Liikennevirasto

2018

# Arctic Ocean Railway Report

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Finnish Transport Agency
Helsinki 2018

*Cover photo: Simo Toikkanen*

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# Foreword

The Finnish Transport Agency was responsible for drawing up the Arctic Ocean Railway Report in collaboration with the Norwegian Railway Directorate (Jernbanedirektoratet). The Finnish Transport Agency commissioned two separate studies. Sitowise Oy drew up a technical report, while Ramboll Finland Oy analysed the transport potential and impacts of the alternative routes. Jernbanedirektoratet commissioned Norconsult AS to conduct similar analyses on the Norwegian side.

Matti Levomäki from the Finnish Transport Agency chaired the steering group for the Arctic Ocean Railway Report. In addition to representatives from the Finnish Transport Agency, the steering group also had representatives from the Norwegian Railway Directorate (Jernbanedirektoratet), Swedish Transport Administration (Trafikverket), Regional Council of Lapland, Ministry of Transport and Communications, Ministry of Economic Affairs and Employment, Lapland Chamber of Commerce, Rovaniemi Development Ltd, Federation of Municipalities in Eastern Lapland, Torne Valley Sub-region, Sea Lapland Development Centre, Federation of Municipalities in Northern Lapland, and Lapland Centre for Economic Development, Transport and the Environment.

Helsinki, March 2018

Finnish Transport Agency

# Contents

# 1 Introduction

On 29 June 2017, the Ministry of Transport and Communications asked the Finnish Transport Agency to collaborate with the Norwegian Railway Directorate to perform a feasibility study of the implementation of an Arctic Ocean Railway. The deadline of this task was 28 February 2018.

Its goal was to research the proposed Arctic Ocean Railway project, identify potential routes, and analyse user requirements, potential business models and demand potential. The Ministry of Transport and Communications required this study to be performed in collaboration with the Norwegian Railway Directorate. The study had to draw on ongoing work to draw up the Regional Strategic Plan 2040 for Northern Lapland. This work involves making a report on the region's railway connections and transport system, including an investigation into alternative routes for a rail connection between Sodankylä and Kirkenes, so that this route can be indicated in the Regional Strategic Plan. The Regional Strategic Plan is scheduled for completion during 2018.

The Finnish Transport Agency was responsible for drawing up the Arctic Ocean Railway Report in collaboration with the Norwegian Railway Directorate (Jernbanedirektoratet). The Finnish Transport Agency commissioned two separate studies. Sitowise Oy drew up a technical report, while Ramboll Finland Oy analysed the transport potential and impacts of the alternative routes. Jernbanedirektoratet commissioned Norconsult AS to conduct similar analyses on the Norwegian side.

The opinions of stakeholders in both Finland and Norway were sought during the studies. Discussions with stakeholders were held in Rovaniemi on 5 December 2017, and Jernbanedirektoratet organised a comparable event in Tromsø on 16 January 2018. The ongoing analyses of potential routes for the Arctic Ocean Railway were presented at the *Logistics in the Torne Valley* seminar in Sweden on 22 November 2017, and also at meetings of various working groups in Finland. A lot of well-justified written feedback was also received from a number of stakeholders. Separate negotiations were conducted with the Sámi Parliament in Inari on 18 January 2018, in accordance with Section 9 of the Act on the Sámi Parliament.

# 2 The Arctic Ocean Railway as part of the global transport system

Finland is a sparsely populated country with long internal distances. Finland is also far from central market areas. This is why transport costs have a relatively high impact on the final price of products in Finland in comparison to other countries. The functionality of transportation and transport infrastructure has a great impact on the competitiveness of businesses and on mobility in general.

When viewed from a logistical perspective, Finland is an island and completely dependent on transport via the Baltic Sea. It is therefore important for Finland to improve its logistical position and accessibility. Although Finland cannot move its geographical location, it can significantly improve both its logistical position and accessibility. Finland could become a node for Northern European passenger, freight and telecommunications traffic.

This is important, as the momentum of globalisation is still increasing. The focus of international trade and production is increasingly shifting towards Asia, which is why improved connections to Asia are becoming important throughout Europe. China in particular wishes to actively enhance its connections to Europe through, for example, Arctic regions.

The future competitiveness of Europe is clearly linked to transport connections, and in particular to the functionality of the Trans-European Transport Networks (TEN-T). The European Union (EU) has defined the nine most strategically important TEN-T Core Network Corridors. Finland and Sweden are linked to Continental Europe along two core network corridors: North Sea–Baltic (NSB, links Baltic ports to North Sea ports) and Scandinavian–Mediterranean (Scan-Med, extends from Finland and Sweden to the Mediterranean Sea). Although these core network corridors extend to southern areas of Finland and Sweden, they leave the greater part of both countries outside the transport network.

Finland has proposed extending the current core network corridors into Northern Finland. According to this proposal, the NSB Extension would extend from Helsinki to Tornio and include existing sections of the core network: the main Helsinki–Tornio railway line and Highways 4 and 29 between Helsinki and Tornio.

Central Europe's main transport network and major ports are extremely busy. The EU needs new alternative routes that will help prevent the most challenging transport bottlenecks. The TEN-T development project that will have the greatest impact on Finland is the Rail Baltica line, which will link the Baltic countries and Poland via Germany. Finnish shipments and transit traffic passing through Finland will play a significant role in Rail Baltica's demand potential, and thereby also the profitability of the project. Also part of this vision is the Helsinki–Tallinn Railway Tunnel, which would connect Finland to the European rail network and improve Finland's connections to the south.

On a broader scale, the Arctic Ocean Railway is also connected to the aforementioned projects, that is, Rail Baltica and the Helsinki–Tallinn Tunnel. The Arctic Ocean Railway should therefore be seen as part of the global transport system. A railway connection from Finland to the Arctic Ocean would improve Finland's connections to the north. The Arctic Ocean Railway would connect the Arctic region and its vast natural resources to both Finland's railway network and – via the Helsinki–Tallinn Tunnel and Rail Baltica – to Central Europe and beyond. The Arctic Ocean Railway would provide an alternative route for Finnish imports and exports. A connection to the Arctic Ocean's deep, ice-free harbours would open up a connection to the Atlantic and Northeast Passage, and thereby significantly increase Finland's transport capacity and improve its logistical position and accessibility. Thanks to these connections, Finland's significance as a Northern European transport route would increase.

# 3 Alternative routes studied

## 3.1 Technical solutions

The Arctic Ocean Railway Report (Sitowise, 2018) drew up five alternative routes for the Arctic Ocean Railway, and then studied both their special technical characteristics and feasibility. The technical investment costs of each new alternative were calculated, and the costs of sections that are already planned or in existence were altered to correspond to the current index. No routes were given priority – the technical aspects of all the alternatives were considered as standalone options.

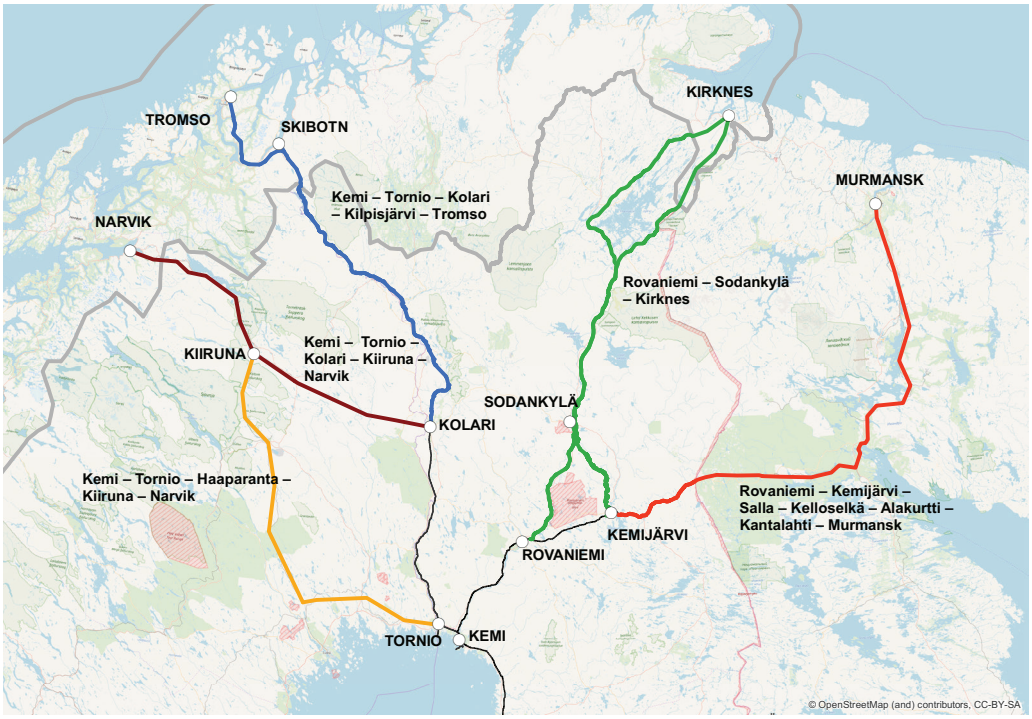



*Figure 1. The five alternative routes for the Arctic Ocean Railway.*

Five different routes to the Arctic Ocean were examined: Rovaniemi–Kirkenes, Kolari–Narvik, Tornio–Narvik, Kolari–Skibotn–Tromsø, and Kemijärvi–Murmansk (Figure 1). Three of these routes primarily harness the existing rail network, while two routes would use completely new tracks outlined during the study.

The potential uses of the different routes and tracks vary greatly. Some would operate almost solely as freight lines, while others could also carry passenger traffic. The lines terminating in Kirkenes and Tromsø could be used for tourist traffic, as long as the stations were located close to tourism centres. On the other hand, these routes would also have a great impact on local residents, reindeer husbandry, and the natural environment.

The routes taken by the new lines best account for both local topographical features and the special characteristics of the Arctic region. They have been designed to avoid residential areas, waterways, nature reserves and Natura 2000 areas whenever possible. They have also been optimised to require the fewest possible number of bridges and tunnels.

The study also examined an alternative that would have skirted Lake Inari to the east, but this was abandoned at the outset, as almost 60 kilometres of track would have to be laid through the Vätsäri Wilderness Area. The Øvre Pasvik National Park also lies right on the other side of the national border.

The Arctic Ocean Railway is, by Finnish standards, a considerably large-scale project. The total length of Finland's current rail network is just under 6,000 km. The total lengths of the alternative routes for the Arctic Ocean Railway are:

- Rovaniemi–Kirkenes 465 km or Kemijärvi–Kirkenes 445 km
- Kemi–Kolari–Tromsø 610 km or Kemi–Kolari–Skibotn 519 km
- Kemi–Kolari–Narvik 543 km
- Kemi–Tornio–Haparanda–Narvik 633 km
- Kemijärvi–Alakurtti–Murmansk 564 km

**Rovaniemi–Sodankylä–Kirkenes**

This route would branch northwards from the existing track at Rovaniemi, and then follow Highway 4 to Sodankylä. Alternatively, existing track could be used up until Kemijärvi, from where a new section of track could be built to the east of Highway 5. This route would run through the Pyhätunturi and Luosto tourism centres to Sodankylä, bypassing the Sakatti mining area. The track would follow the power-line land corridor between the Loka and Porttipahta Reservoirs to Saariselkä, where it would then run through a long tunnel. The Saariselkä–Ivalo section would then again follow Highway 4. There would be almost 40 km of tunnels between Ivalo and Inari, and numerous small lakes after the track heads north-east from Inari. On the Norwegian side, there would be another two tunnels before the track's terminus at a new port in Kirkenes.

**Kemi–Kolari–Kilpisjärvi–Tromsø**

The rail section between Kemi and Laurila is electrified, but the section north of it is not. The northernmost section of track currently in use in Finland is Tornio–Kolari. The following section, from Kolari to Rautuvaara, is temporarily closed to traffic. A new railway line would pass Hannukainen and Äkäslompolo, and then follow Highway 21 from Muonio to Kilpisjärvi. This route is challenging, as it would run under several fells and forested hills, and numerous short bridges would also be required. It would also be impossible to completely avoid all of the protected areas in the northwestern 'arm' of Finland. In Kilpisjärvi, the track would run through a tunnel under the western side of Saana fell all the way to the Norwegian border.

The topographical features on the Norwegian side are also challenging. The height difference between Kilpisjärvi and Skibotn is about 500 metres. The track to the south of Skibotndalen would run almost completely through a tunnel, and tunnel sections would account for almost half of the 42-kilometre stretch between Kilpisjärvi and Skibotn.

The section between Skibotn and Tromsø boasts the greatest height differences of the route, and therefore also the longest tunnel sections in relation to the overall length of the track section. The Norwegians have examined this section and decided on an alternative that would bypass the fjord. This extremely expensive section of track would need to be further specified in follow-up planning. This study did not examine the changes that would be required at Skibotn harbour if it were to be used as the terminus for the Arctic Ocean Route.

**Kolari–Narvik**

As in the Tromsø alternative, the Kemi–Kolari track section would require some improvements if a railway line to Narvik (converging with the Kiruna line) were to be built from Kolari to Kaunisvaara via Svappavaara. A railway line has been planned from the Kaunisvaara mine to either Kolari (from where ore would be transported to the Port of Kemi) or Svappavaara (from where the ore line continues to Narvik). If both lines were built, Finland would have direct rail connections to Kiruna, Sweden and Narvik, Norway. However, due to different track gauges, this connection would require load transfer.

**Kemi–Haparanda–Narvik**

There is an existing rail connection from Tornio, Finland to Narvik, Norway via Haparanda, Sweden. However, this rail connection is only infrequently used, as the line section Laurila–Tornio is not electrified and Finland and Sweden uses different track gauges. The single-track line between Boden and Narvik has too few passing places to ensure sufficient capacity in the future. The Haparanda–Boden section has been recently renovated and partly relaid. This section is currently only in use for freight transport, but there are plans to open it up to passenger traffic as well. In addition to electrification, more extensive freight traffic would require not only new railway bridges but also the construction of either a load transfer station or bogie exchange station.

This route would have minimal impact on the environment, as any required measures would constitute improvements to existing infrastructure or changes in its immediate vicinity.

**Rovaniemi–Kemijärvi–Kandalaksha–Murmansk**

A rail connection from Kemijärvi to Kandalaksha, Russia (connecting to the St Petersburg–Murmansk line) was built via Salla during the Second World War, but was later dismantled. There has never been regular traffic crossing the border along this line. Finland currently has rail connections to Murmansk via border stations in Vainikkala, Imatrankoski, Niirala and Vartius.

The Rovaniemi–Kemijärvi section has been renovated and electrified. The Kemijärvi–Kelloselkä section is in bad condition and lacks both electrification and safety equipment. There are no longer any tracks running from Kelloselkä to the national border. On the Russian side, there is a 72-kilometre section of unused track bed from the Finnish border to Alakurtti. It is, however, in bad condition and would require both renovation and considerable adjustments. There is just under 100 kilometres of lightly trafficked, non-electrified track between Alakurtti and Ruch'i. The electrified single-track section between Ruch'i and Murmansk is just under 300 kilometres long and heavily trafficked.

## 3.2 Investment costs

The calculated costs of each route take into consideration both the construction of new sections of track and the development of existing track.

Track investment costs are computationally substantially more expensive in Norway than in Finland. The cost estimate for each route has been adjusted to the cost level of April 2017, when the Cost Index of Civil Engineering Works (MAKU) stood at 135.00 (2005 = 100). The cost estimates included a ten per cent risk provision. It has been assumed that each country will take responsibility for the costs of the track located in its own regions.

*Table 1. Cost estimates for the alternative routes, EUR million.*

| Route | Cost estimate, inc. 10% risk provision | | | | Total |
|---|---|---|---|---|---|
| | Finland | Sweden | Norway | Russia | |
| Rovaniemi–Sodankylä–Kirkenes | 2,063 | | 856 | | **2,919** |
| Kemijärvi–Sodankylä–Kirkenes | 1,913 | | 856 | | **2,786** |
| Kemi–Kolari–Kilpisjärvi–Tromsø | 2,271 | | 5,178 | | **7,449** |
| Kemi–Kolari–Kiruna–Narvik | 86 | 1,397 | | | **1,483** |
| Kemi–Haparanda–Kiruna–Narvik | 22 | 631 | | | **652** |
| Rovaniemi–Kandalaksha–Murmansk | 101 | | | 649 | **750** |

In addition, the Norwegians have estimated that the establishment of a new harbour in Northern Norway would cost approx. EUR 500 million.

## 3.3 Environmental impacts of track construction

In order to curb climate change, we must seek more environmentally sustainable solutions and modes of transport. Travellers are more environmentally aware, but are also seeking new experiences. For tourist traffic, this could have a significant impact on the percentage of people choosing whether to fly or travel by train. Alongside costs, logistics also consider both energy efficiency and the type of energy to be used, as they will have an impact on how freight traffic is distributed between road and rail transport. As traffic volumes increase, transport choices will have increasing significance for the environment.

Track construction always changes the natural environment. Lapland's natural environment is extremely vulnerable, and changes may be longer-lasting than they would be further south. The region has a lot of untouched wilderness and a great many areas of significant natural value, some of which are extremely extensive. Protected areas account for about half of the area of Northern Lapland, and 38 per cent of Tunturi Lapland (Fell Lapland). These valuable nature sites have been considered and bypassed during route planning.

A route to the east of Lake Inari was abandoned during the planning process, as it would have run through the Vätsäri Wilderness Area. The Øvre Pasvik National Park also lies right on the other side of the national border.

Environmental impact assessments will be updated later, at both the planning and design phases, with the aid of ground visits and inventories. When planning the railway, ways of reducing its environmental impact will naturally be considered. At this stage, cost calculations have already accounted for the construction of fences along the entire length of the line to prevent accidents involving reindeer.

The Arctic Ocean Railway Report has focused on examining the current state of the natural, scenic and cultural environment for those areas in which there is no existing track. Increased traffic along track sections that are already in existence or under development will also exacerbate adverse environmental factors, such as obstacles and noise. As stated in the Regional Strategic Plan for Eastern Lapland, more detailed planning for the routes will safeguard practical business and development requirements for reindeer management in these regions. Cultural factors are also extremely important in Northern Finland.

**Line to Kirkenes**

The planned railway line largely follows Highway 4, along which habitation is also centred. The most significant habitation clusters along the track are Rovaniemi, Sodankylä, Vuotso, Saariselkä, Ivalo, Inari, Kaamanen, Sevettijärvi and Kirkenes.

The track section between Sodankylä and Näätämö has been planned to run through a zone that lies between extensive protected areas. The protected areas indicated in the Regional Strategic Plan for Northern Lapland follow the national borders for these protected areas. The most extensive protected areas are wilderness areas and nature reserves. One important reason for the protection of wilderness areas is to safeguard Sámi culture and natural sources of livelihood. Conservation areas also have a major impact on tourism in Lapland. Lake Inari is part of Finland's national shore conservation programme. The track passes Lake Inari at a distance that should be sufficiently far away so as to have no direct impact on the area. The area between Sevettijärvi and Näätämö has the greatest amount of lakes in Finland, which must be taken into consideration at later planning stages.

There are also many natural and scenic sites of value on the Norwegian side. In Norway, the line will have to run through two tunnels before terminating at a new harbour in Kirkenes.

**Line to Tromsø**

This line largely follows Highway 21 in the Torne River Valley, along which habitation is also centred. The track's route diverges most from Highway 21 in the area between Kolari and Muonio, where it largely runs through areas of uninhabited forest. The most significant habitation clusters along the track on the Finnish side are Kemi, Keminmaa, Tornio, Haparanda, Ylitornio, Pello, Kolari, Muonio, Palojoensuu, Kaaresuvanto and Kilpisjärvi. On the Norwegian side, the track's natural terminus is the Port of Tromsø. Due to bedrock topography, other natural conditions and high construction costs, Skibotn could also be an alternative terminus.

The track section from Kemi to Kolari follows the existing railway line. North of Kolari, the line runs close to several mining areas.

Western Lapland contains many untouched natural environments, protected areas, and other areas of natural value. The most extensive protected areas are wilderness areas, nature reserves, and many areas of protected swampland. For example, the line runs alongside the Pallas-Yllästunturi National Park. Natura 2000 sites and other conservation areas are primarily located on the Finnish side in the northern part of the planning area.

One of the most difficult regions has been the northwestern 'arm' of Lapland, and in particular the area around Saana fell. As the track cannot be laid in the narrow, scenically valuable land corridor between Saana fell and the lake, it must instead run through a tunnel.

The topography of the Norwegian side is very varied, and will therefore require plenty of tunnels and bridges. The track section between Skibotn and Tromsø will bypass the fjord and Lyngen Alps (a landscape protection area). After running through a tunnel, the line will terminate to the north-east of Tromsø. The route on the Norwegian side was planned by Norconsult AS.

# 4 The transport potential of the alternative routes

Although there is currently a railway connection from Finland to the Arctic Ocean via Sweden and Norway, transportation primarily occurs by road. Freight traffic in Northern Finland mainly consists of raw timber, metal, paper, pulp, ore concentrate, and chemicals. There are also rail connections to the Port of Murmansk in Russia via border stations in Vainikkala, Imatrankoski, Niirala and Vartius.

The Arctic Ocean Railway's potential transport flows can be studied on a number of levels. Within Finland, the railway would enable a domestic rail connection from Southern Finland to a port in the Arctic Ocean and – depending on the chosen route – possibly also from Upper Lapland to Southern Finland. In Finland's surrounding areas, the Arctic Ocean Railway could also serve northern regions of Sweden, Norway and Russia, and also shipments arriving via the Northeast Passage.

The estimated transport potential of the routes has been based on a study of transport costs. The transport costs for investment alternatives (tracks already built) have been compared to alternatives that lack existing tracks and infrastructure. Transport forecasts assume that the railway would be opened to traffic in 2030. The forecasts extend to 2060.

For low-value-added products (such as liquid and dry bulk; mass-produced basic industrial products), transport costs are almost completely defined by the route and mode of transport. However, for high-value-added products (such as food and beverages; components for the assembly and electronics industries), transportation time and punctuality are also important.

Transport costs have been defined according to the Finnish Transport Agency's unit prices for project evaluations. A price of $380 per tonne has been used as the bunker (oil) price for maritime transport (Rotterdam Bunker Prices 11/2017). The costs for various modes of transport are therefore based on current prices. It is obvious that these costs may vary greatly during the evaluation period (which extends to 2060).

## 4.1 The Arctic Ocean Railway's potential role in transportation between Finland and its surrounding areas

Finland currently has 10–15 major projects in the pipeline for either opening new mines or expanding existing mining operations. The most significant projects with regard to transport requirements are the Hannukainen iron ore mine (Kolari), Sokli phosphate mine (Savukoski), Suhanko mine (Ranua), Kevitsa mine expansion (Sodankylä), and Mustavaara mine (Taivalkoski). The Sakatti mine project (Sodankylä) may also have long-term potential.

The Hannukainen and Sokli mines hold the most significant transport potential for the Arctic Ocean Railway. According to the mine's owner, Hannukainen Mining Oy, the Hannukainen iron ore mine in Kolari will open in 2022 and production will be up to full speed in 2023. The mine is expected to produce an estimated 2.0 million tons of iron ore concentrate and a small quantity of other metals over a period of 18 years. According to Hannukainen Mining's estimate, the company intends to export the iron ore concentrate primarily within the Baltic Sea region, so maritime transport will not require as deep a draught as for long-haul exports. The most likely harbours will therefore be Ajos (in Kemi) and Oulu.

The Norwegian mining company Yara is planning to open a phosphate mine in Sokli, in the Savukoski region of Eastern Lapland. The planned operations would encompass the mining of phosphate ore and iron mineral reserves in Sokli's carbonate massif region. According to Yara, 1.54 million tons of phosphate ore concentrate and 0.3 million tons of iron ore concentrate would be produced per annum. If the mine is opened, the phosphate and iron ore will be enriched in Sokli and transported to Yara's production facilities in Norway for further processing. The most likely harbours are Kemi and Oulu. If the Arctic Ocean Railway is built, the Ports of Kirkenes and Murmansk would also be options. Using the Port of Kirkenes would be slightly more cost-effective than using Kemi or Murmansk (Figure 2). However, Kokkola or Oulu would be more viable harbours for the mine's byproduct (iron ore concentrate, 0.3 million tons per year

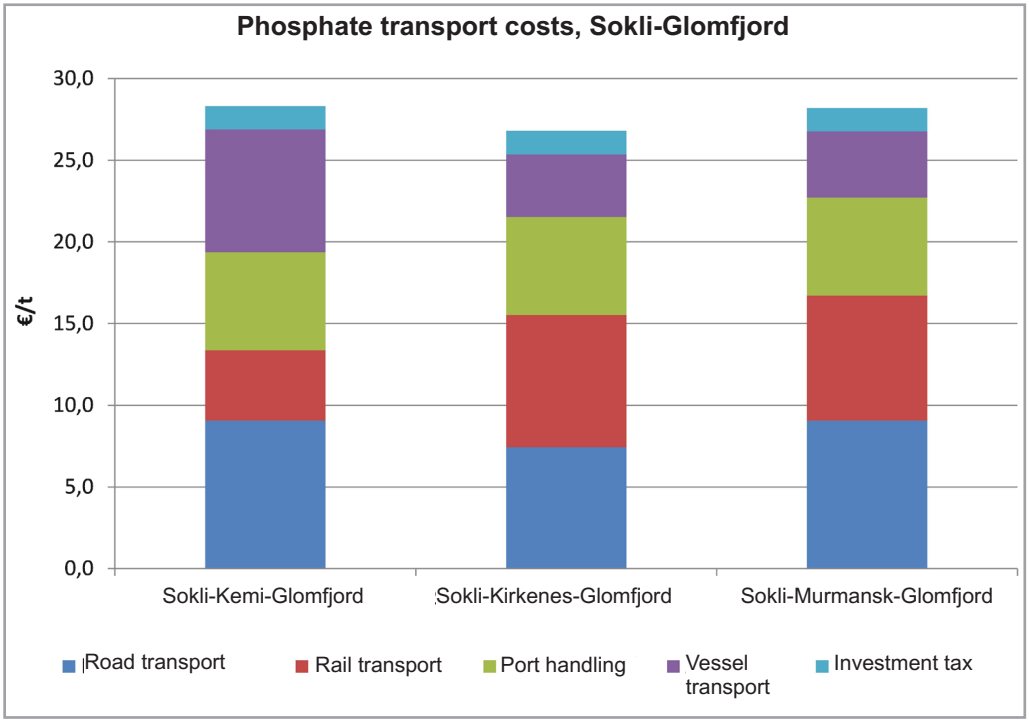



*Figure 2. A comparison of the costs of transporting the Sokli mine's phosphate from Sokli to Glomfjord*

The Kevitsa mine is a large copper and nickel mine in Sodankylä. It opened in June 2012 and is owned by the Swedish company Boliden. The mine produces about 250,000 tons of copper and nickel ore concentrate per annum. All shipments are currently made to Kemi by road, from where they continue to Harjavalta by train. If the Arctic Ocean Railway is built, the mine would have a direct rail link from the mine to Kemi and Harjavalta.

A copper and nickel mine – the Sakatti mine – is also being planned in Sodankylä. The mining company Anglo American is the majority shareholder. The project is still at the ore prospecting stage.

On the Swedish side, an iron ore mine was briefly in operation in Pajala. Kaunis Iron AB acquired the mining permits for the Pajala mine from Northland's bankruptcy estate, and has announced that it will reopen the mine in summer 2018. No production volumes for the newly opened mine have yet been confirmed, but a preliminary figure of 2.0 million tons per annum has been given. During the mine's previous operational period, 90-ton loads were transported by road to Svappavaara, from where they continued by rail to the Port of Narvik. This will also be the most likely solution when the mine reopens. Exports will probably be headed for Europe and the Middle East. The Pajala mine would benefit greatly from the Arctic Ocean Railway if it were to take either the Kolari–Narvik or Kolari–Tromsø route. A direct rail connection would remove the need for road transport and load transfer, which would significantly lower transport costs.

In addition to mining products, the Arctic Ocean Railway could also be used to transport raw timber. According to Metsähallitus' estimates, only the Kirkenes route would hold any significant potential for the domestic transport of raw timber. About 200,000–300,000 cubic metres of raw timber could travel along this section of track per annum. However, if Boreal Bioref decides to build its bioproduct mill in Kemijärvi, the need for such transportation may be considerably reduced or even end completely. The Kemijärvi bioproduct mill would use about 2.8 million cubic metres of raw timber. According Boreal Bioref's estimates, about 400,000–500,000 cubic metres of this timber could be imported from Russia if the Kemijärvi–Alakurtti–Murmansk rail connection were built.

The primary product of Boreal Bioref's bioproduct mill would be softwood pulp, about 0.5 million tons per annum. The main market area for softwood pulp is China, to which products would be transported either via the Trans-Siberian Railway or by ship. These shipments could also utilise the Arctic Ocean Railway running to Kirkenes and the Northeast Passage.

## 4.2 The Arctic Ocean Railway's potential role in the transportation of natural resources in the Barents Region

A connection to the Arctic Ocean's deep, ice-free harbours would open up a connection to the Atlantic and Northeast Passage, and thereby significantly increase Finland's transport capacity and improve its logistical position and accessibility. The Arctic region could become a major investment site (oil, gas, offshore activities). There are planned projects worth an estimated EUR 140 billion in the Barents Region. Could the Arctic Ocean Railway benefit the transportation of natural resources in the Barents Region?

Most shipments of natural resources in the Barents Region involve oil and gas. Vessel transport is a more cost-effective option for these shipments than rail transport. This is why shipments to Finland's oil refineries are best handled by vessel transport, and particularly to those refineries located on the coast. LNG shipments to inland production facilities are usually very small, making road transport by tanker a likely option. This also means that, at current costs, it would not be financially viable to transport oil and gas products through Finland by rail to Central or Eastern Europe.

The launch of oil and gas production in the Arctic Region could also lead to the transportation of a variety of investment goods from south to north. Vessel transport would be more affordable for these shipments as well. The transport of these investment goods would entail low-volume, irregular, project-based shipments that are poorly suited to rail transport.

## 4.3 The Arctic Ocean Railway's potential role in maritime transport through the Northeast Passage

Global warming has caused ice cover to melt in the Arctic Region. As a result, the Northeast Passage has become a more important transportation route between Europe and Asia. The majority of maritime transport between Europe and Asia currently passes along a route that runs through the Mediterranean Sea, Suez Canal and Indian Ocean. The Northeast Passage offers a shorter sea route from Europe to Asia. For example, the distance between Rotterdam and Yokohama is 37 per cent shorter through the Northeast Passage than through the Suez Canal. The distance between Rotterdam and Shanghai is 26 per cent shorter. As vessel speeds are lower in the Northeast Passage than on the Suez route, the chronological gain is not quite as much as the difference in distance, but using the Northeast Passage is still the faster option.

The major factors influencing use of the Northeast Passage are low water depths and demanding ice and weather conditions. Currently, the entire length of the Northeast Passage is only ice-free during September and October. In practice, the route is never completely ice-free even then, due to drifting ice floes and pack ice. With the help of icebreakers, the sailing season can be extended from the end of June to the beginning of December. During the ice-free season, vessels travelling through the Northeast Passage have averaged 10–14 knots. Vessel speeds fall to about eight knots when the assistance of icebreakers is required.

Due to challenges and uncertainties relating to the navigability of the Northeast Passage, its use in international maritime transport has so far remained minimal. A total of 10.2 million tons of goods were transported through the Northeast Passage in 2017, the majority of which were internal shipments within Russia or Russian exports.

The key question with regard to the Northeast Passage is what kind of role it would take in transport between Europe and Asia. There is no definite answer to this question. Currently, the Northeast Passage does not constitute a competitive option for maritime transport between Europe and Asia, but this could change in the long term if the climate continues to get warmer.

Another question is what role the Arctic Ocean Railway would play in shipments through the Northeast Passage. Could these shipments benefit from the Arctic Ocean Railway and Finland's rail network? These days, most goods are transported in containers.

Under the current system, container traffic between Europe and Asia mainly runs through major North Sea ports, where volumes are sufficiently large for 10,000+ TEU vessels. Feeder vessels are used for feeder traffic to these ports from Finland and other countries in the Baltic Sea region. The Arctic Ocean Railway, combined with FinEst Link and Rail Baltica, would provide an alternative route, particularly to Finland and Eastern European countries.

With current transport costs, container traffic via Finland is not financially viable. This is illustrated in the following diagram, which compares transport costs for large units (EUR/TEU) from the Barents Sea to Tampere. Vessel transport to Vuosaari is clearly more affordable than rail transport to Tampere via Kirkenes. Although the containers are first transported to Rotterdam and from there to Vuosaari by sea and to Tampere by rail, this alternative is still more affordable than rail transport via Kirkenes. Transportation through Finland will not be financially viable unless there are significant changes in either rail and maritime transport costs or technical advancements.

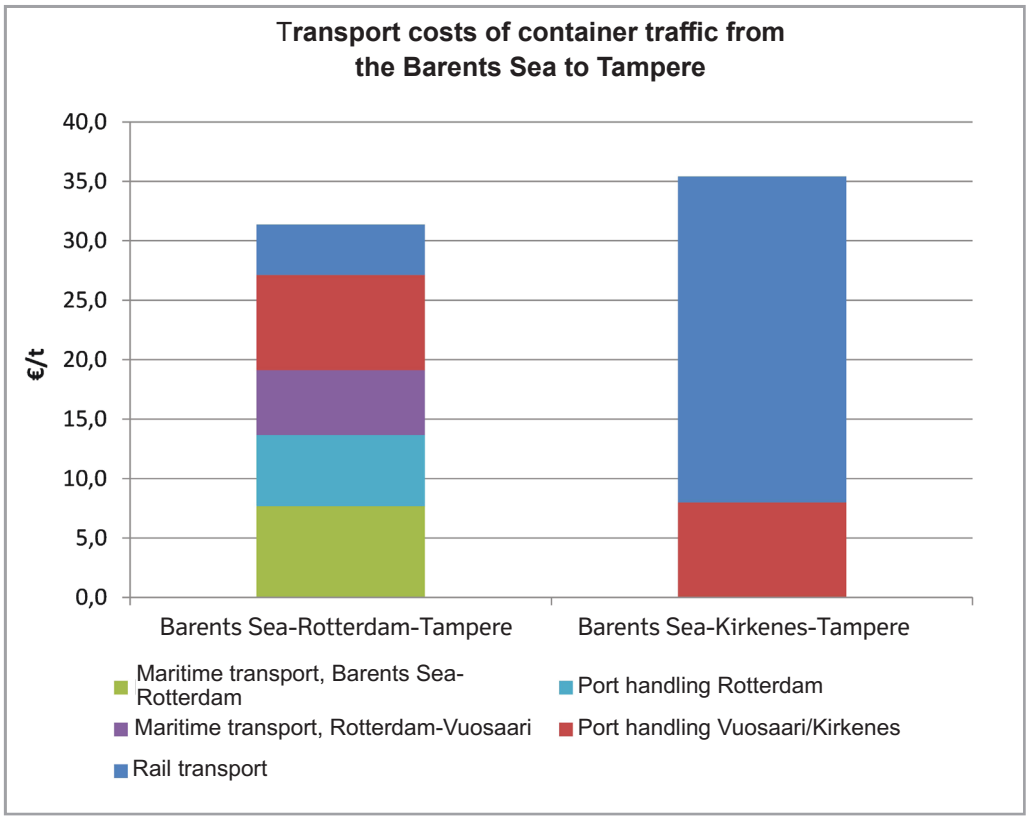



*Figure 3. Container transport costs from the Barents Sea to Tampere*

## 4.4 Norwegian transport forecasts

The impact of the alternative routes on transportation in Norway was studied separately. The transport forecast drawn up by the Norwegians extends to 2060. An examination of this forecast indicates that only a small fraction of Norway's shipments could be transferred to the Arctic Ocean Railway. Projected transport volumes are shown in the following table. Shipments would consists of fish, refrigerated products, and industrial products.

*Table 2. Transport forecasts for Norwegian products*

| Route | Shipments in 2060, tons |
|---|---|
| Rovaniemi-Kirkenes | 372 000 |
| Kemi-Skibotn-Tromsø | 234 000 |
| Kemi-Kolari-Narvik | 98 000 |
| Kemi-Tornio-Narvik | |
| Kemijärvi-Murmansk | |

## 4.5 Transport potential in general

Projected transport volumes for the alternative routes are shown in Figure 4. It is worth noting that the aforementioned transport potentials involve considerable uncertainties. Changes in transport costs or other conditions may have a significant impact on the selection of transport routes.

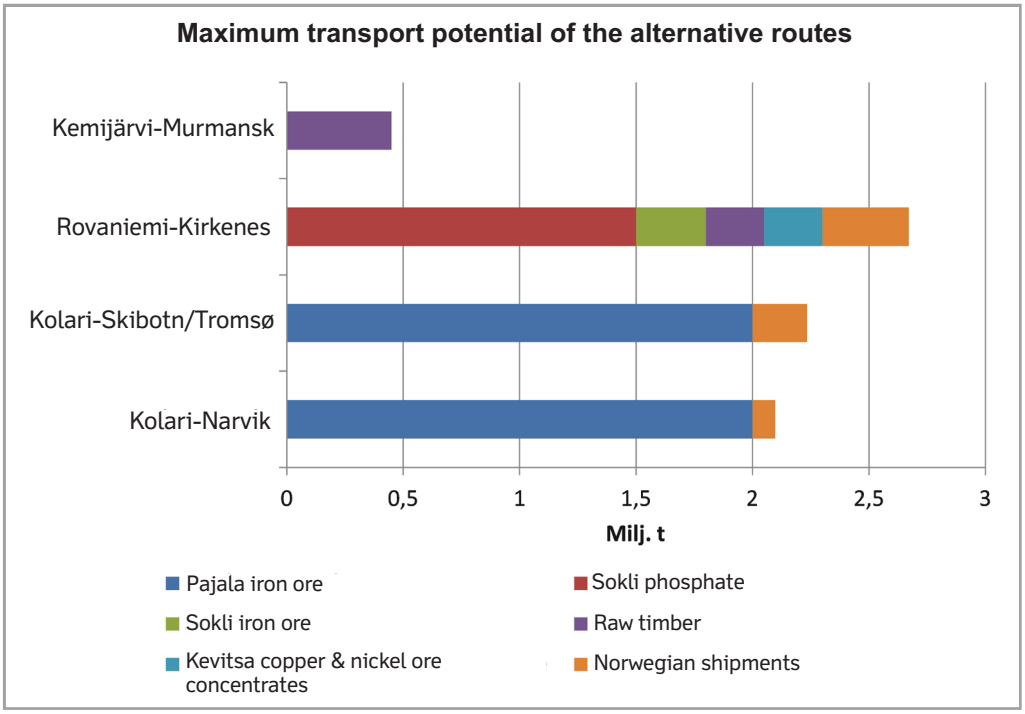



*Figure 4. The maximum transport potential of the alternative routes*

# 5 The Arctic Ocean Railway's role in passenger traffic

Passenger traffic can also benefit from the Arctic Ocean Railway. The Tromsø and Kirkenes alternatives hold the greatest potential for passenger traffic. Tromsø is a university city of 70,000 inhabitants in Northern Norway. Tromsø Airport, Langnes provides connections to about 20 places in Norway and the rest of Europe. A rail connection from Tromsø to, for example, Oulu via the Arctic Ocean Railway would be about 750 km and take about 4.5–6.5 hours, depending on train speeds.

Kirkenes is the main urban area in Norway's Sør-Varanger Municipality and has about 3,000 inhabitants. There is an air connection from Kirkenes to four places in Norway. A rail connection from Kirkenes to Rovaniemi via the Arctic Ocean Railway would be about 520 km and take about 3.5–4.5 hours, depending on train speeds. The most significant passenger potential of the Kirkenes route would most probably come from the Rovaniemi–Sodankylä section, as Sodankylä does not have an airport. Passenger transport could be arranged between Rovaniemi and Sodankylä, so that one IC train from Helsinki (the night train, for example) could continue from Rovaniemi to Sodankylä in the morning and return in the evening. This solution would lead to much lower running costs than operating a rail connection along the entire Arctic Ocean Railway.

To run financially viable passenger traffic between Kolari–Tromsø and Rovaniemi–Kirkenes with two trains in each direction per day would require about 600,000 passengers per annum (one train in each direction per day, about 300,000 passengers per annum). Passenger traffic – mainly tourist traffic – would probably be generated for the track in question over the long term. Tourist traffic is currently highly seasonal, but will probably become year-round in the long term.

# 6 Impact assessments

The Arctic Ocean Railway would impact transport costs, employment, tax revenue, supply security, etc. These factors have been examined with the aid of impact assessments.

## 6.1 Regional economic impacts

Investments in transport have regional economic impacts, particularly during the construction phase. Major construction projects often affect employment and business activities within their sphere of influence in a number of ways. Impacts on employment can be divided into direct impacts on employment; investments in the manufacture of intermediate products and their multiplier impact on employment; and employment impacts arising from increased consumption as a result of increased income.

The percentage of the total impact on employment accounted for by direct and indirect impacts will vary by sector. These percentages will also vary by region, depending on how well the skills and services available in the region match the project's requirements. In principle, employment impacts can be estimated using a variety of different methods. All these methods involve uncertainty factors. This is particularly true in the estimation of indirect impacts and regional leaks. Society and its economic structures change so much that, even with hindsight, it is not possible to precisely define what a particular investment has achieved. Its effects are usually buried beneath larger changes. For these reasons, forecasting long-term impacts on employment, and thereby also on regional economies, is only possible at the level of order of magnitude estimates.

In spite of the reservations associated with these methods, it is still possible to use an input-output model to obtain reliable order of magnitude estimates of the impacts of construction projects on employment. The estimated employment impacts presented in this report are based on Statistics Finland's input-output coefficients. The estimated employment impacts of the alternative routes are:

*Table 3. The employment impacts of the alternative routes during the construction phase*

| Route | Employment impact, persons, Finland (and Lapland) |
|---|---|
| **Rovaniemi-Kirkenes** | approx. 20 500 (12 000-14 000) |
| **Kemi-Skibotn-Tromsø** | approx. 25 000 (14 000-17 000) |
| **Kemi-Kolari-Narvik** | approx. 2 000 (1000-1500) |
| **Kemi-Tornio-Narvik** | approx. 200 (100) |
| **Kemijärvi-Murmansk** | approx. 1 500 (1000) |

The ‘number of people’ refers to the number of people employed, not person work years. The employment impacts for each alternative route are roughly divided 50-50 between direct and indirect impacts. The greatest impacts on employment will naturally be generated by the Rovaniemi–Kirkenes and Kolari–Tromsø alternatives, as their investment costs are the highest.

## 6.2 Municipal tax revenue

Construction of the railway will affect municipal tax revenue through changes in both employment and business activities. The estimated municipal tax revenues are based on employment impacts in Lapland and the average municipal tax in 2015 (about EUR 3,100 per inhabitant). Using this method, the following municipal tax revenues would be generated by the alternative routes:

*Table 4. The municipal tax revenues generated by the alternative routes during the construction phase*

| Route | Municipal tax revenues during the construction phase |
|---|---|
| Rovaniemi-Kirkenes | 37-43 MEUR |
| Kemi-Skibotn-Tromsø | 44-52 MEUR |
| Kemi-Kolari-Narvik | 3-4 MEUR |
| Kemi-Tornio-Narvik | 0,5 MEUR |
| Kemijärvi-Murmansk | 3,0 MEUR |

Tax revenue has been allocated to each municipality according to the employees’ home municipality. When examining these municipal tax revenues, it should be kept in mind that this is the tax revenue generated per person – not per person work year – as calculated using the input-output model. The total number of person work years will depend on the nature of the employees’ contracts (full-time or part-time). These estimated tax revenues can therefore be considered to be maximum values that do not account for the nature of the employees’ employment contracts.

## 6.3. Socio-economic profitability

Assessing the socio-economic profitability of the alternative routes is challenging. There is great uncertainty associated with transport potentials in particular, as they need to be examined for a period of many decades. For instance, the opening up of the Northeast Passage may cause major changes in transport flows that cannot yet be predicted. Using the transport forecasts made during this study, all of the alternatives are equally unprofitable. However, this may change over the long term. One large mine or major changes in the costs of different modes of transport could significantly change the situation.

## 6.4 Reindeer husbandry

Reindeer husbandry is the main occupation of about 1,000 people in Finland, and also provides a significant secondary income for another thousand people. Reindeer management also involves a large number of associated occupations that financially revolve around reindeer. The most important of these are the production of meat, the processing of other reindeer products, and tourism. Changes in reindeer husbandry can therefore have an indirect impact on these business activities. According to a 2014 study, reindeer husbandry in Finland and Sweden generated employment for about 15,000 people and total net sales of about EUR 1.3 billion.

The Kolari–Tromsø and Rovaniemi–Kirkenes alternatives (including Pajala–Svappavaara) will have the greatest impact on reindeer husbandry. New track may have the following impacts on reindeer management:

- Impacts on reindeer pastures (pastures no longer available for reindeer; changes in herd ranges, the fragmentation of pastureland, and uneven grazing)
- Residues of harmful substances in reindeer fodder
- Impacts on reindeer grazing (disturbances)
- Impacts on reindeer management (operational, such as disruptions in reindeer herding routes; or structural, such as changes in the possible use of separation or barrier fences within the project area, or the possibility that they may become completely unusable)
- Accidents involving reindeer (in traffic or the project area)
- Impacts on reindeer health and wellbeing
- Socio-economic impacts, and impacts on the profitability of the reindeer industry
- Impacts on reindeer management culture

Changes in reindeer grazing impact commercial meat production and slaughterhouse income, thereby reducing the profitability of the industry. Workloads and reindeer management costs may rise, and reindeer may also require extra fodder in the winter. This will raise costs and lower profitability.

At this stage, it has not been possible to evaluate the economic impacts of the Arctic Ocean Railway on reindeer husbandry.

## 6.5 Sámi homelands

The Kolari–Tromsø and Rovaniemi–Kirkenes alternatives would run through Sámi homelands. The Arctic Ocean Railway would impact the livelihoods and culture of the Sámi people. The extent of these impacts cannot be evaluated at this stage, except for the aforementioned impacts on reindeer husbandry. In connection with this report, the Ministry of Transport and Communications engaged in negotiations with the Sámi Parliament on 18 January 2018, in accordance with Section 9 of the Act on the Sámi Parliament (974/1995). These negotiations covered the content of the Arctic Ocean Railway Report.

As planning for the Arctic Ocean Railway continues, the authorities (including those in Norway and Sweden) will engage in further negotiations with the Sámi Parliament on issues that require further analysis.

# 6.6 Supply security

The majority of Finland's imports and exports are transported via the Baltic Sea. Consolidating these shipments along a single route makes Finland vulnerable in a crisis situation. A rail connection to the Arctic Ocean would improve Finland's supply security, as Finland would have an alternative route available.

From a purely supply security perspective, the best alternatives would be Kolari–Tromsø and Rovaniemi–Kirkenes. The same track gauge is used along the entirety of these routes. These tracks would almost exclusively be used to transport goods into Finland, thereby avoiding any conflicts over the prioritisation of transport.

The Tornio–Narvik and Kolari–Narvik routes would also improve supply security. However, these alternatives would mean different track gauges on the Finnish and Swedish sides. Transportation priorities would also have to be agreed on between three countries. Problems may also be caused by insufficient capacity.

The Kemijärvi–Murmansk alternative holds no significance for supply security, as any such transport from Russia can already be handled using existing lines and border crossings.

# 7 The potential use of HCT combinations in Northern Finland

The use of HCT combinations in Northern Finland was also examined in connection with this report. HCT (High Capacity Transport) combinations refer to vehicle combinations that are longer or heavier than normal, yet are not categorised as special transports. HCT traffic is only permitted on predefined routes to ensure that the roads are suitable for larger-than-normal transports.

HCT combinations can be used to operate cost-effective connections over distances that are too short for rail transport, where there is no rail connection, or as feeder routes from forests and mines to the closest rail terminal. There is potential for the use of HCT combinations in mining and raw timber shipments in particular. Product shipments in the forestry industry hold less potential, as rail transport is more affordable.

More extensive use of HCT combinations in Northern Finland would require basic repairs to the sections of the road network where they would be used. Opening up HCT transport connections to the Arctic Ocean would require close international cooperation, as the alternative routes that have been examined include sections of road in Norway and Russia. Amendments would also be required to national legislation in the transit countries. However, HCT combinations do not constitute an alternative to the Arctic Ocean Railway, as rail transport would be the more affordable option over such long distances.

# 8 Financing options

The investment costs of the alternative routes examined in this report vary greatly. The investment costs of the Kemi–Tornio–Narvik, Kemi–Kolari–Narvik and Kemijärvi–Alakurtti–Murmansk rail connections are about EUR 22–101 million on the Finnish side. Implementing an investment of this scale can be done using currently available financing models, such as direct budget financing.

However, implementing the Kolari–Narvik and Kemijärvi–Alakurtti–Murmansk routes would also require significant investments in Sweden (EUR 1.4 billion) and Russia (approx. EUR 650 million). It must be assumed that the investments in question can only be implemented if they are also socio-economically feasible for Sweden and Russia.

The investment costs for the Kemi–Kolari–Tromsø and Rovaniemi–Kirkenes rail connections are both close to EUR 2.0–2.3 billion on the Finnish side. However, there is a significant difference between the investment costs of these two alternatives on the Norwegian side. The costs for the Tromsø route would be EUR 5.2 billion, compared to EUR 0.85 billion for the Kirkenes route.

The investment costs for both of these routes would be so great for both Finland and Norway that their construction would require an extensive financing base. Financing would have to be sourced from the State, regions, the EU, users, and others who would benefit from the railway.

The actual construction could be implemented in a number of ways (lifecycle project, company model, alliance model). The chosen method would, however, be dependent on the financing model.

# 9 Conclusions

As Finland is located far from central markets, it is important for Finland to improve its logistical position and accessibility. This can be achieved by creating new transport connections to both the north and south. To the north, this would mean a connection to the Arctic Ocean, and to the south a connection to the European rail network via the Helsinki-Tallinn Tunnel and Rail Baltica. The Arctic Ocean Railway should therefore be seen as part of the global transport system. Curbing climate change also requires changes in the proportions of total transport volumes accounted for by different modes of transport.

A railway to the Arctic Ocean would improve Finland's connections to the north and provide an alternative route for Finland's imports and exports. This would improve Finland's logistical position and accessibility, and could also enable Finland to become a more significant Northern European transport route.

A rail connection to the Arctic Ocean could be implemented in a number of ways. This report studied five alternative routes: Kemi–Tornio–Narvik, Kemi–Kolari–Narvik, Kemi–Kolari–Tromsø, Rovaniemi/Kemijärvi–Kirkenes, and Kemijärvi–Alakurtti–Murmansk. Table 5 shows a summary of the impacts of each of these alternatives.

*Table 5. Summary of impacts*

| | Tornio-Narvik | Kolari-Narvik | Kolari-Tromsø | Rovaniemi-Kirkenes | Kemijärvi-Murmansk |
|---|---|---|---|---|---|
| **Investment costs** | Low in Finland, Sweden, EUR 0.6 billion | Low in Finland, Sweden EUR 1.4 billion | Over EUR 2 billion in Finland, high in Norway at over EUR 5 billion | Approx. EUR 2 billion in Finland, EUR 0.85 billion in Norway | Low in Finland, about EUR 0.65 billion in Russia |
| **Finland's logistical position** | Minor impact | Minor impact | Clear improvement | Clear improvement | Minor impact |
| **Finland's accessability** | Minor impact, does not improve accessibility for Lapland | Minor impact, does not improve accessibility for Lapland | Improved accessibility for both Finland and Lapland | Improved accessibility for both Finland and Lapland | Minor impact, slight improvement in accessibility for Lapland |
| **Supply security** | Minor impact | Minor impact | Clear improvement | Clear improvement | No significance |
| **Environmental impacts** | None | Minor impact on the Finnish side | Challenging on the Finnish side | Significant impact | Minor impact on the Finnish side |
| **Reindeer husbandry** | No impact | No impact on the Finnish side, impacts in Sweden | Definite impacts in both Finland and Norway | Definite impacts in both Finland and Norway | No impact |
| **Sámi homelands** | No impact | No impact on the Finnish side, impacts in Sweden | Definite impacts in both Finland and Norway | Definite impacts in both Finland and Norway | No impact |

All of the alternatives are technically feasible. The construction of the railway is also possible with regard to the environment, as long as Lapland's delicate landscape and cultural factors are taken into account during planning. Potential shipments for the Arctic Ocean Railway primarily consist of minerals, fish products, raw timber, and processed forestry industry products. Potential shipments also include the natural resources of the Barents Region and products that may be transported through the Northeast Passage in the future. There is, however, a lot of uncertainty involved in forecasting future shipments. Passenger traffic can also benefit from the Arctic Ocean Railway. Passenger traffic – mainly tourist traffic – would probably be generated for the Arctic Ocean Railway over the long term.

The costs of the alternative routes vary greatly. Their costs are affected by factors such as terrain and the length of new track sections. The total costs for the routes range from EUR 650 to 7,500 million: Tornio–Narvik MEUR 652, Kolari–Narvik MEUR 1,483, Kolari–Tromsø MEUR 7,449, Rovaniemi–Kirkenes MEUR 2,919, and Kemijärvi–Alakurtti–Murmansk MEUR 750. Investment costs on the Finnish side range from EUR 22 to 2,270 million.

There is an existing rail connection for the Kemi–Tornio–Narvik route. The upside of this alternative is that it would be affordable to implement, particularly on the Finnish side. It would also be quick to implement. The Kemi–Tornio–Narvik route would also improve Finland's supply security to some extent. However, this route would not improve Finland's logistical position or Lapland's accessibility. Finland and Sweden's different track gauges also cause difficulties for this route. The Kiruna–Narvik section of the track is also heavily trafficked, which means that there may not be sufficient capacity for other traffic.

The Kemi–Kolari–Narvik route has similar impacts to the Kemi–Tornio-Narvik route. The implementation of this route would require Sweden to lay track between Pajala and Svappavaara. Sweden currently has no plans to build the line in question.

The Kemi–Kolari–Skibotn–Tromsø route would lead to a clear improvement in Finland's logistical position, Lapland's accessibility, and Finland's supply security. However, this route would be expensive to build, particularly on the Norwegian side due to challenging terrain. The investment costs for this alternative would be EUR 7.5 billion, of which Norway's share would be about EUR 5 billion. Building this route would also be challenging due to its environmental impacts. It would also have a definite impact on reindeer husbandry and the Sámi people.

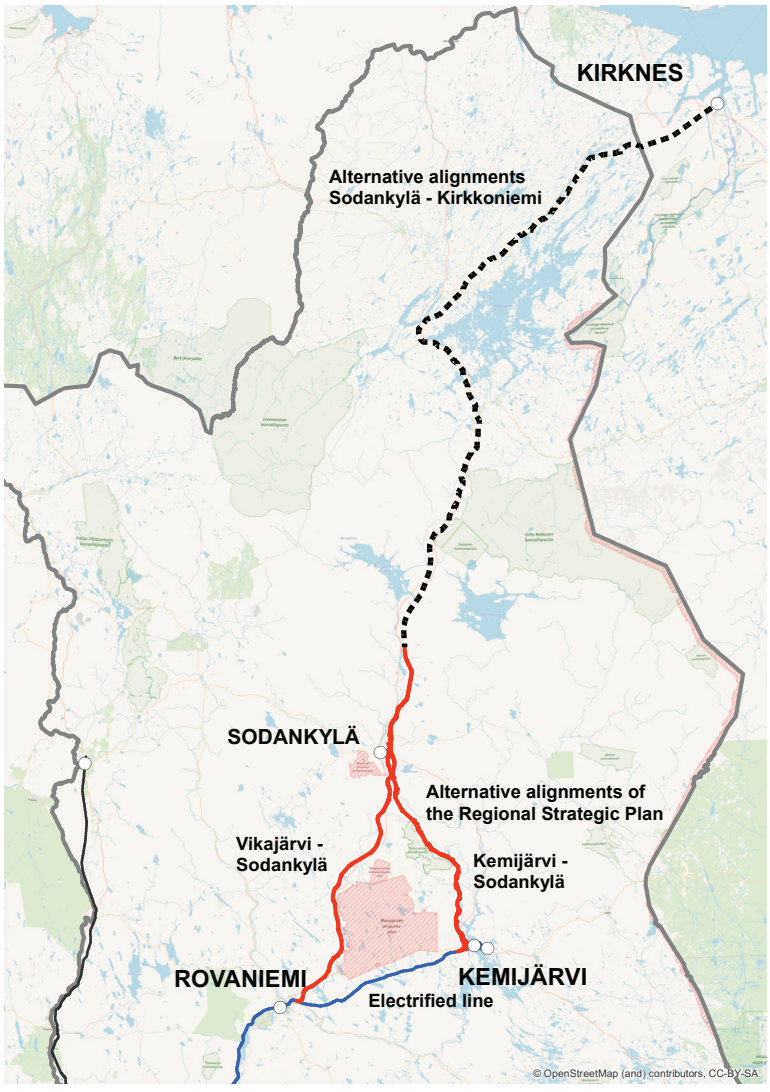
The Rovaniemi/Kemijärvi–Kirkenes alternative would lead to a clear improvement in Finland's logistical position, Lapland's accessibility, and Finland's supply security. Although the Kirkenes line would require similar investment costs to the Kolari–Tromsø route on the Finnish side, the investment costs on the Norwegian side would be significantly lower for the Kirkenes route (EUR 0.85 billion). This alternative involves challenging environmental impacts, and would also affect reindeer husbandry and the Sámi people.

The Kemijärvi–Murmansk route would improve Eastern Lapland's accessibility, but would have only a minor impact on Finland's logistical position and accessibility. This route has no significance for supply security, as Finland already has good rail connections with Russia. The route would have no impact on either reindeer husbandry or the Sámi people.

A good, year-round rail connection to the Arctic Ocean's deep, ice-free harbours would improve Finland's logistical position, accessibility and supply security. On the basis of its impacts and implementation, the most realistic alternative is a rail connection from Rovaniemi or Kemijärvi to Kirkenes (the alignment will be determined later). However, the Arctic Ocean Railway involves a lot of uncertainty factors that require further analysis. The ongoing preparatory work for the Regional Strategic Plan for Northern Lapland will act as a good basis for further analyses, as it covers the Kirkenes route. A report on the region's railway connections and transport system, including an investigation into alternative routes for a rail connection between Sodankylä and Kirkenes, is being drawn up as part of the Regional Strategic Plan 2040 for Northern Lapland. A rail connection between Rovaniemi and Sodankylä has already been marked in the Regional Strategic Plan for Rovaniemi and Eastern Lapland, which was drawn up in 2014.

The Arctic Ocean Railway involves many impacts on the environment, economy, and Sámi people. These impacts require further analysis. Akwé: Kon Guidelines should also be appended to the Regional Strategic Plan for Northern Lapland. This process will involve impact assessments of the railway and rail traffic on the Sámi people and Sámi culture.

Further investigation into the Arctic Ocean Railway will require cooperation with Norway. This can be done by establishing a joint task force with the Norwegians to define the next stages in the process and their schedule.



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