Residuals bunker ban in the IMO Arctic waters

Cost implications for Russian trade flows - a case study

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Content

1 Introduction

The IMO has agreed to start working on the development of a ban on the use and carriage of heavy fuel oil (HFO) for use by ships in Arctic waters (hereinafter referred to as 'Arctic HFO ban'). Such a ban would not prohibit the carriage of HFO in bulk as cargo, but would require ships sailing in the IMO Arctic waters to only use non-HFO bunker fuels and to only carry non-HFO bunker fuels for use by ships. This ban would result in the reduction of black carbon emissions and reduce costs and damages in case of an oil spill. On the other hand, the Arctic HFO ban would impose additional costs on ship owners/operators who would otherwise have used HFO or blends thereof and/or carried these fuels for use.

Concerns have been raised regarding the potential impact of an Arctic HFO ban on maritime trade, in particular on Arctic communities and economies. In this context CE Delft (CE Delft, 2018) has, in a study commissioned by the European Climate Foundation (ECF)[1], assessed the costs and benefits of an Arctic HFO ban. In that study, the potential impact of an Arctic HFO ban on consumer prices was analysed by means of two case studies. One case study estimated the potential ban-related costs for consumers in Greenland and the second case study looked into the potential ban-related costs of food shipped to Iqaluit in North Canada.

Almost the entire northern coast of the Russian Federation adjoins the IMO Arctic waters (see Figure 1) and according to ICCT (2017), Russian-flagged vessels dominated shipping activity, fuel consumption, and HFO consumption in the IMO Arctic waters in 2015. This makes Russia an important consideration in negotiations related to an Arctic HFO ban.

The aim of this report is to analyse the potential cost and price impacts of an Arctic HFO ban in a case study for Russia. Shipping in Arctic waters adjacent to Russia is to a large extent transportation of fossil fuels and similar commodities. Therefore, the case study focusses on crude oil transport. This study complements CE Delft (2018). The study does not comprehensively assess the cost implications of an Arctic HFO ban on Russian trade flows.

[1] Residuals bunker fuel ban in the IMO Arctic waters: An assessment of costs and benefits (CE Delft, 2018).

Figure 1 – IMO Arctic waters

Source: Polar code (MEPC 68/21/Add.1, Annex 10).

1.1 Aim of study

The aim of this study is to estimate the potential additional shipping costs of an Arctic HFO ban and to analyse the potential cost pass-through for a product that is transported by ships in the Russian territory of IMO Arctic waters.

1.2 Approach

The additional shipping costs induced by an Arctic HFO ban were estimated and the potential cost pass-through was analysed for a specific Russian case.

A relevant case was selected in the first instance and data and information required for this case study was collected from English language literature by means of desk research.

The study assumes that the Arctic HFO ban would become effective in 2021 and the analysis also focusses on that year. Accordingly, the Arctic HFO ban-related additional shipping costs were estimated for the ships' expected 2021 activity, for the expected 2021 bunker fuel prices and considering the fact that in 2021 ships will have to comply with the global sulphur cap.

Regarding the ships analysed, we assumed that their 2021 activity is in accordance with their 2017 activity. We have found no evidence suggesting that the route of the ships will change before 2021. And although the amount of cargo shipped by the ships analysed might be higher in 2021 compared to 2017, the trend of annually increasing volumes shipped by the ships considered that started in 2012 seems not to prevail in 2018, making a projection difficult.

1.3 Structure of the report

In Chapter 2 of the report, the selection of the analysed case is explained and the selected case is presented. The case study is elaborated in Chapter 3. Chapter 4 provides conclusions.

2 Selected case

The study estimates the additional shipping costs induced by an Arctic HFO ban and analyses the potential cost pass-through for crude oil shipped from the Varandey export terminal in the Russian IMO Arctic waters to the Kola Bay near Murmansk by means of three shuttle tankers.

2.1 Selection of the case study

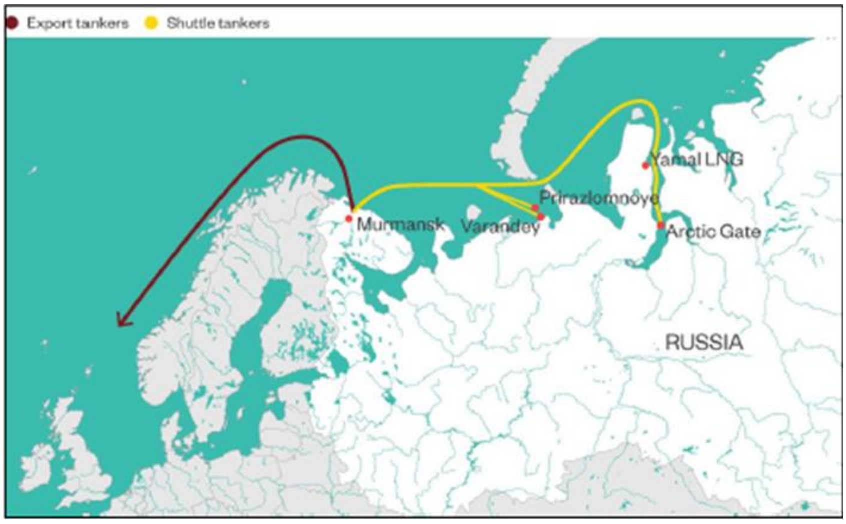
The Varandey case was selected as it is an example of an established Russian transport flow, which we expect to be impacted by the Arctic HFO ban to an extent that makes it a relevant case for the aim of the study. According to ICCT (2018), the Kapitan Gotsky, one of the shuttle tankers that services the Varandey terminal, had the highest HFO consumption of all ships active in the IMO Arctic waters in 2015.

In addition, relevant data and information for the project are sufficiently available in English language literature as the Varandey project dates back to 2000.

2.2 Presentation of the case

The Varandey crude oil export shipment terminal is, due to the shallow sea, located approximately 20 km offshore the Varandey settlement in the Pechora Sea, a southeastern part of the Barents Sea (see Figure 2).

Figure 2 - Russian Arctic maritime petroleum terminals in operation 2017



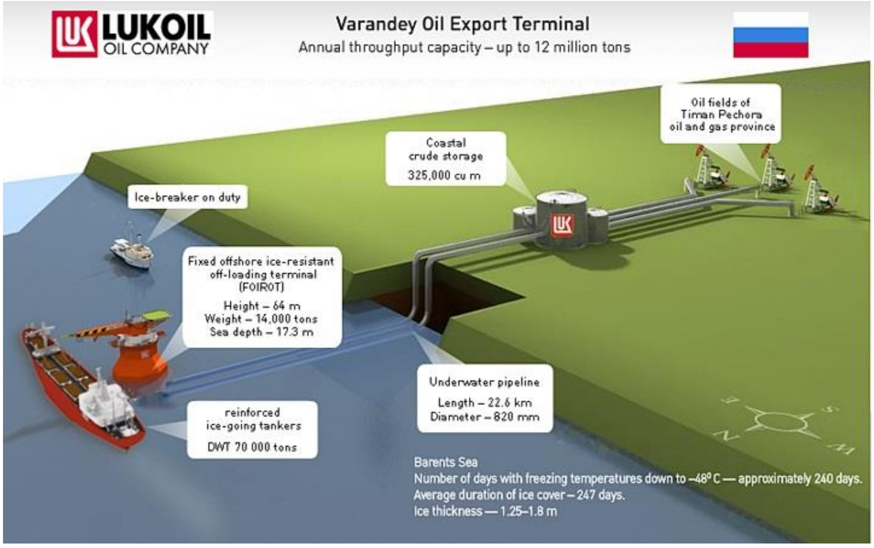
Source: (Kirkenes Næringhage et al., 2017).

The terminal is owned and operated by LUKOIL.

The current terminal, a Fixed Offshore Ice-Resistant Oil Terminal[2], was built in 2008 and is considered the world's northernmost oil terminal operating all year round.

The terminal services different onshore oil fields, with the oilfields and the terminal being connected by pipelines to onshore tanks (Figure 3).

Figure 3 - Illustration of the Varandey oil export terminal



Source: CHNL (2015).

The crude oil that is loaded onto ships at the Varandey terminal has been delivered to different destinations in the past. Until the end of 2013, oil from the Varandey terminal was delivered to the Murmansk-based Belokamenka floating storage facility or directly to ports in Europe, the USA and Canada (LUKOIL, 2015). After 2013, the oil was carried to a loading facility near the village of Kirkenes (Norway) (LUKOIL, 2015). Currently, the oil is shipped by shuttle tankers to Kola Bay where the oil is reloaded ship-to-ship onto the terminal tanker 'Kola' near the Port of Murmansk. Conventional tankers then bring the oil further to Rotterdam and other west European terminals (Staalesen, 2017); (Staalesen, 2018b).

LUKOIL has concluded long-term charter agreements for three Panamax shuttle tankers with Sovcomflot (SCF) to serve the Varandey project: the Vasily Dinkov, the Kapitan Gotsky, and the Timofey Guzhenko (Sovcomflot, 2018a)[3].

Table 1 – Tankers chartered by LUKOIL to shuttle between Varandey terminal and Murmansk

Ship	Tonnage	Cargo tank capacity	Owner	Build date
Vasily Dinkov	71,254 dwt	82,880 m^3	Sovcomflot	January 2008
Kapitan Gotsky	71,228 dwt			May 2008
Timofey Guzhenko	71,294 dwt			February 2009

Source: (Sovcomflot, 2018b); (Clarksons Research, 2018).

2 The use of term FOIROT is unclear in the literature. While some sources use the term as 'Fixed Offshore Ice-Resistant *Oil* Terminal' others use it as 'Fixed Offshore Ice-Resistant *Offloading* Terminal' instead.

3 In August 2017, the Vasily Dinkov's long-term time-charter has been extended for five years (Sovcomflot, 2017).

The deadweight tonnage of each tanker is approximately 71,200 dwt and the volumetric cargo tank capacity is approximately 83,000 m^3 (see Table 1). The tankers have double, icebreaking hull structures and can break ice of up to 1.5 metres thick (Sovcomflot, 2009), which is why, most of the time, they do not depend on icebreakers for their trips between the Varandey terminal and Murmansk. However, two icebreaking ships (multi-purpose icebreaking supply vessel Toboy, and the multipurpose icebreaker Varandey) can support the ships' operation at the Varandey terminal (Akvaplan niva et al., 2015).

The Varandey terminal has an annual out-shipment capacity of 12 million tons of crude oil (LUKOIL, 2008), however, the maximum capacity has not yet been used. From 2009 to 2017, between 3.1 and 8.2 million tonnes per year were shipped out (see Table 2), with an annual average of 6.2 million tonnes.

Table 2 – Crude oil throughput at Varandey terminal [million ton] in the period 2008-2017

2008 (from June on)	2009	2010	2011	2012	2013	2014	2015	2016	2017
1.7	7.4	7.5	3.9	3.1	5.4	5.9	6.6	7.9	8.2

Sources: (Akvaplan niva et al., 2015); (Staalesen, 2016); (Staalesen, 2018a).

We have checked the robustness of this data as follows: Summing up the volumes presented in Table 2, it can be concluded that around 58 million tonnes of oil have been shipped out at the Varandey terminal in the period 2008-2017. SCF's Annual Report 2017 (Sovcomflot, 2018a) provides that "By the end of Q1 2018, SCF's vessels had safely transported 60 million tonnes of crude oil for this project." Sovcomflot started servicing the project in 2008. We can therefore conclude that the collected data is robust.

3 Case study

If an Arctic HFO ban was implemented, the tankers shuttling from the Varandey terminal to Murmansk would be required to use and carry for on-board use ban-compliant bunker fuel when sailing in IMO Arctic waters.

Accordingly, depending on the bunker fuel the tankers will use to comply with the 2020 sulphur requirement, the tankers may have to switch to another fuel, leading to higher operational costs.

In order to estimate these additional shipping costs, we first estimate the tankers' fuel consumption (Section 3.1) and subsequently estimate the tankers' ban-related additional shipping costs for three different scenarios, representing the different options to comply with the 2020 sulphur requirement (Section 3.2). The estimation results will be discussed in Section 3.3. Section 3.4 finally discusses the potential price impact.

3.1 Estimation of fuel consumption

One shuttle tanker is estimated to have consumed around 305 tonnes of HFO on average per roundtrip in 2017.[4] Considering that each of the three shuttle tankers sailed on average 44 roundtrips in 2017, the average 2017 fuel consumption of one of the tankers is estimated to amount to around 13,300 tonnes. In total, the three shuttle tankers are estimated to have consumed around 39,900 tonnes of HFO in 2017.

This estimation is explained in detail below and the results are discussed in Section 3.3.

There is no information on the fuel consumption of the tankers shuttling between the Varandey terminal and Murmansk available in the literature, which is why we have estimated the fuel consumption of the three tankers.

As the design and the equipment of the three ships are very similar, we assume that their bunker fuel consumption levels are the same.

To determine the shuttle tankers' fuel consumption per roundtrip we first estimated the tankers' average time at sea, their average time at the Varandey terminal, and their average time in/near the Port of Murmansk per roundtrip as follows.

Based on the total amount of crude oil loaded on ships in 2017 at the Varandey terminal (8.2 million tonnes) and the tankers' cargo capacities (estimated to be around 56,000 tonnes), we estimated the number of roundtrips per tanker in 2017 to be 44. This means that a roundtrip per tanker lasted on average around 8 days, including idle time in/near the Port of Murmansk.

[4] This includes the days that the tankers are idling in/near the Port of Murmansk. In a year with less roundtrips, the fuel consumption per roundtrip might thus be lower due to longer idling time.

Assuming an average speed at sea of 12.2 knots (according to the Third GHG Study (IMO, 2014) the average 2012 at sea speed of oil tankers falling in the 60,000-79,999 dwt category), the ships would be at sea for around four days per trip.[5] Given the tankers' pumps' capacity, the capacity of the Varandey terminal's pumps and the tankers' expected cargo volume per trip[6], we estimated the tankers to load and unload the crude oil for around 0.5 day respectively per trip.[7] The remaining three days per roundtrip, the tankers would, on average, be in/near the Port of Murmansk.

Subsequently, we estimated the per day fuel consumption of the tankers when they are active at sea, when they load/unload and when they idle in/near Murmansk.

According to (Clarksons Research, 2018), the tankers dispose of a diesel-electric propulsion system with in total three diesel generators; two larger generators (in total 22,400 kW) and one smaller generator (4,200 kW).

The fuel consumption for propulsion purposes per day active at sea is estimated to amount to around 60 tonnes of HFO per day, based on the installed power of the two larger generators, an engine load factor of 60%[8] and a Specific Fuel Oil Consumption (SFOC) of 180.6 g/kWh[9].

The per day fuel consumption necessary to cover the energy demand for non-propulsion purposes at sea and when idling in port is estimated to amount to around 9 tonnes of bunker fuel per day and during pumping activity to amount to around 11 tonnes of bunker fuel per day.

This estimation is based on the average fuel consumption of main engine, auxiliary engine and boilers of oil tankers falling in the 60,000-79,999 dwt category as presented in the Third IMO GHG Study (IMO, 2014).

Table 3 summarizes the estimation of the HFO consumption of a shuttle tanker per roundtrip.

Table 3 - Estimated HFO consumption of a shuttle tanker per roundtrip

Estimated average number of days per roundtrip...		Estimated HFO consumption per day [tonnes; rounded]	Estimated HFO consumption per roundtrip [tonnes; rounded]
..at sea	4	67	269
..loading at Varandey terminal	0.5	9	4
..unloading in Kola Bay	0.5	11	5
..idling in Kola Bay	3	8	25
Total			305

5 By means of the Google maps distance calculator, we have estimated the total distance covered in a roundtrip to amount to around 1,100 nautical miles.

6 90% of maximum capacity.

7 This assumption is in line with (Efimkin, 2015) stating: "The pumping units ensure transportation of 8,000 m^3 of oil per hour and guarantee full loading of the tanker with DWT of 70 thousand tons within 10-12 hours."

8 According to the Third IMO GHG Study (IMO, 2014), the 2012 average at-sea main engine load factor of oil tankers falling in the 60,000-79,999 dwt category was 57%.

9 SFOC of this engine class under ISO conditions (Wärtsilä, 2017).

3.2 Estimation of additional shipping costs

The ban-related additional shipping costs depend on how, in the baseline, the ships will comply with the MARPOL Annex VI sulphur regulation, which requires ships to use fuels with a sulphur content of 0.5% m/m or less or to take measures that result in equivalent emissions. We therefore estimated the Arctic HFO ban-related additional shipping costs for three scenarios. Each scenario represents a different option with which the shuttle tankers might comply with the 2020 sulphur requirement.

To comply with the 2020 sulphur requirement:
- the tankers might be converted from diesel-electric to LNG electric vessels (Scenario 1);
- the tankers might use low-sulphur HFO (LSHFO) instead of HFO in on-board diesel generators (Scenario 2);
- the tankers might be equipped with a scrubber and keep on using HFO in diesel generators (Scenario 3).

Table 4 summarizes the estimated ban-related additional shipping costs for the three shuttle tankers in total for the year 2021 and for the three different baseline scenarios.

Table 4 - Expected 2021 ban-related additional transportation costs for three Panamax tankers shuttling between Varandey terminal and Murmansk [million USD_{2021}]

	Price Sensitivity Scenarios		
Baseline Scenarios	**Low**	**Base**	**High**
Scenario 1: LNG electric		0	
Scenario 2: Low-sulphur HFO (LSHFO)	0.3	1.3	2.4
Scenario 3: HFO in combination with scrubber	4.6	7.3	10.0

In the first scenario, when the tankers are converted to LNG electric ships in the baseline, no ban-related additional transportation costs would accrue, since LNG is a fuel that is compliant with an Arctic HFO ban.

In the second scenario, in which the tankers would use LSHFO in the baseline, the ban-related additional transportation costs are estimated to range from 0.3 to 2.4 million USD in 2021, depending on the bunker fuel price. In the base price scenario, with a medium bunker price spread between distillate fuel and LSHFO, the ban-related additional costs are estimated to amount to around 1.3 million USD in 2021, which approximately is a 6% increase of the bunker fuel expenditures.

In the third scenario, in which the tankers would use HFO in combination with a scrubber in the baseline, the Arctic HFO ban-related additional costs are estimated to range from 4.6 to 10 million USD in 2021, depending on the bunker fuel price. In the base price scenario, with a medium bunker price spread between distillate fuel and HFO, the ban-related additional costs are estimated to amount to around 7.3 million USD in 2021, which approximately is a 50% increase of the bunker fuel expenditures[10].

Related to the amount of crude oil expected to be shipped out at the terminal in 2021 (8.2 million tonne), these additional HFO ban-related transport costs range from 0.1 to 0.3 USD/tonne for Scenario 2 and from 0.6 to 1.2 USD/tonne for Scenario 3 (see Table 5).

[10] Considering the operational scrubber costs in the baseline as fuel expenditures too.

Table 5 - Estimated 2021 ban-related additional transport costs per tonne of crude oil shipped out at the Varandey terminal [USD_{2021}/tonne]

	Price Sensitivity Scenarios		
Baseline Scenarios	**Low**	**Base**	**High**
Scenario 1: LNG electric	0		
Scenario 2: Low-sulphur HFO (LSHFO)	0.1	0.2	0.3
Scenario 3: HFO in combination with scrubber	0.6	0.9	1.2

These estimations are explained in detail below and the results are discussed in Section 3.3.

In Scenario 2, the tankers would have to switch from LSHFO to a ban-compliant fuel, which we assume to be distillate fuel. And the ban-related additional costs would be equal to the difference between the expenditures for distillate fuel under the ban and the expenditures for LSHFO in the baseline, i.e. the situation when the ban was not introduced.

Fuel expenditures are calculated based on the fuel consumption estimation as presented in Section 3.1. It is thus assumed that the shuttle tankers' number of roundtrips in 2021 is the same as in 2017.

The bunker fuel prices applied in the analysis are presented in Table 6. Three bunker fuel price scenarios are differentiated, with a low, medium and high price spread between distillate and baseline fuel. These scenarios are consistent with the scenarios used in (CE Delft, 2018).

Table 6 - 2021 bunker fuel price scenarios (USD_{2021}/metric ton)

	Low Case Scenario		Base Case Scenario		High Case Scenario	
	Price	**Price spread wrt distillate**	**Price**	**Price spread wrt distillate**	**Price**	**Price spread wrt distillate**
Distillate	616		583		550	
LSHFO	595	-21	535	-48	475	-75
HFO	466	-150	368	-215	270	-280

In Scenario 3, the tankers would have to switch from HFO to a ban-compliant fuel, which we assume to be distillate fuel. The ban-related additional costs would be equal to the difference between the expenditure for distillate fuel under the ban and the expenditure for HFO plus the operational expenditures for the scrubber in the baseline.

The same fuel consumption data and fuel price data as in Scenario 2 are applied.
The operational scrubber costs have been roughly estimated by applying the average power of the ships to the operational cost formulas for scrubbers as presented in (CE Delft et al., 2016).

3.3 Discussion of results

To estimate the Arctic HFO ban-related additional shipping costs, the 2017 fuel consumption of the three shuttle tankers was estimated in the first instance.

Comparing the estimated 2017 fuel consumption of 13,300 tonnes for one shuttle tanker with data from (ICCT, 2018), it may be concluded that our estimation is conservative in the sense that we have not underestimated the tankers' fuel consumption:
- According to (ICCT, 2018), the Kapitan Gotsky operated for nearly 166 days in the IMO Arctic in 2015, consuming over 7,000 tonnes of HFO. This means that according to (ICCT, 2018) the tanker's per day HFO consumption in the IMO Arctic amounted to around 42 tonnes per day. According to our estimation, the shuttle tankers consumed around 58 tonnes per day in the Arctic waters.[11]
- According to (ICCT, 2018), the three shuttle tankers under consideration consumed in 2015 between 0.21 and 0.24 tonnes of HFO per nautical mile in the IMO Arctic waters. According to our estimation, the shuttle tankers consumed around 0.27 tonnes HFO per nautical mile.

When estimating the ban-related additional shipping costs we have assumed that ships, if necessary, switch to distillate fuel due to the Arctic HFO ban. However ships might be converted to LNG electric ships instead if this is a cheaper option. An estimation of these ban-related costs is associated with relative high uncertainty, given that both conversion and 2021 LNG prices are uncertain.[12] We therefore confine the analysis to a switch to distillate fuels, but it is important to note that ban-related costs might be lower than the costs derived in this study.

When estimating the ban-related additional shipping costs, we have also assumed that ships, if they have to switch to another fuel type due to the ban, sail on ban-compliant fuel on the entire roundtrip. Note that Murmansk is located outside the IMO Arctic waters and that the tankers might also choose to use LSHFO on their outbound voyage from Murmansk. When entering the IMO Arctic waters, the LSHFO would need to be used up and the ships would have to switch to ban-compliant fuel not before entering the IMO Arctic waters.[13] The necessity to bunker LSHFO before each roundtrip can be expected to lead to high transaction costs, at least for ships that cross the border to the IMO Arctic waters on a regular basis. The frequency of bunkering can be expected to increase and thus time spent and effort put into bunkering too. This is why we have not considered this possibility here. Should the transaction costs for using LSHFO on the voyage to the IMO Arctic waters actually be lower than the additional fuel expenditure for using Arctic HFO ban-compliant fuel, the ban-related additional shipping costs would be lower than estimated.

[11] If you consider the tankers' fuel consumption not only in the IMO Arctic waters, but also outside the IMO Arctic waters the average per day consumption for an entire roundtrip, also entailing idling time in Kola Bay, is lower and amounts to 35 tonnes per day.

[12] To our knowledge, a conversion from diesel-electric to LNG electric is feasible, but has so far very rarely been applied, at least to ships other than LNG carrier. See for example: Europe's First Dredger Dual-fuel Conversion Underway in Dunkurque

[13] The tanker would then sail around 400 nautical miles on LSHFO and the remaining 700 nautical miles of the roundtrip on ban-compliant fuel.

3.4 Potential price impact

If the Arctic HFO ban-related additional transport costs were fully passed through onto the buyer of the crude oil stemming from the Varandey terminal, the 2021 price for crude oil stemming from the Varandey terminal would increase by maximally 0-0.1% in Scenario 2 and by maximally 0.1-0.2% in Scenario 3 (see Table 7).

Table 7 - Estimated maximum 2021 Arctic HFO ban-related price increase for crude oil stemming from the Varandey terminal

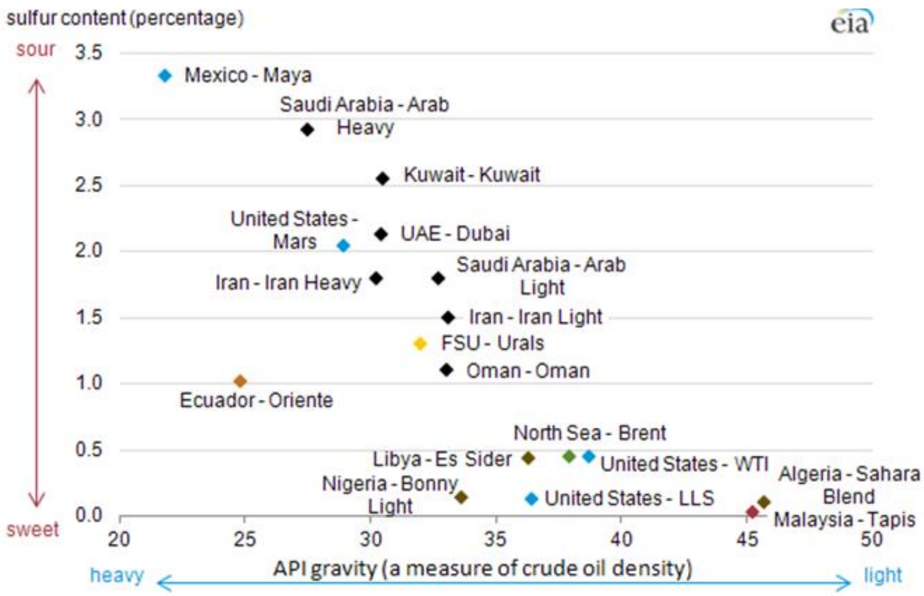
	Price Sensitivity Scenarios		
Baseline Scenarios	**Low**	**Base**	**High**
Scenario 1: LNG electric	0		
Scenario 2: Low-sulphur HFO (LSHFO)	0.0%	0.0%	0.1%
Scenario 3: HFO in combination with scrubber	0.1%	0.2%	0.2%

The 2021 crude oil price in the absence of the ban is thereby assumed to be 69.1 USD per barrel or 517 USD per tonne, which is in line with the World Bank's Commodity Markets Outlook (Worldbank, 2018).

However, it is questionable whether the ban-related costs can actually be passed on to the buyer.

Many types of crude oil are produced around the world and the market value of an individual crude stream reflects its quality characteristics (eia, 2012). Crude oils that are light (higher degrees of API gravity, or lower density) and sweet (low-sulphur content) are usually priced higher than heavy, sour crude oils (eia, 2012) (see Figure 4).

Figure 4 - Density and sulphur content of selected crude oils



Source: (eia, 2012).

Russia has several oil grades, including Russia's main export grade, Urals blend; Urals blend is a mix of heavy sour crudes from the Urals-Volga region and light sweet crudes from West Siberia (eia, 2017). The mixture and thus the quality can vary, but Urals blend is generally a medium gravity (about 31°) sour (about 1.4% sulphur content) crude oil blend and, as such, is generally priced at a discount to Brent crude (eia, 2017). Varandey grade crude oil is a light (37.8°API) and fairly sweet (0.42% sulphur content) crude (eia, 2017). If marketed on its own, Varandey crude oil might thus be more valuable than Urals blend.

The ban-related additional transport costs can only be passed through onto the buyer if competing suppliers, offering a comparable crude oil quality, would also increase their prices. This is unlikely to be the case, however, because we expect comparable crude oil qualities to be shipped in IMO Arctic waters only to a very small extent, if at all (see Figure 4 and Annex A).

If the ban-related additional transport costs are not or only partially passed through onto the buyer, other actors in the value chain will have to carry (part of) the costs. Depending on the charter contract, this could for example be the shipper of the crude oil and/or the owner of the tanker. This may trigger the use of alternative compliance options, such as switch to LNG if cheaper or the search for alternative transport modes, such as pipelines.

Note that the costs of the Arctic HFO ban will, depending on the product that is shipped and the according market structure, be incurred by different actors in the supply chain.
For a product other than crude oil, the cost incidence of the Arctic HFO ban can thus be very different.

4 Conclusions

The study estimates the additional shipping costs of a ban on the use of heavy fuel oil (HFO) and on the carriage of HFO for use by ships in Arctic waters and analyses the potential cost pass-through for a specific Russian case: crude oil that is shipped by three shuttle tankers from the Varandey export terminal in the Russian IMO Arctic waters to the Kola Bay near Murmansk.

The study assumes that the Arctic HFO ban would become effective in 2021 and the analysis also focusses on that year. Accordingly, the Arctic HFO ban-related additional shipping costs were estimated for the ships' expected 2021 activity, for the expected 2021 bunker fuel prices and considering the fact that ships in 2021 will have to comply with the global sulphur requirement for maritime ships that becomes effective in 2020.

Table 8 summarizes the estimated ban-related additional shipping costs for the three shuttle tankers in total for the year 2021 and for the three different baseline scenarios, reflecting the different options with which the shuttle tankers might comply with the 2020 sulphur requirement.

Table 8 – Expected 2021 ban-related additional transportation costs for three Panamax tankers shuttling between Varandey terminal and Murmansk [million USD_{2021}]

	Price Sensitivity Scenarios		
Baseline Scenarios	**Low**	**Base**	**High**
Scenario 1: LNG electric		0	
Scenario 2: Low-sulphur HFO	0.3	1.3	2.4
Scenario 3: HFO in combination with scrubber	4.6	7.3	10.0

In the first scenario, when the tankers are converted to LNG electric ships in the baseline, no ban-related additional costs would accrue as the use of LNG would comply with an Arctic HFO ban.

In the second scenario, in which the tankers would use low-sulphur HFO in the baseline, the ban-related additional costs are estimated to range from 0.3 to 2.4 million USD in 2021, depending on the bunker fuel price. In the base price scenario, with a medium bunker price spread between distillate fuel and LSHFO, the ban-related additional costs are estimated to amount to around 1.3 million USD in 2021, which is approximately a 6% increase of the bunker fuel expenditures.

In the third scenario, in which the tankers would use HFO in combination with a scrubber in the baseline, the ban-related additional costs are estimated to range from 4.6 to 10 million USD in 2021, depending on the bunker fuel price. In the base price scenario, with a medium bunker price spread between distillate fuel and HFO, the ban-related additional costs are estimated to amount to around 7.3 million USD in 2021, which is approximately a 50% increase of the bunker fuel expenditures[14].

[14] Considering the operational scrubber costs in the baseline as fuel expenditures too.

These costs represent 0–0.2% of the value of the crude that is transported (see Table 9).

Table 9 – Estimated Arctic HFO ban-related maximum price increase for crude oil stemming from the Varandey terminal

	Price Sensitivity Scenarios		
Baseline Scenarios	**Low**	**Base**	**High**
Scenario 1: LNG electric		0	
Scenario 2: Low-sulphur HFO (LSHFO)	0.0%	0.0%	0.1%
Scenario 3: HFO in combination with scrubber	0.1%	0.2%	0.2%

When estimating the ban-related additional shipping costs, we have assumed that ships, if they have to switch to another fuel type due to the ban, sail on ban-compliant fuel on the entire roundtrip. Should tankers however choose to use (LS)HFO fuel on their outbound voyage from Murmansk[15], which is located outside the IMO Arctic waters, ban-related additional shipping costs would be lower than estimated.

Because the majority of the competing crude oil suppliers are not likely to be affected by the Arctic HFO ban, it is not likely that the ban-related additional shipping costs can be passed onto the buyer of the crude oil in the case analysed.

Other actors in the value chain, like for example the shipper or the owner of the tankers then have to incur the ban-related costs. This may trigger the use of alternative compliance options, such as switch to LNG if cheaper or the search for alternative transport modes, such as pipelines.

Note that the costs of the Arctic HFO ban will, depending on the product that is shipped and the according market structure, be incurred by different actors in the supply chain.
For a product other than crude oil, the cost incidence of the Arctic HFO ban can thus be different.

[15] When entering the IMO Arctic waters, the (LS)HFO would need to be used up and the ships would have to switch to ban-compliant fuel not before entering the IMO Arctic waters

5 References

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A Annex

If crude oil is shipped in IMO Arctic waters, it can be expected to be extracted in Russia, the United States or Canada.

In 2017, approximately 30% of the global crude oil production can be attributed to these three countries with the global share of Russia (around 14%) and the United States (around 13%) being much higher than for Canada (around 2%) (OPEC, 2018).

We expect that only a small share of the crude oil produced in these three countries is shipped in IMO Arctic waters.

Russian crude oil is exported either by pipeline or by ship. Russian's ports from which crude oil is exported are predominantly not located in the Arctic and do not predominantly depend on crude oil that is shipped through the Arctic, but on crude oil delivered by pipelines (see Table 10).

Table 10 - Crude oil exports from major Russian ports, 2016

<table>
<tr><th>Port</th><th>Thousand barrels/day</th><th>Supplied by</th></tr>
<tr><td>Novorossiysk</td><td>1,407</td><td>Caspian Pipeline Consortium</td></tr>
<tr><td>Primorsk</td><td>978</td><td rowspan="2">Baltic Pipeline System</td></tr>
<tr><td>Ust-Luga</td><td>669</td></tr>
<tr><td>Kozmino</td><td>594</td><td>Eastern Siberia-Pacific Ocean (ESPO) Pipeline</td></tr>
<tr><td>De Kastri</td><td>230</td><td rowspan="2">Pipelines from Sakhalin</td></tr>
<tr><td>Prigorodnoye</td><td>112</td></tr>
<tr><td>Murmansk</td><td>185 (~4%)</td><td>Oil is shipped to Murmansk</td></tr>
<tr><td>Others</td><td>180</td><td></td></tr>
<tr><td>Total</td><td>4,355</td><td></td></tr>
</table>

Source: (eia, 2018).

In 2017, about 65% of total US crude oil production came from five states:
- Texas - 38%;
- North Dakota - 11%;
- Alaska - 5%;
- California - 5%;
- New Mexico - 5%;
- and only the 5% produced in Alaska are potentially shipped in the Arctic waters, if at all (eia, 2018).