers in the land of eternal cold and ice. In the beginning of the 20th century, the North Pole “was one of the very last places on earth which had not been mapped, explored or claimed by a ‘modern’ state” (Emmerson, 2011:99). Military and sovereignty factors attracted most of the attention both before and after the Second World War. Only 50 years later, a new, extremely powerful and important factor arose. That factor was energy economic needs in conjunction with geopolitical factors, which together have transformed the Arctic into a “major goal of exploration” (Emmerson, 2011:15).

Commercial oil and gas activities have been taking place in the Arctic for more than 90 years, starting in the 1920s in Norman Wells in Canada’s Northwest Territories, northern Russia and Alaska. During World War Two, extensive oil and gas exploration was launched in northern Alaska, northern Russia and Canada’s Mackenzie Delta (AMAP, 2007). In the 1950s, new trends in Arctic exploration arose and further development and understanding of the great importance of the northern territories caused a transformation in public opinion about the economic value and meaning of the region.

During the 1960s and 1970s, events in the Middle East provided powerful and persuasive reasons for Arctic development. Political instability in the major oil exporting countries made development of oil fields in the Arctic both commercial and advisable. When oil prices significantly increased in the 1970-1980s, Arctic oil and natural gas became an attractive investment for both governments and companies.

In the USA, oil and gas industry in the Arctic began to develop in 1958 with industry-sponsored exploration drilling. During 1968 and 1969, 13 discoveries were made, including large oil and gas reserves on Alaska's North Slope. The Trans-Alaska Pipeline System was completed in 1977, allowing production to begin at Prudhoe Bay and nearby fields. The 1960s were productive for oil and gas discoveries in Russia in the Yamalo-Nenets Autonomous Okrug and the Nenets Autonomous Okrug, where production began in 1972 and the 1980s, respectively. In Canada, cooperation between government and industry resulted in the creation of the Panarctic Oils Company. Sometime
later, in the 1970s, Canadian government investments led to offshore exploration drilling and huge discoveries in the Mackenzie Delta and the Beaufort Sea. Since that time, nearly 90 wells have been drilled in the Beaufort Sea, 34 wells have been drilled in Nunavut’s High Arctic Islands and 3 have been drilled in the Eastern Arctic offshore (AMAP, 2007). Greenland also entered the Arctic hydrocarbons exploration ‘club’ with test drillings in 1976 and 1977 (and later in 1990), which occasionally failed to prove economic feasibility of resources development.

Though the exploration and development of Arctic hydrocarbon resources is both challenging and expensive, and much of the region lacked the necessary infrastructure to transport oil and gas to the major markets, billions of dollars’ worth of both oil and gas has been produced in the Arctic regions of Canada, Norway, Russia and the USA since the 1970s (AMAP, 2007).

By the 1980s and 1990s, oil and gas activities extended further along the Arctic frontiers. In Canada, the small field Bent Horn was developed in the islands of the High Arctic thanks to a new technological approach. The Norman Wells field made a comeback in the early 1980s when a pipeline was built south to Alberta, though a bit later oil and gas exploration and production activities in Canadian Arctic almost stopped, because of a lack of infrastructure, changing market conditions and governmental policies. Norway started operations in the Barents Sea in 1981 and the Norwegian oil company Statoil discovered a huge Snøhvit gas field. Offshore exploration in Russia have also opened up large resources potential, as in the Shtokman and Prirazlomnoe fields, but the breakup of the Soviet Union led to a steep decrease in production in the 1990s. Conversely, a new period of exploration of northern Alaska arose. Exploration extended to offshore frontiers, new offshore discoveries were made, near shore fields were developed and production began.

Interest in exploring the Mackenzie Delta and Beaufort Sea has increased in recent years with the announcement of the construction of the Mackenzie River Valley pipeline. New licenses were issued in these regions in 2007 and 2008. The North Slope may also enter an intensive exploration phase if a natural gas transportation pipeline is built in the near future. Greenland’s offshore development strategy changed in 2010, when oil company Cairn Energy discovered hydrocarbons for the first time and the first offshore oil and gas exploration licenses were granted (Ernst&Young, 2013).
Comparatively high oil prices, political instability in major oil and gas exporting countries, government incentives and new technological approaches opened the Arctic frontier to future oil and gas production in the 2010s. Today, an exploration process is unfolding in Alaska (US), offshore Greenland, the Norwegian Sea and the Barents (both Russia and Norway) Sea. The first oil from the Beaufort Sea could be delivered as early as 2020 and from the Chukchi Sea after 2022. Norway plans further expansion of the Barents Sea as its main petroleum province in future years (Ernst&Young, 2013). Russia’s goal is to intensify the development of Arctic petroleum resources offshore as its primary strategic issue related to its stability and prosperity, which is why two state-owned companies - Gazprom and Rosneft - are advancing seismic research and exploration of oil and natural gas fields in Arctic waters.

As can be seen from this brief historical overview, the factors that stimulate Arctic oil and natural gas development are not very different from those encouraging today’s interest in exploring the Arctic region. They include the geopolitics of energy resources, the economic interests of both industry and government, strategic and governance issues, and the availability of technologies and infrastructure. These factors shape decisions about exploring hydrocarbon resources in the Arctic.

**The USGS breaks the Arctic ice**

There are undoubtedly issues other than external ones for the economic interest in exploring Arctic resources. For example, there is a possibility of highly promising oil and natural gas resources according to the United States Geological Survey estimates (USGS, 2008a, 2008b). At the same time, probability assessments of Arctic hydrocarbon resources made by United States Geological Survey (USGS, 2000, 2008a, 2008b), Wood Mackenzie (2006) and others are controversial. A USGS (2000) study has shown future prospects for Arctic oil and natural gas exploration and has influenced the new interest in Arctic offshore oil and natural gas exploration. Another authoritative source - Wood Mackenzie (2006) - provided a very skeptical overview and made an estimate of undiscovered resources much lower than that of the USGS (2000), with significant amount of those resources deemed very remote and expensive. However, the ‘bonanza’ had already occurred. Further USGS studies from 2008 and later provided scientific justification to explore.
The U.S. Geological Survey Circum-Arctic Resource Appraisal (CARA) (USGS, 2008a, 2008b) is based on probability-geological methodology and appraises technically recoverable resources from large fields. The study estimates, that the Arctic holds approximately 22% of the world’s undiscovered conventional oil and natural gas \(^1\) (approximately 30% of the world’s undiscovered natural gas resources, 13% of the world’s undiscovered oil resources, and 20% of the world natural gas liquids (NGL), which are included in natural gas resources, Fig. 1) (USGS, 2008c).

Approximately 80% of these resources are predicted to be offshore, but in relatively shallow water (less than 500 meters) (Gautier et al., 2009). These resources are primarily located in the West Siberian Basin and the East Barents Basin (47%) (Fig. 2) and a significant portion is predicted to consist of natural gas and NGLs (94%) (Budzik, 2009). The 10 largest oil and natural gas provinces account for 93% of the total undiscovered resources. Approximately 61 large oil and natural gas fields have been discovered within the Arctic Circle: 43 in Russia (35 in the West Siberian Basin), 6 in Alaska, 11 in Canada’s

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\(^1\) Arctic Mean Estimated Undiscovered Technically Recoverable.
Northwest Territories, and 1 in Norway. The Eurasian side of the Arctic is more natural-gas-prone, whereas the North American side is more oil-prone.

Fig. 2: Oil and natural gas basins in the Arctic region (Budzik, 2009)

Arctic production volumes (not only offshore) have reached billions of cubic meters of both oil and natural gas. The Arctic share of oil production is approximately 10% of global production, and its share of natural gas production is approximately 21% of global production (by 2008, including both on- and offshore) (Glomsrød and Lindholt, 2008). Considerable resources remain to be exploited. According to Budzik (2009), approximately 550 oil and gas fields have been found in the Arctic basins. There are several world-class petroleum provinces (northern Alaska, the East Barents Sea, and the South Kara/Yamal basins) where the largest discovered fields are located (such as Urengoyskoe and Shtokman fields, Prudhoe Bay).
Although oil and natural gas resource potential in the Arctic, especially offshore, is very promising, the feasibility of their extraction is questionable and sometimes very speculative. Thus, estimations of the Arctic undiscovered hydrocarbon resources do not consider technological or economic risks (see Gautier et al., 2009). Overall, the Arctic offshore oil and natural gas resource potential is highly debatable because of the need for advanced technologies and massive long-lead capital investments. Their extraction is challenged by instability in terms of weather conditions, the sensitive environment, and so on.

**The challenges of offshore Arctic exploration**

Extremely promising resource-appraisal forecasts on the peak in oil prices resulted not only in huge interest and new leaps in oil and gas exploration activities in the offshore Arctic but also in the need for huge investments, innovative technologies and ecological monitoring. However, this strong interest has some surprising elements both on a global and a regional level.

The World Energy Outlook (WEO, 2008) paid a great deal of attention to unconventional hydrocarbon resources, including in the Arctic. In 2008, at the beginning of the ‘Arctic rush’, the cost of Arctic oil resources was expected to be very high (between $40 and $100 per barrel, when oil prices were approximately $80-90 before the economic crisis of 2008-2009) (IEA, 2008; BP, 2015) (Fig. 3). The same observation applies to Arctic natural gas resources. Arctic offshore hydrocarbons extraction costs are expected to be even higher. If the economic feasibility of Arctic hydrocarbon resources is not obvious, the question is what drives development activities.

The expectations for Arctic offshore oil production were very modest - less than 200 thousand barrels per day (10 mln toe per year) by 2035 (IEA, 2008). Simultaneously, as mentioned above, there are numerous companies pursuing exploration projects, including as Shell in the Chukchi and Beaufort Seas, Russian companies Rosneft and Gazprom in the Barents and Kara Seas, Cairn in offshore Greenland and international energy companies such as ExxonMobil and Eni. Some development could move more quickly. If offshore development plans are realized, total Arctic offshore production may increase considerably (WEO, 2013:472). However, the oil production costs for various resource categories set forth in Fig. 3 do not include technological progress. New
technologies could probably lower these costs, although they are high and the environmental risks substantial.

Fig. 3: Oil production costs for various resource categories, USD/bbl (IEA, 2013a; EIA, 2015), adapted by the author

Technologically, some difficult questions have arisen. Insufficient geological and geophysical knowledge about the Arctic offshore areas (especially in the Russian Arctic); harsh climate environmental conditions; a lack of operation, storage and supply facilities; and health, industrial safety and environment issues all have influenced development plans.

Changing climate issues and possible environmental impacts strongly influence offshore hydrocarbon resources development (Fig. 4).
This is true not only because of melting ice or permafrost, infrastructure hazards (Prowse et al., 2009), etc., but also because of changing policies on CO₂ and other emissions. International climate negotiations are moving into a critical phase and important decisions should be made during 2015 (IEA, 2014:86-87). The United Nations Framework Convention on Climate Change (UNFCCC) has pursued a low-carbon track that counteracts Arctic offshore development plans. 

Policy and environmental communities have requested more coordinated decisions that target CO₂ emissions reduction. This places stress on resource economics (Shell, 2014:70-71), which means both higher costs and better technologies.

Ecological issues are pending due to challenging environmental and operational complexity, both of which can cause pollution and leakages. There is very limited knowledge about the industrial and ecological safety of Arctic offshore hydrocarbon resources (for instance, Marichev, 2013), although it is broadly questioned in academic sources and the mass media. The oil and natural gas industry has made significant advances in detecting, containing and cleaning up spills in Arctic environments (JIP, 2013). However, oil-spill response

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\(^2\) CO₂ emissions reduction is considered under three scenarios: ‘Oceans’, ‘Oceans – clean and green’ and ‘Mountains’, applying different economic, social and governance parameters.
technologies (for example, in-situ burning\(^3\)) are far from admissible, and it is difficult to estimate the consequences of an accident in the Arctic seas.

According to the National Snow and Ice Data Center (NSIDC, 2014) and the Alfred Wegener Institute for Polar and Marine Research (AWI, 2014), the Arctic climate has experienced significant change, including sea ice retreat and permafrost melt. One example of risk estimations is the estimation of public infrastructure damages caused by climate change in Alberta (Canada) (Larsen et al., 2008). Energy infrastructure and the transport system are the most vulnerable to the effects of climate change (from now until 2030, the likely share of additional costs will be as follows: roads 25%, water and sewer systems 30%, airports 24%), which would have economic and social consequences in all sectors of human activity. Due to substantial future climate challenges, some argue the need to rethink the oil and natural gas industry business strategies in a sustainable manner.

Another serious ecological concern is Arctic methane (Dyupina and van Amstel, 2013; Kvenvolden et al., 1993), which is now more easily released, possibly from destabilized gas hydrates. The primary reason for this could be climate change and ice cap melting (Reagan and Moridis, 2007; Shakhova et al., 2010). The risk remains uncertain, but accurate scientific investigation is needed, especially of offshore oil and natural gas activities, which can affect and be seriously affected by methane flux (Dyupina and van Amstel, 2013).

Academics see the future challenges of oil and natural gas production in the Arctic in a different way, and have expressed additional concerns. The study by Economides and Wood (2009) analyzes future gas prospects but barely discusses the potential of Arctic offshore petroleum resources. More short-term narrow forecasts of Arctic oil and natural gas exploration (such as that by Johnston, 2010) are based on the quantity and location of oil and gas reserve projections made by the United States Geological Survey (USGS, 2000, 2008a). Proactive region-focused studies are made by Soderbergh et al. (2010), who examine Russian natural gas production based on reserves in existing giant fields and their potential export capacity to Europe, and by Glukhareva (2011), who studies oil and natural gas resources production and transportation prospects from the western Russian Arctic. Soderbergh et al. (2010) argue that the Yamal Peninsula is the most promising oil and natural gas bearing region. Although

\(^3\) When controlling the burning of spilled oil with fire booms, 50-98% of spilled oil can be burned (JIP, 2013).
most of Russia’s undiscovered natural gas resources are in the Arctic region, primarily offshore, its discovered resources are not commercial in the near term. Moreover, it is predicted that those resources are not likely to have an impact on production before 2030, but post-2030 results are also under consideration. For Arctic offshore fields, the bottlenecks are primarily financial resources and long project lead times. One outcome study suggests three scenarios for future European Union (EU) gas supply from Russia, which is rather optimistic.

Lindholt and Glomsrød’s (2011, 2012) long-term studies of the robustness of the Arctic supply and resources accessibility suggest a model that describes future oil and natural gas demand and supply. The model’s main variables represent prices, costs and reserves, with a focus on profitability. Those authors illustrate future Arctic oil and natural gas supply and demand under three scenarios - the reference scenario (based on IEA data), the high oil price scenario and the low resource scenario. According to the relevance scenario, future shares of global production are predicted at a level that is 8-10% lower than today because of the rise in unconventional hydrocarbons production. Harsem et al. (2011) suggest an analysis of economic, geopolitical and climate factors that influence future oil and natural gas prospects in the Arctic in a very broad manner. All of the articles describe counteracting trends in the energy industry and oil and gas resources production forecasts, which are dependent on a set of variables. Hasle et al. (2009) study the decision-making process in exploration activities in the Arctic under the pressure of environmental risks.

To summarize, in the Arctic’s challenging external and internal environment with high geopolitical turbulence, oil and natural gas projects are longitudinal and demand both investments and technology. These activities and future trends should be assessed and measured to enable an understanding of the question for the Arctic’s hydrocarbon resources.
Delimiting the Arctic scope

Arctic oil and gas activities imply the broad variability of geographical and physical parameters: deposits located offshore, onshore or partly onshore, explored from on- or offshore installations, located in Northern or Arctic seas, seasonal ice-covered seas or ice-free water. Moreover, Arctic borders may vary depending on governance, average temperature, vegetation, permafrost, etc. (Bjørnbom, 2014). The Arctic offshore area should be specified and described for the purposes of research and data collection because the specific area studied has a direct influence on data collection and interpretation.

According to some publications in professional oil and gas magazines, e.g., Eie and Rognaas (2014), the Arctic begins at 67° Northern latitude. However, those authors underline a primary area of confusion: the offshore oil and natural gas industry tends to ascribe some projects to the Arctic that are located far from the Arctic Circle. Energy companies classify projects due to harsh (Arctic-alike) weather conditions with a broad variability of geographical and physical parameters. Baffin Bay Sea is covered by ice more than 6 months per year. However, climate conditions in the abovementioned areas can be much less harsh than they are inside the Arctic Circle.

Arctic weather conditions are defined as including extreme cold (less than -40°C), severe storms, underwater and subwater ice, frequent and long-lasting fog, permafrost, shallow seawater areas, strong sea currents, gusty winds (up to 36 m/sec), severe ice conditions, sea bottom plowing, darkness and considerable sea level changes (up to 5 m) (NSIDC, 2014; Bellona, 2007). The classical, widely used definition of the Arctic region is based on a parameter of an average temperature of the warmest month below 10°C (Köppen–Geiger climate classification, Köppen, 1936). Due to changing climate conditions, this border may vary from year to year. It does, however, include the vast Arctic Ocean, and onshore parts of the Arctic region have an average temperature line during the warmest month of below 10°C.

In addition to the climate-related definition of the Arctic, there is a technical definition. Though technology level varies significantly, the common technological trend in Arctic offshore exploration is subsea, automatized, remote-controlled and unmanned drilling and production units (RG, 2014). There are few examples of such technologies worldwide, and probably only single example in the Arctic offshore - the Snøhvit natural gas project in the Barents
Sea. Some of the Arctic’s oil and natural gas deposits are located partially offshore and are developed both from onshore and offshore facilities. Those located only partially offshore can also relate to the Arctic offshore experience as an ‘entry point’ to the Arctic offshore.

Statoil has offered a more practical definition that highlights three Arctic zones; the company argues that the “Arctic is not only the Arctic” (Reuters, 2014). These three regions are the workable Arctic, the ‘stretch’ and the extreme. The Norwegian Barents Sea and Canadian East Coast are examples of the ‘commercial Arctic’. However, exploration is occurring beyond the ‘workable’ Arctic. Attempts are being made to pioneer along the frontiers, such as the Chukchi Sea, Russia’s Western and Eastern Arctic seas, and Greenland’s offshore, which are close to ‘the stretch’ and the extreme Arctic.

According to AMAP (1998), a merely geographical definition contains variations in temperature and permafrost. The Arctic region is described through a variety of physical, geographical and ecological parameters: geography, climate, vegetation, meteorology, geology and marine environment (Table 1). However, only a few factors - geography, climate and vegetation - are used in the AMAP definition. The first factor is climate boundaries (north of the 10°C July isotherm) (Linell and Tedrow, 1981; Stonehouse, 1989; Woo and Gregor, 1992; cited in AMAP, 1998) and the presence of permafrost (Barry and Ives 1974; cited in AMAP, 1998). The second factor is treeline, which is a vegetation-related Arctic boundary (north of this line, trees do not grow). The third factor is geographical (Arctic Circle). There are also three types of Arctic areas that are classified by AMAP (1998) depending on a combination of the above-referenced factors: High Arctic, Low Arctic and Sub-Arctic (region south of the Arctic, Linell and Tedrow, 1981, cited in AMAP, 1998), all of which are also implied in Statoil’s practical definition.

Table 1: Parameters of Arctic boundary definition (AMAP, 1998:9-24)

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geographical</td>
<td>Area north of the Arctic Circle (66°32'N)</td>
</tr>
<tr>
<td>Climate (temperature)</td>
<td>Area north of the 10°C July isotherm (mean July temperature of 10°C); the presence of permafrost</td>
</tr>
<tr>
<td>Vegetation</td>
<td>Terrestrial Arctic (the northern limit beyond which trees do not grow)</td>
</tr>
<tr>
<td>Ecological</td>
<td>High Arctic, Low Arctic and Sub-Arctic (based on a combination of climate and vegetation parameters)</td>
</tr>
<tr>
<td>Marine</td>
<td>Oceanographic characteristics (along the convergence of cool, less-saline surface waters from the Arctic Ocean and warmer, saltier waters from oceans to the south)</td>
</tr>
</tbody>
</table>
The political and administrative definitions of the Arctic region may deviate from the natural and geographical definitions. Emmerson and Lahn (2012:9) argue that the Arctic is not likely to become a “truly single regulatory space”: international organizations and Arctic countries define it differently based on “environmental conditions, geological prospectivity, physical accessibility, population levels, economic development and political salience”. For example, the International Maritime Organization (2010:6) defines the Arctic solely as the Arctic Ocean, although Arctic countries identify as Arctic those areas north of 60°. However, if to look to the 60° parallel, some onshore and offshore areas and some other countries enter the research scope: Iceland and its waters, some territorial waters of the UK, half of Russia, etc. If we choose the ‘lower’ 60° latitude, the Arctic becomes too broad.

Finally, USGS reports (USGS, 2008a), scientific publications (Gautier et al., 2009) and the US Energy Information Administration (Budzik, 2009), all of which have the purpose of evaluating Arctic oil and natural gas resource potential, clearly define the area of research as all areas north of the Arctic Circle (66.56° (66°34′) north latitude).

To conclude, there is not one Arctic, but many (Emmerson and Lahn, 2012), which are defined to meet particular needs. For example, for oil and natural gas development the key distinction is onshore versus offshore. AMAP (1998) modifies the Arctic boundary to include “elements of the Arctic Circle, political boundaries, vegetation boundaries, permafrost limits, and major oceanographic features” and to address “source-related research issues ... within and outside the Arctic” (AMAP, 1998:10).

In this research, the focus is Arctic offshore oil and natural gas resources, and the interest is to exclude a loose interpretation of the Arctic offshore area. Aiming for an applicable, simplistic definition for the purposes of research in the offshore Arctic area, and taking into account the most authoritative Arctic oil and natural gas resources research appraisal by USGS (Gautier et al., 2009), this study was limited only by geographical parameters. This is also because the vast majority of Arctic oil and natural gas resources are located within the Arctic Circle (Budzik, 2009), which means that the Arctic offshore oil and natural gas projects studied are located in the Arctic offshore areas of five Arctic countries (i.e., the country-by-country approach) - Canada, Greenland, Norway, Russia and the USA - which lie north of the Arctic Circle (66° 33′ 44″). The country-by-country approach is justified by the method of data collection and its unification (see corresponding chapters). The main Arctic offshore areas include the Barents,
Pechora and Kara Seas; Ob and Taz Bays; Beaufort Sea; waters of the Canadian Arctic archipelago; Prudhoe Bay; the Chukchi and Norwegian Seas; and Greenland’s waters (i.e., Baffin Bay, the waters south and east of Greenland, and the Greenland Sea). Fig. 5 is a map of the study that contains both defined geographical borders and the locations of oil and natural gas projects.

![Arctic map, adapted by the author](image-url)

**Fig. 5:** Arctic map, adapted by the author
Purpose and research questions

Industrial activities in the Arctic changed significantly over the study period. More specifically, the energy and extraction industries became very important to Arctic economies. At the same time, there are numerous factors (both external and internal) driving not only regional development but also offshore oil and natural gas exploration. The aim of this research is to provide deeper insight into offshore hydrocarbon development activities in the Arctic.

The specific research aims are as follows:

- to identify factors that influence Arctic offshore hydrocarbon production (driving forces) and to examine their influence;
- to understand the scope and significance of Arctic offshore hydrocarbon development; and
- to provide a better understanding of current trends in Arctic offshore hydrocarbon development.

This research aims help to provide a better understanding of current trends in Arctic offshore oil and natural gas development and of how to maintain Arctic offshore oil and natural gas production in a manner that is safe and sustainable.

To target the research goal, several research questions were developed. They are as follows:

**RQ1:** Why does Arctic offshore hydrocarbon production matter?

**RQ2:** What factors influence Arctic offshore hydrocarbon production and how?

**RQ3:** How much oil and natural gas production occurs offshore in the Arctic?

**RQ4 (Ph.D.):** How do these influencing factors interact and what can be done to move Arctic offshore oil and gas production toward sustainability?

These questions (RQ1-RQ3) are sequentially formulated from this study’s aims and from the research process. RQ4 is a cohesive question that integrates the results of the other studies (for future research).
Arctic offshore oil and natural gas exploration and production are multicomponent processes. To narrow the research scope and focus on the identified research aims, the overall project has been divided into several interrelated and consecutive parts. These parts comprise studies that examine the factors driving Arctic offshore hydrocarbon resources development (i.e., one study per paper). The research design is schematically presented in Fig. 6.

![Research design](image)

**Fig. 6:** Research design

However, it is possible that during the study, additional factors that influence Arctic offshore hydrocarbon production will be identified. In that event, more studies will be planned.
Methodology

Society’s interest has moved beyond simple economic studies and commercial exploitation of resources. Resource management has become a more complex issue that now focuses not only on human aspects and environmental issues but also on an integrated, sustainable analysis; it has lost its focus on resources development. This thesis argues that to bring global energy and the global economy to a new level, it is necessary to study the past. Historical research provides a critical link between past and present (Given, 2008:395). Aiming to provide deeper insight into Arctic offshore oil and natural gas development as a very challenging and debatable industrial activity, the historical approach has been chosen as a dominant theoretical framework for the thesis and two papers. The single case study has been chosen as a research strategy. The historical method of data collection was conducted through desk research on primary and secondary sources.

Historical framework

Classically, the historical method studies the occurrence, formation and development of objects in chronological order. It consists of techniques and guidelines for the use of primary sources and other historical evidence to provide an account of the past, with deep philosophical roots in epistemology.

The historical method appeared in the late 1800s (Gottshalk, 1969; Golder, 2000), stimulated by the desire to develop a self-sustaining method to analyze data (Langlois and Seignobos, 1898; Marwick, 1970; Golder, 2000). Its primary goals were to develop accurate descriptions, to understand events in their full context (Elton, 1967), and to identify laws or generalizations (McCullagh, 1984). Golder (2000:158-159) presents an approach to the historical method in five stages: (1) select a topic and collect evidence; (2) critically evaluate the sources of the evidence; (3) critically evaluate the evidence; (4) analyze and interpret the evidence; and (5) present the evidence and conclusions. The key procedures involve collecting, verifying, interpreting and presenting evidence from the past. Golder also advocates the usefulness of the historical method in marketing (and in other fields). He argues that the historical method is underevaluated, and conducts a comprehensive review to justify its usefulness. The primary strengths of the historical method by Golder (2000:167) are its applicability to longitudinal
analysis, its ability to extract findings from existing data and its ability to adequately deal with complex phenomena. However, some researchers consider the historical (archival) method unreliable (Bonoma, 1985). Its limitations include the following: the difficulties of confirming theory in a complex environment (Nevett, 1991); the method’s descriptive (rather than explanatory) character; the method’s possible interpretive biases (Calder and Tybout, 1987; Nevett, 1991); and the method’s time-consuming data collection strategy (Chandy and Tellis, 2000). Some limitations may be compensated for by collecting more factual data and more accurate records (Golder and Tellis, 1993), and by using mixed research strategies in a single case study (Bayus et al., 1997).

To address the relatively negative view of the historical method presented above, one “must retain the objectivity of the scientific method, following its structure as closely as possible” (Savitt, 1980:54). That means the study should approach “the structure of a well-defined experiment” (Marwick, 1970:105; cited in Savitt, 1980:54), its data collection and analysis techniques, both qualitative and quantitative (Hollander et al., 2005).

Some authors, such as Savitt (1980), Nevett (1991) and Smith and Lux (1993), argue for historical research in a different way: to study the past precisely, to use the past to supplement one’s main research or to explain changes over time. These approaches are somewhat different than the traditional version of the historical method, which in an accurate combination can provide a path to a more modern way of applying the historical framework. Moreover, most historians’ research objectives are similar to many marketing researchers’ objectives, which makes today’s historical study more contemporary and focused on recent issues.

Historical research can take many forms depending on research aims, data availability and data quality (Given, 2008:398). The most common forms include oral history, autobiographical narrative, life history and case study. These methods are usually are used in combination with other approaches to include more innovative and contemporary methods of data collection. This research consists of a focused case study; the historical framework helps us to explore the phenomenon.

As examples of historical frameworks, Grübler et al. (1999) study technological change using a combination of historical analysis and modeling to improve the understanding of technological change with reference to historical patterns. Historical context is part of a heat pump study by Hepbasli and Kalinci (2009), historical trends are studied in American coal mining by Höök and Aleklett (2009) and a broad historical review of wind energy technology is
conducted by Ackermann and Söder (2000). Longitudinal approaches and variations on historical frameworks are welcomed in marketing and management studies (Aaker and Day, 1986; Bayus et al., 1997; Golder and Tellis, 1993; Low and Fullerton, 1994; Menon and Menon, 1997; Nevett, 1991; Zaltman, 1997) and consumer behavior (Hudson and Ozanne, 1988; Smith and Lux, 1993). From a managerial perspective, the historical approach is appropriate for studying strategic issues (Aaker and Day, 1986; Golder, 2000; Prahalad, 1995). In economic history, the historical approach is used not only to discover the past but also “to contribute to economic theory by providing an analytical framework that will enable us to understand economic change” (North, 1994:359).

The usefulness of the historical method in the context of this study is as follows. The historical method is based on the identification and analysis of contradictions in the development process through time, as along with regularities of technological development. The method contributes to an in-depth understanding of the issue and provides an opportunity to formulate more well-grounded recommendations. This helps to account for the past and improve our understanding of both the present and the future. Moreover, the historical method does not stand in opposition to quantification methods, which are essential to studies in which the main markers are production volumes and investments; instead, the historical method is open to a combination of methods.

Important changes in how modern researchers treat data have also influenced their treatment of the historical method. Historical research is changing as more data and data types become available online. The important issues of data collection and sources - such as reliability, validity and trustworthiness - have prompted new improvements due to the broad availability of primary and secondary sources online (Given, 2008).

**The historical approach to Arctic issues**

The historical perspective on the Arctic oil and natural gas issue has not been very widely presented. Studies are mostly limited to reviews of mining trends in the Arctic frontier regions (related to a variety of natural resources extractive industries) and papers about the social effects of those activities (for example, Haley et al., 2011). Archaeological research from the historical perspective is more diverse (for example, natural resource exploitation in the polar regions, particularly in Svalbard, by Avango et al., 2010). Oil and natural
gas activities are not often addressed, although there are some studies that resemble historical studies focusing on natural resources extraction and/or energy sources.

Natural resource exploitation on Spitsbergen is studied by Avango et al. (2010) from a long-term historical perspective. Aiming to define the driving forces of large-scale natural resources exploitation in the North, to examine at international competition for natural resources and to identify the consequences for Arctic geopolitics, those authors argue that “in order to understand the current quest for natural resources in the Arctic and its political consequences, research is called for into the history of similar developments in the high Arctic in the past” (Avango et al., 2010:1).

The historical method is applicable to all of the fields of study that have a need for some historical knowledge and that can vary in the depth of their analysis with the use of both qualitative and quantitative factors (to discover origins, theories, breakthroughs, etc.). Historical methods help secondary data analyses to identify previous social and economic opinions, perceptions and how those opinions and perceptions have evolved over time to form a base for analyzing both ongoing trends and future challenges. This is shown in the recent study by Fjaestad (2013), which uses the historical context to study wind power through a successful case in Sweden. This study shows that by using “time-specific historical conditions” (Fjaestad, 2013:124), it is possible to discuss influential factors related to a developing energy sector. Moreover, it is important to discover the possibility of using past experience for future projects.

Returning to the Arctic region itself, the historical study by Elzinga (2009:313) shows “an archaeology of knowledge” and the theoretical foundations of polar research. A long-term historical perspective targets the incentives for polar research over 125 years and identifies differences in driving factors.

A narrower case of political and institutional regimes as shown through the example of the Shtokman field is made by Mineev (2010) to study the role of political forces in an organizational field. That study conducts a short historical investigation of oil and natural gas politics and the Shtokman project to provide a background for better understanding interrelated factors and to support macro- and micro-level analyses.

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4 A gas and condensate field in the Barents Sea (Russia), its development was frozen indefinitely in 2013.
One example of contemporary studies of Arctic energy issues is the paper by Harsem et al. (2011), which has the same research scope as this thesis and more specifically, explores factors influencing future oil and natural gas development in the Arctic. However, those authors choose to study a broad and nuanced perspective on the issue from both “climate-driven changes” (abstract, Harsem et al., 2011) and the available literature. This results in a short-term review of the most debatable issues around Arctic hydrocarbon resource development, such as climate, politics and market conditions, and the dependence of Arctic oil and natural gas resources development on a complex set of variables as an outcome. Here it is worth underlining that oil and gas industries in the Arctic cannot be properly studied without an understanding of the historical experience.

A variety of cases in Arctic history, from first expeditions to new technologies and climate change, have had different impacts. However, the current interest in Arctic offshore oil and natural gas resources following more than 90 years of oil and natural gas exploration and development in the Arctic region (AMAP, 2007; Ernst&Young, 2013) has attracted a wide response from socioeconomic and geopolitical spheres worldwide. This provides a motivation for a consecutive study of this multicomplex issue, with history as the starting point.

The common belief is that historical method only targets the past (Golder, 2000), not the present and the future. Obtaining a better understanding of the past makes it possible to address the future differently and to provide insight into the present (Golder, 2000; Nevett, 1991; Savitt, 1980). It is worth underlining that returning to history is neither purpose nor the genuine orientation of this research. Instead, history is a tool that helps us create a mental picture of the Arctic not only as it exists now but also in how it will shape the future by opening lifecycle stages of oil and gas industry through time. It also provides a perspective for further discussion and studies in fields related to both energy and the Arctic.

**Methodological approach**

The historical approach is the major theoretical framework because it helps target research aims, addresses research questions and supports data collection and analysis techniques. However, the historical approach is likely to be used in combination with other approaches (Bayus et al., 1997; Nevett, 1991).
The case study has been chosen as a research strategy. The justification for choosing this strategy was found in several sources (Saunders et al., 2009; Robson, 2002; Morris and Wood, 1991; Bengtsson et al., 1997; etc.). Robson (2002:178) defines the case study as “a strategy for doing research which involves an empirical investigation of a particular contemporary phenomenon within its real life context using multiple sources of evidence”. According to Morris and Wood (1991), the “case study strategy is of particular interest when the aim is to gain a rich understanding of the context of the research and the processes being enacted”. Thus, the case study seem especially well suited to develop rich descriptions of interdependent factors because case study research normally is based on the goal of understanding complex phenomena (Bengtsson et al., 1997). Because the research topic is considered complex and multivariate, the use of the case study provides an opportunity to obtain sources of new research questions and to gain a deeper understanding of the interplay in the Arctic region of the exploration of offshore hydrocarbon resources.

Fig. 7: The research ‘onion’ (Saunders et. al., 2009), developed for this study

The research approach is relatively inductive. It is a proper method of achieving the formulated aims with the use of historical and qualitative data. Moreover, it is helpful when researchers have “special qualities and pre-
understandings” of the topic; the inductive approach makes it possible to “achieve more rich and thorough understanding in research question” (Bengtsson et al., 1997). However, in practice some of the analytical procedures of qualitative data combine inductive and deductive approaches (Saunders et al., 2009). This particular research tends to use a more general inductive (or abductive) approach for the purposes of analyzing qualitative evaluation data, summarizing data, establishing links between the evaluation or research objectives and the end outcome.

The research methods to be used are descriptive and explanatory to establish causal relationships among the driving factors (Sanders et al., 2009) and to more deeply explore the history of Arctic offshore hydrocarbon resources exploration and production using the driving factors. However, no research is valuable without ‘finding a mystery’ and there should not be limitations to explore.

**Data collection methods**

When choosing a data collection method for this research, the main criteria were the following: to provide a deeper understanding of the topic, to obtain proper and precise answers to research questions and to optimize time and resources. Based on the historical framework, the historical method for data collection was used to ensure the reliability and validity of both the data and the sources. Although “there is no single particular method for data collection that has advantages over the others” (Yin, 1994), there are advantages and disadvantages depending on the issue. In the case of oil and gas companies, access to the required information is very complicated, especially in the frontier regions, with respect to know-how, geopolitics and commercial interest. Managers and administrative personnel do not willingly share information about future strategic plans. Corporate (business) data can provide all of the necessary first-hand information, however, due to poor historical studies in the past and its commercial value, access to these data is mostly restricted (Savitt, 1980). Accordingly, deciding on a data-collection method requires both establishing what data are available and designing the research to maximize that data (Saunders et al., 2009). The advantage of the modern way of treating the historical method is that more records are available online.
Some other complications have been overcome by using multiple data sources, which makes data more reliable (Bengtsson et al., 1997:477; Srinivasan et al., 2004). The use of both primary and secondary data can help eliminate methodological challenges (potential sources are outlooks, companies and governments’ strategic plans, media sources, business reports, company press releases, internal company documentation and reviews, academic papers, and analytical materials). The use of secondary data also saves time. Additionally, the data collection techniques employed may vary and are likely to be used in combination (Saunders et al., 2009:145-146). Savitt (1980) urges giving more attention to the distinction between primary and secondary data sources to minimize data gaps and maximize data credibility. The use of primary and secondary sources is also a necessary condition for reliable historical research.

In this study, data collection is primarily conducted through desk research that is applicable to the historical method. A similar data-collection method has been used in studies by Chandy and Tellis (2000) of radical product innovation, Sood and Tellis (2005) of technological change and innovations, and studies of pioneer firms’ survival (Srinivasan et al., 2004), dominant designs (Srinivasan et al., 2006), and high-tech markets (Tellis et al., 2009). The use of the historical data collection method in these studies is primarily justified by the longitudinal character, their easily targeted research aims, their ability to study the effects of time, or simply the absence of databases.

Combined data collection techniques are likely to be used during additional research (i.e., not only documentary analysis but also interviews and expert rounds, following the collection of the primary data).

Arctic offshore hydrocarbon resource exploration is a hot topic in world economics and geopolitics and the situation around it changes rapidly while new information appears, new cooperation agreements are concluded, new oil and natural gas field discoveries are being made, etc. That is why on the one hand, it is crucial to monitor media and periodical sources continuously. On the other hand, there is no methodological need for a deeper recollection of events and opinions. Theories and explanations can be formed based on the historical data by using methods of analogy and homology. In the way, there is historical continuity with the present day.

The choice of data sources and data collection methods is strongly connected to information trustworthiness. Secondary data sometimes could fail to provide the information that is needed to answer research questions. To make
information more reliable, Dochartaigh (2002) therefore suggests choosing a number of areas and checking the authority of documents available via the Internet to increase each source’s reliability. Moreover, it is important for case researchers to achieve a high level of reliability and to provide a full and detailed description of their data and sources by gathering information from multiple sources. This can be accomplished by investigating authorship and classification, describing how data is gathered, compared and confronted, determining whether multiple investigators were used, etc. (Bengtsson et al., 1997; Golder, 2000). Moreover, according to Bengtsson et al. (1997), such a detailed description serves two purposes. First, it increases the reader’s confidence in the author’s thoroughness and in-depth understanding of the case material. Second, it improves the reader’s ability to gain insight into the study and to make an independent interpretation of the data. A detailed description of data, sources and additional researcher comments not only increase reliability but also provide a better understanding to readers of both the topic and the research outcome.

Ethical issues related to accuracy and interpretation can arise during data collection. This means that to avoid ethical issues, it is worth to confirming that data are collected accurately and fully. Another general ethical principle is related to researcher objectivity. To avoid biases, especially while using the historical method, a researcher must be aware of his or her own subjectivity and understand its influence on data collection and analysis (Savitt, 1980). These conditions can be fulfilled by following a well-planned initial research structure and by depending on researchers’ competence and knowledge of both the research topic and the research process. Data can be verified by comparing qualitative factors or by conducting a statistical analysis; they can be analyzed through quantitative or graphical analysis (as done by Tellis et al., 2009).

The group of studied sources was significantly extended because both primary and secondary sources in English and Russian were used. Sources in Russian are not widely available for studies, because primary corporate reports and press releases usually are not translated. The use of Russian-language sources provided a broader data overview and significantly contributed to the study. These sources also helped verify quantitative data and render those data trustworthy.
A case of Arctic offshore hydrocarbon resources: identifying factors

Framing Arctic issues as a separate case helps to show Arctic resource extraction in a more specific and precise manner. The historical context refers to political, environmental, cultural and other decisions and events that can be linked to the studied issues (Given, 2008:392). A critical perspective in a historical context provides an opportunity to identify and examine factors that influence Arctic offshore oil and natural gas resources development from a longitudinal perspective and provides an opportunity to evaluate the key perspectives.

The identification of factors is a broadly used method of conducting a qualitative study. It is also a matter of choice and theory. There are some examples of how it can be done, especially in energy research. The study in the area of energy savings by De Groot et al. (2001) suggests an extensive survey among numerous firms to investigate empirically how they can potentially be influenced by environmental policies. This strategy has helped to achieve research aims and study decision-making process in firms. In a sphere of environmental standardizing and standardization certifications (Curkovic et al., 2005), the number of factors or influences are analyzed through qualitative case studies. This study used exploratory, qualitative data collection methods (structured interviews) and field data collection; it also used examples from managerial experiences. This study concludes with an evaluation of the driving factors. In another energy study, in which the aim was to identify factors that predict attitudes toward local onshore wind development, the method used was the case study with questionnaire data collection and multiple regression analysis (Jones and Eiser, 2009). These are good examples of identifying factors of influence for in-depth study.

In the case of this particular project, the historical framework and historical (longitudinal) method of data collection provide an opportunity to identify the number of influencing factors (studied together for oil and natural gas). As in previously mentioned studies, this research uses a case study strategy and a literature and historical review to identify the relevant factors. There are numerous factors that make the Arctic a challenging and interesting subject of exploration, namely, geopolitics, governance, climate change, indigenous issues and economic opportunities, all of which were identified from the global context. The factors follow from the historical overview are: geopolitics of energy resources, the economic interests both of industry and government, strategic and
governance issues, and the availability of technologies and infrastructure. These factors are validated both from the literature and the historical review. Three factors have been chosen to access, measure and evaluate Arctic offshore oil and natural gas development according to the research aims: geopolitics, investments and technology. Geopolitics is a background factor.

**Empirical data collection and sources**

To target the research aims and answer the questions posed, desk research was conducted based on the principles of the historical method of data collection (additional research steps touched upon in previous chapters may include primary data collection through interviews). The chosen method is based on a country-by-country approach. Therefore, data on discovered fields have been collected, focusing on operating oil and natural gas fields. Some fields are planned to produce oil or natural gas (or both) for some time and other fields are planned to be turned into production during upcoming years and have approved operation plans. Accordingly, information on those topics has also been collected. To store the information, data tables have been constructed. Fifty-five fields located in the above-mentioned area were identified as follows: Canada - 3, Norway - 14, Russia - 29, US - 9, Greenland - 0.

The following information was collected for each identified oil and natural gas deposit: country, area, field name, resource type (oil, natural gas, condensate) and volume, date of discovery, date of development start, date of production start, project costs, operator, license holder, number of wells drilled and host type (development concept). Data on oil prices during the studied period were also collected.

The data search included primary and secondary sources both in English and Russian (for details, see the Appendix). The data collection was conducted in the following way. First, an extensive search for oil and natural gas deposits was conducted using primary official sources from the governmental institutions responsible for mineral resources extraction in each Arctic-five country. The completeness of data available differs among the countries. In the USA (Alaska oil and gas conservation commission, Minerals Management Service Alaska Region and U.S. Department of the Interior Bureau of Land Management), there is full information available describing fields and provinces oil and natural gas production on a monthly and yearly basis. In Norway (Norwegian Petroleum
Directorate, “Oil Facts” report), official information reviews for each field are published annually and a mobile application (“Oil Facts” by Norwegian Petroleum Directorate and Norwegian Ministry of Petroleum and Energy) provides monthly production volumes. Canadian (National Energy Board Canada, Government of Newfoundland and Labrador, Aboriginal Affairs and Northern Development Canada, Canada-Newfoundland and Labrador Offshore Petroleum Board) and Greenlandic (Naalakkersuisut Government of Greenland) official institutions provide data on production volumes. However, it is difficult to evaluate the quality of that information because of the absence of Arctic offshore production and thus, no particular data were obtained from these sources. In Russia (Government of Russian Federation, Ministry of Natural Resources and Environment of the Russian Federation), it is more challenging to find data: field-related data are not very openly provided compared to other countries, and the data that are provided are primarily in Russian. Others Arctic-five countries’ data are translated into both English and any other native or state language.

The data from official governmental sources were verified and supplemented by primary corporate public sources of oil and gas companies working offshore in the Arctic (BP, CairnEnergy, Eni, ExxonMobil, Gazprom, Rosneft, Shell, Statoil, etc.). Most companies operating in Arctic offshore fields do corporate reports on volumes of oil and natural gas produced, along with plans for production start-ups, technological approaches, etc. This information is public and can be used as a trustworthy source to complement and verify governmental sources. Because the Arctic offshore is a frontier, companies are mostly willing to show their expertise on such fields and therefore data are available.

Missing data were taken from secondary sources such as academic peer-reviewed publications and public media sources (company announcements, online professional journals such as the Oil & Gas Journal, ROGTEC Magazine, etc.). These sources provide wider perspective on the topic, along with expert opinions and forecasts. Some online databases (Offshore Technology and SubSeaIQ) have chronological descriptive data on fields and their development. However, these sources were used with great attention to their credibility.

Because data sourced from different places can sometimes be expressed in differing units, the data were unified. Further information on terminology and units is included in the corresponding chapter.
Justification for the data-collection method was found in (Kjärstad and Johnsson, 2009). In an attempt to obtain deeper insight into global oil resources and the balance of oil supply and demand, Kjärstad and Johnsson (2009) analyzed a variety of sources from different levels (country, company and field levels). Kjärstad and Johnsson (2009) use data sources and databases of institutions such as AAPG (American Association of Petroleum Geologists), IEA (International Energy Agency), USGS (United States Geological Survey) and IHS Energy, which are considered the most comprehensive databases in the energy industry. Information has also been sourced from countries’ official resource ministries and agencies (including the Norwegian Petroleum Directorate, the US Minerals Management Service, Canada’s National Energy Board and other authorities) annual reports, company reports, consulting companies, professional journals (e.g., the Oil & Gas Journal), conference presentations and other contemporary sources of information. Shafiee and Topal (2010) have also used databases such as EIA and BP in their attempt to study fossil fuel prices from a long-term perspective. In studies that apply the historical data method, scholarly journals, books and online business databases are also used (Srinivasan et al., 2006; Tellis et al., 2009).

Following the data collection, criteria were applied depending on the purposes of each paper. For the first paper, the oil and natural gas deposits for which the investment data were known were selected because that is the key element of analysis. The investment data used are either data about total project development investments or capital project costs that have been announced and published. For the second paper, the criteria were actual oil and gas production and known technological development concepts. The technical details of these concepts are beyond the scope of the study.

The time frames for the studies were identified based on empirical data. That means that the earliest time frames were chosen according to the first wells drilled in the offshore Arctic, first discoveries or investment projects, and first volumes of offshore oil and natural gas produced. The final time frame was chosen based on production plans and approved development plans. However, it is important to note that this study does not make any forecasts; instead, it makes projections based on approved development plans.

Detailed information on what fields were studied and what sources of data were used are available in the Appendix.
Research limitations

This research has both strengths and weaknesses in its structure and in the topic itself. Conducting research on energy issues is challenging because energy has a strong influence on global economics and growth.

One of the main diverging points of research is its timeliness. Currently, the Arctic is of particular importance to circumpolar countries and world geopolitics. That means research is both in demand and influential. It also means that data can be politicized or biased due to the turbulent economic and political environment: the researcher needs to be aware of that issue and address it. Here, the researcher had the will and motivation to overcome these limitations to show the variety of implications and to make a contribution. Limitations in the availability of data that show the historical perspective are also challenging both because of such data’s possible commercial value and because of the absence of relevant studies or records. This has a direct impact on data credibility and the trustworthiness of the results. Methods of overcoming data limitations were discussed in previous sections.

The weaknesses of the research structure are as follows: numerous points of drivers’ intersections in the case, a strong geopolitical context and a debatable research subject. The driving factors of Arctic offshore hydrocarbon resources development may have crossing, reinforcing and/or reversing influences on each other and on Arctic offshore oil and gas production. An improper study outline may result in an inaccurate analysis and invalid outcomes.

It is believed that limiting the research scope will help overcome challenges and improve the study. It was decided to conduct research on a country-by-country basis with a focus on Arctic offshore oil and natural gas resources development in a pre-defined offshore area of the five Arctic countries. The focus of the study is oil and natural gas offshore development in the Arctic through oil and gas fields. Other factors of Arctic regional development and both external and internal factors of influence are studied through the prism of the main focus. These limitations were applied to the research frameworks and methodological approaches.

This study has been conducted independent of any oil/gas/energy/operation/state-owned/private company involved in Arctic oil and natural gas resources exploration and development; that independence has both advantages and disadvantages. Access to data and their interpretation without
additional professional support might result in incorrect interpretations. However, conducting independent research renders it less company-biased. This is how to obtain a clear view without any company biased, contribute to the Arctic offshore resources exploration process, and provide society with researchers and analysts’ opinions.

The research scope limitations apply to the number of issues studied in the case, which are primarily limited by capacity and timing. The main issues are (actual and projected) volumes of oil and natural gas produced in the offshore Arctic, investments into offshore oil and natural gas resources development and the technological approaches used to extract these resources. It limits other important factors, such as climate change, governance and infrastructure availability. However, it is strongly believed that the chosen key factors are capable of serving the research goals and can provide an answer to the research questions. The factors that fall out of this particular research provide material for future studies.
Terminology and units

Energy is a broad term. It includes variety of sources and their use. To eliminate possible misunderstanding, some working definitions were sourced from the World Energy Outlook of the International Energy Agency (WEO, 2013), an authoritative analytical publication in the energy sphere.

“Oil includes crude oil, condensates, natural gas liquids, refinery feedstocks and additives, other hydrocarbons (including emulsified oils, synthetic crude oil, mineral oils extracted from bituminous minerals such as oil shale, bituminous sand and oils from coal liquefaction) and petroleum products (refinery gas, ethane, LPG, aviation gasoline, motor gasoline, jet fuels, kerosene, gas/diesel oil, heavy fuel oil, naphtha, white spirit, lubricants, bitumen, paraffin waxes and petroleum coke)” (WEO, 2013:664). However, this research addresses hydrocarbon production. Consequently, the variety of hydrocarbons listed in this definition is irrelevant. “[Natural] Gas includes natural gas, both associated and non-associated with petroleum deposits, but excludes natural gas liquids” (WEO, 2013:661). “Condensates are liquid hydrocarbon mixtures recovered from associated or non-associated gas reservoirs” (WEO, 2013:661).

‘Hydrocarbons’ usually refers to oil and oil products in the WEO (2013). From the chemical point of view, hydrocarbons are organic compounds consisting entirely of hydrogen and carbon. As defined by Schlumberger (2014), the most common hydrocarbons are natural gas, oil and coal, which are a complex mixture of hydrogen and carbon. For the purposes of this study and to simplify its language, ‘hydrocarbons’ is used to designate a combination of oil, natural gas and condensate. It is also the most appropriate definition for this purpose.

The next issue is the definition of (hydrocarbon) resources and reserves, both conventional and unconventional. The definition of resources and reserves differ depending on country. In the USA, the petroleum classification scheme of the USGS and the Minerals Management Service is used, whereas Canada uses the Canadian Securities Administration (these two are correlated), and in Norway, the responsible governmental institute is the Norwegian Petroleum Directorate (which is more or less correlated with the others).
The Russian petroleum classification is quite different. Those differences, however, are beyond the scope of this research. More information on resources and reserves classification can be found in AMAP (2010) and the Society of Petroleum Engineers (2005). Because the research in the two paper studies targets produced volumes of oil, natural gas and condensate, only the short definition is sourced from AMAP (2010) for the reader's information and is presented in Fig. 8. This definition is recommended by the Society of Petroleum Engineers, the World Petroleum Congress and the American Association of Petroleum Geologists resource classification scheme, which accounts for major elements of petroleum assessment.

**Fig. 8: Resource classification scheme (AMAP, 2010:2_5)**

<table>
<thead>
<tr>
<th>Total petroleum-initial-in-place</th>
<th>Production</th>
<th>Project Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discovered petroleum-initial-in-place</td>
<td>Reserves</td>
<td>On production</td>
</tr>
<tr>
<td></td>
<td>Proved</td>
<td>Under development</td>
</tr>
<tr>
<td></td>
<td>Proved plus Probable</td>
<td>Planned for development</td>
</tr>
<tr>
<td></td>
<td>Proved plus Probable plus Possible</td>
<td></td>
</tr>
<tr>
<td>Sub-commercial</td>
<td>Contingent resources</td>
<td>Development pending</td>
</tr>
<tr>
<td></td>
<td>Low estimate</td>
<td>Development on hold</td>
</tr>
<tr>
<td></td>
<td>Best estimate</td>
<td>Development not viable</td>
</tr>
<tr>
<td></td>
<td>High estimate</td>
<td></td>
</tr>
<tr>
<td>Unrecoverable</td>
<td>Prospective resources</td>
<td>Prospect</td>
</tr>
<tr>
<td></td>
<td>Low estimate</td>
<td>Lead</td>
</tr>
<tr>
<td></td>
<td>Best estimate</td>
<td>Play</td>
</tr>
<tr>
<td></td>
<td>High estimate</td>
<td></td>
</tr>
<tr>
<td>Undiscovered petroleum-initial-in-place</td>
<td>Unrecoverable</td>
<td></td>
</tr>
</tbody>
</table>

Range of uncertainty
Reserves are “the quantities of hydrocarbon resources anticipated to be recovered from known accumulations from a given date forward” (AMAP, 2010:2_8) (given by U.S. resource definitions for assessing resources on the Outer Continental Shelf). According to WEO (2013) (which also uses USGS classification), resources include everything: known oil (including cumulative production and reserves in reservoirs), reserves growth and undiscovered oil.

Undiscovered resources are the most topical resources in the frame of this study. They are resources “postulated, on the basis of geologic knowledge and theory, to exist outside of known fields or accumulations...” (AMAP, 2010:2_8).

There are two types of resources distinguished - conventional and unconventional. According to WEO’s (2013) liquid fuels classification, conventional refers to crude oil and natural gas liquids, when unconventional resources accumulate extra heavy and oil bitumen, light tight oil, gas-to-liquids, coal-to-liquids, kerogen oil and additives. In other words, conventicals are comparatively easy-to-access, medium gravity and medium viscosity (for oil) resources, whereas unconventional are difficult-to-access, of greater density and viscosity, and occur in tight formations. It is worth mentioning that some criteria diverge from this classification in academic sources (Laherrere, 2001; cited in Greene et al., 2006). Greene et al. (2006:516) argue, “the distinction between conventional and unconventional resources is based on technology and economics”. Some time ago, offshore crude was classified as unconventional (Adelman, 2003); now, however, Canadian oil sands are sometimes referred to conventinals (Greene et al., 2006). Rogner (1997) distinguishes between conventional and unconventional hydrocarbons by the possibility of exploiting them with current technologies and under current market conditions. According to Schlumberger (2014:no page), unconventionals are qualified at a particular time by “a complex function of resource characteristics, the available exploration and production technologies, the economic environment, and the scale, frequency and duration of production from the resource”; gas hydrates, shale gas, fractured reservoirs, and tight gas sands are considered unconventional. Arctic oil and natural gas is treated by the International Energy Agency (IEA, 2008) as conventions with respect to the complexity of their extraction technologies. Because perceptions of Arctic (offshore) hydrocarbons differ - mainly because of their extraction complexity, not their chemical composition - they may be called as frontier locations for conventional hydrocarbons (IEA, 2013b:19). In this study, Arctic offshore hydrocarbons are addressed as frontier convenitions because they can be recovered in relatively
conventional manner, but they are proximate to unconventionals due to their remote geographical location, harsh operation conditions and technological extraction advances.

The most-used units in the oil and gas industry are field units (Robelius, 2007). Because this study addresses oil and natural gas production, all of the units in standard use should be addressed. Crude oil is measured in barrels (bbl), barrels per day (bpd), tons (t), etc. Gas can be measured in billions of cubic meters (bcm), billions of cubic feet (bcf), or million tons of oil equivalent (mln toe) (which is a unified measurement to sum oil, gas and condensate volumes).

Field units differ among the countries. In the USA, gas is measured by thousand cubic feet (1000 cf) and oil is measured in millions of barrels (mln boe). Norwegian official sources publish data in million standard square meters (mln Sm$^3$) for oil and condensate, and billion standard square meters (bln Sm$^3$) for gas. Russian companies use billion cubic meters of gas (bcm) and million tons (mln t) for oil. To summarize all of the volumes of oil, natural gas and condensate produced, the million tons of oil equivalent (mln toe) measure has been chosen in this study. The approximate conversion factors were sourced from the BP Statistical Review of World Energy (BP, 2013b) and Facts, the Norwegian Petroleum Directorate’s yearly report (NPD, 2013).

Finally, the definitions of ‘field’ and ‘deposit’ were examined. An ‘oil field’ or ‘oilfield’ is an area of land or seabed underlain by strata yielding petroleum, especially in amounts that justify commercial exploitation (New Oxford American Dictionary, 2005; Schlumberger, 2014), whereas ‘oil deposit’ can also mean an accumulation of oil that is not exploitable. Fields placed on the land are called onshore ones, fields on the bottom of the sea or ocean - offshore fields. On the shoreline, fields can be partly onshore or partly offshore.
Study results

This study aimed to give deeper insight into Arctic offshore hydrocarbon development activities by analyzing the relevant investments and technologies from a historical perspective by answering the following research questions: (1) Why does Arctic offshore hydrocarbon production matter?; (2) What factors influence Arctic offshore hydrocarbon production and how?; and (3) How much oil and natural gas production occurs offshore in the Arctic? A brief overview of studies can be found in Table 2.

Table 2: Summary of studies

<table>
<thead>
<tr>
<th></th>
<th>Cover Essay</th>
<th>Paper I</th>
<th>Paper II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Title</td>
<td>Why does Arctic offshore hydrocarbon production matter?</td>
<td>Offshore Arctic Hydrocarbon Resource Development: Past and Present</td>
<td>Role of technology in expanding accessible oil and natural gas resources in the offshore Arctic</td>
</tr>
<tr>
<td>Research question</td>
<td>RQ1</td>
<td>RQ2, RQ3</td>
<td>RQ2, RQ3</td>
</tr>
<tr>
<td>Method</td>
<td>historical method</td>
<td>historical method, case study, quantification</td>
<td>historical method, quantitative analysis</td>
</tr>
<tr>
<td>Unit of analysis</td>
<td>Arctic offshore oil and natural gas development in the global context</td>
<td>Arctic offshore oil and natural gas fields, investments</td>
<td>Arctic offshore oil and natural gas production, technological concepts</td>
</tr>
</tbody>
</table>

The study provides several insights into Arctic offshore oil and natural gas resources development in the global context via an analysis of the relevant investments and technology from a country-by-country and historical perspective in the maximum period time frame between 1920 and 2025.

Literature and historical reviews show that Arctic issues are broad and appear in a great number of academic studies. There are numerous factors that make the Arctic a challenging and interesting issue to explore: geopolitics, governance, climate change, indigenous issues and economic opportunities. Depending on the methodology, data collection and analysis methods used, these factors are analyzed in combination, in consecutive order or separately.
Based on available data for 55 studied deposits, through 2014, 10 are producing, 6 have approved development plans and 18 have investment data, which were studied. According to the development programs, there will be 22 Arctic offshore fields in production before 2030.

According to the collected data, the Arctic contains approximately 14.8% of the total mean undiscovered oil and natural gas resources compared to the world’s total proven oil and natural gas reserves through the end of 2012, 5.2% of the world’s oil resources and almost 29% of the world’s natural gas resources (including NGL) (USGS 2008b; Gautier et al., 2009; Budzik, 2009; BP 2014c). To date, approximately 550 oil and natural gas fields have been found in the Arctic basins (Budzik, 2009). The cumulative production of the offshore Arctic has reached almost 600 mln toe by the end of 2014, whereas the offshore Arctic produced 55 mln toe in 2013 and 60 mln toe in 2014. This is less than 1% of total world oil and natural gas production (according to total world oil and natural gas production data from BP, 2014c:10,26). It is projected that cumulative hydrocarbon production will double by the end of 2025, however, yearly production volumes are expected to attain 2006 production levels.

Data show that Arctic offshore oil and natural gas resources development is ongoing. In the 2000s, Arctic offshore oil and natural gas production began to grow visibly. Its development is uneven and consists of numerous peaks and gaps in total Arctic offshore oil and natural gas production. These are mostly connected to new production start-ups or the depletion of producing fields, respectively, where the ability to intensify production is also dependent on technology. Over the studied period, the amount of real investments has risen considerably, peaking in 2011-2012. Here, start-ups follow investment programs on a time lag, which shows the influence of the decrease in investments after the crisis events of 2008-2009. Although in upcoming years the cumulative investment trend is likely to remain on the growth track, the oil and natural gas production peak is expected to occur in approximately 2018. There is an explicit tendency for steep decrease, at least in the short term. Further Arctic offshore production will be dependent on production start-up plans after 2020. There are potentially 12 fields, prospects and license areas identified in the offshore Arctic, all of which may contribute to total production in the future.

On a country-by-country level the spread in development is dramatic. Norway is an investment leader, the USA has the largest amount of producing fields, and Canada has almost no ongoing activities, whereas Arctic offshore hydrocarbon resources play a strategic role for Russia. Development is very
dependent on the Arctic countries’ priorities. At the same time, the countries’ trends are not obvious. Alarming changes are occurring in the USA and Norwegian Arctic offshore, where investment trends have diverging tendencies. In the short term, development intensity may continue to decrease due to growing upstream costs, especially in Norway. The currently increasing production in Russia, the majority of which is from one giant field (Yurkharovskoye), is not receiving a proper amount of investment into future production.

Following the period of individualism in Arctic exploration, cooperation agreements between the major energy companies with governmental support have provided an opportunity to scale up development. The main region of cooperation was the resource-rich offshore Russian Arctic. Global geopolitical tensions can seriously harm the business environment. It is most likely that Russia’s massive plans for exploration of Arctic hydrocarbon resources will be postponed due to the highly turbulent economic and geopolitical situations. However, it is most likely that other countries will provide cooperation opportunities in the Arctic later, albeit on a modest scale.

There is also a sharp differentiation between Arctic countries and the most used technologies. The choice of technologies is most likely to follow a path from easy to access nearby shore fields to more distant ones, where technologies used to minimize development costs. Otherwise, the contribution of technology to production volumes is not obvious. More advanced and far-reaching technologies do not visibly extend the projected output of oil and natural gas. Technological choice can also be dictated by climate conditions and ecological requirements. The historical overview has demonstrated a sharp differentiation between Arctic countries and the most used technologies that is dependent on technological availability and climate-geographical characteristics. The trend of Arctic offshore oil and natural gas development will be very dependent on technological factors in the sense of the availability of technologies and technological progress.
Discussion

Arctic offshore oil and natural gas development, being very challenging and investment demanding, has shown to be sensitive to geopolitical and economic events. Production gaps may indicate a variety of crises, structural changes, and geopolitical instability, all revealed in a certain time lag (moreover, these time-lags should be a subject of additional study). This study has shown the possibility of both a negative and positive influence by the changing geopolitical environment on Arctic offshore hydrocarbon resources development.

The first issue related to the current geopolitical turbulence. Because geopolitics are a canvas for most political and economic decisions, they seem to play a significant, multidirectional role in Arctic offshore activities. The Arctic is a relatively stable region with few political risks. Growing instability in the Middle East and North African countries as traditional hydrocarbon producing regions can result in the transfer of oil and natural gas investments to the North. However, the conflict in Ukraine destabilizes achieved cooperation in the Arctic and transforms it into a field of confrontation due to sanctions on technology transfer. However, the substitution of European and American investments and technologies by Asian ones can open up new economic opportunities.

Second, governmental socio-economic incentives to develop the Arctic regions (which have multiple effects on related industries) may reinforce or restrict offshore hydrocarbon resource production. On the one hand, governmental authorities can stimulate industries through investment and tax regimes to advance new projects, such as Goliat in Norway or the Kara Sea projects in Russia. On the other hand, state interest in the Arctic offshore differs from low commercial interest in the West to strategic prioritization in the East. Greenland sees a potential path to independence from Denmark through natural resource exploration, the USA gives a higher strategic priority to shale gas projects than to any others, and Canada ties long-lead-time decisions on Arctic offshore exploration to ecological and infrastructure issues. Economics play a substantial role in most of the projects, but it is political decisions that can significantly influence future development plans. Countries’ internal incentives related to Arctic offshore exploration should be a subject of further investigation.

Governance and geopolitics play significant roles in the ability of the business sector to cooperate on an international level. Cooperation agreements with governmental support are a way to share the risks and exchange technical
expertise. This can be one of the strongest factors positively influencing development with mutual benefits. The main area of cooperation development was Russia and the Norwegian part of Barents Sea. Technology is the most promising area for cooperation given the challenging nature of Arctic offshore activities, however, immediate political issues can postpone such cooperation. From this perspective, technology is a tool used in the geopolitical field: currently, it is used in a manner that is destructive to Arctic offshore oil and natural resources development and cooperation. There is still hope that Arctic offshore oil and gas exploration technologies, in particular subsea technologies, can clear a path to more automatized, safe, and therefore sustainable offshore Arctic activities.

Finally, there is a perpetual issue of oil price. Numerous studies show the direct relationship between crude oil price and industrial development (e.g., BP Energy Outlook 2035 (BP, 2014b)). Rising oil prices place upward pressure (both directly and indirectly) not only on inflation, prices of commodities, etc., but also on economic indicators (IEA, 2011). According to Bøhren and Ekern (1987), petroleum prices volatility and the USD/NOK exchange rate presents the highest risk to the Norwegian petroleum industry (cited in Osmundsen, 1999). The study of Mohn and Osmundsen (2008) shows that there is a direct, robust, long-term influence of oil prices on exploration activities on the Norwegian continental shelf. Crisis events, such as the 2008-2009 world economic crisis, followed by decreasing oil prices, resulted in a lack of necessary investments and the delay or cancellation of some Arctic offshore projects. This is the case of Goliat in the Norwegian part of the Barents Sea and the Shtokman project in the Russian part of the Barents Sea. With respect to correlations between oil price and geopolitics, and the depth of the influence of oil prices on Arctic offshore activities, the current issue of oil price instability at the end of 2014 and price minimum in January 2015 ($45 per barrel, Finam, 2015) can seriously affect future Arctic offshore production plans. As was discussed above, crude oil prices are not the only factor that drives or stalls Arctic offshore oil and natural gas production. From a global perspective, the dependency of Arctic offshore oil and natural gas development on other internal and external factors is very high.

A further step to deepen the analysis of Arctic offshore hydrocarbon resources development is to analyze influential factors together in one basket, aiming to understand causal relationships and to evaluate the ‘power’ of their influence.
Conclusion

The energy world faces dramatic uncertainty, and geopolitics makes a substantial contribution to that uncertainty. New geopolitical and resources perspectives make Arctic offshore hydrocarbon development an international issue of particular interest for the circumpolar and non-circumpolar countries, institutions and international energy companies involved. Arctic issues form a tangle of international relations that are both cooperative and confrontational.

The study has shown the importance of Arctic issues globally and regionally and has provided deeper insight into Arctic offshore hydrocarbon development activities. The factors identified in literature and historical reviews provided an opportunity to measure of the scope of Arctic offshore hydrocarbon development. The study’s results provided an understanding of current trends in Arctic offshore hydrocarbon resources development.

The implications of this study’s results can be useful to help explore other factors that influence Arctic offshore hydrocarbon resources development and to make assumptions about future development. The results of investment and production trends can be used to forecast assumptions. Future studies can address the driving geopolitical and other factors (climate issues, governance or cooperation) in the attitudes of energy companies toward Arctic offshore exploration. These factors should be studied both separately and together. To do so may provide an understanding of future trends in Arctic offshore oil and natural gas resources development, along with the Arctic region overall.
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Appendix

Identified deposits, license areas and prospects (55):
Canada (3): Amauligak, Hecla, Drake Point. Norway (14): Aasta Hansteen (Luva), Skuld (Fossekall / Dompap), Asterix (6705/10-1), Snøhvit (Snøhvit, Albatross and Askeladd), Goliat, Johan Castberg (Skrugard and Havis), Gohta, Skavl, Salina (Pulk), Skalle, Snurrevad, Caurus, Tornerose, Wisting Central. Russia (29): Shtokman, North-Kildinskoye, Murmanskyoye, Ludlovskoye, Ledovoye, Fedynsky High structure, Tsentralno-Barentsevsky license block, Perseyevsky license block, Demidovskoy license block, Persmanovsky license block, Prirazlomnoe, Pomorskoye, North-Gulyaevskoye, Dolginskoye, Varandey-Sea, Medyinskoye-Sea, Pakhtusovsky and Admiralty license blocks, Rusanovskoye, Leningradskoye, Beloostrovskoye, Vostochno-Prinovozemelsky license blocks 1,2,3, Kharasaveyskoye, Kruzenshternskoye, Yurkharovskoye, North-Kamennomysskoye, Kamennomysskoye-Sea, Semakovskoye, Tota-Yahinskoye, Antipayutinskoye USA (9): Nikaitchuq, Oooguruk, Northstar, Endicott, Liberty, Pt. McIntyre, Point Thomson, Badami, Burger.

Data collection sources: