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The role of the socio-technical regime in the sustainable energy transition: A case of the Eurasian Arctic

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ABSTRACT

This study investigates the role of the socio-technical regime in the global energy system transition towards sustainability within the context of exploitation of oil and natural gas resources, illustrated by the case of the Eurasian Arctic. The study design and methodology are inspired by a multi-level perspective framework. The Arctic case is examined through a 'salient–reverse salient' approach. The analysis shows that the exploitation is ongoing, independent of global sustainability goals and strong landscape pressures. We observe a lack of alignment between the different levels of the global energy system, where regime salients dominate over other factors. Incumbent actors acknowledge high levels of inertia and dependency within the oil and gas industry. The study concludes that a deeper focus on the capacities and qualities of the socio-technical regime can facilitate the sustainable energy transition. We suggest a more systematic view of transition studies, and theoretical and methodological pluralism via a combination of frameworks. We highlight the need to include the oil and gas industry as an eligible actor and factor in discussions of the sustainable energy transition, and also suggest 'unlocking' the regime through greater attention to its inertia and momentum.

1. Introduction

The global energy system is shaped by a variety of intertwined trends. On one hand, there is a constant need to satisfy growing energy demand while the global energy balance continues to be dominated by fossil fuels (BP, 2020). On the other hand, the energy industry, and especially the oil and gas industry, are seen as some of the main contributors to climate change and as responsible for a large share of CO_2 emissions (UN, 2017). As the modern energy system is seen as the main cause of and also the key solution to mitigating climate change, there is a global strive towards more sustainable 'configurations' of the energy system (Berkhout, 2002; Smith et al., 2005a). At the same time, the oil and gas industry is perceived to be rather resistant to sustainable change (Bach, 2017; Geels, 2014; IEA, 2018). Indeed, the evidence for resistance can be seen in the hydrocarbon-dominated global energy balance, significant value of fossil-fuel subsidies (IEA, 2020), and also in the continuing expansion in the exploitation of oil and natural gas resources.

One of the special cases of oil and natural gas resources exploitation is offshore in the Arctic. The region is challenging due to its remoteness, lack of infrastructure and harsh natural conditions (temperatures dropping to below -40°C, severe storms, underwater and sub-water ice, frequent and long-lasting fog, permafrost, shallow seawater areas, strong sea currents and gusty winds). Operations in Arctic offshore areas require adaptation of technologies and special engineering competencies, and bring higher risks and costs than other petroleum provinces. However, the region is considered to have high potential for new commercial discoveries (Budzik, 2009; Gautier et al., 2009).

Interest in developing the offshore Arctic oil and natural gas resources on the country-to-country level is diverging (Morgunova, 2020). Norway and Russia are the two circumpolar countries most engaged in the developing of the Arctic offshore resources, having both strategic and socio-economic interests in the region. Other circumpolar countries with an outlet to the Arctic Ocean – Canada and Denmark (via Greenland) and the United States – are engaged, to varying degrees, in oil and natural gas activities in the Arctic. Greenland experiences a widely fluctuating level of activities, mostly dependent on political discussions around Greenland's economic and political independence from Denmark, and oil price (Poppel, 2018). Canadian waters and some of the United States Arctic waters are indefinitely off the oil and gas activities (Government of Canada, 2018; The White House, 2021), while

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there were no commercial offshore drilling in the Canadian Arctic for years.

Other countries (such as members and observers of the Arctic Council) are engaged at different paces in some of the development activities in the region, including resource extraction, socio-economic development, transportation and transit (Jungsberg et al., 2019; Kovalenko et al., 2018). At the same time, due to its special natural conditions, the Arctic region stimulates technological development and economic growth as the region itself is highly unexploited and suggests numerous socio-economic opportunities.

Among the many issues influence the expansion of the oil and gas industry into the Arctic are the presence of conventional oil and natural gas resources, macroeconomic factors, geopolitical issues and ecological concerns. Arctic offshore oil and natural gas exploitation has already experienced ups and downs, which can be observed historically (Morgunova, 2015). Interestingly, despite immense global sustainability challenges and pressures exerted on the oil and gas industry due to environmental and climate issues, the development of oil and natural gas resources offshore Eurasian Arctic is ongoing.

We propose the case of Eurasian Arctic offshore oil and natural gas resources for deeper investigation of the aspects of change towards sustainability in the global energy system in the context of ongoing extensive exploitation of conventional oil and natural gas resources. Arctic offshore is a well-defined geographical area that represents the analytical level of concrete industrial example (Turnheim and Geels, 2019), which enables rich explanations and makes it possible to focus on the processes of change within the global energy system. The aim of our investigation is to gain a better understanding of resistance and stability in the global energy system. The study targets the following questions:

RQ1: *How do actors justify the ongoing oil and natural gas exploration offshore Arctic?*

RQ2: *Based on the Arctic case, what bottlenecks in sustainable energy transition have been observed?*

The first research question is investigated using empirical data collected through semi-structured interviews, while the second is addressed in the discussion part of the paper.

The remainder of this paper is structured as follows. Section 2 is devoted to conceptual framing and methodology. Section 3 introduces the results of the analysis conducted with implied theoretical frameworks. Section 4 comprises the discussion, implications and limitations of the study, followed by conclusions in Section 5.

2. Theoretical approach and methodology

2.1. Theoretical approach

We follow the same 'family of ideas' in our theoretical choices. This paper is built using a notion of a large socio-technical system (LTS), initially introduced by Hughes in 1987 (Hughes, 1989, manuscript of 1987). We investigate the complexity of the energy system as an LTS using the multi-level perspective framework (MLP) (Geels and Kemp, 2007; Geels, 2002). The sustainable energy transition and the role of the socio-technical regime in it are analysed with the help of the 'salient and reverse salient' approach.

2.1.1. Large technological systems and the multi-level perspective

An LTS, as defined by Hughes (1989), includes many technical and social components, and possesses high complexity, which affects the system dynamics and its ability to change (Markard et al., 2012). To structure and analyse this complex interplay of components in a context of change, we took as inspiration the MLP approach and similar studies investigating non-energy LTS (Berggren et al., 2015; Blomkvist and Larsson, 2013; Blomkvist and Nilsson, 2017), as well as various aspects of sustainable energy transition (Geels, 2014; Unruh, 2000). The methodological choice is also supported by the proven ability of the MLP to analyse 'far-reaching transformation processes' of an LTS (Markard et al., 2012, p. 956).

The MLP was initially developed in order to describe and understand the change processes (such as transition and transformation) in a complex system (Geels and Kemp, 2007, p. 445). It is the framework within which complex systems can be mapped out and analysed on three levels: socio-technical landscape, socio-technical regime and niche level. These three levels represent a structural hierarchy of an industry (Geels, 2002) and can visualise the complex interactions between the levels. The landscape level can be described as '*[forming] an exogenous environment: macro-economics, deep cultural patterns, macro-political developments*' (Geels and Schot, 2007, p. 400). It also includes international governance and international geopolitical, economic and social setting. The landscape level has a system formatting character; it creates the framework in which other layers function. At the same time, it is rather inflexible, although the political landscape can change rapidly (Geels and Kemp, 2007). Socio-technical regime is the meso-level formed by engineering practices and routines, as well as dominant technologies linked together (Geels and Kemp, 2007; Geels and Schot, 2007). Social practices, scientists, policy makers and other interdependent groups also help to shape the regime level. The socio-technical regime in general is not eager to change, and possesses certain resistance (Geels et al., 2017). The niche level is the micro-level with special conditions for the rise of radical innovations.

The earlier MLP literature paid a lot of attention to niches (Markard et al., 2012), since they were seen as a key to innovation birth (Hoogma et al., 2002), supporting further diffusion of innovations and building the necessary space for learning and development (Geels, 2005; Geels and Schot, 2007). Niches are considered to be governed by the dominant socio-technical regime and landscape, a configuration that also makes it possible for the innovations to be introduced to the upper two levels through the 'windows of opportunity' (Geels, 2002, pp. 1261–1262) or similar processes such as protective spaces (Smith and Raven, 2012), and market areas (Schot and Geels, 2008). Later studies investigated the diffusion of those innovations into the higher levels of the MLP system (Smith and Raven, 2012; Turnheim and Geels, 2019).

Despite the proven ability to create a viable framework for analysing sustainability transitions, which makes it one of the most widely used approaches in this study domain (Köhler et al., 2019), the MLP is subject to some criticism. First, the MLP has been criticised for a lack of attention towards the existing regimes (Genus and Coles, 2008) in favour of 'green' niche-innovations (Meadowcroft, 2011; Smith et al., 2005a). As Berggren et al. (2015, p. 1027) argued, *'stereotypical conceptualizations'* risk giving a static view on change and excluding the regime actors from the pool of actors able to drive the change. Currently, some transition literature goes deeper into studying regime actors (Turnheim and Geels, 2019) and their transformative capacity, but also argues that radical alternatives predominantly occur as a result of intervention by neighbouring regimes. Second, according to Smith et al. (2005a), the MLP is poor from the aspect of considering the direction of the landscape pressures, and if those are not directional, the transition is unlikely to occur. Meadowcroft (2011) underlined the importance of coordination (such as political framework) within the regime in order to make change happen. Finally, Berggren et al. (2015) argued that the borders between the levels of an LTS analysed with the help of the MLP are much lower, especially when it comes to technology development and diffusion of innovations in the larger industrial sectors. This argument may be well supported by the example of the oil and gas industry where, due to its size and capital intensity, not only regime and niche, but regime and landscape levels also stay close together and are very much interrelated.

Recognising these limitations and gaps, we use the MLP framework to investigate the processes of change in the global energy system by analysing the dominant regime – the oil and gas industry. Simultaneously, we address the aforementioned critics by focusing on the regime and its qualities, such as resistance and stability. Thus, the character of the study tends towards a more evolutionary view of change, which can be seen as opposite to the radicalisation of sustainable energy transition mechanisms (for example, *'…destabilization and decline of existing fossil fuel regimes'*)(Geels, 2014, p. 21).

2.1.2. Salients and reverse salients of large technological systems

Being aware of a 'messy complexity' (Hughes, 1989) of the global energy system, multi-dimensionality of the current socio-technical change (Köhler et al., 2019), and targeting more theoretical 'pluralism' in current sustainability transition studies (Hopkins et al., 2020; Köhler et al., 2019), we apply the concepts of 'salient' and 'reverse salient' for deeper investigation of the regime. As defined by Hughes (1989, p. 73), *'reverse salients are components in the system that have fallen behind or are out of phase with the others'*. Salients are those components of the system that are ahead of the system development, suggesting a higher or improved system performance, thus creating tension.

The concepts of salient and reverse salient have been mostly applied in the historical analysis of previous technological development, as well as in deep conceptual analysis (Dedehayir, 2009), but can be efficiently applied to larger systemic contexts (Dedehayir and Mäkinen, 2011). The concept of reverse salient with respect to similar concepts (such as 'bottleneck or 'technological imbalance') (Dedehayir, 2009, p. 575) possesses a certain degree of conceptual freedom, since it can be applied not only to technological artefacts but also for other components of the system. The concepts of salient and reverse salient are useful in understanding the system dynamics and future evolution trends (Dedehayir and Mäkinen, 2011), defining the 'critical problems' (for example, the most critical components of a system that require solutions and can be altered by innovations), and also in analysing salient and reverse salient pressures for regime change or identifying salient knowledge (e.g., Smith et al., 2005a). We use those concepts to depict the salients and reverse salients of the Eurasian Arctic offshore oil and natural gas exploitation from the perspective of actors and experts in the regime.

2.2. Data collection

Given the exploratory nature of the study, we adopted a case study strategy. The data collection was conducted in three steps. The first step was directed towards gathering background data from primary and secondary sources, including company reports, national strategies, policy documents, and industrial and academic publications with the purpose of defining the scope of the empirical data collection.

The second step was empirical data collection by means of two rounds of interviews. The first round consisted of preliminary unstructured interviews (March 2018) with no predetermined questions in order to allow flexibility in the interview process (Saunders et al., 2009). Based on the results of the first round of interviews, a second round of semi-structured interviews was conducted (July, August and September 2018, within the framework of a workshop dedicated to Arctic offshore oil and natural gas activities, and during a research visit to China). The topics covered were factors influencing offshore Arctic oil and natural gas exploration activities, and actors' justification of ongoing activities. A semi-structured interview protocol was used to ensure that the key topics are addressed.

The third step included verification and data triangulation from additional data collection activities, such as observations and records during the conferences and workshops, with the purpose of enriching data and reducing possible interview bias (Eisenhardt, 1989).

The empirical data consists of 16 interviews, with a total combined length of 480 min. The selection of interviewees was conducted based on their expertise and ability to provide rich explanations, while an additional criterion for selection was to ensure representation diversity. Interviewees represented the oil and gas industry sector, the energy sector, academia, and were geographically widespread (China, Norway, Russia, USA, and other European countries), although their academic and professional focus predominantly lies in Eurasian Arctic. Therefore, we kept the analytical focus of the study on the exploitation of offshore Eurasian Arctic oil and natural gas. Detailed information about the interviews is available in Table 1.

2.3. Data analysis

The data analysis was performed by means of an analytical process including coding. After being transcribed, each interview was examined in order to assign codes to the corresponding evidence. Different categories of factors (such as governmental, technological, economic, ecological and geopolitical) were labelled from 1 to 5 depending on their nature, where factors that did not fall into any of the categories were classified as 'other' (labelled 6). At the next stage, the coded data was structured according to the labelling and went through the second round of analysis to be classified as salients or reverse salients of the exploitation of Eurasian Arctic offshore oil and natural gas resources. At the third stage, the data within each category were analysed in order to define the similarities between the identified evidence to be structured into the more specific factor groups. The results were summarised in line with the applied coding procedure. Data analysis includes no quantitative weighting of factors and does not pretend to establish the importance of one factor over another.

The reliability and validity of the study is secured through the use of all the aforementioned procedures, including the general guide approach, the semi-structured interview protocol, as well as additional data verification and triangulation. Reliability of data analysis is also supported by interview quotations, thus ensuring credibility and confirmability (Easterby-Smith et al., 2008; Robson, 2002; Saunders et al., 2009).

Table 1
Detailed information about the interviewees

#	Affiliation	Areas of expertise	Current country affiliation	Date of interview
1	industry, academia	oil and gas, energy resources economics and management	Norway, Russia	March 2018
2	industry, academia	oil and gas, energy economics, energy technologies	Russia, USA	March 2018
3	industry, academia	oil and gas, upstream, offshore, Arctic technologies	Norway, Russia	March 2018
4	industry, academia	oil and gas, upstream	Austria	July 2018
5	academia	industrial ecology, oil and gas	Russia	July 2018
6	industry	oil and gas, Arctic exploration, energy economics	Russia	July 2018
7	academia	oil and gas, logistics	Norway	July 2018
8	academia, industry	oil and gas, upstream	Serbia, Austria	August 2018
9	academia, industry	natural gas economics and management	Norway	August 2018
10	academia	management, economics of energy resources	Russia	August 2018
11	academia, industry	oil and gas, offshore, ecology	Norway	August 2018
12	industry	oil and gas, upstream	Russia	August 2018
13	academia, industry	oil and gas, offshore, ecology	Russia	August 2018
14	academia	energy management, environmental science	China	September 2018
15	academia, industry	energy, sustainability, geopolitics	China	September 2018
16	academia	Energy engineering	China	September 2018

3. Results

3.1. Salients and reverse salients of the exploitation of Eurasian Arctic offshore oil and natural gas resources

Table 2 presents a summary of the data analysis with six categories and 27 factors, subdivided into salients (S) and reverse salients (RS) of the development of Eurasian Arctic offshore oil and natural gas resources. A description of each factor, along with discussion of related empirical data, follows in Sections 3.1.1–3.1.6. Section 3.2 focuses on the most important salients and reverse salients according to the respondents' views, and their potential affiliation with the system levels – landscape and regime.

3.1.1. Governmental (institutional)

Strategic interests (1.1S) of governments generally coincide with the intensity of industrial activities in the Arctic. In some circumpolar countries engaged in oil and natural gas exploitation activities, the strategic national priority of the Arctic region development affects the level of state support for commercial activities (for example, one of the interviewees mentioned how *'…some projects may be subject to political influence'*) (also, Petrov, 2018). In certain countries, such as Russia, government is far more involved in the exploitation of Arctic offshore oil and natural gas resources and shows economic interest via the state oil and gas companies (Morgunova, 2020).

Poor governmental support (1.2RS) is related to issues connected with tax breaks and economic benefits for the companies to develop the Arctic region. Even though governments may advocate for the need to increase commercial activities offshore Arctic, governmental financial support is not in place. Some interviewees stated: *'the state is not interested…', 'government support is extremely small'*. High risks and costs with no governmental support hold back commercial companies from those activities.

Underdeveloped legislation (1.3RS) is also related to poor governmental framework, where underdeveloped strategies and policies fail to create a stable and clear institutional environment (interviewees mentioned '*constantly changing* [conditions]*', 'no strategy', 'gaps in the legislation'*). These hinder companies from entering Arctic projects.[1]

3.1.2. Technological

New relevant technologies (2.1S) open possibilities for the companies to explore new areas for oil and natural gas. Many interviewees mentioned advances in technological solutions that lower extraction and transportation costs (subsea installations, floating natural gas liquefaction facilities, etc.), reduce environmental risks, ensure safety in the ice conditions, and bring other benefits for the companies operating offshore Arctic. An engineer at a large company mentioned, *'technologies for the Arctic offshore projects are developing rapidly'*, whereas a researcher emphasised the decreasing costs that new technological solutions bring: '*…new* [technological] *opportunities …allow us to extract these resources with a low cost component'*.

Expensive and complex technologies/no suitable technical solutions, expertise (2.2RS) is a contemporary challenge. Even though some technological solutions exist, not all of them are viable due to high costs, installation and usage complexity. For example, interviewees with an industrial or engineering background mentioned the following: *'…these problems* [seismic in ice conditions] *have not been solved', 'these are expensive and complex technologies, so they are not very promising'*. Lack of technological expertise is also an issue for some of the oil and gas companies.

Absence of infrastructure (2.3RS) needed to support more intensive exploitation of Arctic offshore oil and natural gas resources is one of the barriers that several interviewees underlined. For example: *'The Northern regions have the problem of there being no infrastructure.'* The availability of transport, energy and search and rescue infrastructure along the vast, sparsely populated Arctic territories and coastal zones varies considerably. In general, the need to create a supportive infrastructure increases development costs for the energy companies. The absence of infrastructure also requires higher technological adaptation or the search for new solutions due to the specific Arctic environment and remoteness of the industrial sites.

3.1.3. Economic (resource)

Rich in resources (3.1S) offshore Arctic territories attract the attention of companies and governments as a way to increase their resource base or as a strategic deposit for the country's future energy needs. High resource potential may also be one of the factors for increasing sovereignty claims (cf. Valková, 2017).

New economic opportunities (3.2S) are seen as one of the stimulating factors for governments and companies. This factor was underlined by seven interviewees. Maritime transit routes are also attractive for both Arctic and non-Arctic states (Kovalenko et al., 2018). The resource potential of the offshore Arctic itself is not always highlighted as the main reason for development of the region, but it is the exploitation of natural resources and development of related infrastructure in the Arctic. An engineer at a large company referred to the following: *'In addition to directly mining and drilling, a huge cluster of suppliers is also involved. One job in the Arctic creates 14 jobs in other industries in other regions. Therefore, when we estimate revenues from implementation of a project, we cannot only take into account the cost of oil. It is necessary to take into account the formation of the multiplicative effect.'* Nevertheless, the Arctic energy projects that were considered to be primarily of geopolitical and strategical value turned out to be showing return on investment (Dillow, 2018).

Growing energy demand/demand for oil and gas resources (3.3S) globally stimulate both producers and consumers to search for new energy resources, including the conventional ones. This factor is also one of the strongest motives towards the exploitation of Arctic offshore resources according to nine out of the 16 interviewees. Arctic oil and natural gas offshore attract both producers and consumers willing to contract future production volumes in order to secure the future energy supply (for example, China – '*… The Chinese government has the ambition to develop these* [Arctic offshore] *resources'*, South Korea and Japan).

Decreasing production/resource base (3.4S) of oil and gas producing countries, specifically Russia and Norway, stimulates them to search for new resources. One academic reflected: '*There is de facto no alternative* [for Norway] *to entering the Arctic'*. In both countries, Arctic offshore is a natural continuation of the major oil- and gas-producing regions with high resource potential and high probability for huge discoveries (Gautier et al., 2009). An interviewee from an oil and gas upstream sector commented: *'…some companies see it as a chance for them to significantly grow production.'*

Resource dependency (3.5S) implies dependency on oil and gas as a source of energy to satisfy energy demand. One interviewee concluded, *'it is impossible to neglect the traditional energies'*. Oil and natural gas are also a source of income for oil- and gas-producing countries. This income is of particular importance to Russia and Norway, as the budgets and finances of these countries are largely dependent on oil and gas export income: *'For Russia and Norway – countries that are very dependent on the export of petroleum products – there is no choice'* (stated by a person from an oil and gas upstream sector).

High costs/risks (3.6RS) of oil and gas exploitation activities offshore Arctic are related to environmental issues and severe conditions of nature including icing, as well as other institutional and technical reverse salients such as insufficient governmental support, absence of infrastructure, absence of requisite technical solutions and expertise. According to the interviewees, Arctic offshore oil and natural gas resources

[1] This does not mean, however, that enabling the sustainable energy transition requires blocking legislation development, not developing infrastructure or constraining the technological progress (such as sanctions).

Table 2
Salients and reverse salients of the exploitation of Eurasian Arctic offshore oil and natural gas resources S (no fill) – salient; RS (grey fill) – reverse salient.

Factors / Interviews		I1	I2	I3	I4	I5	I6	I7	I8	I9	I10	I11	I12	I13	I14	I15	I16
1.Governmental (Institutional)	1.1(S) Strategic interests	*		*					*	*	*	*	*	*	*		
	1.2(RS) Poor governmental support	*	*	*									*				
	1.3(RS) Underdeveloped legislation	*		*			*										
2.Technological	2.1(S) New relevant technologies		*	*			*		*		*	*		*			
	2.2(RS) Expensive and complex technologies/no suitable technical solutions, expertise	*	*	*			*				*		*	*			
	2.3(RS) Absence of infrastructure		*		*	*	*					*	*				
3.Economic (resource)	3.1(S) Rich in resources		*	*		*	*		*			*					
	3.2(S) New economic opportunities	*	*	*			*				*	*		*			
	3.3(S) Growing energy demand, demand for O&G resources		*			*	*	*		*	*				*	*	*
	3.4(S) Decreasing production/resource base	*	*		*		*	*	*								
	3.5(S) Resource dependency			*				*	*	*			*			*	
	3.6(RS) High costs/risks		*	*	*							*	*	*			
	3.7(RS) Volatile and low oil prices	*			*		*					*	*				
	3.8(RS) Resource competition/alternative energy resources	*		*	*		*	*	*			*	*	*	*	*	
	3.9(RS) Other economic priorities	*													*	*	
4.Ecological	4.1(S) Acknowledgement and higher involvement			*		*	*	*		*			*	*	*		*
	4.2(RS) Region environmental sensitivity			*	*	*	*	*					*				
5.Geopolitical	5.1(S) Securing resources and territories, resource nationalism	*									*		*				
	5.2(RS) Political risks		*	*								*	*				
	5.3(RS) Sanctions	*			*		*						*	*			
6. Other	6.1(S) Inertia and dependency			*					*	*		*		*			
	6.2(S) Regionalisation			*							*						
	6.3(RS) Natural prerequisites		*	*	*	*	*										
	6.4(RS) Reputational risks				*					*			*	*			
	6.5(RS) Access to markets			*	*		*						*				
	6.6(RS) Internal changes in the oil and gas companies (re-orientation of business models)							*	*			*		*			
	6.7(RS) Social resistance, public acceptance				*			*		*			*			*	

are *'not at all competitive'* and are *'roughly twice as expensive'*.

Volatile and low oil prices (3.7RS) constitute the main challenge for governments and companies willing to exploit Arctic offshore oil and natural gas resources. Lower oil prices do not permit companies to receive returns on investment for long-term and high-risk Arctic offshore projects. Volatile oil pricing increases investment risks and creates instability and unpredictability on the energy markets (IEA, 2019).

Resource competition/alternative energy resources (3.8RS) challenge Arctic offshore oil and natural gas resources exploitation (discussed by 11 interviewees). Renewable energy and other non-renewable unconventional oil and gas resources, such as shale, become available at lower costs. Many interviewees considered Arctic offshore resources to be less attractive, since traditional oil and natural gas resources face competition from alternative and renewable energy: *'…new energy resources like wind, solar, geothermal that can completely substitute the eventually decreasing oil and gas sector'; 'alternative fuels and even energy sources are becoming more interesting and promising, as well as less risky'*.

Other economic priorities (3.9RS) compete for investments with the development of the Arctic region. Some governments redirect towards socio-economic issues, development of other energy or natural resources, thus supporting offshore oil and natural gas projects less intensively. As exemplified by an experienced high-ranking manager in an oil and gas company: '*it* [a large-scale offshore Arctic natural gas project] *went down in the list of priorities and was blocked by the development of other natural resources.'*

3.1.4. Ecological

Acknowledgement and higher involvement (4.1S) of ecological and environmental issues by energy companies and governments result in higher health, safety and environment standards (Dietz et al., 2020). Energy companies claim to be paying greater attention to the application of best practices and technical solutions to provide safe operations in the Arctic region, as stressed by a specialist dealing with offshore technologies and ecological safety: *'with the development of technology, we see that attention to environmental issues is growing more and more… do not forget about environmental monitoring. Companies use the best available technologies, all sorts of innovations in production that are capable of protecting the environment from negative anthropogenic influence.'*

Region environmental sensitivity (4.2RS) creates additional challenges for those companies and governments willing to exploit offshore Arctic oil and natural gas resources. The Arctic region has its own specifics compared to other oil- and gas-producing regions, due to cold climate, ice conditions and the absence of support infrastructure. Industrial accidents, such as oil spills, have a very low probability of occurring, but when they do occur they will seriously harm the environment, and flora and fauna (issues mentioned by six interviewees). Even though technology for the extraction of resources from remote and harsh environments is improving generally, ecological risks are very high because there is limited technological expertise in prevention and mitigation of spills and similar accidents in the harsh Arctic conditions (Necci et al., 2019).

3.1.5. Geopolitical

Securing resources and territories, resource nationalism (5.1S) plays one of the strongest roles in stimulating greater governmental interest towards the Arctic region in general and offshore Arctic in particular. As one experienced manager of an oil and gas company commented: *'It was found that there are very few "uncapitalised" resources, hence the surge of interest in the Arctic, notwithstanding the fact that it is the last territory to be divided up among the developed countries.'* Apart from territorial claims, there are geostrategic issues connected to sovereignty (including military activities), control over transport routes and, finally, access to natural resources. The interests of Arctic and non-Arctic states are diverging and becoming extremely asymmetrical, for many reasons

(Morgunova and Westphal, 2016).

Political risks (5.2RS) in the Arctic region are generally low compared to other oil- and gas-producing regions. However, in the case of Arctic offshore territories, some major political risks exist due to the large number of disputed territories and rather underdeveloped national and international legislation for regulating activities offshore Arctic. An oil and gas upstream engineer pointed out: *'when political decisions intervene in projects, there is a lot of political pressure and this can become too risky and economically inappropriate.'*

Sanctions[2] (5.3RS) are applied by the United States and the European Union to the Russian oil and gas sector. They limit investments and technological transfer, and also harm technological cooperation, creating additional risks for environmental safety in the Arctic (Morgunova and Westphal, 2016). Sanctions are especially harmful to those national and international companies working or willing to work offshore in the Russian Arctic. Western companies were forced to leave offshore projects in the Russian Arctic, while Russian companies had to stop exploitation due to deficient technology (Mitrova et al., 2018, p. 17).

3.1.6. Other

Inertia and dependency (6.1S) were mentioned by the interviewees from both academia and industry in connection with the development of the oil and gas industry: *'The development of the* [oil and gas] *industry is inertial and gradual'; '…it is natural to invest in what I am already doing.'* Within the discussion, these concepts were also linked to dependency on the existing infrastructure – *'…the existing pipelines will soon be half-empty. They need something to be filled'* – and employment – *'…about 200,000 people are employed in this industry* [in Norway]*'*. In general, the interviewees acknowledged the presence of inertia and dependency in the oil-and-gas industry, and considered those as rather strong factors in the maintenance of extensive development of conventional energy resources such as offshore in the Arctic.

Regionalisation (6.2S) was mentioned by interviewees as an aspect of the development of energy markets that drives forward the exploitation of Arctic offshore oil and natural gas resources. Each country has preferable local energy resources, which are more secure and accessible, even though they may be less sustainable (Frei, 2004). Arctic offshore oil and natural gas resources constitute a more expensive but conventional and more geopolitically accessible regional resource for some countries (for example, as one academic dealing with energy resources management commented, '… [the Arctic comprises] *an interest for regional markets'*). As with the acknowledged case of Norway, this is oil and natural gas from the Barents Sea and the Spitsbergen area, while for Canada and the United States, current priorities are oil sands and shale, respectively. In this respect, regional and local energy resources may be preferable for some countries due to lower or no geopolitical risks and implying higher energy security (cf. Sovacool, 2012).

Natural conditions (weather conditions, access, etc.) (6.3RS) in the Arctic region, especially offshore, require intensive adaptation of the existing technical solutions. These conditions include extreme low temperatures, severe storms, underwater and sub-water ice, frequent and long-lasting fog, permafrost, strong sea currents and winds (described in more detail in Morgunova, 2015). One of the main challenges underlined by the interviewees is ice waters, which constitute the main difference between the exploitation of Arctic offshore oil and natural gas resources and other offshore areas.

Reputational risks (6.4RS) for the oil and gas companies are inherently high due to ecological and environmental impacts of the industry. In the offshore Arctic, ecological risks are even higher due to the fragile nature in the region and limited knowledge on oil spill mitigation under the sea ice. Some accidents, such as the Exxon Valdez oil spill and the Macondo well blowout resulted in financial losses but also reputational damage to the oil and gas companies (Feria-Domínguez et al., 2016). An oil-and-gas upstream engineer explained: *'the risks you are facing in the Arctic are substantially higher, because if something goes wrong in the Arctic, if there is any small-scale disaster such as Macondo, you are gone as a company.'* Therefore, according to the interviewees, some companies prefer to lower their reputational risks and intentionally redirect their activities to other regions.

Access to markets (6.5RS) for Arctic offshore oil and natural gas may be complicated due to higher competition with other energy sources. The production sites are distanced from the main markets, and those resources generally have higher costs than many alternatives (Petrick et al., 2017). As one interviewee from an oil-and-gas upstream reflected, *'… There need to be huge production volumes in the Arctic as it is very expensive … and likely directed to large-scale consumers'*. The access to markets clearly depends on the development of corresponding infrastructure.

Internal changes in the oil and gas companies (re-orientation of business models) (6.6RS) are happening throughout the sector. National and international companies diversify their business portfolios and become energy companies (for example, Statoil became Equinor (Equinor, 2018)). This was exemplified by the statement of a specialist in offshore ecological safety, *'I think … it is really some fundamental realignment from an oil company to an energy company. We have also seen that Equinor is focusing very much on the different aspects of energy, for example, renewables'*. Many oil-and-gas companies start to invest in unconventional and alternative energy technologies and resources, or apply their technical expertise in complementary sectors (e.g., Repsol, 2019). These changes draw off investments from conventional oil and natural gas resources, specifically the more investment-intensive Arctic offshore resources.

Social resistance, public acceptance (6.7RS) of oil and natural gas activities considerably influences the development of the industry, as admitted by five interviewees. The deeper embeddedness of the technological systems into the wider social and economic context is not a radically new factor (for instance, Hughes, 1989; Rip and Kemp, 1998), but social acceptability and public engagement are becoming increasingly important for the industry (cf. Pinto and Kennedy, 2019). According to the interviewees, the growing negative perception of oil and natural gas and public concerns over the ecological and environmental conditions of the Arctic region have affected companies' decisions and prevented some from moving into the Arctic.

3.2. Why is Eurasian Arctic offshore oil and natural gas exploitation being carried out?

The analysis of the qualitative data using the salient–reverse salient approach provides more understanding of why the exploitation of Eurasian Arctic offshore oil and natural gas resources is being carried out, and how oil and gas actors justify related activities.

The salients are ahead of the frontline, moving the exploitation forward. Strategic interests of the countries to develop the region or to establish their presence there (S1.1), and the growing energy demand including that for oil and natural gas resources (S3.3), are considered the two strongest stimuli for governments and companies to be engaged in the Arctic oil and natural gas activities offshore, also justifying those activities from the actors' perspective. The strong influence is also shown by new technologies (S2.1), economic opportunities (S3.2), acknowledgement and higher involvement in ecological issues (S 4.1).

The reverse salients are falling behind 'the exploitation front', thus constraining offshore Arctic oil and natural gas exploitation activities. The strongest reverse salients are competition among energy resources (RS3.8), and technological reverse salients such as expensive and complex technologies, absence or unavailability of suitable technical solutions (RS2.2). The most prominent salients and reverse salients are those components that are most critical for the regime actors to exploit the Arctic offshore oil and natural gas resources.

[2] Sanctions are commercial and financial penalties applied by certain countries against other ones.

Further, there are some important findings when applying MLP through ascribing the salients and reverse salients to the certain levels of the system. Many salients and reverse salients occur on both landscape and regime levels, as the governmental and institutional ones (factor group 1). They play significant roles in how regime actors address the issue of the exploration of Arctic offshore oil and natural gas resources at the national and international level. They also influence the scope and intensity of the development of these resources. However, a divergence between the governmental goals and industry capabilities has been observed. The aims of the government in exploring Arctic offshore oil and natural gas resources (S1.1) should ideally align with the oil and gas industry capabilities (reflected by interviewees as RS1.2 and 1.3) and the demand for these resources, which is not always the case. This may be explained by weaker business incentives than strategic national priorities. At the same time, there are strong economic incentives towards ongoing exploitation for some countries and companies (S3.2–3.5), which also arise from both landscape and regime levels. For example, the two strongest salients, S3.2 and S3.3, are referred to by the interviewees both in a macroeconomic context (for example, the expansion of international shipping and trade, global energy demand growth), and from the national and industry perspective (potential synergetic effect for national economies, and the need to secure national energy demand). Interestingly, some salients and reverse salients describe the condition of the regime or landscape. Those include S3.1 and RS6.3.

The interrelation of salients and reverse salients with each other, as well as between the levels, is still considerable. The geopolitical concerns related to political risks (RS5.2), geopolitical pressures in the form of sanctions (RS5.3), and energy security issues (e.g., S3.5) are connected with governmental strategic interests (S1.1). Interestingly, regionalisation (S6.2) and resource nationalism (S5.1) as factors of macro-political development seem to be downplaying other factors, especially in tense geopolitical conditions. Resource competition (RS3.8) is somehow negligible, despite being strongly recognised by the interviewees. Empirically, this interplay of factors is realised in manifesting the continuing Arctic resource exploitation by some countries with high strategic interest in the region, despite low oil prices (RS3.7).

We found no salients or reverse salients of a technological or innovation character related to the niche level. According to the interviewees, the technological innovations exist and occur within the industry or with the help of the industry (e.g., S2.1). The example of such technologies is underwater seismic in ice conditions. However, some reverse salients of character other than technological can be interpreted as niche factors. Growing public engagement in climate change and environmental issues, as well as readiness to adjust consumer behaviour (RS6.7), make the oil and gas industry undergo change. With respect to the latter, higher involvement and acknowledgement of ecological issues by the oil and gas industry (S4.1) can be translated as a way to secure business and a way to obtain a social licence to operate in the Arctic.

An important finding is the recognition by the interviewees (such as the regime actors) of the competition from alternative energy sources (RS3.8), and inertia and dependency of the industry (S6.1). Oil and gas companies experience price competition (fewer subsidies, lower margins, etc.), which makes them less willing to become involved in risky Arctic offshore projects. At the same time, they acknowledge the inertial characteristics of the industry, where some Arctic projects are taking place even in a situation of high risks and costs. This may be because of the already locked-in investments. Further, some interviewees underlined the importance of internal changes occurring in the oil and gas companies (RS6.6), as a reorientation of business models, diversification of business, and associated change of a company name (as in case of Equinor (2018)). This reverse salient can be seen as a signal for changes in the regime.

With an application to the country perspective, the regime salients seem to be stronger than any other salients or reverse salients. Global frameworks and policies, such as climate mitigation policies (e.g., United Nations, 2019), do not penetrate the regime level or do so unevenly between the countries. In the case of Russia, this unevenness is intensified by sanctions (RS5.3), which further stimulates the exploitation of Arctic offshore oil and gas resources. The Canadian case of a moratorium on oil and gas activities in the Arctic seems to be much more aligned with global frameworks, even though it prioritises that country's goals on sustainable Arctic economy. The US example of changing policies towards the exploitation of the Arctic oil and gas further visualises the dominating power of regime (The White House, 2021). It allows us to conclude that, in some cases, the landscape factors seem to have weaker influence at the regime level than the regime factors. The power of the regime factors may be further exaggerated by the possible decisive and envisioning role of oil and gas resources acquired in relation to the socio-economic development of the Arctic, as even some countries not engaged in the exploitation of these resources seem to be highlighting their importance for the region (Lempinen and Lindroth, 2021).

4. Discussion

Based on the performed analysis of the regime exemplified by the oil and gas industry in the offshore Arctic, we suggest some insights into the sustainable energy transition and bottlenecks along the way.

4.1. *What can we learn from the Arctic case, and what does that mean for the sustainable energy transition?*

The interplay of the salients and reverse salients in the Eurasian Arctic case signals a weak link between the socio-technical landscape and regime levels. Despite the weak linkage, companies seem to manage the landscape level regulations, adjusting them to the dominating practices of the regime level. As a result, the influence of the landscape factors on the regime may be much lower than anticipated. In the case of the Arctic, the influence of macroeconomic and geopolitical pressures may be marginal, as well as contrary to what is expected (Morgunova and Westphal, 2016). This may be the reason why sustainability initiatives (UN, 2019) have so far shown a rather modest effect on changing the regime in some regional environments, as on the regime level quite other forces are dominating. Some of these forces may be related to the powerful transformative political processes around the oil and gas resources exploitation or the envisioned benefits of the oil-and-gas-related development (Lempinen and Lindroth, 2021). The finding calls for additional attention to the qualities of interaction between the levels (Meadowcroft, 2011; Smith et al., 2005b), and specifically with the regime level (Berggren et al., 2015).

Lesser receptivity of the oil and gas regime to the imposed landscape pressures may also be explained by the fact that the industry is far larger than a regional infrastructure system (Turnheim and Geels, 2019), with much more complex interactions between the social, economic, technical, and other dimensions. Remarkably, most of the companies engaged in offshore oil and natural gas resources development in the Eurasian Arctic are state-owned, who capable of creating the *'broader institutional power'* (Geels, 2014, p. 34). Because of this type of engagement, governments act both as system builders and regime actors, while also significantly affecting political landscape (e.g., as discussed by Hess, 2014). This duality creates further mismatches in interaction between the MLP levels (relating to critics by Smith et al., 2005a) and application of landscape pressures (Berkhout et al., 2003), while limited understanding of those interactions may cause misinterpretation.

The regime qualities seem to be important for managing sustainability transitions, and may therefore be unfairly understated by the transition scholars. The case of the Eurasian Arctic shows that even though many transformative pressures are mobilised, the oil and gas industry is not fully abandoning the costly and risky resource development options. The most possible reason is the nature of the oil and gas industry, which incorporates its strategic national importance for many countries, heavy governmental regulation, and capital intensity of projects. These qualities affect incumbent actors (both national and international energy companies) who rarely possess a 'transition' level of flexibility in their business activities.

The key finding of this study is a high degree of acknowledgment by the actors of inertial characteristics of the industry (see Section 3.1.6). This finding directly relates to the classical studies of industrial dynamics by Hughes (1989), where the oil and gas industry is one of those industrial examples where a high level of 'technological momentum' exists. Although some sustainability transition authors heavily criticise the notion of technological momentum as a misconception related to its physical understanding (e.g., Geels, 2014), in our view it unites the notions of dependency an inertia, and provides the missing perspective on the qualities of the regime and 'inertial' behaviour of incumbent actors. Furthermore, inertia represents a huge amount of financial resources, engineering practices and technical artefacts.

A logical question that arises is: would it not be better to involve the oil and gas industry in the global sustainable energy transition than try to destabilise it? The actors of the oil and gas regime are pushed off to the backyard of energy transition (Bach, 2019), while the purposeful regime destabilisation discards the resources and restrict innovation processes. Some studies have shown that excluding the regime actors from the pool of actors able to drive the change actually limits the change (Berggren et al., 2015; Essletzbichler, 2012). In order to overcome the resistance of the regime, we suggest looking at it from an 'unlocking' perspective (Smith et al., 2010, p. 445), which can be an opposing view to the radicalisation of energy transition mechanisms of phasing out the existing systems (Geels, 2014; Geels et al., 2017). Keeping in mind the considerable time needed for the change to take place in any LTS (Markard et al., 2012, p. 956), we again stress the importance of coordinating transition efforts.

4.2. Limitations and future research

While the findings of the study have a broader relevance for sustainability transition research, generalisations should be made with care. This is because the overall Arctic case has its specifics. Arctic represents a very special geographical area with very strong national and sovereignty interests. Further, it is important to distinguish the Eurasian and the North American Arctic, as they have differing characteristics. Additionally, the oil and gas industry and its qualities have not been studied sufficiently within the domain of sustainability transitions and closely related areas of research such as industrial dynamics or innovation studies.

Empirical data have indicated many factors but may be limited to cover some aspects of the development of the Arctic region such as indigenous issues. Even though indigenous issues were not in the direct focus of this study, their absence may indicate the dominating 'extractivist' logics (Wilson and Stammler, 2016) of the respondents. Potential bias of the respondents may also include the need to establish a certain feasibility of exploitation of Arctic offshore oil and gas, and overall tendency to overemphasise the importance of these resources.

Nevertheless, we see the study results and theoretical elaborations as timely and emergent in relation to more 'systematic' views on transition studies (Köhler et al., 2019), while bringing theoretical and methodological pluralism (Hopkins et al., 2020) by means of the investigation of a rarely studied case and combination of theoretical approaches.

We suggest continuing investigating the case of exploitation of Arctic offshore oil and natural gas resources from the perspective of other circumpolar countries, specifically the North American Arctic, as it may bring a better understanding of different mechanisms and attitudes towards exploitation or preservation of these resources. Further, we see as a fruitful direction the analysis of other cases of the exploitation of oil and natural gas resources in extreme conditions, such as those presented by the Canadian oil sands, Brazilian pre-salt deposits, gas hydrates in Japan, and similar, within the MLP framework and regime as a focal point. These can provide a clearer picture of regime transformative capacity and its role in sustainability transitions. In terms of the approach, a mixed method or qualitative weighing of the various factors may be useful to establish the importance of one factor over another.

5. Conclusion

A wide variety of trends affects the global energy system. Among those is the need to fulfil the growing energy demand still mostly covered by fossil fuels, and the need to transform in order to mitigate climate and environmental issues. We investigated these multidirectional challenges in the energy industry through the specific and rarely studied case within sustainability transition literature – the exploitation of oil and natural gas resources in the offshore Arctic. It represents 'an extremity' of oil and gas activities due to remoteness, challenging environment, high risks and costs. Despite everything, this exploitation is ongoing.

The analysis of the qualitative data resulted in the identification of 27 salients and reverse salients of the exploitation of Eurasian Arctic offshore oil and natural gas resources, and showed the mismatch between landscape pressures and regime level activities. This leads us to conclude that not all the landscape pressures penetrate equally down to the regime level, while regime salients dominate over other factors. The oil and gas industry seems to be even less susceptible to outer landscape pressures, mostly following the needs and routines of the regime. The regime qualities are an important aspect within sustainability transitions and have been unfairly disregarded by transition studies.

The Arctic case reveals a different angle on the sustainable energy transition, as it shifts the attention to regime perspectives and qualities, connections between the levels, and coordination of the outer pressures. Importantly, the study shows there is actually a high degree of acknowledgment of inertial and dependency characteristics of the oil and gas industry by the actors interviewed. This leads us to a discussion on the possibility of higher involvement of the oil and gas industry in the sustainable energy transition process. We suggest 'unlocking' the regime through paying greater attention to its inertia and momentum, and accordingly revising the theoretical frameworks and approaches of sustainability transitions.

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