Elinkeino-, liikenne- ja ympäristökeskus
Centre for Economic Development, Transport and the Environment

The Market, Infrastructure, and Distribution of Alternative Fuels for Transport in the Western Barents Region

Summary report

WSP FINLAND OY

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29.2.2024

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During 2022 and 2023, a total of four preliminary studies were conducted on the markets, infrastructure, and distribution of alternative fuels for transportation in the Barents region in Finland, Sweden, and Norway. These studies focused on (1) the electrification of transportation, (2) hydrogen and gas as alternative fuels for transportation, (3) alternative fuels for heavy vehicles and machinery, as well as (4) the possibilities for electric and cross-border aviation in the Barents region. The goal of this report is to consolidate key observations and findings from these studies.

The transition to alternative transportation fuels is driven by goals and regulations set by the European Union to reduce emissions. Developing public charging infrastructure for alternative fuels plays a crucial role in promoting the adoption of emission-free vehicles. However, progress in development of alternative fuel infrastructure and vehicle fleet in the Barents region has been slow. Challenges include regional geography, long distances, low traffic volumes, and cold weather conditions.

Regarding electrification, passenger cars are rapidly adopting electric powertrains, and this trend is also extending to urban bus services, taxis, and city logistics. The public charging network for electric vehicles in the Barents region is relatively comprehensive. However, there are gaps in coverage, particularly in Finland, where public funding support has not been directed at the same level as Norway and Sweden to areas where a high-power charging network has not emerged through market forces. Additionally, heavy-duty vehicles require purpose-built charging stations to meet their needs, but implementing such infrastructure in quieter traffic areas remains challenging.

Gas and hydrogen are expected to play a smaller role in passenger car transportation. The primary applications for hydrogen and liquefied biogas are likely to be in heavy-duty transport, where electrification is challenging due to long charging times or limited battery range. Currently, the adoption of gas for transportation in the Barents region is hindered by the lack of a comprehensive refuelling station network. Hydrogen, while not widely used as a transportation fuel yet, has several ongoing projects related to its production and distribution. Multiple refuelling stations for both liquefied gas and hydrogen are planned for the region.

In the context of heavy-duty vehicles and machinery, the transition to alternative fuels has been slower compared to passenger cars. While the emphasis has been on using biodiesel (HVO-diesel) to reduce emissions, competition in the industry has limited its voluntary adoption by businesses. Electric-powered machinery is seen as a potential solution, especially in mining operations and tasks where vehicles and equipment are smaller and operate within confined areas, such as ports or industrial sites. Implementing alternative fuels in heavy-duty transport and machinery faces challenges related to fuel availability, lack of suitable technology (especially in specific industries), long lead times for equipment delivery, fuel and equipment costs, and intense price competition within the industry.

Electric commercial aviation is expected to take off within the next decade, especially as small electric aircraft are anticipated to enter the market. However, for small-capacity planes, ticket prices tend to be high, which initially limits the commercial potential of electric aviation. In the Barents region, the primary challenge for electrifying regional air travel lies in securing funding. The most promising opportunities in the region are related to electrifying existing publicly supported connections in Northern Norway, where the Norwegian government has committed to reducing carbon dioxide emissions from aviation.

Contents

Terminology

TERM	EXPLANATION
Charging point	A fixed or movable interface that enables the transfer of electricity to an electric vehicle. The charging point may have one or more connectors for different connector types, but it can only charge one electric vehicle at a time. Charging points do not include devices with an output power of up to 3.7 kilowatts (kW) whose primary purpose is not charging electric vehicles.
Charging station	A single physical device located in a specific place, consisting of one or more charging points.
Charging pool	A charging pool refers to one or more charging stations located in the same specific place. In Finland, charging stations that are within a maximum distance of 200 meters from each other belong to the same pool. Typically, charging stations or pools in Finland serve both directions of travel, as it is uncommon to have separate service stations on each side of the road.
Public charging point	A charging point intended for electricity distribution, to which all users have access. The provider of a public charging point may charge a fee for the use of the charging point. They can be located on a public or privately owned site and their use may be subject to time limits and different identification, usage and payment conditions set by the operator.
Basic charging point	A normally powered charging point that allows electricity transfer to an electric vehicle at a maximum power of 22 kW (alternating current, AC; plug type Type2).
Fast-charging point	A fast-charging point, also called rapid charging point, that enables the transfer of electricity to an electrically powered vehicle with a power of over 22 kW: slow direct current charging point $P < 50$ kW, fast direct current charging point 50 kW $\leq P <$ 150 kW (direct current, DC; plug type CCS).
High-power charging point	A high-power charging point, also called ultra-rapid charging point, that enables the transfer of electricity to an electrically powered vehicle at high speed with a power of over 150 kW: level 1 - ultra-fast direct current charging point 150 kW $\leq P <$ 350 kW, level 2 - ultra-fast direct current charging point $P \geq$ 350 kW (direct current, DC; plug type CCS).
Home charging	Charging that takes place at the car's main storage location, which happens mostly at night. During the night, an estimated 80-90% of all the energy required by electric cars is charged. (plug type Type1, Type2 or Schuko).
Methane gas, biogas	Methane gas can be fossil natural gas or gas produced in the natural decomposition process of plants, etc., which is called biomethane. In Finland, in everyday language, biogas refers to methane gas cleaned from raw biogas, which can be filled into gas cars. In other countries, biogas (biogas) often refers to raw biogas and biomethane (biomethane) refers to cleaned gas, which can be filled into gas cars.

Compressed Gas	Compressed gas is methane gas, which is abbreviated as CNG (Compressed Natural Gas) when the gas is fossil natural gas or CBG (Compressed Biogas) when the gas is biomethane. Compressed gas is stored in filling station tanks and car fuel tanks at a pressure of about 200 bar.
Liquefied Gas	Liquefied gas is methane gas, which is abbreviated as LNG (Liquefied Natural Gas) when the gas is fossil natural gas or LBG (Liquefied Biogas) when the gas is biomethane. Methane gas must be kept below -162 degrees Celsius in order to remain in a liquid state. Liquefied natural and biogas are only used as fuel for heavy traffic.
Bunkering	Bunkering refers to the refueling of a ship's fuel tanks.
Hydrogen gas or hydrogen	Hydrogen gas, or hydrogen, must be industrially produced from hydrocarbons or water, for example. In car tanks, hydrogen is stored as a gas at about 700 bar pressure or as a liquid at -253 degrees Celsius. Green hydrogen is hydrogen that has been produced by breaking down water into hydrogen and oxygen in electrolysis with renewable electricity, such as wind or solar power.
Biodiesel, first generation (FAME)	The term biodiesel has previously referred to the so-called first-generation bio-based diesel, or fatty acid methyl ester (FAME, Fatty ACID METHYL ESTER). The esterification process limits the use of low-quality or impure raw materials, such as waste and residues. Its mixing ratio with fossil diesel is limited in Europe (up to 7 volume percent), and many car manufacturers also limit the use of FAME-type biodiesel due to the risk of engine damage. Nowadays, biodiesel is expanding to become a general term that also covers second-generation renewable, higher-quality biodiesels (HVO diesel).
HVO diesel, renewable diesel	HVO diesel (Hydrotreated Vegetable Oil) is a so-called second-generation biodiesel, which is made from renewable raw materials, such as waste and rapeseed oil. HVO is similar in properties to traditional diesel, and it is suitable for all diesel engines. HVO diesel can be used as fuel in high concentrations up to 100 percent. Compared to traditional diesel, HVO reduces carbon dioxide emissions by about 90 percent.
Electric aviation	In this report, electric aviation is defined as aircraft powered by battery electricity and aircraft using hydrogen in a fuel cell. Battery electricity means that the aircraft has a built-in battery that is charged before flight and that supplies energy to the electric motor during flight. Hydrogen in a fuel cell means that the hydrogen fuelled into the tank reacts with the oxygen in the atmosphere in the fuel cell, producing electricity, water, and heat at the same time. The produced electricity is used to run the electric motor and to charge and maintain a small battery in the machine.

Introduction

Background and objectives of the summary report

Finland served as the chair of the Barents Euro-Arctic Council (BEAC) from 2021 to 2023. The priorities of the chairmanship were sustainable development, people-to-people contacts, transportation and logistics, and the green transition. The Barents Regional Council (BRC) brings regional expertise to the Barents cooperation. The members of the Barents Regional Council are Lapland, Northern Ostrobothnia, Kainuu, and North Karelia regions from Finland, Västerbotten and Norrbotten counties from Finland and Troms and Finnmark county as well as Nordland County from Norway. The Russian Barents region has been left out of the project's review area due to Russia's war of aggression launched against Ukraine in February 2022. Barents cooperation will in the future focus particularly on Nordic cooperation.

Regions and counties have a key role in promoting cooperation between people in the Barents region. The work program of the Barents Euro-Arctic Council and its transport and logistics working group has highlighted the need to promote cross-border cooperation in the Barents region and to facilitate cross-border transport in the wide arctic zone of Barents.

During 2022 and 2023, a total of four preliminary studies were conducted on the markets, infrastructure, and distribution of alternative fuels for transportation in the Barents region. These studies focused on the potential use, availability, capacity needs, and required infrastructure for alternative energy forms in the Barents region in Finland, Sweden, and Norway. The project compiled a knowledge base that allows the transportation sector of the Barents region to be examined and developed as a whole, instead of just country-specific reviews. The project was implemented with funding granted by the Ministry of Foreign Affairs for cooperation in the Baltic Sea, Barents, and Arctic regions.

The reports prepared in the project are:

- Public charging station network for electric cars in the Barents region - Development report (WSP Finland Oy, 2023)
- Gas and hydrogen study - Methane gas and hydrogen used as fuels in transportation in the Barents region (Sitowise Oy, 2023)
- Preliminary survey on alternative fuels for heavy traffic and working machinery in the Barents region (Ramboll Finland, 2023)
- Preliminary study of electronic and transverse air traffic in the Barents region (Sitowise Oy, 2023)

The aim of this report is to compile the key observations and results from these studies, and to prepare a condensed summary analysis based on the results of the preliminary studies. Alternative power sources are currently developing rapidly. Changes may have occurred in the information and results of the reports after their completion, and some of these changes have been considered when preparing the summary.

Barents region

The Barents region comprises the land areas around the Barents Sea and the Cap of the North. The pre-feasibility studies prepared in the project have limited the area of examination to the Western Barents region, which covers northern Finland, Sweden, and Norway (figure 1). In Finland, the Barents region comprises the regions of Lapland, Kainuu, Northern Ostrobothnia and North Karelia. In Sweden, the region comprises the counties of Norrbotten and Västerbotten. In Norway, the region comprises the county of Troms and Finnmark as well as county of Nordland.

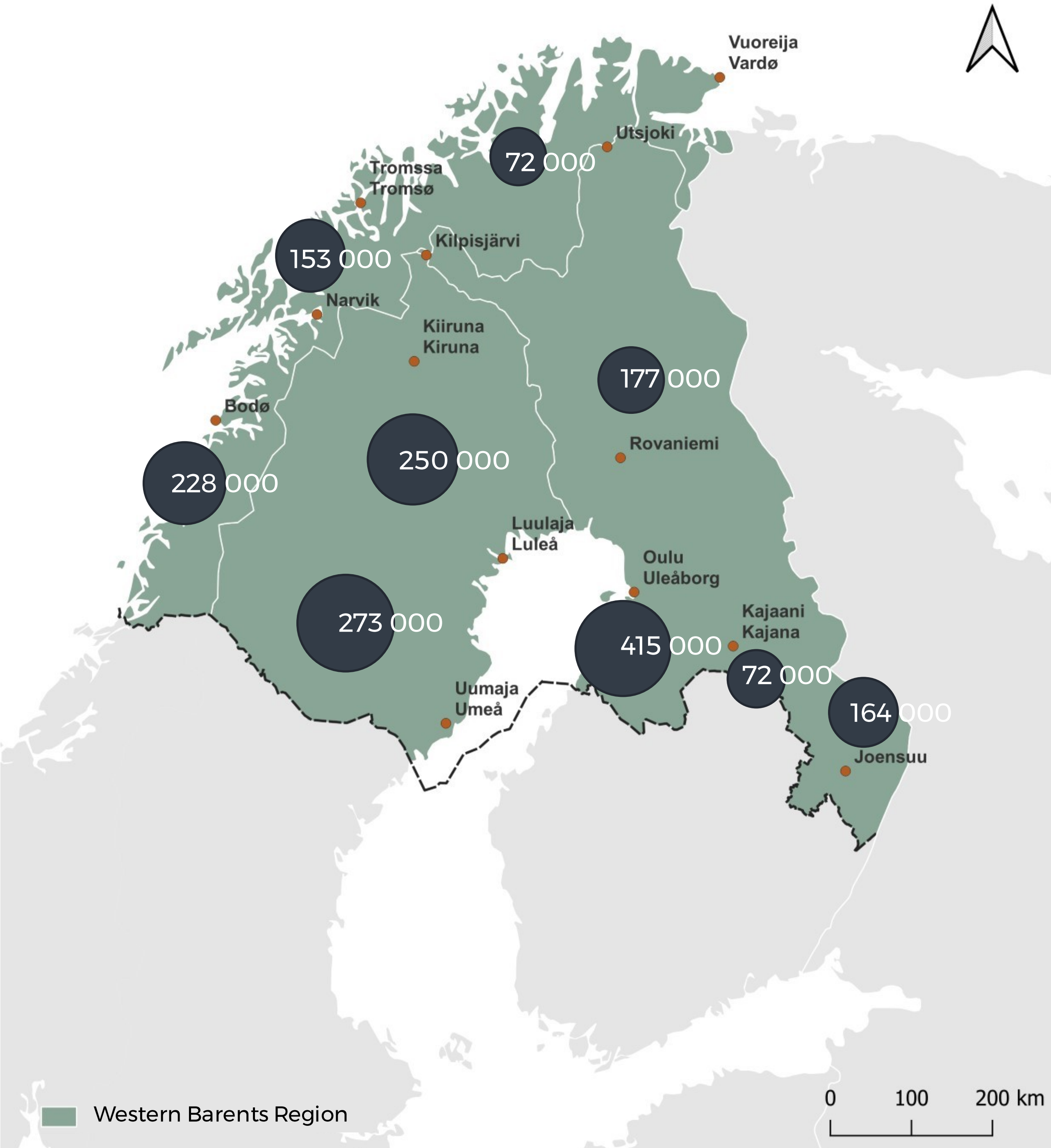

Figure 1. The boundary of the project's pre-study area covering the Barents region of Finland, Sweden, and Norway and the populations of each area. (Image: WSP Finland Oy)

Climate goals and steering measures for traffic emission reduction targets

The European Union is committed to ambitious climate policy. The EU's climate and energy targets have been tightened several times, and the targets are currently being raised. The goal of the European Green Deal is to make Europe the world's first climate-neutral continent by 2050. The goal is to be achieved through the EU's climate law, which made climate neutrality by 2050 binding EU legislation. To implement the European Green Deal, old legislation is currently being updated in the EU and new laws are being enacted to achieve the 2030 target of a 55% reduction in emissions. The legislative package is known as "Fit for 55". The package includes, among other things, emissions trading, national emission reduction targets, carbon sinks in the land use sector, and regulation of transport emissions.

The emission reduction targets of Finland, Sweden and Norway are guided by the targets set by the EU, as Norway has also signed an emission reduction agreement with the EU. To achieve these targets, each country has developed national programs aimed at carbon neutrality to prevent climate change. In terms of transport emission reduction targets, Finland, Sweden, and Norway will at least halve domestic transport emissions by 2030 compared to the 2005 level. The target is ambitious, and to achieve the target, the consumption of fossil fuels should be halved in the same period.

Regulation related to alternative fuels

Regulation on the deployment of alternative fuels infrastructure

As part of the European Green Deal’s Fit for 55 package, the Council of the European Union approved a new regulation on the deployment of alternative fuels infrastructure (hereafter AFIR regulation) in July 2023. The regulation sets mandatory targets for the deployment of charging and hydrogen refuelling infrastructure for road transport, shore-side electricity in sea and inland ports, and power supply for parked aircraft. The regulation mainly concerns public infrastructure to be built along the Trans-European Transport Network (TEN-T), i.e., charging and refuelling stations, which are freely accessible to everyone. When a certain minimum number of charging and refuelling points are available everywhere in the EU, consumers’ concerns about the difficulty of charging or refuelling a vehicle are reduced. The AFIR regulation promotes a user-friendly charging and refuelling experience: pricing should be fully transparent, minimum payment options uniform, and information provided to customers consistent throughout the EU. The effective implementation of the AFIR regulation requires national regulation, including authorities and penalties. The regulation will be applicable to member states from spring 2024 onwards.

According to the AFIR regulation, the charging infrastructure for electric passenger and light commercial vehicles must be increased at the same pace as vehicles are put into use. For this purpose, the publicly available charging infrastructure must provide a charging power of 1.3 kW for each battery-powered electric car registered in any member state. In addition, from 2025 onwards, fast charging pools with a power output of at least 400 kW in both directions of travel and with at least one 150 kW charging point must be implemented on the Trans-European Transport Network (TEN-T) at intervals of 60 km. The targets will tighten for the core network by 2030, when the 60 km intervals must have a power output of at least 600 kW in both directions of travel and the charging pool must include at least two charging points, each with an individual power output of at least 150 kW. A similar target must be achieved on the comprehensive network by 2035. For low-traffic TEN-T network roads, Member States may set less stringent requirements. The AFIR regulation also sets requirements for heavy-duty vehicles. From 2025 onwards, charging pools for heavy-duty vehicles with a power output of at least 1,400 kW must be implemented on the TEN-T network for at least 15% of its length. Similarly, the requirements will increase by 2030, when the core network must have a charging pool at intervals of 60 km, with a power output of at least 3,500 kW and the comprehensive network at intervals of 100 km, with a power output of at least 1,400 kW. In addition, charging stations must be installed for overnight charging at safe and supervised parking areas and for distribution vehicles at urban nodes. In the Barents region, the definition of an urban node is likely to be met by Oulu and Luleå.

Regarding gas, the AFIR regulation requires that by 2025 there should be liquefied gas (LNG/LBG) refuelling points at least along the main roads in road transport, so that vehicles using methane can operate everywhere in the EU. Hydrogen refuelling stations should be at least 200 kilometers apart on the TEN-T core network and in urban nodes by the end of 2030. As for ports, the regulation obliges ports to provide shore power to container and passenger ships that stay in the port for at least two hours or that do not use any other emission-free energy source while in the port. This helps to reduce carbon dioxide emissions from maritime transport and significantly reduce air pollution in port areas.

Renewable fuel distribution obligation

The purpose of the distribution obligation is to promote the use of sustainable renewable fuels to replace gasoline, diesel, and natural gas in transport. By 2030, the share of energy from renewable sources must be increased to 14% of the final energy consumption in transport in the EU. This has been implemented by nationally imposing an obligation on transport fuel distributors to supply a minimum proportion of renewable fuels for consumption each year. In Finland, the renewable fuel distribution obligation was reduced to 13.5% in 2023 and 2024. The distribution obligation rises gradually and aims to increase to 30% by 2030. In Sweden, it has also been agreed to reduce the distribution obligation to the minimum level mandated by the European Union from the beginning of 2024. In Norway, the proportion of renewable fuels in transport fuels sold must be 24.5%. In addition, at least 9% of all fuel must be primarily made from waste and residues.

Emission limits for cars

At present, carbon dioxide emission limits set for manufacturers of passenger and light commercial vehicles guide manufacturers to produce as low-consuming or zero-emission passenger and light commercial vehicles as possible. The European Parliament decided in February 2023 that from 2035 onwards, new passenger and light commercial vehicles must be zero-emission. Current interim targets for emission reductions are also being tightened so that by 2030, emissions from new passenger cars manufactured in the EU must be cut by 55 percent from the 2021 level. The regulation guides the manufacture and sale of zero-emission vehicles, i.e., fully electric and hydrogen cars. In Norway, a ban on the sale of internal combustion engine cars is planned from 2025 onwards.

The European Commission also proposes tightening the previously agreed carbon dioxide emission limits for new heavy-duty vehicles so that by 2030, the emissions of new heavy-duty vehicles first registered in the European Union must be on average 45% lower (the previous target was 30%) than in 2019. In addition, the Commission proposes reducing the emissions of heavy-duty vehicles by 65% by 2035 and by 90% by 2040. The Commission proposes expanding the regulation to cover not only trucks but also buses and proposes that new city buses should be emission-free by 2030.

Public Charging Station Network for Electric Vehicles in the Barents Region - Development Report

The implementation and objective of the study

The aim of the study was to examine the current state of the public charging station network for electric cars in the Barents region, identify challenges and bottlenecks in the development of the network, identify the needs and potential for the development of the charging network, and prepare follow-up recommendations for the near future development of the charging station network. The work focused particularly on high-power charging (≥ 150 kW output power) serving long-distance traffic. A total of 18 stakeholder interviews and two interactive workshops were conducted remotely in the study.

The report was prepared by the WSP Finland Oy project team, which consisted of Risto Jounila (project manager), Laura Poskiparta, Väinö Jalkanen and Sirje Lappalainen. In addition, Karin Axelsson (WSP Sweden), Emma Nolinder (WSP Sweden) and Julia Obrovac (WSP Norway) participated in the work. The report was prepared between September 2022 and April 2023.

The key findings and results of the study

Development of electric car fleet and charging station network

Electric transport has developed rapidly in recent years. Clear differences can be seen in the development of the electric car fleet in Finland, Sweden, and Norway. The number of electric cars has grown most strongly in Norway, where consumers have been supported in purchasing electric cars in various ways. By the end of 2022 in Norway, the total number of fully electric cars and plug-in hybrid cars was about 820,000 vehicles, which corresponds to about 28% of Norway’s entire car fleet. At the same time, there were about 460,000 electric cars in Sweden and about 150,000 electric cars in Finland.

The electrification of transport has been accelerated by various means, one of which is the implementation of public charging infrastructure to encourage and enable the acquisition of electric cars. The public charging infrastructure develops market-driven along with the development of the electric car fleet, but to accelerate development, countries have granted public support for the implementation of charging points. However, there are significant country-specific differences in the coverage of support in relation to total investments.

In Finland, transport infrastructure support is granted, which supports not only the investments in charging points for electric cars but also charging points for public transport and investments in refueling points for other alternative power sources (such as biogas and renewable hydrogen). Support is granted based on a tender competition according to the power source. In recent years, the scoring of the tender competition has emphasized the development of a high-power charging network and proximity to the TEN-T network. Support can be obtained for 35–45% of acceptable costs. The Energy Agency, under the Ministry of Employment and the Economy (TEM), is responsible for granting the support. For the year 2023, support was available for the implementation of the electric car charging infrastructure, amounting to 8.3 million euros.

In Sweden, the granting of support is divided among three different state authorities, which are the Swedish Transport Administration (Trafikverket), the Environmental Protection Agency (Naturvårdsverket), and the Energy Agency (Energimyndigheten), which grants subsidies for the construction of charging infrastructure for heavy traffic in the form of regional electrification pilots. To target the support, the Swedish Transport Administration has carried out a review of connections that lack a high-power charging point of at least 150 kW within 100 kilometers of an existing charging point. Based on the review, preliminary locations have been determined for the necessary new charging points, and up to 100 percent investment support is granted for the implementation of these charging points. From 2023 onwards, the Swedish Transport Administration grants 100 million Swedish kronor (approx. 9 million euros) for the development of the charging infrastructure. With these measures, the Swedish Transport Administration estimates that a basic level of charging infrastructure availability can be offered throughout Sweden.

In Norway too, public support has in recent years been targeted at areas where public charging infrastructure would not otherwise have been established. In Norway, the state-owned company Enova is responsible for the public funding of the electric car charging infrastructure. In 2022, Enova was granted 100 million Norwegian kroner (approx. 9 million euros) from the Norwegian state budget. This sum was allocated to support new charging points in areas where the charging infrastructure has not emerged market-driven. The funding was allocated through a competition, where the operator offering the lowest price had the opportunity to receive up to 100% support for the realized investment costs.

Public charging network coverage target level

According to the AFIR regulation proposal, member states must ensure that the publicly available electric car charging infrastructure develops in proportion to the fleet of electric passenger and light commercial vehicles. More specific requirements have been set for the minimum coverage of the charging network for the Europe-wide TEN-T road network for the target years 2025, 2027, 2030, and 2035. The negotiation result of the AFIR regulation was approved by the European Commission in July 2023, a few months after the completion of this study. As a result of the negotiations, the goals for the coverage of the charging infrastructure along the TEN-T core network tightened in terms of the output power of the charging points to the year 2025, and an interim target was set for the year 2027. The updated requirements are presented in the table below. The regulation will be applicable to member states from the spring of 2024.

For roads with low traffic on the TEN-T network, member states can set milder requirements. These requirements also tightened as a result of the negotiations. When the average daily traffic is less than 8,500 vehicles, the proposed requirements can also be covered by a single charging pool shared by the directions of travel, whose power requirements follow the requirements of one direction of travel. If there are separate pools for both directions of travel, the total power requirements of these pools can be halved. When the average daily traffic is less than 3,000, the requirement for the maximum distance between charging pools can be increased from 60 kilometers to a maximum of 100 kilometers.

Table 1. Goals for the charging infrastructure of light electric vehicles in road traffic in the AFIR regulation (updated 02/2024).

Goals for the charging infrastructure of electric light vehicles (AFIR regulation)				
	2025	**2027**	**2030**	**2035**
TEN-T core network	A charging pool every **60 km**, with a minimum output power of **400 kW** in both directions of travel, and which should include at least **one** charging point with an individual output power of at least 150 kW.	A charging pool every **60 km**, with a minimum output power of **600 kW** in both directions of travel, and which should include at least **two** charging points, each with an individual output power of at least 150 kW.	A charging pool every **60 km**, with a minimum output power of **600 kW** in both directions of travel, and which should include at least **two** charging points, each with an individual output power of at least 150 kW.	
TEN-T comprehensive network		For 50% of the network, a charging pool every **60 km**, with a minimum output power of **300 kW** in both directions of travel, and which should include at least **one** charging point with an individual output power of at least 150 kW.	A charging pool every **60 km**, with a minimum output power of **300 kW** in both directions of travel, and which should include at least **one** charging point with an individual output power of at least 150 kW.	A charging station every **60 km**, with a minimum output power of **600 kW** in both directions of travel, and which should include at least **two** charging points, each with an individual output power of at least 150 kW.

For the rest of the road network, Sweden has most precisely defined its target state for the charging point network, setting a maximum distance of 100 kilometers between high-power charging points with a power of at least 150 kilowatts. The target applies to state main roads as well as the most important county roads. Norway has not defined kilometer-based targets for the distance between fast and high-power charging points. In Norway, the charging point network is comprehensive and has developed along the main roads in line with the rapidly growing electric car fleet. Finland has not yet defined kilometer-based targets for the distance between fast and high-power charging points. In the national distribution infrastructure program until 2035 (draft 7.2.2023), it has been proposed that by 2030, there will be at least 150 kilowatt charging points within a 50 km radius on the entire main road network of the country.

Current state of the road network and public charging point network for electric cars in the region

The Barents region is largely sparsely populated, and the majority of the region's population is located in the largest cities. The road network is also sparse in the region and there are few alternative modes of transport. Mobility in the area is largely dependent on car traffic. Generally, the traffic volumes in the region are low on most of the road network. In the vicinity of the largest urban and urban areas, the average daily traffic is about 4,000-10,000 vehicles per day and traffic volumes exceed 10,000 drives/day only in the vicinity of the largest cities. On most of the main road network, traffic volumes are below 4,000 drives/day and partly even below 1,500 drives/day (Figure 2).

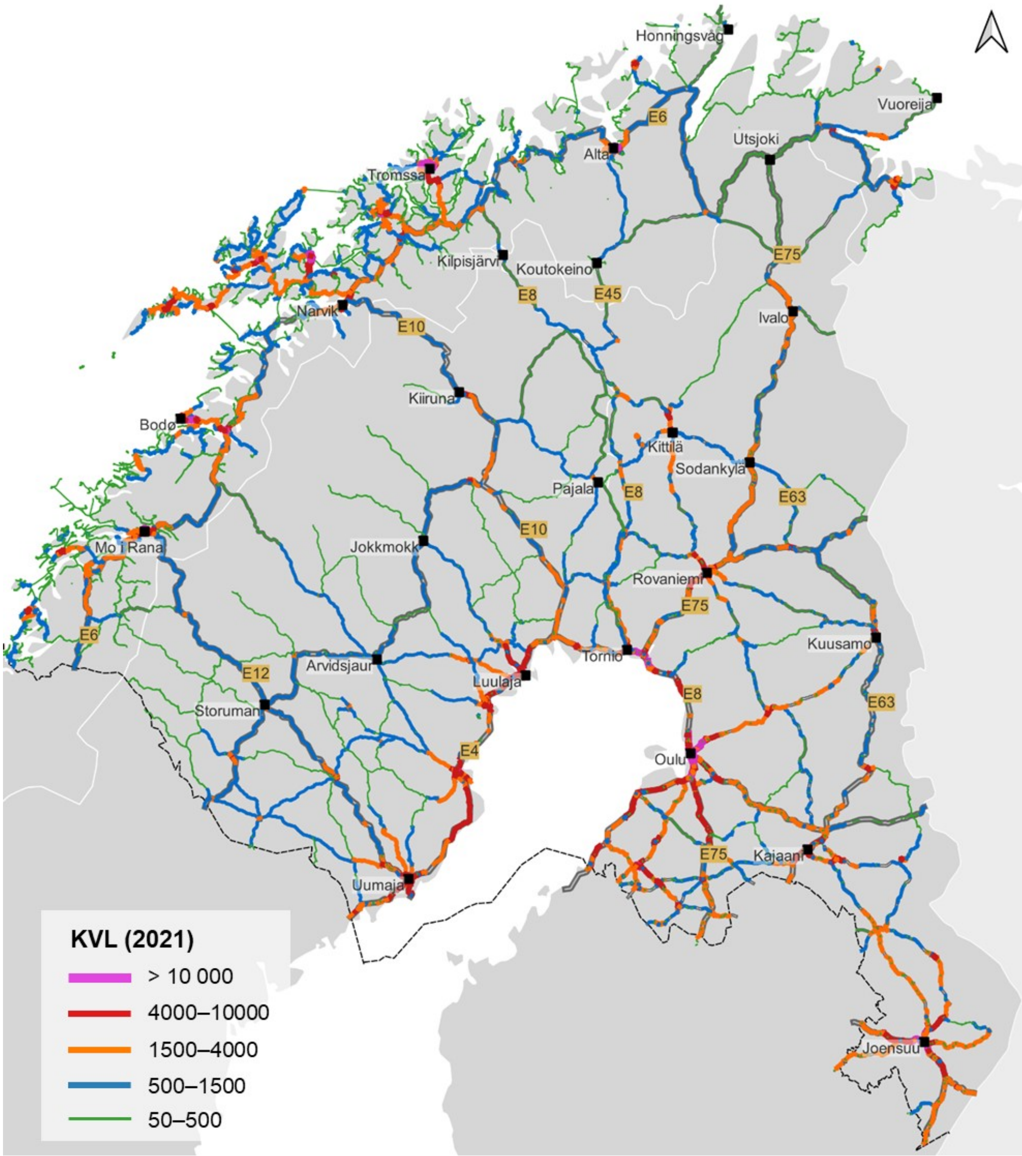

Figure 1. Average daily traffic (ADT 2021) in the Barents region.

The European-wide transport network (TEN-T) is only in Sweden and Finland for the core network. Highway 4 (E75) runs from Finland through Oulu and Tornio to Sweden to Luleå and Umeå (E4) continuing along the coast towards southern Sweden. In addition, in Sweden E10, which runs from Luleå towards Kiruna and the Norwegian border, is part of the TEN-T core network. TEN-T comprehensive network is in all countries, and it also connects the main road network of Finland and Norway to each other. After the preparation of this work, highway 21 from Tornio to Kilpisjärvi has also been connected to the TEN-T comprehensive network. In addition to the TEN-T network, there are other important main routes in the Barents regions, such as highway 6 from Joensuu to Kajaani and E95 from Skellefteå via Arvidsjaur towards the Norwegian border.

This study has focused on examining fast and high-power charging points. In the current situation, the public charging point network in the region has developed mainly near cities and along the main roads between them, where traffic volumes are also the highest in the region. The map in Figure 3 shows the fast and high-power charging stations in the region at the beginning of 2023. High-power charging stations (over 150 kW) are located near cities, municipal centers, and tourist destinations.

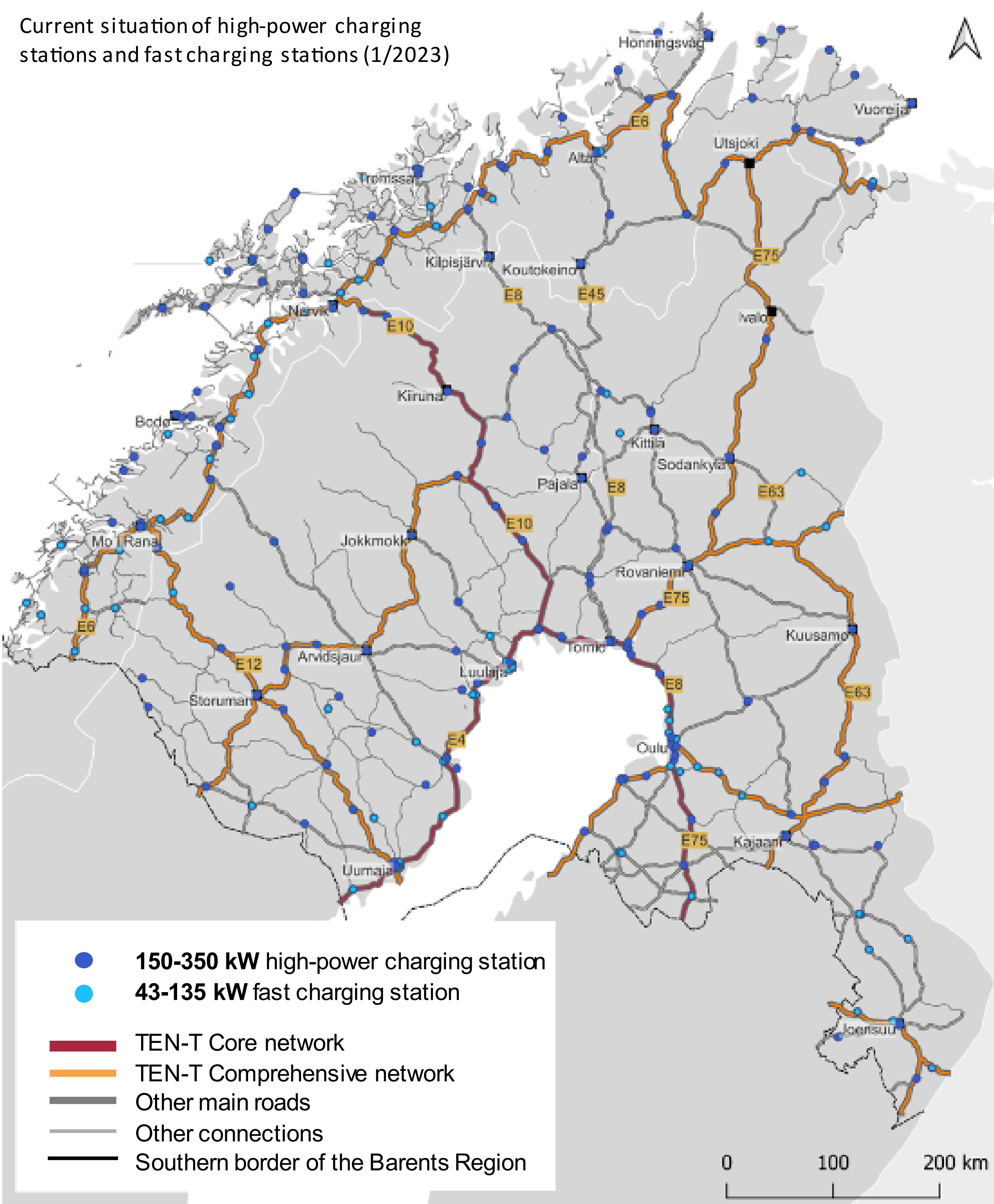

Figure 2. The main road network of the Barents region and the current fast and high-power charging stations (as of 01/2023). After the completion of the study, Highway 21 from Tornio to Kilpisjärvi has been added to the comprehensive TEN-T network and the number of fast charging stations has increased.

The network of fast and high-power charging points is complemented by smaller power public charging points that are left out of this study. These are typically 22 kW basic charging points, which are often at least two in the same location. The electric car's battery is fully charged from the basic charging point in about 1-2 hours depending on the car model. Basic charging points are often located in connection with parking spaces of grocery stores, hotels, municipal halls, or travel centers. These places are spent a little longer. Often, there are also lower-power charging points in connection with a fast or high-power charging point, which increase the charging point capacity. At the same time, they provide service reliability in situations where the fast or high-power charging point is faulty.

Coverage of the public charging point network in relation to the goals

The work carried out an examination of the coverage of high-power charging points on the main road network. The analyses were prepared separately for the TEN-T network and the rest of the road network, which covers the other main roads and the most important regional roads in the area. The examination took into account the obligations for the TEN-T road network according to the AFIR regulation proposal.

The coverage of the charging point network was assessed using spatial data methods with the distances (60 km and 100 km) from the current high-power charging points according to the AFIR draft regulation. The analysis took into account the mitigations provided by the draft regulation. For road sections where the vehicle traffic is less than 10,000 veh. /day, it is sufficient that the total power requirements comply with the requirements of one direction of travel. For road sections where the vehicle traffic is less than 4,000 veh. /day, it is sufficient that there are high-power charging pools at 100 km intervals. Almost the entire area has traffic volumes below 10,000 veh. /day, so the total power requirements can comply with the requirements of one direction of travel. A similar analysis has been prepared for the rest of the road network in the area with a target distance of 100 km.

The AFIR regulation has been approved by the European Union after the completion of the study, and the following changes have been made to the previously mentioned mitigations: the vehicle traffic limits have changed from 10,000 vehicles to 8,500 vehicles per day, and from 4,000 vehicles to 3,500 vehicles per day. Therefore, the analyses prepared in the study are indicative.

The results of the review are presented on the maps on the following pages. The map in Figure 4 shows the road sections where the requirements of the AFIR proposal were not met at the time of the study, and the map in Figure 5 shows the results of the review for the rest of the main road network. Based on the review, the requirements of the AFIR proposal are almost fully met on the TEN-T network in Norway. The only need identified based on the review was for one new high-power charging station and for increasing the power of three fast charging stations to over 150 kilowatts. In Sweden, a need for five new high-power charging stations and two charging station power upgrades was identified. In Finland, a need for nine new high-power charging stations and three charging station power upgrades was identified.

Table 2. Summary of the required number of new charging stations on the TEN-T network in the region.

The number of required charging stations in the region			
	Finland	**Sweden**	**Norway**
New ultra-rapid charging station	8	5	1
Current charging station power upgrade	3	2	3
Total (of which along TEN-T Core Network)	**11 (2)**	**7 (4)**	**4 (0)**

Based on the review, the deficiencies on roads outside the TEN-T network in Finland are significantly more extensive than in Sweden and Norway. In Norway, deficiencies are only on the smallest coastal roads, some of which have high-power charging stations, even though traffic volumes remain even below 500 vehicles per day. In Sweden, deficiencies are focused on smaller roads and the E95 road, where traffic volumes remain below 1,500 drives per day.

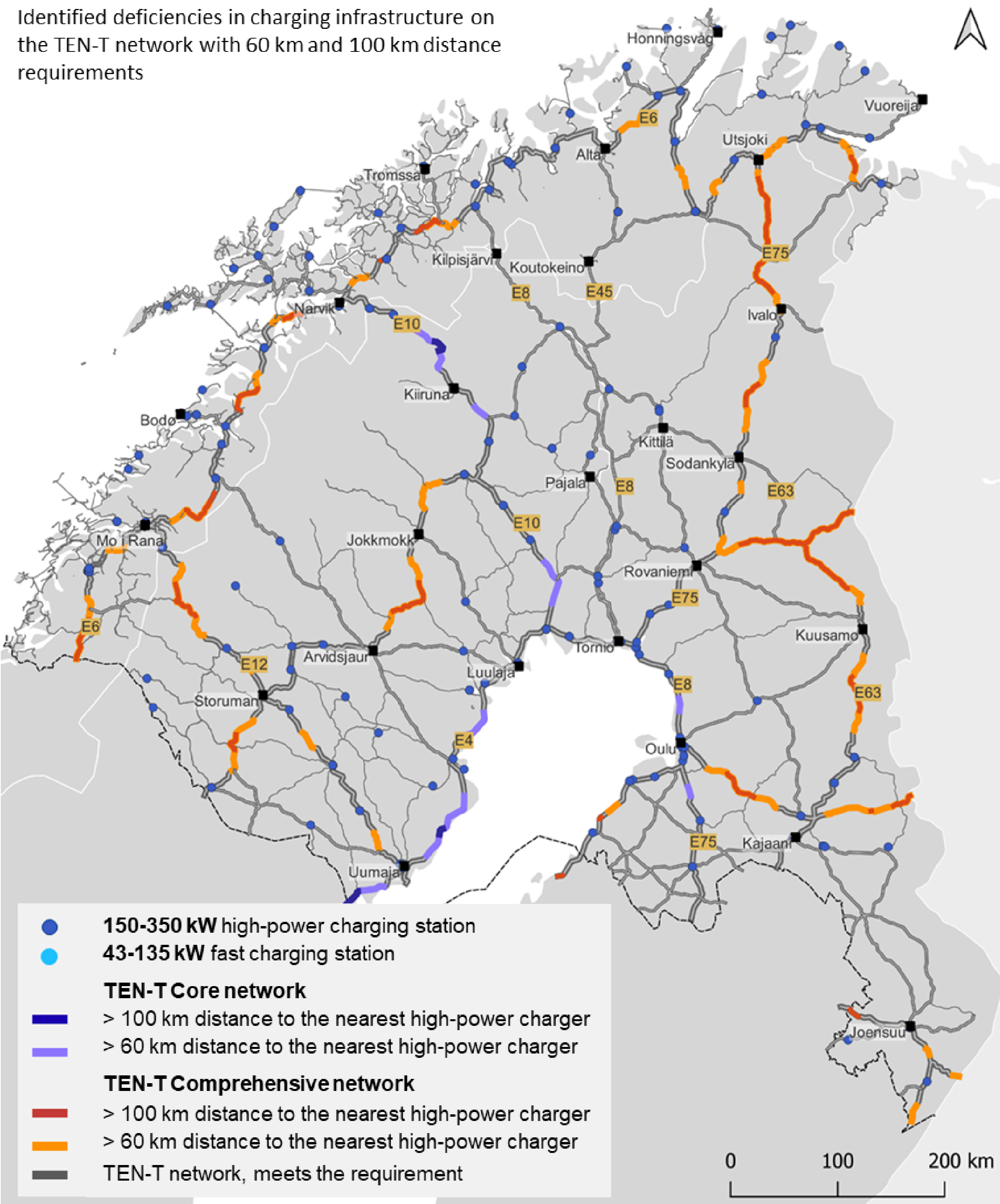

Figure 3. Fulfillment of the 60 km and 100 km distance requirements of the AFIR regulation proposal on the TEN-T road network (01/2023).

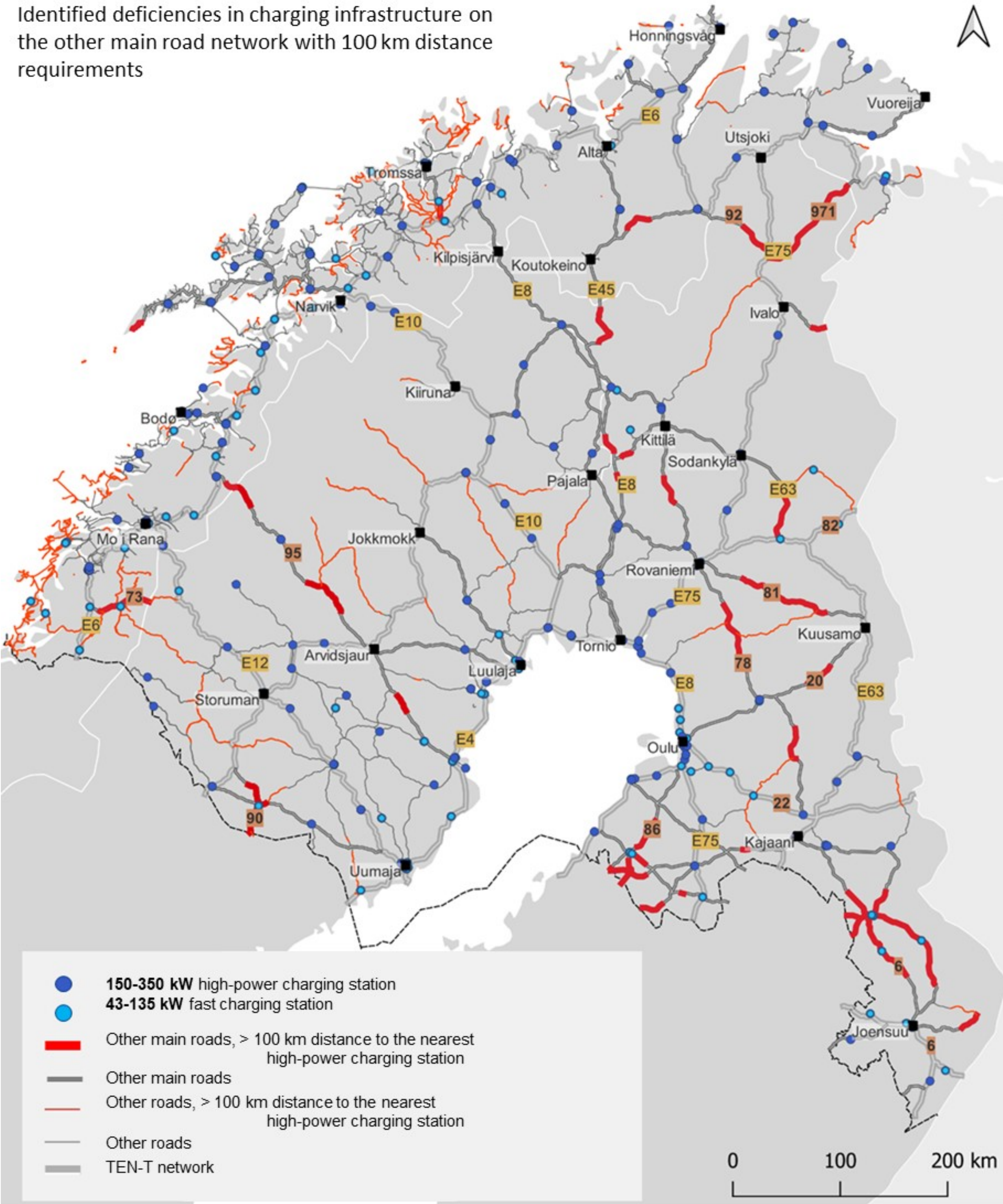

Figure 4. Shortcomings of high-power charging points in terms of the 100 km distance target on other road networks (01/2023).

Identified development needs in the coverage of the charging point network

Based on the results of the analysis, potential locations were defined for developing the coverage of the public charging point network in the near future. The analysis took into account the locations of existing urban areas, commercial services and tourist destinations. Likewise, the local needs that emerged during the expert interviews and interactive workshops carried out during the work were taken into account. The aim was to get an overall picture of the type of environment in which charging points should be able to be placed in the future, in order to enable smooth mobility by electric car. The proposed locations are indicative and based on expert assessments.

The identified potential locations for new charging points on the TEN-T network are shown in the map below (Figure 6). The requirements of the AFIR Regulation for the core network must be met by 2025. The core network deficiencies are greatest in Sweden, where a large part of the TEN-T core network in the study area is located. From a tourism perspective, the E10 road between Kiruna and Narvik, which belongs to the core network, has been identified as an important development target. For the TEN-T comprehensive network, the objectives should be achieved by 2030. Especially for Finland, new charging points have had to be proposed in areas where the built environment is scarce and traffic volumes are very low, such as Vuotso, Peranka and Iivantiira. In particular, locating a new charging point on the Inari - Utsjoki connection is challenging so that the AFIR Regulation's 100 km distance requirements are met. For cross-border tourist traffic, the important connections for the comprehensive network were the E12 road between Umeå and Mo i Rana in Norway and Sweden, and the highway 4 (E75) connection between Finland and Norway via Utsjoki. In particular, the inadequate charging point network on highway 4 between Finland and Norway makes it difficult for tourists to arrive from Norway to Saariselkä, for example.

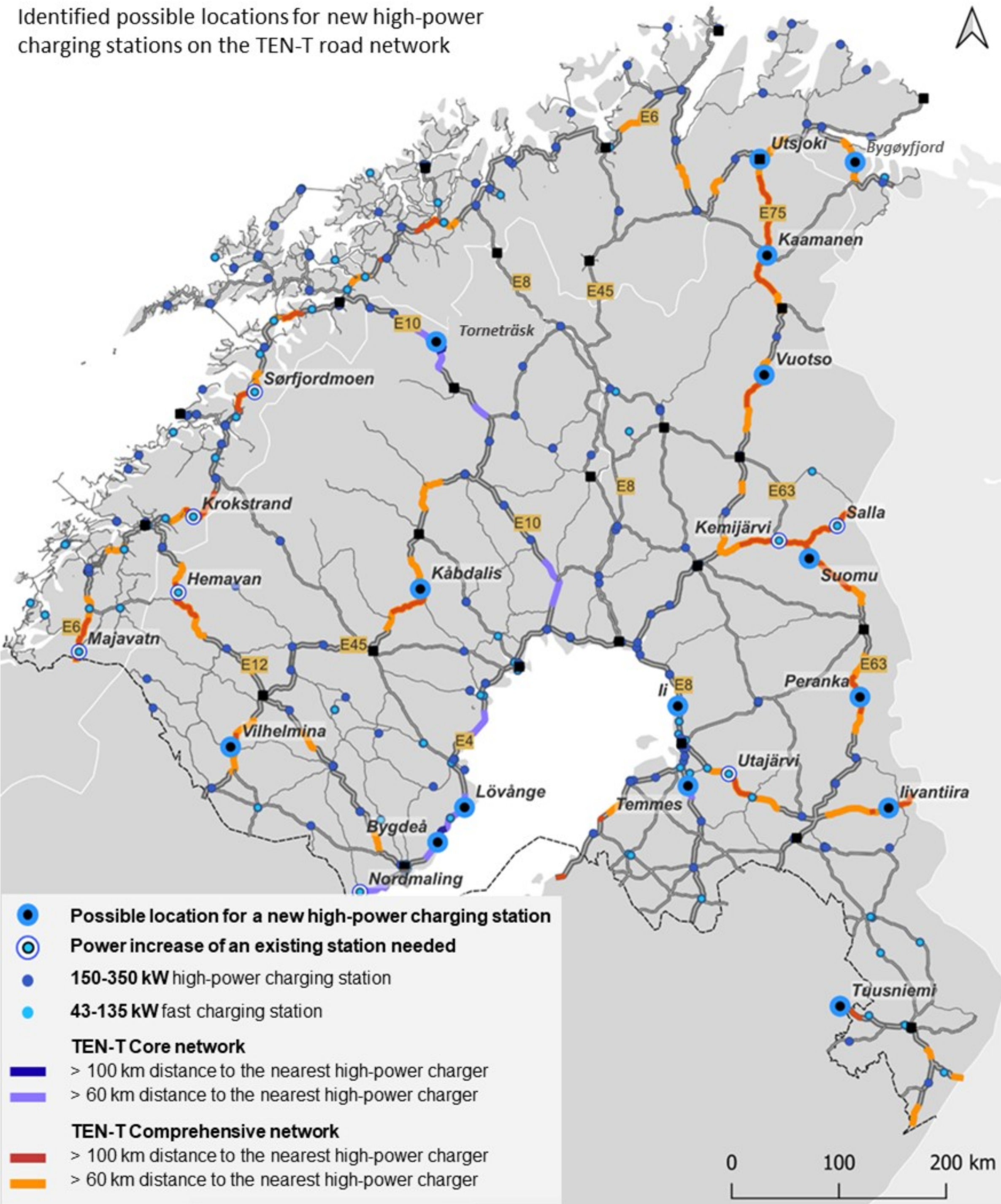

Figure 5. Identified potential locations for new high-power charging points on the TEN-T road network (01/2023).

Bottlenecks in the development of charging infrastructure

During the work, various challenges and bottlenecks were identified in the development of the charging point network. The information is based on interviews conducted during the work and discussions held in interactive workshops.

- **User potential:** Implementing charging infrastructure is challenging for road sections where traffic volumes are low and distances between urban areas are long. The potential number of users remains small, and it is difficult to make charging point operations profitable.
- **Importance of tourism:** Tourism is a significant industry throughout the area. Tourism is seasonal, and for this reason, there is a large seasonal variation in the area's traffic volumes. Tourism increases the user potential of charging points but also creates challenges for charging operations. Due to seasonal variation, it is difficult to find enough customers for part of the year, while during the busiest season, the same charging station may not be able to offer sufficient charging point capacity.
- **Operating costs:** The implementation of more efficient public charging points requires state support in almost the entire area. As the number of users is small, operating costs also rise high. High operating costs have even become an obstacle to the implementation of the charging point, even though investment support would have been available for the implementation of the device itself.
- **Power charges in electricity contracts:** One factor increasing operating costs is the power charge included in the electricity contract, which is determined, for example, by the highest consumed hourly power during the last 12 months. The power charge poses challenges especially at those charging points where usage varies seasonally according to the holiday and tourism season. In some cases, the avoidance of high-power charges caused by seasonal variation has led service providers to reduce the output power of charging points from what the charging point's capabilities would allow.
- **Allocation of public funding support:** In terms of the regional coverage of charging points, a bottleneck in Finland has been identified as the allocation of investment support along the TEN-T network in recent years. This is especially evident in the coverage of charging points in northern and eastern Finland, as the TEN-T network is sparse in these areas. In Sweden, applying for public funding support is considered cumbersome and the wish is to centralize the application of grants to one place and enable the application of support throughout the year.
- **Slowness of municipal permit practices:** One of the factors slowing down the process is the municipal permit practices and processing times. Municipalities may take up to 12–18 months to process permits. In this case, the charging point is likely to be left unimplemented, as there are usually restrictions on the use of public funding support and the payment of support is based on actual costs. For example, in Finland, the support granted must be used within 20 months of the support decision.
- **Paying for the charging service:** The provider of public charging usually charges for the service provided. The payment for the charging service cannot yet be made with a payment card, but the payment is made with the charging services' own RFID tags, web applications, QR codes or text message payments. Especially in cross-border traffic, paying for the charging service is becoming increasingly difficult, as the number of operators and applications also increases. So far, not all operators have wanted to offer roaming capability, and at the moment, roaming cooperation between the Nordic countries is weak. Downloading the necessary applications to one's own phone during a trip in the region can be difficult in certain areas due to the weak coverage of the mobile network.
- **Finding central locations for charging operations:** The placement of charging stations slows down the development of charging infrastructure and this requires cooperation with both municipalities and other landowners. At least in Sweden, one bottleneck has been finding locations for charging points from sufficiently central locations and with a sufficiently fast schedule.
- **Electricity network availability:** As we move towards implementing high-power charging stations, the availability of a sufficiently powerful electricity network has posed challenges. The delivery time for strengthening the electricity network can vary from a few months to even years, which can pose challenges with the rapid development goals of charging stations.

Conclusions and recommendations for the future

Based on the reviews, the public charging network for electric cars in the region is relatively comprehensive. The most deficiencies in the coverage of the charging network are in Finland, where the development of the electric car fleet has also been the slowest. In sparsely populated areas there are few alternative modes of transport for private cars. Thus, the development of alternative fuels and distribution networks is particularly important so that such areas can be involved in the green transition at all.

In the Barents region, the role of public high-power charging as part of the charging infrastructure is emphasized due to long distances. In principle, the distribution network should develop market-driven, but this may not be enough in the region. In Sweden and Norway, the challenge has been identified and investment support has been targeted more strongly to areas where the high-power charging network has not been created by the markets. In Finland too, it has been recognized that in sparsely trafficked areas there are probably no prerequisites for market-driven implementation, but so far public funding support has not been targeted regionally in the same way as in Sweden and Norway. Especially in Finland, the easternmost and northernmost parts of the main road network have poor prerequisites for the market-driven development of high-power charging due to low traffic volumes and long distances. Also, finding potential locations has been found to be challenging especially in the northernmost areas of Finland, which cover a wide range of forest and fell wildernesses, where there is hardly any existing infrastructure besides the road crossing the area.

In addition to identifying the shortcomings of the electric car charging network, development targets have been identified to promote the smooth movement of electric cars between the countries.

- **Role of municipalities and provinces in the region:** The own activity of municipal and provincial actors in identifying user needs, exchanging experiences, and allocating space for slower charging points is important. Public functions can also offer public use charging points. A good tool is to develop a strategy for the development of the electric car charging network, which also takes into account municipal, provincial, and cross-border traffic. From the perspective of operational reliability, it is also necessary to ensure that there are alternatives for charging stations in the same geographical areas.
- **Marketing:** Promoting the common visibility of the region by utilizing cross-border public charging infrastructure for electric cars in the region's marketing. Marketing the area as an electric car-friendly area and cooperating with the region's largest tourism operators.
- **Emergencies:** In the future, it should be examined whether measures and guidelines are needed for situations where the car battery is depleted in the northern region. Long distances and cold conditions pose risks to motorists, which need to be prepared for by the authorities.
- **Guidance:** Investigating the need for information offered along the roads and opportunities for improvement, for example in situations where the next charging station is over 100 kilometers away.
- **Accessibility:** Developing common standards or guidelines for the accessibility of charging points.
- **Collaboration models and exchange of experiences:** Sharing experiences of good practices and collaboration models in implementing charging points in low-traffic areas.
- **Monitoring:** Continuing to promote the work and monitor the development of the charging network in the Barents region's transport and logistics sector working group. Monitoring the development of public high-power charging, especially in areas of quiet traffic.
- **Payment systems**: Monitoring the development of payment systems. Cooperating between countries to facilitate and standardize the payment of the charging service, to facilitate smooth travel also on cross-border trips.

Gas and Hydrogen Study - Methane Gas and Hydrogen used as Fuels in Transportation in the Barents Region

The implementation and objective of the study

The objective of the study was to compile an up-to-date knowledge base on the production and distribution networks of natural gas, biogas and hydrogen used as fuels in transport in the Barents region, based on the analyses and studies already carried out and ongoing, as well as interviews. In addition to the interviews, a webinar workshop was held for the industry stakeholders. The study covers **methane gas** and **hydrogen gas**.

The study was prepared by the project team of Sitowise Oy, consisting of Pirkka Hartikainen (project manager), Katja Ojala and Marko Tikkanen. The study was carried out between November 2022 and April 2023.

The key findings and results of the study

Methane gas as a transport fuel

Methane gas can be either fossil natural gas or biomethane. Biomethane is gas produced by natural decomposition processes. Biogas can be produced by digesting almost any biological raw material except wood. In Finland, the raw materials used are mainly waste-based raw materials such as biowaste, wastewater, sludge, manure and organic by-products of industry. In Sweden, field crops are also used as raw materials. Raw biogas must be refined into biomethane suitable for transport use before it can be distributed at filling stations.

In terms of reducing emissions, it's crucial whether the gas used as a fuel in transport is biomethane or fossil natural gas. Biomethane is a 100% renewable transport fuel and thus a much cleaner fuel than natural gas. Biomethane should be preferred over fossil natural gas in transport. However, natural gas is the cleanest fossil fuel, obtained from natural gas and oil deposits. The emissions of a gas car are lower than those of a petrol car. The carbon dioxide emissions from the exhaust pipe of a gas car are about a quarter lower than those of a petrol car when running on natural gas, but there is no difference with diesel cars. Biomethane significantly reduces fossil carbon dioxide emissions, as its carbon is plant-based. Gas cars do not produce any particulate emissions.

Methane gas production in the region

Norway is one of the world's largest producers of natural gas. In 2021, Norway produced a total of about 119 billion cubic meters of natural gas. In the Barents region, natural gas is produced in Norway from the Snøhvit natural gas deposit. In Finland and Sweden, all methane gas production is biogas. Biogas is also produced in Norway. In 2021, biogas was produced for transport use as refined biomethane in Finland 156 GWh, in Sweden 1,508 GWh, and in Norway 282 GWh.

In the Barents region, biomethane suitable for transport fuel is produced in Finland in six plants, in Sweden in four plants, and in Norway in one plant. There is no information available on the production volumes of all plants, but it is known that plants producing large amounts of biomethane per year are at least the co-treatment plant in Oulu, the wastewater treatment plants located in Boden and Luleå in Sweden, and the co-digestion plant located in Skellefteå in Sweden. These plants are estimated to produce a total of about 5,800 gas passenger car consumption equivalent amount of biomethane per year.

New biogas production plants are planned in the Barents region in Finland to Tornio, Oulu (Laanila and Rusko), and Nurmes, and in Norway to Skibotn. With the production volumes of the new biogas production plants planned for the region, the share of biomethane in the energy consumption of the region's transport could be approximately doubled, making the share of biomethane about 1.7% of the region's total transport consumption. However, a more significant increase in the share of biomethane requires investments in large-scale biogas production.

Summary of transport energy consumption and demand for methane gas in road transport

Transport energy consumption includes the energy consumption of road transport, rail transport, domestic water transport, and air transport. Road transport makes up a large part of the total energy consumption of transport, but methane gas only makes up a small part of the energy consumption of road transport in Finland, Sweden, and Norway.

Table 3. Summary of the energy consumption of transport in Finland, Sweden, and Norway and its development.

	Finland (2021)	Sweden (2020)	Norway (2021)
Total energy consumption in transport	47 500 GWh	82 000 GWh	53 800 GWh
Total energy consumption in road transport	44 000 GWh	74 000 GWh	39 000 GWh
Share of gas	251 GWh (0.57 %)	1 000 GWh (approx. 1–2 %)	343 GWh (0.9 %)
Share of natural gas	110 GWh (0.25 %)	-	5 GWh
Share of biogas	141 GWh (0.32 %)	Most of the consumed gas	338 GWh
Direction of development in road transport energy consumption	Slightly increased in recent years	Slightly decreased in recent years	Remained the same The share of biomethane has increased

Sources: Tilastokeskus, Energimyndigheten & Statistisk sentralbyrå

The study assessed the order of magnitude estimates of the shares of different energy sources in the transport energy consumption in the region by relating the total energy consumption of transport (road and rail transport, domestic water and air transport) in Finland, Sweden and Norway to the population of the Barents region and the whole of Finland, Sweden and Norway (Figure 7). In the Barents region, the share of natural gas in the total transport energy consumption is estimated to be about 0.7% and the share of biogas about 0.9%. (The sources of the population figures used in the estimate are Statistisk sentralbyrå, Statistikmyndigheten and Tilastokeskus))

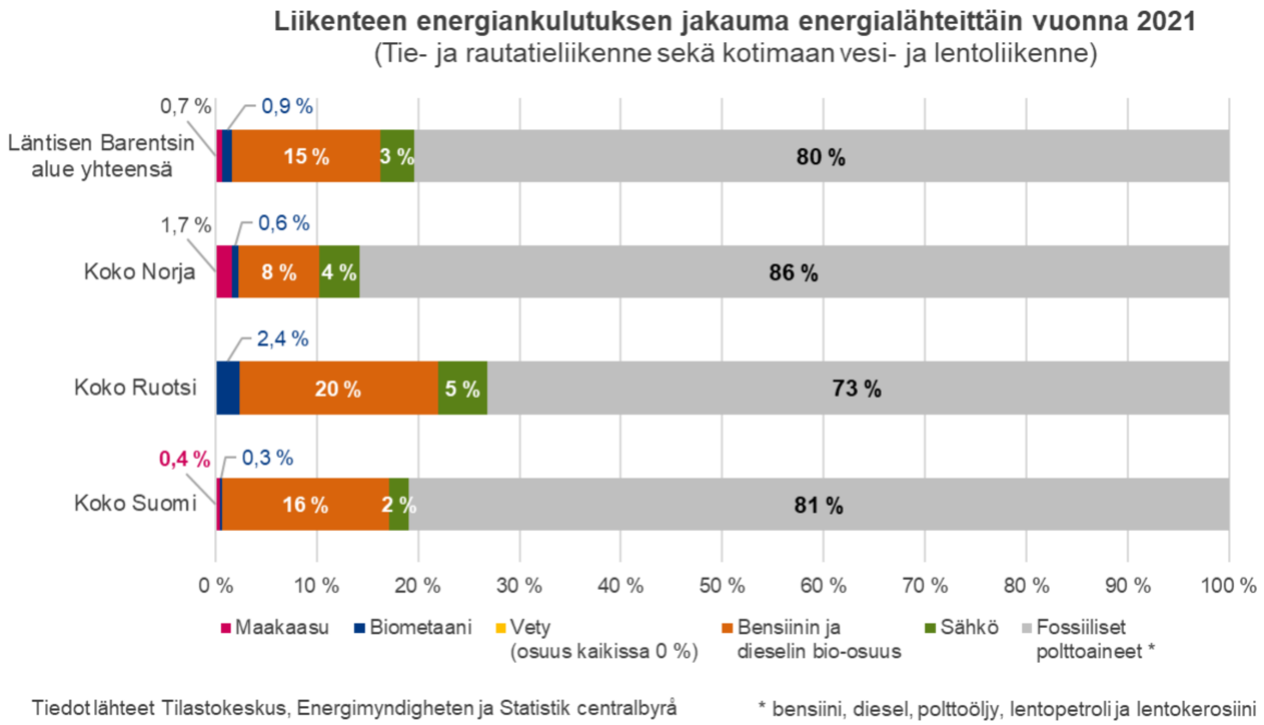

Figure 6. Distribution of transport energy consumption by energy source in the Barents region, Norway, Sweden and Finland in 2021. The statistics include road and rail traffic as well as domestic water and air traffic. The meanings of the colours from left to right are: Natural gas, Biogas, Hydrogen, Bio share of gasoline and diesel, Electricity, and Fossil fuels.

Network of methane gas refuelling stations in the region

The usability of gas cars in the region is currently hampered by a sparse refueling station network. The network is shown in more detail in Figure 8. Compressed gas (CNG/CBG) cars have only 15 refueling stations in the region, of which the northernmost is located in Boden, Sweden, at the height of the Gulf of Bothnia. Liquefied gas (LNG/LBG) can be refueled from three stations, located in Oulu, as well as Luleå and Umeå in Sweden. Adding gas refueling stations comprehensively throughout the region is a prerequisite for the proliferation of gas cars and would enable travel from the south to the region's tourist destinations by gas cars as well.

In the region, a significant portion of goods are transported by trucks. With the power transition in heavy road traffic, the area has become of interest to companies distributing gas. New gas refueling stations have just been completed or are planned in the region in Finland to Keminmaa, Kitee, Rovaniemi, Nurmes, and Tornio. In addition, the goal is to open gas refueling stations elsewhere in the region over the next five years. Possible locations for new gas refueling stations are in Finland Kajaani, Kemijärvi, Kuusamo and in Sweden Kiruna. In Norway, new biogas refueling stations are planned to Alta, Bjervik, and Tromsø. In addition, the construction of gas refueling stations elsewhere in Northern Norway is being considered, where the refueling stations could serve, for example, the truck transports of the Northern Norwegian salmon industry. Liquefied gas refueling stations for heavy traffic can also be equipped with refueling connectors for vehicles using compressed gas, so the refueling stations could also be used by passenger cars and vans. As liquefied gas warms up at refueling stations, boil off gas is always produced, which should be distributed to vehicles using compressed gas.

Figure 7. Current and planned gas refuelling stations in the Barents region (2022). Blue ones refer to the current stations, green ones refer to stations of which the implementation has been confirmed. The brown ones refer to planned stations. In addition to the locations shown in the picture, the construction of refueling stations is also planned elsewhere in Northern Norway.

Gas car fleet in the region

In the Barents region, as well as elsewhere in Finland, Sweden and Norway, the share of gas passenger and gas vans in the passenger and van fleet is only 0-3%. In the vehicle fleet forecasts, the share of gas passenger and gas vans is not expected to increase significantly in the coming decades. In the carbon dioxide emission limits set by the European Union for passenger cars, gas passenger cars are treated in the same way as other combustion engine cars and do not take into account whether the fuel is natural gas or biomethane. Car manufacturers' interest in producing gas passenger cars has waned. At the moment, they are produced only by the Volkswagen Group, which has already announced that it will stop developing gas passenger cars. In addition, the European Union's decision on the emission-free status of cars sold in practice prohibits the sale of combustion engine passenger cars in the European Union from 2035 onwards, excluding cars using synthetic fossil-free electricity-produced electric fuel as fuel. In the light of current developments, gas does not seem to become popular as a fuel for passenger and vans at least in the near future. In the future, the use of gas in transport will depend on what the European Union decides on the emission limits for heavy transport.

Gas is a much more important alternative fuel for heavy vehicles both now and in the future. Liquefied gas is especially a potential alternative fuel for long-distance transport trucks and buses. The share of gas buses in the bus fleet is about 20% in Sweden and less than one percent in Finland and Norway. In Finland, there are about 60 gas buses, and the number is expected to triple by 2030 to about 200 buses, when the share of the entire bus fleet would be 6-7%. In Sweden, the number of gas buses is estimated to grow slowly from the current about 2,800 buses and the number is not expected to be much higher than the current number in 2030. In Norway, the number of gas buses is expected to increase almost sixfold from about 770 buses to about 4,300 buses by 2030, when the share of gas buses in the entire bus fleet would be about 26%.

The share of gas trucks in the truck fleet is less than 2% in Sweden and less than one percent in Finland and Norway. In Finland, there are about 460 gas trucks, and the number is expected to more than double by 2030 to almost 1,300 trucks, when the share of the entire truck fleet would be about 4%. In Sweden, the number of gas trucks is estimated to increase about fivefold from about 1,400 trucks to less than 7,000 trucks in 2030. In Norway, the number of gas trucks is expected to halve from less than 600 trucks to a maximum of about 300 trucks in 2030. There are a total of about 80 gas trucks registered in the Barents region, of which there are about 40 in Finland, about 40 in Sweden and none in Norway.

Table 4. Number of gas cars by country and in the Barents region.

Number of gas cars (number by country in the Barents region in parentheses)				
	Finland (status 09/2022)	**Sweden (status 12/2021)**	**Norway (status 12/2021)**	**Barents region total**
Gas passenger cars	17 200 (900)	52 600 (1 090)	2 000 (a few)	**approx. 2 000**
Gas buses	60 (3)	2 800 (65)	770 (0)	**approx. 70**
Gas trucks	460 (40)	1 400 (40)	600 (0)	**approx. 80**

Sources of table data: Traficom, Trafikanalys ja Statistisk sentralbyrå.

Hydrogen gas as a transport fuel

Hydrogen and its derivatives are expected to play an important role in reducing carbon dioxide emissions in sectors where emissions are difficult to reduce, and alternative solutions are either not available or difficult to implement. Such sectors include heavy industry, maritime, aviation and heavy transport. Low-emission hydrogen and low-emission hydrogen-based fuels are important for reducing carbon dioxide emissions from heavy industry and long-distance freight transport, where other clean energy alternatives, such as direct electrification, pose technical challenges or cannot be implemented. Converting hydrogen to electricity in a fuel cell does not produce any harmful emissions at all and hydrogen fuel cell vehicles are considered zero-emission vehicles during driving, just like battery electric vehicles. The emissions of a hydrogen car during driving are only water vapor.

It is essential for emission reduction how hydrogen is produced. The hydrogen used as a transport fuel should be green hydrogen, which is produced by splitting water into hydrogen and oxygen by electrolysis with renewable electricity instead of producing hydrogen from natural gas by steam reforming. The Barents region has good opportunities to produce the electricity needed for electrolysis, for example, by land or sea wind power in the Gulf of Bothnia area.

According to a report published by the International Energy Agency IEA in 2019, a very small part of the total demand for clean hydrogen was used in transport (IEA, 2019). In Finland, Sweden and Norway, the share of hydrogen in the fuels consumed by road transport is so small that it is not statistically recorded. The use of hydrogen as a transport fuel is still in its infancy, but the demand for hydrogen is expected to increase significantly in the coming decades. According to the basic forecast of the European Union, transport would have the largest share of the demand growth, and in 2050 transport would account for about 206 terawatt hours or about 26% of the total hydrogen energy demand. (European Commission, 2020)

Hydrogen car fleet in the region

At present, only a few car manufacturers produce hydrogen cars, and the supply of hydrogen car models is clearly narrower than the supply of combustion engine car models, both in passenger and vans and in heavy vehicles. In Finland, Sweden and Norway, there are a total of about 250 hydrogen cars, almost all of which are passenger cars:

- **Norway:** 200 hydrogen cars (12/2021)
- **Sweden:** 44 hydrogen cars (12/2021)
- **Finland:** 2 hydrogen cars (10/2022)

In Finland and Sweden, hydrogen cars are not expected to become more common in the current decade. In Norway, there are two car fleet forecasts, according to which there would be either about 600 or 5,000 hydrogen passenger cars in the Norwegian car fleet in 2030. According to both forecasts, there would be about 10 hydrogen buses in the Norwegian car fleet in 2030. Hydrogen trucks in the Norwegian car fleet are expected to be in 2030 according to one forecast about twenty, and according to another forecast almost 8000. According to the latter forecast, the growth of the number of hydrogen trucks would also continue strongly in Norway after 2030. Hydrogen vans are not expected to become more common in Norway in the current decade.

Hydrogen production in the region

Although there are no companies producing hydrogen for use as a fuel in transport in the Barents region, there are several ongoing hydrogen-related projects. A joint stakeholder network of actors located around the Gulf of Bothnia will accelerate the region's hydrogen industry with the hydrogen valley project. In the joint Finnish and Swedish Gulf of Bothnia hydrogen gas transmission network project, a pipeline network with investment costs of about 3.5 billion euros will be built by 2030 for the transmission of hydrogen. Both projects will also accelerate the proliferation of companies producing for transport use in the region. Transport-related hydrogen projects in the region include at least Norway's zero-emission hydrogen ferry project.

Hydrogen is produced in all countries mainly for industrial needs. In the Barents region, there was hydrogen production only in Finland in three locations in 2020, of which Eastman's and Nouryon's production plants are located in Northern Ostrobothnia in Oulu and Terrafame's production plant in Kainuu in Sotkamo. The table below shows a summary of hydrogen production by country in 2020.

Table 5. Hydrogen production by country in 2020.

	Suomi	Ruotsi	Norja
Hydrogen production	145 000 tonnes / year	180 000 tonnes / year	225 000 tonnes / year
Production plants	16 pcs	12 pcs	No information
Production plants in the Barents region	3 pcs	-	-

Sources of table data: Statistics Finland (Tilastokeskus), Government of Finland, Fossilfritt Sverige and DNV GL.

Hydrogen refuelling station network in the region

In addition to the narrow or completely missing selection of car models, the spread of hydrogen cars is especially hampered by the almost completely missing hydrogen car refueling stations from the Barents region. There was only one hydrogen car refueling station in the region at the time of the survey, in Umeå, Sweden. In Finland, there are no hydrogen car refueling stations in the whole country, and in Sweden and Norway there were five refueling stations at the time of the survey. There are no refueling stations for hydrogen-powered ships, trains and airplanes in Finland, Sweden or Norway.

In order for the use of hydrogen as a transport fuel to be possible in the Barents region, a comprehensive hydrogen refueling network should be built throughout Finland, Sweden and Norway. The hydrogen refueling station network is implemented fastest with the support of the states and by several refueling station operators. Hydrogen storage and transportation over longer distances is technically challenging. Hydrogen should not be transported by truck over 150 kilometers. Small-molecule and easily volatile hydrogen should be transported over longer distances in high-pressure pipelines or, for example, bound to ammonia and separate hydrogen from ammonia at the point of use. Hydrogen can also be produced at refueling stations by electrolysis and stored at refueling stations, eliminating the need to transport hydrogen at all. Hydrogen production locally at refueling stations is particularly suitable for the northern parts of the Barents region, where the distances are long.

Hydrogen distribution in the region is of interest to hydrogen distribution companies due to the power transition in heavy road transport. New hydrogen car refueling stations are under construction in Luleå, Sweden, and planned for the coming years at least in:

- Finland: Liminka, Kalajoki/Ylivieska region, Tornio region, Oulu region, Sodankylä and Inari
- Sweden: Arvidsjaur, Piteå, Storuman and Umeå
- Norway: Bodø region, Gamvik, Mo I Rana region, Narvik and Nordreisa

In addition, hydrogen refueling stations are being built and planned also elsewhere in the Nordic countries. Hydrogen refueling stations for heavy road transport can also be implemented so that passenger cars and vans could also use the refueling stations.

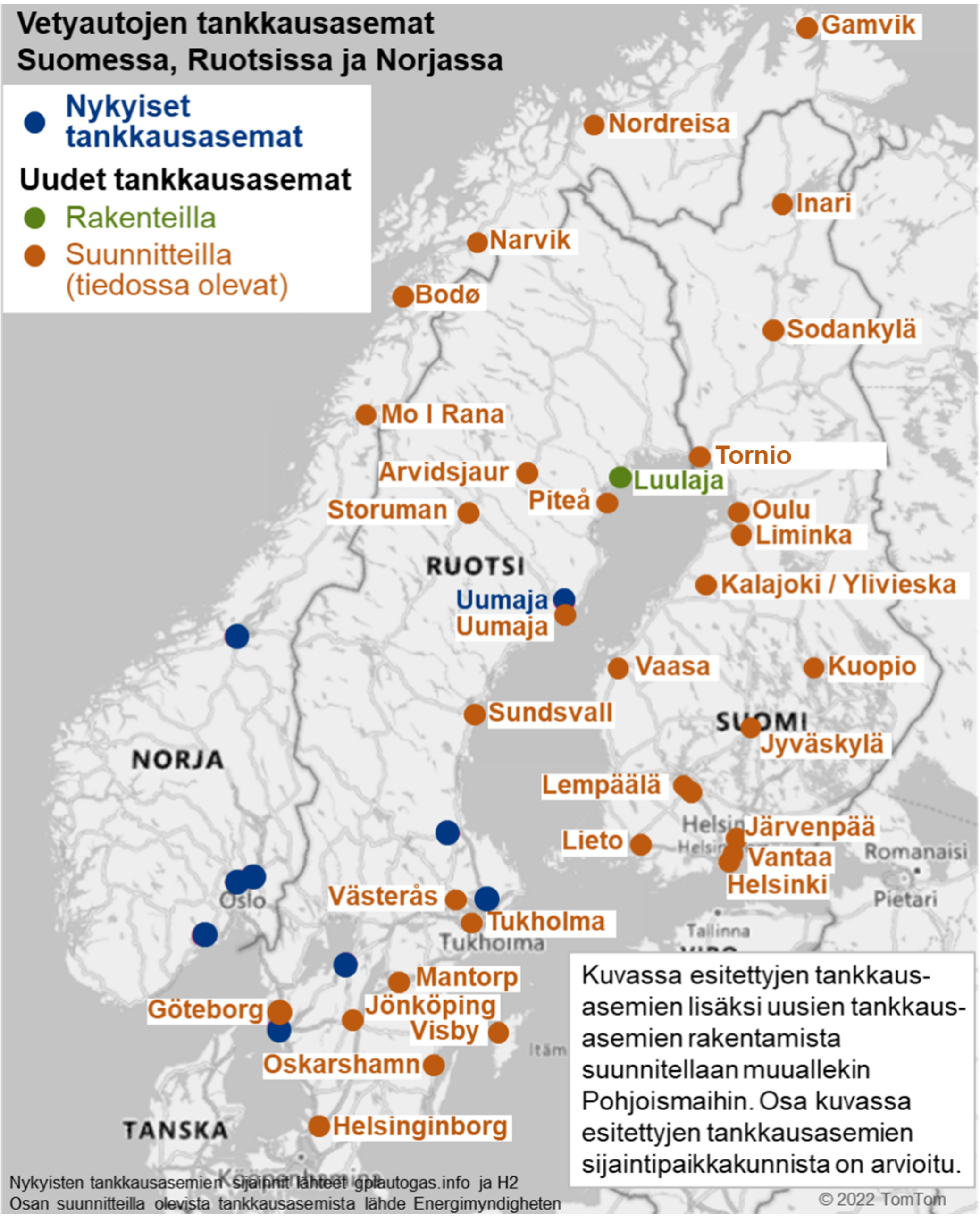

Figure 8. Current hydrogen car refuelling stations (blue), stations under construction (green) and planned hydrogen car refuelling stations in Finland, Sweden and Norway. In addition to the locations shown in the picture, the construction of new hydrogen refueling stations is also being planned elsewhere in the Nordic countries.

Methane gas and hydrogen in water transport

Liquefied gas (LNG) is a potential alternative fuel for ships, which can achieve significant reductions in ship emissions. Almost all new ships can use liquefied gas as a fuel in addition to marine diesel. In Finland, Sweden and Norway, all of the liquefied gas used in maritime transport is still fossil natural gas. Liquefied biomethane has only been tested on ships in test runs in Norway. Gas consumption on ships is high compared to cars and liquefied biomethane production is not sufficient for ship use on a large scale. The use of liquefied biomethane (LBG) as a ship fuel is hampered by the adequate availability and price of biomethane. Maritime transport has not been subject to any economic steering measures that would make it worthwhile to use liquefied biomethane as a ship fuel. In Norway, maritime transport is subject to an obligation, according to which 2% of the fuel used by maritime transport must be biomethane. In order for liquefied biomethane to become more common as a ship fuel, public authority guidance and support measures and increased biomethane production would be required.

Ship bunkering with natural gas is already possible in at least ten ports in the Barents region (Figure 10). In Finland, the share of liquefied natural gas (LNG) in domestic water transport energy consumption is about 5%, in Sweden the share of foreign maritime transport and domestic water transport energy consumption is at most about 3% and in Norway the share of foreign maritime transport and domestic water transport energy consumption is about 10%.

In Finland, Sweden and Norway, hydrogen is not consumed in water transport at all, or its amount is so small that it is not statistically recorded. There are no refueling stations for hydrogen-powered ships, trains and airplanes in Finland, Sweden or Norway.

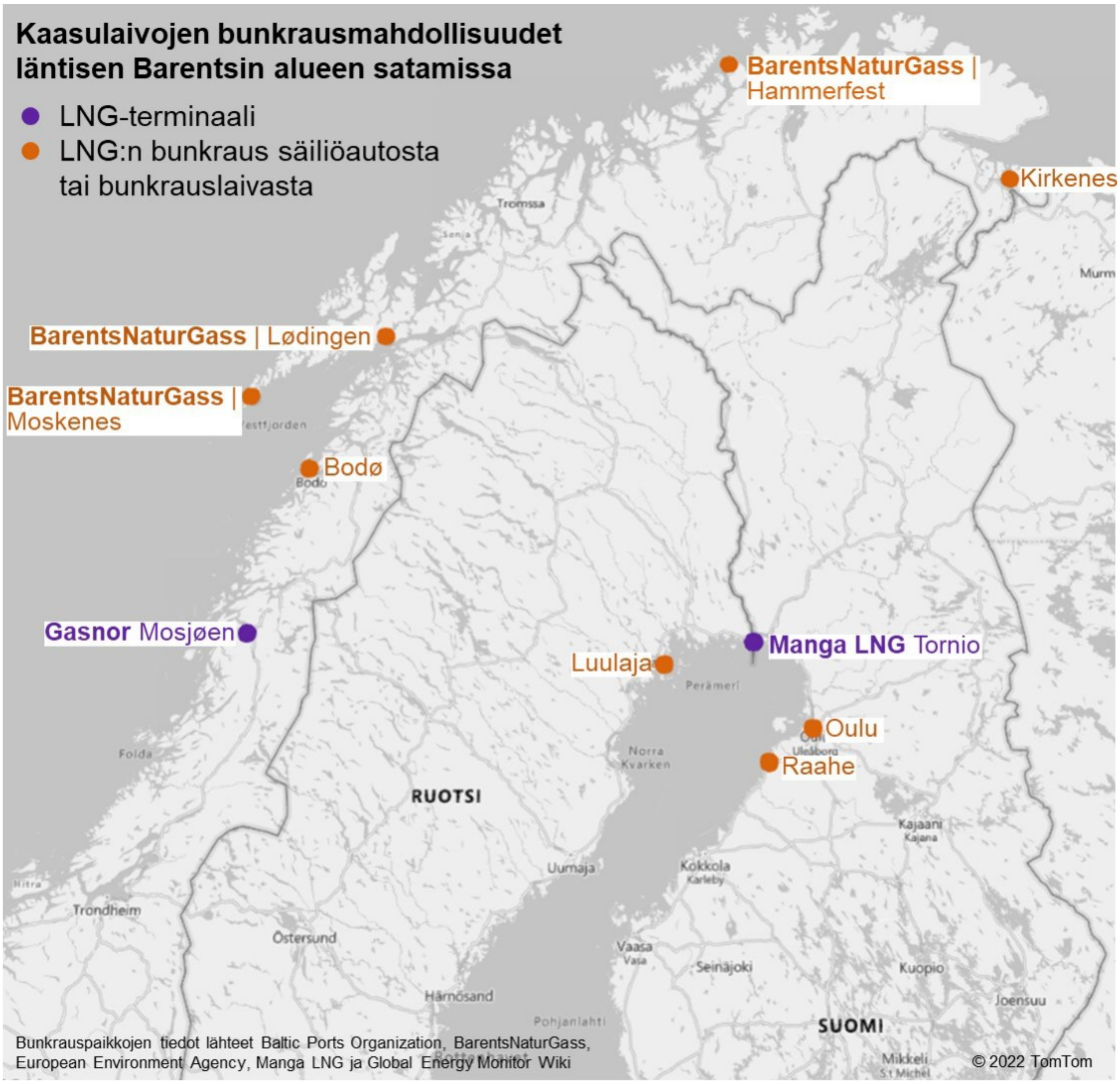

Figure 9. Bunkering possibilities for gas ships in ports in the Barents region. Locations marked in blue represent LNG terminals and Brown points represent LNG bunkering from a tanker truck or bunkering ship.

Methane gas and hydrogen in rail transport

The rail networks are electrified in the Barents region except for some sections. There are currently no gas or hydrogen powered locomotives in the region. In all countries, studies have been or are being prepared on replacing diesel locomotives used on non-electrified sections with locomotives using alternative power sources (electricity, battery electric, hybrid and hydrogen). According to a study by the Finnish Transport Agency (2018), a gas locomotive can be economically competitive in Finland in the future. Hydrogen train feasibility studies are being conducted in Sweden and Norway. There are no hydrogen refueling stations for trains in Finland, Sweden, or Norway.

Preliminary Study on Alternative Fuels for Heavy Traffic and Working Machinery in the Barents Region

The implementation and objective of the study

The objective of the study was to examine the use, availability, and future possibilities and constraints of alternative fuels in heavy-duty transport and machinery in the Barents region of Finland, Sweden, and Norway. The alternative fuels examined in the study are biogas (compressed and liquefied biogas), renewable diesel (HVO), ethanol diesel, hydrogen, electricity, and natural gas (compressed and liquefied natural gas). The current use and future potential of alternative fuels are examined from the perspective of different industrial sectors. These include mining, forestry, ports, transport logistics, road construction and maintenance, and public transport. The original study was prepared in English.

The study was prepared by conducting a survey that was distributed to the key stakeholders of the industrial sectors examined in the work in Finland, Sweden, and Norway. The survey was answered by 21 parties. In addition, a total of 11 thematic interviews were conducted to deepen the views obtained by the online survey. The study examined, for each country, the national and regional strategies and roadmaps for alternative fuels, the roadmaps for carbon neutrality of heavy-duty transport and machinery, the legislation regulating the use of alternative fuels, and the statistics on the current use of alternative fuels and energy/fuel use in heavy-duty transport and machinery in general.

The study was prepared by Ramboll Finland, where the working group consisted of Jukka Korri, Jaakko Takala, and Mira Helve. In addition, Emma Fält (Ramboll Sweden) and Erik Vaet (Ramboll Norway) participated in the work.

The key findings and results of the study

Finland

Alternative fuels in heavy-duty vehicles and work machines in the current situation

At the end of 2022, there were a total of 14,827 trucks, 1,714 buses and 58,360 vans registered in the Barents region in Finland. In 2022, 98.0% of trucks, 99.5% of buses and 98.1% of vans were diesel-powered. The share of heavy-duty vehicles powered by other fuels is still very small in the region in the current situation.

According to previous studies, organizations operating heavy vehicles and work machines in Finland have experience of alternative fuels mainly from liquid biofuels and especially HVO (Hydrotreated Vegetable Oil) diesel. No user experiences of electric work machines have been reported in previous studies. However, it has been estimated that the number of electric machines will increase in the future, especially in small machines. On the other hand, it has also been estimated that the supply of electric work machines on the market will not be sufficient in the near future. (Finnish Transport Infrastructure Agency, 2021).

Based on the survey and interviews carried out in the study, the use of alternative fuels is still very low in the Barents region in Finland in heavy-duty vehicles and work machines. The share of alternative fuels in the total fuel consumption of the organizations examined in the study was relatively low, usually 0-10% of total consumption. HVO diesel was the most common alternative fuel used in heavy-duty vehicles. No operators using hydrogen as a fuel were identified or found in the Barents region of Finland. The most common reason for using alternative fuels in the survey was to achieve the organization's environmental goals. On the other hand, the interviewees also emphasized that the use of alternative fuels depends a lot on the requirements set by the customer.

Availability of alternative fuels

The spread of alternative fuels in heavy transport and work machines is hindered by long distances and the availability of alternative fuels in the Barents region. The production and distribution of alternative fuels has developed market-driven where there is most demand for them. For example, public charging points for electric vehicles have not been distributed geographically evenly in Finland, but most of the charging infrastructure has been built in cities where there is most traffic. For example, about half of the charging infrastructure for electric buses is in the Helsinki region and about half in Turku, Tampere, Jyväskylä, Kuopio, Lahti, Savonlinna, Joensuu and Oulu.

The distribution network for biodiesel and bioethanol has also been implemented according to market conditions, and the distribution network does not cover the eastern and northern parts of Finland. In Lapland, the availability of biodiesel and bioethanol is limited to Rovaniemi, and in Kainuu to Kajaani (Ministry of Transport and Communications, 2020). The availability of HVO diesel is good only in the largest cities in Finland, and there is no distribution to Northern Finland yet. As for gaseous fuels, there is only one LNG terminal in Tornio in the Finnish Barents region, and seven CNG/CBG distribution points suitable for trucks. The northernmost distribution point is located in Oulu. Oulu also has the only LNG/LBG distribution point suitable for trucks in the Finnish Barents region. There are no alternative fuels available for inland waterway transport in Finland alongside fossil fuels. At the moment, shore power is not available for vessels in Finnish inland ports due to economic viability.

Based on the responses to the survey conducted in the study, HVO diesel was considered to have the best availability from the perspective of heavy transport and work machines in the Barents region of Finland. Especially respondents working in ports, road construction and road maintenance felt that the availability of HVO diesel is good from the perspective of their own organization. However, the responses highlighted that if customers start to require the use of biofuels more than currently, the demand for HVO diesel will quickly exceed production volumes. The availability of raw materials limits the production of HVO diesel.

Opportunities and challenges for the spread of alternative fuels in heavy transport and work machines

Previous studies have estimated that diesel will still be used in heavy transport in Finland at least until the 2020s and in buses until 2050. In lighter transport (less than 3.5 tons), electric and hybrid options are expected to become more common faster. Due to the distribution obligation law, the share of renewable fuels will increase until 2030. The bio-share of diesel is estimated to be 43.3% in 2029 and the ethanol blending ratio of gasoline is assumed to be 6.84% after 2029 (Vasara, Lehtinen & Laukkanen, 2020).

In the survey and interviews conducted in the study, representatives of organizations showed clear interest in increasing the use of alternative fuels, especially HVO diesel, biogas and electricity, but in practice their wider adoption is prevented by the costs of fossil-free fuels and the lack of suitable work machines or vehicles. In addition, according to previous studies, the heavy transport industries would already be ready to use especially fossil-free diesel more, if the customers of transport and the producers of biofuels would participate in solving the availability and cost issues (Vasara, Lehtinen & Laukkanen, 2020).

The goal is that all new construction sites could be implemented fossil-free from 2030 onwards, when the permitted fuels for work machines and vehicles would be electricity, biogas, hydrogen and liquid biofuels. There are no obstacles to the use of biofuels in work machines nowadays, and in almost all categories there are machines for which the manufacturer has officially approved the use of biofuels. The problem with alternative fuels is perceived to be their economic unprofitability. In the interviews, a strong view emerged that the use of alternative fuels depends mainly on the customer’s interest. If the customer requires the use of fossil-free fuels and is willing to pay the additional costs incurred, it is easy for the contractor to choose HVO diesel instead of regular diesel. Otherwise, the use of fossil-free fuels is usually not an option due to their higher price. In addition, HVO diesel except for the availability of all alternative fuels was considered poor in the Barents region of Finland.

The market for electric work machines is expected to develop significantly from the current situation, where electric work machines are available in a limited way. The electrification of heavy vehicles or work machines is hampered in particular by the unsuitability of technical solutions and the challenges related to charging. In addition, the availability of work machines and heavy vehicles using alternative fuels is also poor, and delivery times are long.

The electrification of logistics transport for heavy traffic requires a set of measures that create an initial boost for the electrification of heavy traffic. In addition to the acquisition support for electric vehicles, the charging infrastructure serving heavy traffic also needs a significant support input at the beginning. (Technology Industries, 2022). The mining industry is seen to have significant potential for the widespread use of electric work machines. By electrifying work machines, emissions could be reduced, as well as the need for ventilation in mines. In the forest industry, electrification of work machines could also reduce emissions in logging, and the development of electric work machines suitable for forestry has already started in Finland. The mining and forestry sectors and road transport logistics operators reached by the study found electric vehicles and work machines interesting, but the characteristics of the available vehicles did not yet meet the needs and safety requirements of the operators. In addition, the lack of or non-existent charging possibilities for machines and transport vehicles was considered a problem. Electric work machines were seen in the survey as potential solutions especially in tasks where vehicles and work machines are smaller and lighter, and they operate in a small area, such as ports or factory areas, where their charging could also be carried out in the same location.

The companies reached by the study considered the introduction of hydrogen-powered vehicles and work machines in their own organization to be a very distant idea. The prerequisite for the spread of hydrogen in heavy traffic is that investments are also made in the distribution infrastructure in locations where there is less traffic.

Sweden

Alternative fuels in heavy-duty vehicles and work machines in the current situation

Sweden is in a leading position globally in the use of biofuels. The share of renewable energy sources in all energy used in the transport sector in 2018 was 29.7%. Most of the biofuels are used blended with other diesel and gasoline fuels.

About 5% of the buses registered in the Barents region of Sweden are electric and 8% are gas-powered. The share of light trucks powered by electricity is about 1%, but the number of light trucks powered by both electricity and ethanol has increased significantly in the last couple of years. Heavy trucks powered by electricity are still rare in the Barents region of Sweden.

In Sweden’s public transport, biofuels and electricity have become more common as power sources for buses, especially in local transport in densely populated areas. In less populated areas and longer-distance public transport, the transition to alternative power sources is somewhat slower. Based on the survey conducted in the study, about 30-70% of the power in public transport in the Barents region of Sweden is biogas, HVO diesel or electricity, depending on the area and municipality.

The forest industry accounts for a significant part of the heavy transport in northern Sweden. Forest work machines still operate mainly on fossil fuels in the current situation, and the same challenges as in Finland hamper the electrification of the sector. The use of alternative fuels in the mining industry is also still low. The mining industry has set a goal that 50-95% of mining work machines would be electrified by 2035. There are development projects underway for the electrification of mining work machines.

No electrification of work machines is expected in ports during the next decade, as the development of work machines progresses slowly, and on the other hand, also because the port work machine fleet ages slower than the work machines in the forest and mining industries.

Availability of alternative fuels

Local production of liquefied biogas was available in the Barents region of Sweden at two production plants. The accessibility of biogas filling stations in northern Sweden is very poor.

The availability of HVO diesel in the Barents region is better than other alternative fuels according to the survey conducted in the study. However, its use is prevented by its higher price compared to regular diesel. According to the survey, the availability of ethanol diesel in the Barents region of Sweden is limited.

There are no official statistics on the use of hydrogen in Sweden. Hydrogen is usually used near the production site, and there are no hydrogen networks or other large-scale distribution routes for hydrogen. There are currently five hydrogen filling stations in Sweden, one of which is located in the Barents region in Umeå.

The electric charging infrastructure has increased in the Barents region in recent years, but the development of charging stations for heavy vehicles has been slow.

Liquefied (LNG) and compressed (CNG) natural gas is delivered to the region in relatively small quantities, and it is mainly used in various industrial processes. The survey responses also emphasized that the availability of LNG and CNG in the region is poor.

Opportunities and challenges for the spread of alternative fuels in heavy transport and work machines

The strategic goal in Sweden is to transfer as much of the heavy transport as possible to rail and water transport. The most significant ongoing project in the Barents region is the implementation of a railway connection between Umeå and Luleå. However, the national roadmap for heavy transport also emphasizes the development of charging and distribution infrastructure for alternative fuels, which is seen as a prerequisite for the development of emission-free heavy transport.

According to the survey conducted in the study, the organizations operating in the Barents region of Sweden are interested in increasing the use of alternative fuels. In heavy transport, the interest is in biogas, HVO diesel, hydrogen and electricity. In work machines, potential is seen in HVO diesel, hydrogen and electricity.

As in Finland, the profitability and availability of alternative fuels were also seen as the biggest obstacles to the spread of alternative fuels in Sweden. One of the challenges related to heavy vehicles and work machines is that in many industries, the use of alternative fuels requires investing in new vehicles and machines. Investing in more expensive machines first and then operating with more expensive fuels is not economically viable for companies. HVO diesel is considered to be the best available biofuel in the region in the current situation. Companies see increasing the use of HVO diesel as the easiest solution from the company's perspective. However, it was also stated that there is a risk that there are no projects or measures underway to improve the availability of HVO diesel and ethanol diesel during the study.

There are currently over 100 hydrogen filling station projects under preparation in Sweden, which are aimed at being operational in the near future. This is expected to change the role of hydrogen as a transport fuel significantly. There is also a cross-border infrastructure project between Finland and Sweden to support the hydrogen market, which aims to develop a hydrogen pipeline network around the Gulf of Bothnia. The goal is to start operations in 2030, and to provide secure hydrogen transfer from producers to consumers. In addition, it has been estimated that the fossil-free steel plants planned for northern Sweden that use hydrogen could create new demand for hydrogen in other industries as well.

In the Barents region of Sweden, there is an excess of electricity production mainly due to hydroelectric power, and as a result, the price of electricity has been lower than in the southern parts of Sweden. The number of electric car charging stations in the Barents region is increasing, and some of the new stations are also aimed at heavy transport. However, the number of charging stations suitable for heavy transport is still very low throughout Sweden. The new charging stations and the steel plant projects planned for northern Sweden at the same time increase the pressure on the electricity grid and increase the total demand for electricity.

The main obstacle to the spread of biogas use in transport in the Barents region of Sweden is that there are no gas pipelines in northern Sweden, and the gas market has to be created without an existing gas network. Other challenges related to gas are the scarcity of gas-powered vehicles and the long geographical distances.

The deliveries of compressed and liquefied natural gas to the region are limited, and the global political situation has made the supply of natural gas in Europe more uncertain than before. There are currently no plans for the construction of liquefied natural gas terminals in the Barents region of Sweden. According to the study, companies do not plan to increase the use of compressed and liquefied natural gas in their operations, and some of the respondents also expressed uncertainty about the development of gas-powered vehicles.

Norway

Alternative fuels in heavy-duty transport and work machines in the current situation

Alternative fuels are used in Norway, especially in the transport sector, where their use is advanced compared to many other European countries. The share of FAME and HVO diesel in diesel sales is about 14% and the share of bioethanol is about 6% of gasoline sales. The use of biofuels in Norway is largely based on legislation aimed at reducing traffic emissions. In 2022, 24.5% of the fuel sold for road use had to be biofuel. However, almost all biofuels are mixed with other diesel and gasoline products, and the sale of pure biofuel is very limited. Electricity is widely used as an alternative power source in Norway, especially in passenger cars, but it is also becoming more common in light trucks.

The use and distribution of alternative fuels have not been evenly distributed geographically, even though electricity and biofuels are now widely used in Norway, especially in passenger car traffic. For example, in the Barents region of Norway, there is no production or distribution of biogas intended for traffic use, nor liquefied biogas refueling stations. The use of liquid biofuels appears to be low, if biofuels mixed with other fuels according to the national blending requirement are not taken into account. The share of electric cars in Northern Norway is lower than in the rest of the country in both passenger cars, buses, and light trucks.

Alternative power sources are used very little in heavy traffic and heavy work machines in the Barents region of Norway. The supply and demand of alternative power sources in the Barents region are limited, even though there is a lot of industry and business in the area. This is also reflected in the registration statistics of heavy vehicles using alternative power sources. Only the share of electric vans seems to make up a small part (1.5%) of the entire van fleet in the area. Other heavy vehicles registered in the area that use alternative power sources are individual tractors and trucks operating on electricity or gas. No hydrogen-powered heavy vehicles have been registered in the area.

Availability of alternative fuels

In Norway, liquid biofuels are mainly imported. The same companies that distribute regular diesel and gasoline products distribute biofuels. Biofuels are brought by ships to terminals and distribution facilities, and then distributed by tank trucks directly to large consumers or filling stations. According to a study, there are no filling stations for biofuels in Northern Norway, which means that fuels are likely to be distributed directly to consumers. Currently, in the Barents region of Norway, there are no filling stations for compressed (CBG) or liquefied biogas (LBG). Also, there are no natural gas (CNG/LNG) filling stations in the area (NGVA Europe).

Due to lower electricity prices, electricity is one of the most attractive alternatives to fossil fuels in Northern Norway. At the same time, there are some challenges in the availability of electricity due to grid constraints. Weak local electricity transmission capacity in some areas imposes restrictions on the use of electricity. For example, a mining operator interviewed in the study would be willing to electrify their vehicles and work machines due to low electricity prices, but the electricity grid operator does not have sufficient capacity for the mining company’s needs. According to the Norwegian grid company Statnett, the grid must be expanded and updated to meet growing demand in the coming years. Also, the infrastructure for charging electric cars is considerably less common in the northern parts of Norway compared to the rest of the country, which is likely to affect the prevalence of electric vehicles in the Barents region of Norway.

Opportunities and challenges for the proliferation of alternative power sources in heavy traffic and work machines

The Norwegian government has defined in the national transport plan that by 2030, all new heavy road vehicles, 75 percent of new long-distance buses, and 50 percent of new trucks should be emission-free. In addition, by 2025, all new city buses should be emission-free or use biogas. The Norwegian government has taken measures to accelerate the introduction of low-emission vehicles and machines and to create demand for alternative fuels throughout Norway. The government plans to use, among other things, carbon dioxide taxes, fuel blending obligations, and other regulations to strengthen the demand for alternative fuels.

Regarding biofuels, it is likely that especially due to the increasing blending obligation, the demand for biofuels will increase throughout Norway. From 2023 onwards, the blending obligation will also cover fuels used by working machines, so that 7% of fuel sales must be biofuel. As in Finland and Sweden, the use of biofuels is limited by their higher price compared to regular diesel. According to the representatives of the Norwegian construction companies interviewed, it is not possible for companies to use biodiesel and remain competitive in terms of prices with companies that use regular diesel. To solve the problem, the Norwegian government has proposed new legislation that would require public procurement to take into account climate and environmental criteria, which should have a 30% weight when making public procurement. This would aim to encourage companies to use alternative fuels.

Previous studies have shown that there is a lot of untapped potential in the Barents region of Norway to produce biogas from household waste as well as waste from the fish, farming, and forestry industries. Several biogas production plants are planned for the area. The largest project is a biogas production plant in Skibotn, which uses organic waste from 41 northern municipalities in the counties of Troms and Finnmark as raw material. Production is expected to start in 2025. The companies behind the production plant have also received public funding to build biogas refueling stations in Alta, Tromsø, and Bjerkvik, as well as funding for the acquisition of 16 biogas trucks and other heavy vehicles operating on biogas.

The Norwegian government has developed a hydrogen strategy and roadmap, aiming to build a hydrogen value chain in Norway. The government participates in the development of the value chain through legislation and by funding research activities and projects that promote the supply and demand of hydrogen. (The Ministry of Petroleum and Energy, 2021). In Northern Norway, several projects related to hydrogen production and distribution are underway, such as a production plant in Glomford, Nordland County, and the establishment of a hydrogen refueling station for passenger, line, and freight vehicles in Bodø. The projects primarily focus on maritime and energy-intensive industrial production. However, with the establishment of new production facilities and emerging value chains, there may be potential demand for hydrogen in other industries as a power source for road vehicles and work machines.

Troms and Finnmark County also have their own hydrogen strategy, one of the goals of which is to establish at least one large-scale hydrogen production plant in the region. The strategy initially targets the adoption of hydrogen as a power source for taxi and bus transportation, and hydrogen infrastructure is expected to emerge along bus routes. The strategy estimates that hydrogen may become popular as a power source for other heavy traffic after buses, but this would require the implementation of hydrogen infrastructure also in less populated parts of the county where there is no bus traffic. Therefore, it is estimated that the share of hydrogen as a power source for trucks and other heavy traffic will not be as significant in the region.

Electricity is already a widely used energy source in Norway, especially for personal vehicles, and it is expected to play an important role in the coming years. The development of battery technology has increased affordable options also for buses and small trucks. In addition, there is great anticipation for the electrification of heavier trucks in Norway. Norwegian government agency Enova provides financial support for the construction of charging infrastructure and support for companies to acquire electric vehicles, trucks, and machines for road and construction traffic. At the same time, however, it has been estimated that in Northern Norway, the weak electricity network infrastructure will continue to limit the use of electricity as an alternative fuel at least in the short term. The electricity network capacity in Northern Norway is mainly reserved, and it needs to be expanded to meet new demand. Although Statnett, the Norwegian transmission grid company, has several plans to strengthen the network, the lack of capacity is likely to cause a bottleneck for large electrification projects in Northern Norway in the coming years.

Preliminary Survey of Electronic and Transverse Air Traffic in the Barents Region

The implementation and objective of the study

The aim of the preliminary study was to investigate the possibilities of transverse electronic air traffic in the Barents region and to draw up a roadmap towards a possible future scenario. The focus of the review was on identifying prerequisites, challenges, and opportunities, taking into account in particular technological development, economic perspectives, and the current state and development possibilities of infrastructure. In addition, the aim was to analyze air traffic in similar areas and assess the usability of existing practices in the Barents region.

The study was carried out in collaboration with Sitowise Oy (main consultant), Enontekiö Airport, and the University of Lapland. The team included Katja Ojala (project manager), Anni Karelehto and Johannes Haikonen from Sitowise Oy, Marko Halla and Johannes Impiö from Enontekiö Airport, and Timo Aarrevaara and Ari Huhtamo from the University of Lapland. The study was conducted between February and June 2023.

The key findings and results of the study

Electricity as a propulsion force for air traffic

With the carbon dioxide emission reduction targets for the transport sector, the development of air traffic has particularly turned to battery electricity, biofuels, and hydrogen in fuel cells, combustion engines, or as synthetic fuel. New power sources are expected on the market by the end of this decade. Air traffic will become increasingly environmentally friendly in the future, but especially electric air traffic could potentially also bring cost savings to operations. However, the change requires infrastructure investments and capital for fleet renewal.

The focus of the study is to examine the internal air traffic of the Barents region from the perspective of electrifying aircraft. In the study, electric air traffic is defined as battery-powered aircraft and aircraft using hydrogen in fuel cells. Battery electricity means that the aircraft has a built-in battery that is charged before flight and that feeds energy to the electric motor during flight. Hydrogen in a fuel cell means that the fuel tanked hydrogen reacts in a fuel cell with atmospheric oxygen, producing electricity, water, and heat at the same time. The produced electricity is used to drive the electric motor and charge and maintain a small battery in the machine. (Huhta et al., 2023)

Hydrogen can also be utilized in air traffic in other ways: by burning in a combustion engine and when producing synthetic aviation fuels. When burning in a combustion engine, modified jet turbines are used, which burn hydrogen and air into water, heat, and nitrogen oxides. Synthetic aviation kerosene-like fuel, on the other hand, can be produced so that hydrogen (and oxygen) is made from water by electrolysis (chemical decomposition caused by electric current), which is synthesized with carbon dioxide into fuels equivalent to fossil fuels. In addition, so-called hybrid solutions have been under development, where hydrogen is utilized both in a fuel cell and in a combustion engine (cf. hybrid powertrain). (Huhta et al., 2023)

The current state of air traffic and regional structure in the region

The Barents region is a sparsely populated area with a reasonably dense airport network and hardly any railway connections. International tourism is a key industry widely around the area, in addition to which there are clear industrial concentrations in the area. Over the years, there has been transverse publicly supported air traffic in the Barents region, but the connections have not been permanent.

The current air traffic in the Barents region is mainly domestic traffic in Norway. In the Barents region in Norway, there are almost 40 domestic air connections, most of which are state-supported connections. In Sweden, there are two internal connections in the region, although one is part of a route connection arriving from and returning to Stockholm, but it is still possible to buy a ticket for it. In Finland, Finnair operates between Ivalo and Kittilä as part of a triangle flight from Helsinki, but no ticket is sold for the connection. Thus, there are no internal connections in the Barents region from Finnish airports.

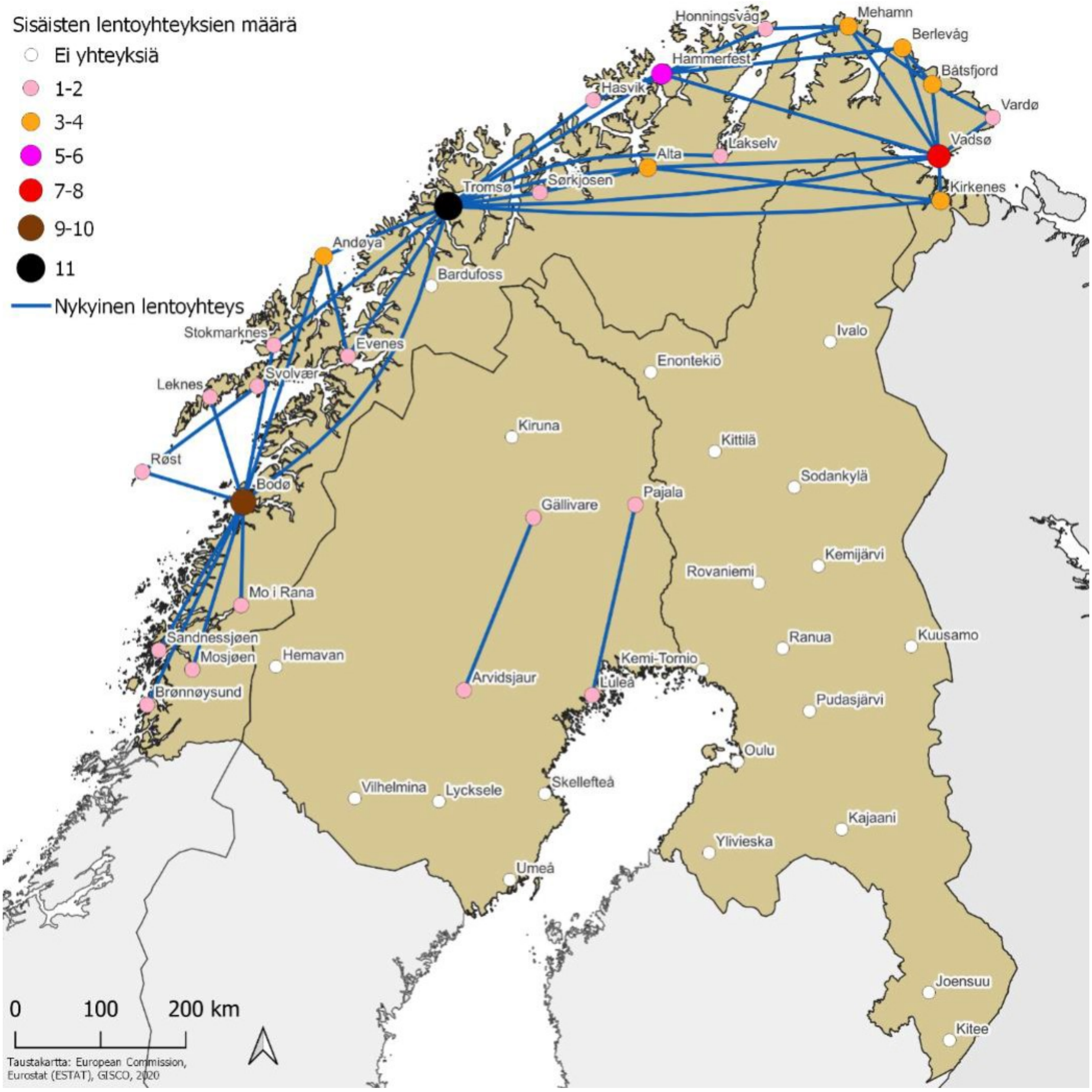

Figure 10. Internal air connections in the Barents region and their numbers by airports and locations. The blue lines represent the currently existing internal flight connections in the region. There are no internal flight connections from the airports marked in white in the Barents region. Source: Flightmapper.

In Finland and Sweden, it is characteristic to arrange internal connections through one airport, which in Finland is Helsinki-Vantaa Airport and in Sweden Stockholm Arlanda Airport. In Finland and Sweden, cross-traffic and connection traffic from airports are built on the basis of road transport. Norway's strategy is different because the obstacles to road and rail traffic are a fragmented coastline and altitude differences, which is why the benefit of air traffic in time is higher compared to other Nordic countries' road and rail traffic. Thus, the volume of use of small aircraft and narrow-bodied aircraft is significantly larger in Norway. This is also supported by public service obligation tendered air routes implemented in Norway since 1996.

The largest airports in the Barents region measured by passenger numbers are Bodø and Tromsø in Norway, both of which had over a million passengers in 2022. Airports with over half a million passengers were in Finland Oulu and Rovaniemi, in Sweden Umeå and Luleå, and in Norway Evenes (Harstad/Narvik).

From the perspective of market-based air traffic, the population base in the surrounding areas of the region's airports are small. Over 100,000 people live in the areas of Umeå, Luleå, Oulu, and Joensuu within a 50-kilometer radius of the airport. Over 50,000 people live in the 50 km impact areas of Rovaniemi, Kajaani, Kemi-Tornio, Ylivieska, Skellefteå, Tromsø, Evenes (Harstad/Narvik), and Bodø.

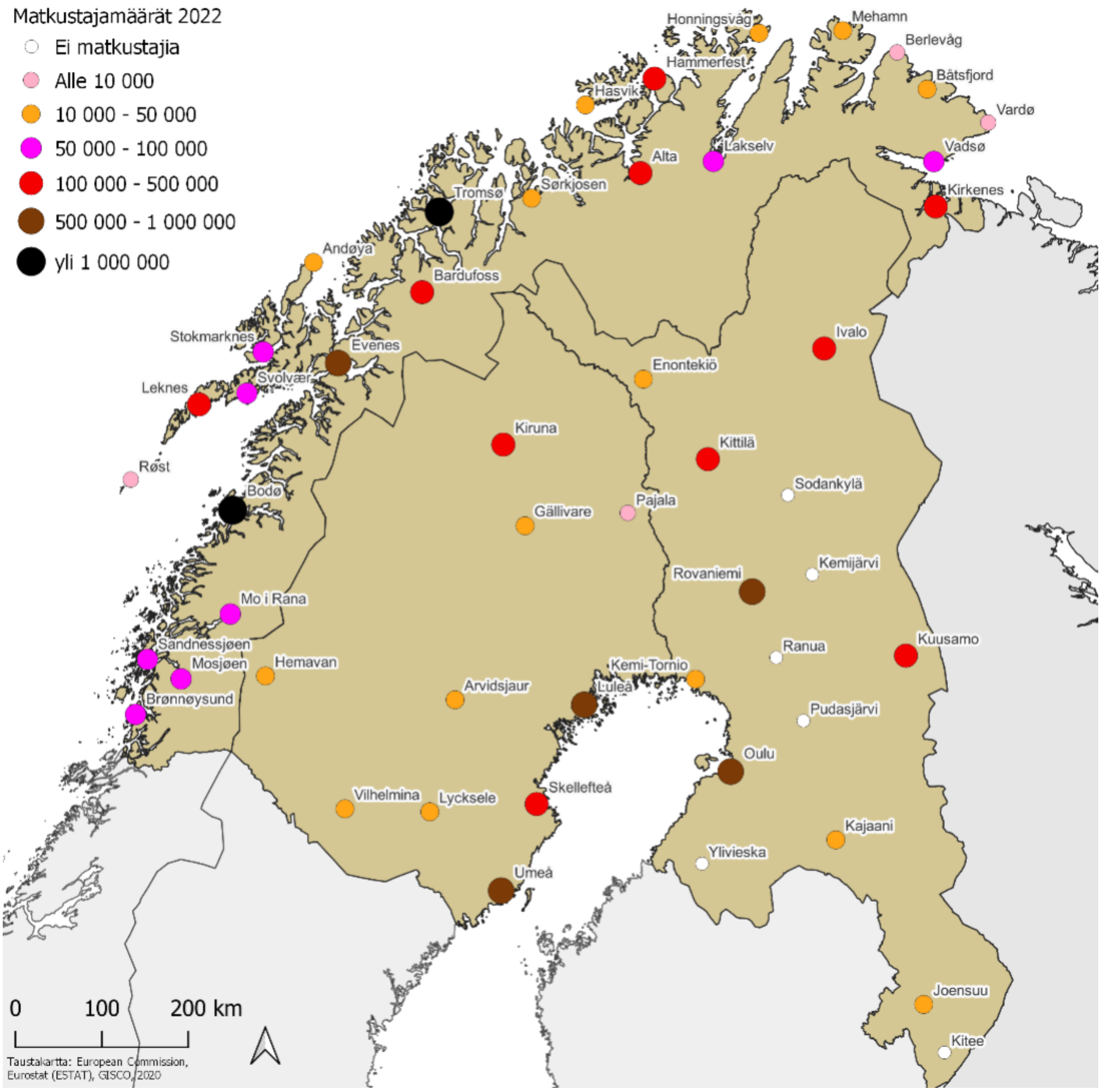

Figure 11. Passenger numbers at airports in 2022. The numbers include passengers from both domestic and international flights, as well as scheduled and charter flights. There were no passengers at the airports marked in white. Sources: Avinor, Finavia, Swedavia, municipal airport websites.

In Finland, there is one university central hospital in Oulu and four other central hospitals in the Barents region. In Sweden, there is one university central hospital in Umeå and six other central hospitals in the region. In Norway, there is one university central hospital in Tromsø and eight other central hospitals.

The Barents region has a lot of international tourism. Due to the Levi and Ylläs tourist centers located in the impact area of Kittilä airport, the importance of tourism for Kittilä airport is particularly great. It is estimated that up to half of the bed capacity of the Barents region is located in the impact area of Kittilä airport. In addition to Kittilä, especially in the areas of Kuusamo, Kajaani, and Tromsø, there is a significant bed capacity, over 10,000 beds.

At the moment, the region's air travel season is strongly focused on the winter season, from November to March. In Finland and Sweden, only the larger city airports (Oulu, Rovaniemi, Umeå, Luleå, Kiruna) passenger numbers and air traffic supply remain at the same level all year round, as air travel also has a strong other demand (e.g., business travel, domestic trunk traffic). In Norway, demand is distributed more evenly, as air traffic plays a strong role as part of the domestic transport system.

Common industries in the Barents region are particularly mining, forestry, and metal industry. Mining is widely spread in the area, and the metal industry is concentrated around the Bay of Bothnia. Oil and gas industry is on the Norwegian coast.

Prospects for the development of electric aviation

Air traffic accounts for about 3% of the world's carbon dioxide emissions. However, the amount of air traffic is expected to continue to grow in the future, and without measures, carbon dioxide emissions are predicted to double by 2050. However, the industry aims to reduce carbon dioxide emissions by about 60% by 2050. The largest emission reductions are believed to be achieved through improved fuel efficiency (45%) and biofuels (35%). Battery electricity and hydrogen are believed to enable a reduction in carbon dioxide emissions of less than five percent. (MPP, 2022.) The relatively small share of battery electricity in air traffic emission reduction targets is due to its suitability as a power source for only relatively short flights. As for hydrogen, challenges related to transport and storage are considered to be moderately large.

The clear advantages of battery power are its significant impact on reducing emissions and its quick turnaround time. However, challenges are brought by the limited capacity of batteries per unit weight, which shortens flight distances to 500–1000 km (of which the length of a commercial route can be about 60%), and the need for charging infrastructure. Hydrogen combustion also enables significant emission reductions, but the distribution and storage of hydrogen bring their own challenges. An additional challenge in a hydrogen combustion engine is that refueling on medium and long flights requires 2–3 times the current refueling time. The challenge with biofuels, on the other hand, is that they can only achieve a 30–60% reduction in emissions, but otherwise they are very compatible with current fleet, operating models, and airport infrastructure. (MPP, 2022)

Electric airplanes are expected to hit the market within about ten years. Several aircraft manufacturers are currently developing battery-powered airplanes, hydrogen-powered airplanes, and various hybrid solutions. The speed and schedule of the development of electric aviation depend on technological innovations, especially in three different areas: battery technology, electric motor technology, and efficient integrated aircraft body/power design technology. (Adu-Gyamfin & Goodin, 2022). The first machines to be used commercially are likely to be small and have a commercial range of about 200–300 kilometers. At a later stage, we can expect aircraft with a commercial range of 400 km. In the second half of the decade, the lengths of the ranges can still grow from this.

The potential of electric aviation in areas such as the Barents region, is strongly based on assumed cost savings. According to theoretical calculations made, the cost-saving potential of electric flying consists of the cheaper price of electricity compared to the same amount of energy in jet fuel, and maintenance costs, which are expected to be less for an electric motor than for a combustion engine. Both energy costs and maintenance costs are estimated to be 50–70% lower for electric aircraft than for combustion engine aircraft. (Heart Aerospace, 2022). Regarding the cost savings of battery-powered aircraft, estimates have been presented in the literature in recent years that vary from about 10% to up to 40% of direct operational costs. The biggest cost factor at the moment is the need to replace batteries every 3000–5000 hours. The actual outcome is significantly affected by the length of the route and other operating conditions. (Shahwan, 2021)

As for hydrogen, operating costs would currently be higher than with fossil kerosene. Based on the calculations made in this study, direct operational costs would increase by about 25% if the market price of hydrogen is assumed to be about $5/kg. However, the price of hydrogen could fall to about $1.5/kg by 2030 due to economies of scale. This is particularly realistic in Finland, where the government's principle decision aims for a significant increase in hydrogen production. Finland would have the potential to produce 10% of the green (emission-free) hydrogen needed in the European Union area (Government, 2023). If the market price of hydrogen drops to the above mentioned $1.5/kg by 2030, it would have the potential to reduce direct operational costs by about 3%.

However, the potential could be greater if it is taken into account that the costs of emitting carbon dioxide tonnes will rise from the current level by 2030.

According to current forecasts, hydrogen as a power source for aviation does not offer a large cost-benefit, but as the scale advantage expands and carbon dioxide emission fees are introduced, hydrogen can become a cheaper alternative. In the Barents region, this has the most impact on those routes that already have traffic. On the other hand, on those routes where new traffic would be desired to start and new power sources would be hoped to provide a boost with lower operating costs, hydrogen is unlikely to be of much help in the coming decades.

Opportunities for electric aviation operations in the region

In this preliminary study, the range for battery electric aviation is limited to 400 kilometers, which is not expected to be exceeded in passenger transport in the foreseeable future. The battery electric aircraft covering distances of up to 200 kilometers would already enable numerous connections within the Barents region. Initially, this range is likely to be suitable for commercial operations of small passenger aircraft. However, in the future, the commercial operating range for battery electric aircraft could expand to 400 kilometers, potentially enabling coverage of the entire Barents region through Oulu, Ivalo, and Bodø airports. Figure 13 illustrates the connections within the region, with distances limited to 200 kilometers, considering the infrastructure requirements for airports and locations that may accommodate aircraft with fewer than 20 seats. The figure also indicates existing air traffic connections on these routes.

Battery electric aircraft require charging infrastructure. According to current views, these aircraft require at least a 1 MW charger, which is already available at Rovaniemi and Skellefteå airports. A standard for such chargers is under development and is likely to be adopted for heavy road transportation as well. Constructing a 1 MW charger at an airport would likely require a minimum of 50 square meters of space and at least a 1250 kW transformer. Additionally, the transformer would need to be connected to a 20 kV network. It is probable that most airports will need to reinforce their electrical grids. For airports located near national transmission networks, grid investments are likely to be easier and less costly than for those farther away.

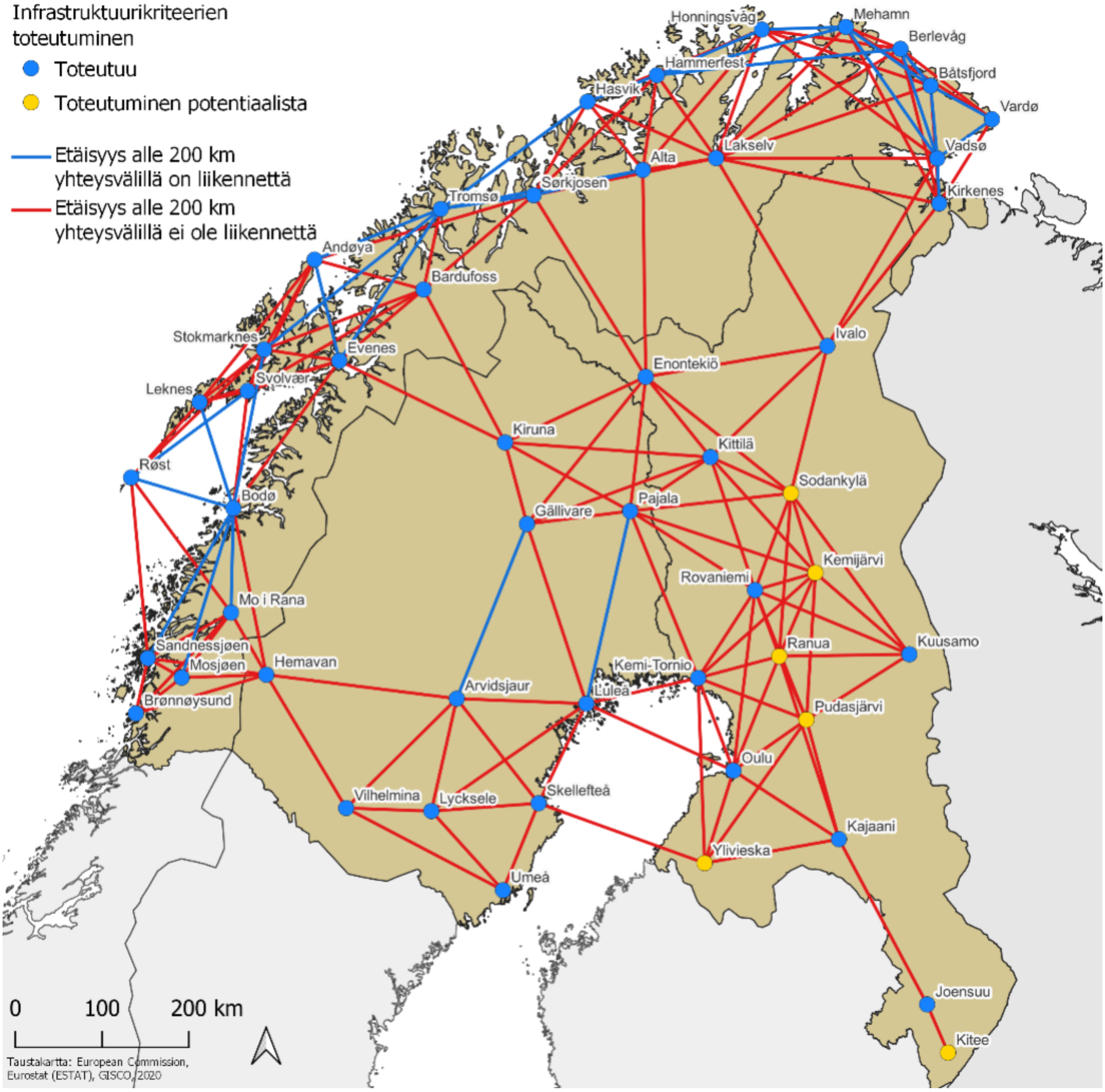

Figure 13. Airports and airfields within 0–200 km distance from each other, which are considered to have potential from the perspective of airport infrastructure. Blue points represent airports where infrastructure criteria are met. Yellow points indicate that there is potential for the realization of infrastructure criteria. The lines between airports represent connection distances of less than 200 kilometers, of which the blue ones currently have traffic, the red ones do not.

The clearest potential for electric aviation lies in electrifying existing connections. According to the current view, operating costs become more cost-effective at the latest when the fleet is being renewed. Additionally, the Norwegian government has expressed its intention to electrify publicly supported domestic air connections. In Northern Norway, the most commonly used aircraft are 50-seaters, but on some routes, passenger loads may be so low that the connection could be operated with an electric aircraft seating fewer than 20 passengers. In Figure 14, blue lines represent connections within 200 km, enabling electrification in the initial phase, while violet lines (200–400 km) have potential for future electrification.

Hydrogen fuel cells currently allow commercial flights up to 1,000 km, and hydrogen combustion engines extend the range to 10,000 km. The Barents region has a maximum diameter of approximately 1,000 km, which means that future hydrogen-powered aircraft will likely be able to operate between all airports in the area. However, hydrogen is not expected to offer the same cost advantage as electric batteries at present, which diminishes its potential for launching new air routes in the region. In addition, hydrogen refuelling infrastructure requires investment, but the refuelling process is similar to current kerosene distribution, and hydrogen can be refuelled into aircraft either from tank trucks or ground-based refuelling equipment.

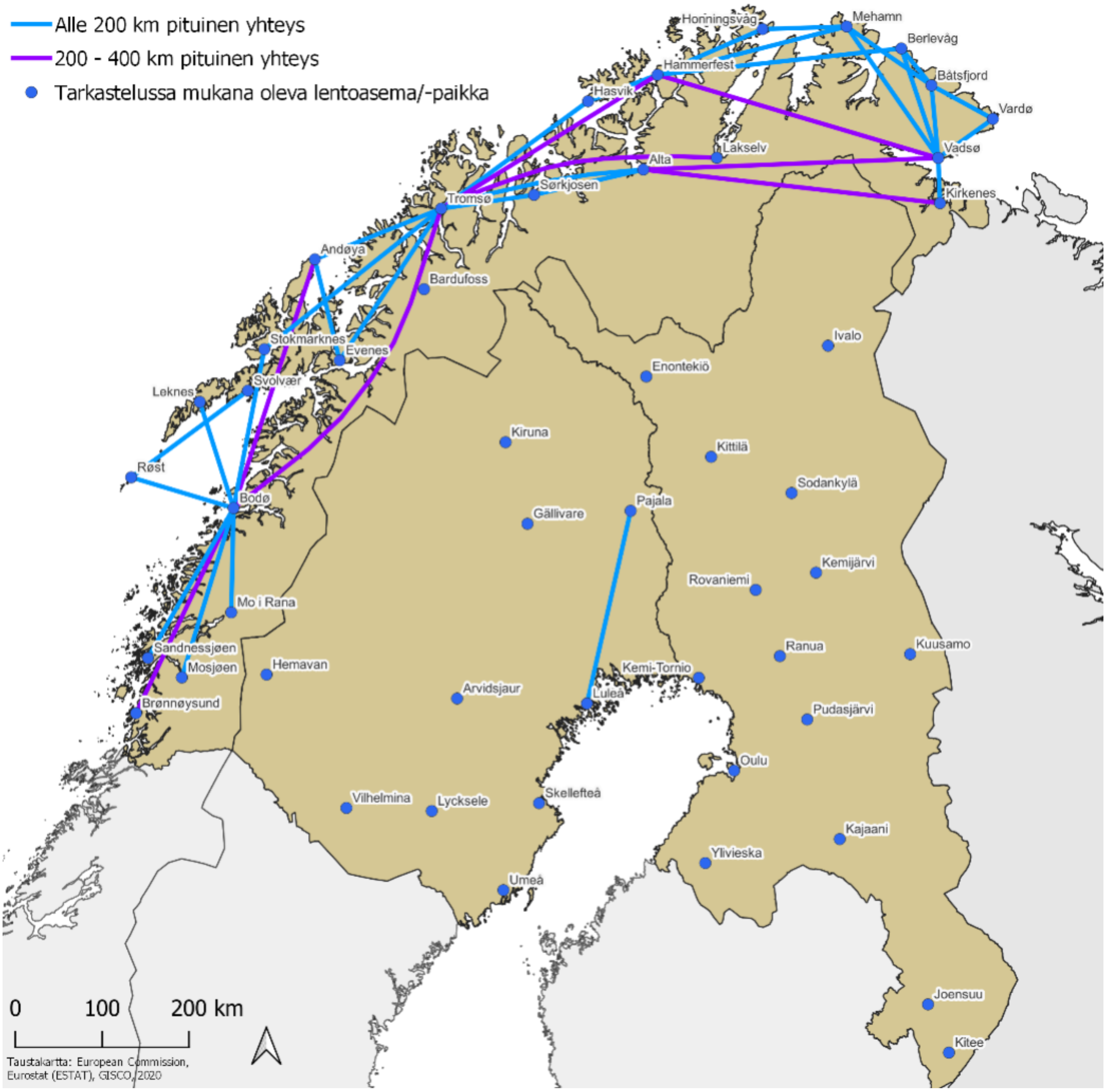

Figure 14. Existing air connections that are less than 200 km (light blue) and between 200–400 km in length (violet).

Based on the population base of the region, the only potential route for electric aviation was considered to be Oulu-Luleå, but its potential is challenged by the ongoing electrification of the Laurila–Tornio–Haparanda railway section, which, when completed, will enable the start of passenger train traffic between Finland and Sweden. When examining the potential created by tourism, it was recognized that electric aviation could serve two types of internal connections in the region: there could be onward connections from incoming scheduled flights to destinations that do not have much suitable flights directly available for tourists, in addition to which there could be round-trip connections aimed at tourists within the area. However, the analysis identified that the area's large tourism clusters, with the exception of the Kajaani area (Vuokatti tourism cluster), already have at least moderate air traffic connections either as direct international scheduled connections, charter traffic connections or transfer connections via capital city airports. Another future potential is seen in round-trip connections, which would be implemented together with a tour operator with larger hydrogen-powered aircraft. With joint route planning and the tour operator's commitment to a certain number of seats, it could be possible to make them economically viable.

In addition to round-trip tourism, another potential user of electric aviation was seen as the taxi flight operation expanding its operations to the Barents region, which would serve industrial workers and possibly also spare parts deliveries. In spare parts deliveries, unmanned aviation solutions would likely be used, making it likely that the first such solutions would be brought into commercial use by a major logistics operator. The operation of personal taxi flights would probably require that an operator who has carried out similar operations elsewhere would be ready to expand it also to the Barents region, or that the current and new companies in the area would proactively work to find an operator.

The future vision of electric and transverse air traffic in the region

It can be considered reasonably certain that within ten years, small, 9-19-seat electric aircraft will enter the market, as several different models are well advanced in development. They are likely to be somewhat cheaper to operate than the current kerosene-powered aircraft of the same size, but exact estimates will only be confirmed once commercial operation with electric aircraft can be started. Hydrogen and hybrid solutions are also likely to come to the market in the 2030s, including larger aircraft, of which the 30-50-seat aircraft are particularly interesting from the perspective of transverse air traffic in the Barents region. However, the same kind of cost savings as with battery electric aircraft are not expected for these, although with carbon tariffs and other economic steering mechanisms, the price of fossil fuels is expected to rise significantly this and the next decade.

Currently, the smallest aircraft in the fleet of airlines operating to the airports in the region are generally at least 40-seaters. This is largely due to the fact that operating costs are not linear. With aircraft seating less than 30, the costs per seat rise significantly higher than the price of an air ticket generally considered competitive, which in practice leads to smaller aircraft being an economically viable solution only for customers paying a considerably higher ticket price (business travel, high-end tourism) or when a public entity pays for the operation and the number of passengers does not require a larger type of aircraft.

The first step towards electric and hydrogen-powered aircraft has already been taken, as the development work of new power sources has started to be financed. The next phase requires that some entity finances the purchase of the aircraft. Currently, about half of the aircraft are directly owned by the airlines and half are owned by leasing companies (ICF, 2023). Both need a view that the aircraft can operate economically viable routes - either so that there is enough demand at sufficient ticket prices or that a public entity commits to paying the costs.

The introduction of electric aircraft in the Barents region over the next ten years seems likely, as Norway has set ambitious goals for the electrification of air traffic: Norway wants to be the first country where electric aircraft have a significant market share, and in addition, all domestic air traffic is aimed to be electric by 2040. The Norwegian government, airport operator Avinor, airlines Wideroe, SAS and Norwegian, and the environmental organization Zero Emission Resource Organisation (Avinor, 2023) have committed to these goals together. The electrification of domestic air traffic will particularly be seen in the Northern Norway region, as a significant part of domestic flights are in that area.

Figure 15 presents a visionary roadmap for achieving the targeted future vision of electric and transverse air traffic in the Barents region. The goal of the first five-year period of the roadmap is to define the vision and strategy of the region by strengthening the transport strategy and the commitment of the public financier to transverse air traffic replacing road traffic. The goal of the next five-year period is to start transverse traffic and strengthen demand. At this point, transverse traffic may still be operated with traditional power sources in order to strengthen the demand base before starting electric traffic. Between 2033 and 2037, electric technology is expected to become established and traffic in the Barents region will also become electrified. In the five-year period starting in 2038, the focus would be on building infrastructure, which would enable, for example, the expansion of air taxi operations to more airports. In the last five-year period, it could be stated that the targeted future vision set in this report has been achieved.

Figure 12. Roadmap for achieving the targeted future vision of electric air traffic in the Barents region. The steps of the roadmap are: 2023: vision and strategy (commitment of public funder to cross-sectional air traffic), 2028: initiation of cross-sectional traffic 2033: establishment of new technology 2038: second transition of technology 2043: realization of strategy (the power source for route traffic is predominantly based on electric and hydrogen fuel cell technology).

The spread of electric aviation in the region requires public or private funders

The start of commercial operation of electric or hydrogen-powered aircraft in the Barents region depends largely on whether any airline, and the parties that finance them, see commercial potential in the internal traffic of the region. Air traffic has traditionally been supported by public entities such as the state and/or municipalities. State-supported connections are generally related to regional equality, the minimum service level of the transport system, and the accessibility of social services. Norway, due to its geography, is one of the countries that subsidizes domestic air traffic the most, and a key reason for the support is the accessibility of health care. (Traficom, 2020). In Norway, the state is committed to financing air traffic if the travel time by road to health care services is too long. The electrification of this traffic can be considered very likely, as there is already an economic commitment, as well as a strong will expressed by the Norwegian state to eliminate carbon dioxide emissions from domestic air traffic altogether by 2040. In Finland, it can be considered unlikely that the state will commit to financing air traffic annually with millions of euros to improve the accessibility of health care services for a small part of the population, taking into account the current economic situation and political climate of the Finnish state.

Municipalities have in some situations supported air connections especially for the needs of the business sector, when the state has not considered the support necessary. However, such routes are expected to have at least some demand related to the population base. Based on the study, the most potential route in the region was seen as the Oulu–Luleå connection, which based on the historical passenger demand would still require public support. Taking into account the population numbers, it is possible that if the route was in operation for several years and its permanence was trusted, the passenger numbers could rise to a level that would also enable commercial activity. However, this would require long-term work and most likely the commitment of some traffic-generating parties to the operation in both locations. However, the initial start-up will and funding should be found from the municipalities that benefit from the route.

Private financiers for transverse air traffic could be actors in the tourism industry and industry. As for tourism, the study did not identify clear potential connections for onward connections, as the largest tourist areas in the region already have at least moderately available scheduled and charter air traffic connections either directly from target markets or via capitals. On the other hand, potential for round-trip tourism was identified, and the strongest route was identified as Tromsø–Rovaniemi. In addition, potential for round-trip tourism was identified between other areas of the Barents region as well. The greatest potential for round trips is in hydrogen-powered aircraft, so that the capacity of flights is sufficient for tour operators. With the hydrogen prices at the end of the decade, the commercial potential of connections can be considered possible if route planning is done in cooperation with tour operators and they commit to using the route.

The Barents region is likely to see a significant number of investments in wind power and mining in the coming years. Both generate air traffic demand in both the investment and production phases, which can create cross-sectional demand. The investment plans are scattered widely across the area, so no clear individual routes emerge. However, during this work, it was identified that taxi flight operations could serve the mobility needs of companies between different investment destinations. The start of taxi flight operations would require either initiative from the current and future companies in the area or the start of taxi flight operations first somewhere else in the nearby area and then expanding to the Barents region.

Conclusions

The transition to alternative fuels in transportation is being accelerated by the emission reduction targets set by the European Union. The development of public infrastructure for alternative fuels plays a crucial role in promoting the adoption of zero-emission vehicles. Electrification of transportation is progressing rapidly, especially in the passenger car sector. Electric vehicles (EVs) are likely to become an attractive option also for taxi services and urban logistics, where the range offered by EVs is sufficient for daily transportation needs. Additionally, electric buses have become a popular choice for city transportation, benefiting from overnight charging at depots.

However, the role of gas and hydrogen as fuels for lighter vehicles appears to be diminishing. Most gas car manufacturers have announced the discontinuation of gas-powered passenger car production. Gasoline cars are likely to be a short-lived phenomenon for personal use. Instead, hydrogen and liquefied biogas are expected to find their primary applications in heavy-duty transport routes that cannot be electrified due to long charging times or limited battery range. The advantages of using hydrogen and liquefied biogas in road transport include long operating ranges and fast refuelling. The extended range is particularly significant for heavy transport in the Barents region, where one refuelling must cover long distances. While hydrogen as a transportation fuel is still in its early stages, demand for hydrogen is predicted to grow significantly in the coming decades. Currently, there is substantial investment in hydrogen production, although challenges remain, especially related to storage and transportation. Auto manufacturers are also dedicating efforts to developing heavy-duty vehicles powered by hydrogen.

The development of alternative fuel distribution infrastructure and the vehicle fleet in the Barents region has been slow. Several factors contribute to this, including the region's geographical structure and the cold weather conditions during the winter. Most of the population is concentrated in major cities, leaving sparse settlements with long distances between them. The area also features extensive forests, mountains, and tundra. Additionally, the road network in the region is sparse, and traffic volumes remain low on most roads. For electric vehicles (EVs), a significant challenge is achieving sufficient range for long distances. Cold weather conditions may reduce the range of the vehicles and increase uncertainty. On the other hand, the use of gas-powered vehicles faces the challenge of inadequate refuelling infrastructure. Currently, the widespread adoption of gas and hydrogen as transportation fuels is hindered by what is known as the “chicken-and-egg” problem. The demand for gas and hydrogen vehicles is partially slowed down by the lack of comprehensive refuelling infrastructure. However, the expansion of this infrastructure is limited due to the insufficient size of the vehicle fleet.

In heavy-duty transport and work machinery, the transition to alternative fuels has generally progressed more slowly than in passenger car traffic. Efforts to reduce emissions have focused on the use of biodiesel (HVO-diesel), which reduces carbon dioxide emissions by approximately 90% compared to traditional diesel. If customers begin to demand the use of biodiesel more than now, the demand for HVO-diesel is expected to exceed supply. However, there are no known investments in improving the availability of HVO-diesel in the Barents region. The use of other alternative fuels face challenges related to the long lifespan of heavy-duty vehicles, significantly higher investment costs for electric and gas-powered vehicles, and deficiencies in public distribution infrastructure. In the case of work machinery, the poor availability of electric-powered machines remains a challenge. The prevailing increase in costs has also weakened the investment capacity of transportation companies. It is challenging for businesses to invest in alternative fuels if customers do not commit to more sustainable transportation and are unwilling to pay higher transportation costs as a result. Especially in the early stages of transitioning to alternative fuels, government financial support for fleet acquisition is essential to make these investments economically viable for companies.

Electrification of transportation in the Barents region

The public charging network for electric vehicles (EVs) in the Barents region is relatively comprehensive. However, there are deficiencies in charging infrastructure coverage, particularly in Finland, where the development of the EV fleet has been slow. Ideally, the public distribution network should evolve based on market demand, but this alone may not be sufficient in the region. In Sweden and Norway, the challenge has been recognized, and state investment aid has been directed more strongly to areas where high-power charging networks have not naturally emerged from the market. In Finland as well, it has been acknowledged that sparsely trafficked areas likely do not have the prerequisites for market-driven implementation. However, so far, state investment aid has not been specifically targeted at regional levels. The Barents region is also home to a significant number of ski resorts and other tourist destinations, which experience substantial domestic and cross-border traffic. Due to the sparse road network in the area, lower-tier roads are often used to access these tourist destinations. A sufficiently comprehensive charging point network is essential for the reliable use of electric cars, especially during the coldest times of the year. However, finding suitable locations for charging infrastructure within adequate distances from each other has proven challenging in some parts of the region.

Public charging infrastructure is primarily designed for passenger cars. The charging standards for passenger cars and trucks differ, making the same charging points not entirely suitable for both vehicle types. While some high-power chargers intended for passenger cars can also accommodate heavy-duty truck charging, parking areas are typically not designed for heavy vehicles. Heavy-duty vehicles require purpose-built charging points. The AFIR regulation also imposes requirements on charging infrastructure for heavy-duty transport. By 2030, the TEN-T core network should have charging hubs every 60 or 100 kilometers based on traffic volume. These hubs must provide a minimum output power of 3,500 kW for the core network and 1,400 kW for the comprehensive network. Implementing charging infrastructure for heavy-duty transport with such high-power requirements also puts pressure on significant reinforcement of the electricity grid. The most cost-effective approach is to establish heavy-duty charging infrastructure as close to the main grid as possible. However, achieving sufficiently efficient charging networks for heavy-duty transport in the Barents region will be challenging, especially in quieter traffic areas. Even deploying lower-power charging stations for passenger car needs has proven difficult.

Biogas in the Barents region

The availability of gas-powered vehicles in the Barents region is currently hindered by a sparse network of refuelling stations. Gas is unlikely to become widespread for passenger cars; its potential lies more in heavy-duty transport and buses. According to vehicle fleet forecasts, the share of gas-powered passenger cars and vans is not expected to significantly increase in the coming decades in Finland, Sweden, or Norway. Instead, growth is concentrated in electric cars, especially for passenger cars. However, the number of gas-powered trucks is predicted to increase in Finland and Sweden, while in Norway, it is expected to decrease from current levels. On the other hand, the number of gas-powered buses in Norway is forecasted to nearly sextuple from around 770 buses to approximately 4,300 buses by 2030, accounting for about 26% of the entire bus fleet. In Sweden, gas-powered buses constitute about 20% of the bus fleet, and their numbers are not expected to significantly increase from the current 2,800 buses. In Finland, the share is projected to reach approximately 6–7% of the bus fleet by 2030.

For heavy-duty transport, liquefied biogas (LBG) can be refuelled at three stations in the Barents region, located in Oulu, Luleå, and Umeå. New biomethane production facilities are being planned for the region, and their production volumes could double the share of biomethane in the region’s transportation energy consumption. Additionally, new liquefied biogas (LBG) refuelling stations for heavy-duty transport are planned in the Barents region, particularly in Norway, with eight planned stations in Nordland, Troms, and Finnmark counties. In Finland, new stations are being considered for Rovaniemi, Tornio and Nurmes. Regarding gas, the AFIR regulation requires that by 2025, there should be LBG refuelling points along major roads to enable methane-powered vehicles to operate throughout the EU. The implementation of gas refuelling stations in Finland has been hindered by the fact that, after subsidies were granted for gas stations between 2018 and 2021, recent infrastructure investment aid has been predominantly directed toward electric charging stations. In Norway, Enova has supported 30 gas refuelling stations, of which 22 offer liquefied biogas (LBG). Among the supported stations are those in Tromsø, Bjerkvik, and Alta, which are expected to open by 2025. In Sweden, funding is provided by the Swedish Environmental Protection Agency (Naturvårdsverket).

Hydrogen as a fuel for transportation in the Barents region

The use of hydrogen as a transportation fuel is still in its early stages, but its demand is predicted to grow significantly in the coming decades. In Finland and Sweden, the adoption of hydrogen-powered cars is expected to be moderate by 2030. In Norway, there are two vehicle fleet forecasts: one estimates around 600 hydrogen-powered passenger cars, while the other predicts nearly 5,000 vehicles by 2030. For hydrogen-powered trucks, the estimates range from about a dozen to almost 8,000 in Norway by the same year.

Currently, there is only one hydrogen refuelling station in the Barents region, located in Umeå, Sweden, with another under construction in Luleå. However, the hydrogen market is evolving rapidly, and several additional hydrogen refuelling stations are planned for the region, strategically positioned along the TEN-T road network. If realized, these planned stations would nearly meet the requirements of the AFIR regulation, except for Sweden's E10 road. According to the AFIR regulation, by the end of 2030, hydrogen refuelling stations should be available at least every 200 kilometers along the TEN-T core network and at urban nodes. In the Barents region, Oulu and Luleå are likely to be designated as urban nodes.

In Sweden, the Swedish Energy Agency granted support for 12 hydrogen refuelling stations for the year 2023, with locations including Luleå, Umeå, and Storuman in the Barents region. In Norway, funding can be obtained for constructing hydrogen refuelling stations, covering 40% of the total costs, up to a maximum of 10 million Norwegian kroner per station. The selection criteria consider 70% cost-effectiveness and 30% market potential. Five hydrogen refuelling stations are planned in the Barents region of Norway. In Finland, the Finnish Energy Authority has granted investment aid for two hydrogen refuelling stations in 2023 and three stations in 2022. These supported projects are located in Uusimaa and Southwest Finland. Due to the scoring criteria for the Energy Authority's investment aid applications, the construction of hydrogen refuelling stations is targeted along the TEN-T network.

Electric aviation in the Barents region

The current air traffic in the Barents region is primarily domestic within Norway. In the Barents region of Norway, there are nearly 40 internal flight connections, most of which are supported by the state. Electric aircraft are expected to enter the market within the next ten years. Initially, commercially available electric planes are likely to be small, with a commercial range of approximately 200–300 kilometers. In later stages, planes with a commercial range of 400 kilometers can be expected. By the second half of the decade, range lengths may increase even further. For aircraft with fewer than 30 seats, the costs per seat rise significantly higher than the generally competitive airfare, practically resulting in smaller aircraft being an economically viable solution only for customers willing to pay much higher ticket prices (business travel, high-end tourism) or when public entities cover the operation costs and passenger numbers do not require larger aircraft.

By 2050, it is believed that battery electric power and hydrogen will contribute to reducing carbon dioxide emissions in aviation by less than five percent. The relatively small share of battery electric power in aviation emission reduction targets is due to its suitability only for short-haul flights. Regarding hydrogen, challenges related to transportation and storage are considered moderately significant.

In the future, the commercial operating range of battery-electric airplanes could extend up to 400 kilometers. This would allow covering the entire Barents region through Oulu, Ivalo, and Bodø airports. In the future, hydrogen-powered aircraft would likely be able to operate between all airport pairs within the region. However, hydrogen is not currently expected to offer the same cost advantage as battery electric power, which affects its potential for launching new air routes in the Barents region.

It is probable that most airports will need to strengthen their electrical infrastructure. Additionally, establishing hydrogen refuelling infrastructure requires investments. The commercial operation of electric or hydrogen-powered planes in the Barents region largely depends on whether any airline or funding entities perceive commercial potential in the region's internal air traffic. In Norway, there is a commitment to reducing domestic aviation's carbon dioxide emissions, and the country already subsidizes internal flights in the Barents region, particularly for healthcare accessibility. Electrification of these connections is considered likely in Norway. However, a similar scenario does not appear likely in Finland.

The most significant question for future development is securing capital and risk-taking capacity to establish air services that will likely require financial support for years. The most promising opportunities lie in tourism connections, potentially operated jointly with tour operators using larger hydrogen-powered aircraft. Such routes could become economically viable through collaborative route planning. However, launching operations will depend on finding both willing airlines and interested tour operators.

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THE MARKET, INFRASTRUCTURE, AND DISTRIBUTION OF ALTERNATIVE FUELS FOR TRANSPORT IN THE WESTERN BARENTS REGION

SUMMARY REPORT

Center for Economic Development Transport and the Environment of Lapland
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