Elinkeino-, liikenne- ja ympäristökeskus

Preliminary survey on alternative fuels for heavy traffic and working machinery in the western Barents region

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1. Introduction

There is a larger project ongoing in the western Barents region, the aim of which is to promote concrete cooperation in the transport sector and cross-border traffic. The project is a key part of the work program of the Barents Euro-Arctic Council and the council's transport and logistics working group for the 2021–2023 period.

The larger project carries out preliminary studies and analysis related to the use potential, capacity needs and availability of alternative forms of energy, as well as the required infrastructure in the western Barents region, which is characterized by, among other things, long distances, difficult winter conditions, limited domestic markets and limited public transport options. In this sub-project of the larger project, Ramboll has conducted a preliminary survey on the utilization of alternative fuels for heavy traffic and working machinery in the western Barents region.

The purpose of the preliminary survey is to find out the current state, availability and use potential of alternative fuels in the western Barents region.

1.1 Scope of the Survey

The goal of the project was to survey and describe

- The use of alternative fuels in heavy traffic and working machinery in the western Barents region
- The users of natural gas, LNG, hydrogen in heavy transport and working machinery in the western Barents region.

In this report the focus is on the following industrial sectors:

- Mining
- Wood harvesting
- Ports
- Transport logistics
- Road building and maintenance
- Public transport

and the following alternative fuels:

- Biogas (CBG/LBG)
- HVO-diesel
- Ethanol diesel
- Hydrogen
- Electricity
- Natural gas (CNG/LNG).

Western Barents region consist of Finnish, Swedish and Norwegian parts of the Barents region (Figure 1).

Figure 1. Western Barents region *(Arctic Centre, University of Lapland, 2023)* (cropped figure).

This survey is a part of a wider project about alternative traffic fuel market, infrastructure and distribution in Barents region. It is implemented with funding from the Baltic Sea, Barents and Arctic region cooperation granted by the Ministry of Foreign Affairs of Finland.

1.2 Methods and the Involvement of the Interest Groups

In this project national surveys of alternative fuel use were performed in Finland, Sweden and Norway. Used methods for making the national surveys were literature review and gathering interest group views and opinions with an online survey and interviews.

In the literature review especially the following types of publications were surveyed:

- National/regional level traffic plans/roadmaps
- De-carbonization of heavy traffic and working machinery plans/roadmaps
- Legislation and other regulation that regulate and/or speed up the utilization of alternative fuels
- Statistics of current utilization of alternative fuels, energy/fuel use for heavy traffic and working machinery in general.

The online survey was published in Finnish, Swedish and Norwegian. The invitation for the survey and later a reminder message was sent by e-mail to 68 different organizations. Invitations were originally sent by ELY Center of Lapland in Finland, Trafikverket in Sweden and by Ramboll in Norway.

Later more invitations were sent to 10 more organizations by Ramboll both in Finland and Sweden. In addition to this activation was conducted by calling the potential respondents by phone and asking them to answer the online survey. All together 22 organizations were contacted by phone in Finland and 18 in Sweden. Organizations and the personnel receiving the invitation were hand-picked to match the requirements set by the steering group of the project.

Eventually 21 answers were received. Distribution of online survey answers is presented in Table 1.

Table 1. Distribution of online survey answers.

Country	Mining	Wood harvesting	Ports	Transport logistics (road transport)	Road building and maintenance	Public transport (busses)
Finland		2	2	5	2	1
Sweden	1	3		1		2
Norway				1	1	

To deepen the views acquired with the online survey also some theme interviews were conducted, 4 in Finland, 4 in Sweden and 3 in Norway. In the interviews the interviewees were allowed to freely describe the current alternative fuel use and its future prospects with their own words. Distribution of conducted interviews is presented in Table 2.

Table 2. Distribution of conducted interviews.

Country	Mining	Wood harvesting	Ports	Transport logistics (road transport)	Road building and maintenance	Public transport (busses)
Finland	1	1		1	1	
Sweden	2		1	1		
Norway	2				1	

1.3 TEN-T Network and AFI Regulation

TEN-T (Trans-European Network, Transport, Figure 2) is a European Union project for developing a network of important traffic routes in Europe. The Trans-European Transport Network (TEN-T) policy addresses the implementation and development of a Europe-wide network of railway lines, roads, inland waterways, maritime shipping routes, ports, airports, and railroad terminals. *(European Union, 2021)* The TEN-T regulatory reform for the development of the European-wide transport network applies also to a small part of the Western Barents region.

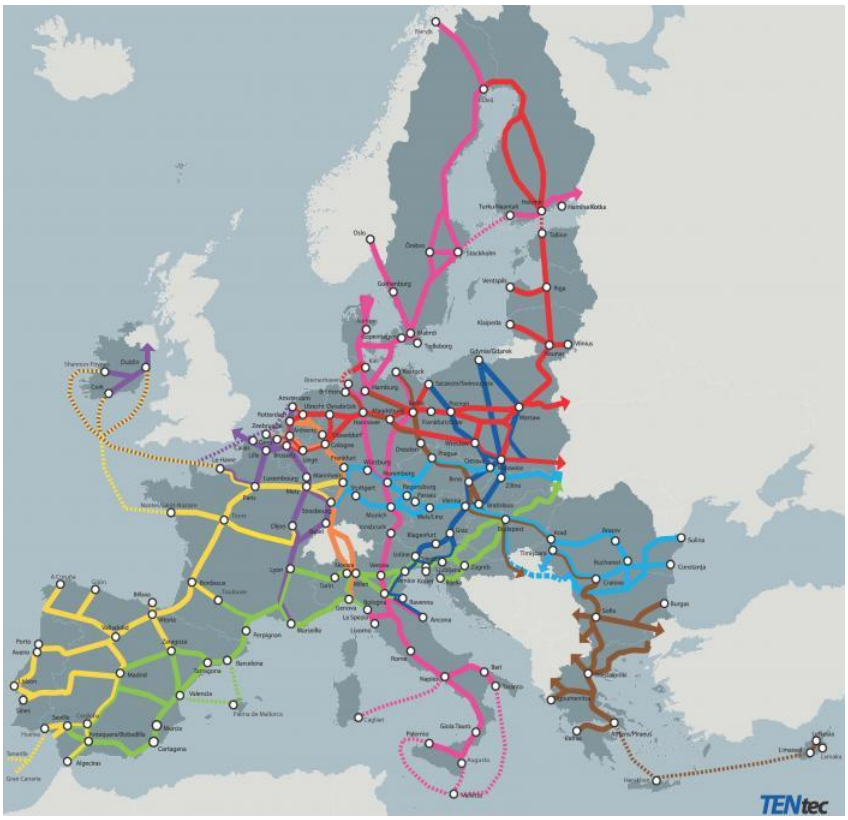

Figure 2. Map of Core Trans-European Transport Network (TEN-T core network). *(European Union, 2021)*

The goal of the TEN-T network is a safe and sustainable EU transport system that promotes the seamless movement of goods and people. The TEN-T guidelines define the projects included in the transport network. The guidelines specify the requirements set for the transport network, development priorities and implementation tools.

In terms of transport networks and their financing, the starting point for the national transport system plan is, in addition to the Main Roads Regulation, the Trans-European Transport Networks (TEN-T) and the Regulation on the Connecting Europe Facility. At the EU level, provisions have also been made on, among other things, traffic emissions, traffic safety, intelligent traffic systems, the provision of transport services, the accessibility, exchange and management of information, as well as the digitization of transport and logistics. (Valtioneuvosto, 2021)

The proposal for regulation on the implementation of alternative fuels infrastructure, i.e. the AFI regulation proposal presents binding national minimum requirements for road vehicles, sea and inland water vessels, and aircraft for the charging and refueling infrastructure of alternative fuels. The proposal mainly concerns public infrastructure to be built along the Trans-European Transport Network (TEN-T), i.e. charging and refueling stations, to which everyone has free access. (European Union, 2021)

The goals of the electric charging infrastructure for heavy commercial vehicles are defined in the AFIR requirements. It is defined that along the TEN-T core network there must be a pool of 1 400 kW output power and a high-power charging point (350 kW) at a maximum interval of 60 kilometers for the use of heavy commercial vehicles by the end of 2025 (in the comprehensive network the same power by 2030 but every 100 km). On year 2030 the requirement for the TEN-T core network is 3 500 kW pool every 60 km. The TEN-T comprehensive network is required to have 3 500 kW pools by the end of 2035. The power requirement is to both directions of the road separately. From the electricity network perspective, it is needed double the power defined in the regulation. The AFIR regulation defines also that hydrogen refueling stations are to be made available along the TEN-T core network and comprehensive network every 150 km by 2030. 19.10.2022 published suggestion for update of AFIR included increase of electric powers of the charging pools from 1 400 kW to 2 000 kW and 3 500 kW to 5 000 kW. The update suggestion includes also possibility for the TEN-T comprehensive network to combine the charging pools of the two directions of the road if there is not very much traffic and the charging pool can be reached easily from both directions. The update suggestion is most likely still changing before the update is entering into force. Neighboring Member States must ensure that the maximum distances are not exceeded by cross-border sections of the TEN-T core network and the comprehensive TEN-T network. (European Union, 2021)

2. Finland

Finnish part of the Barents region consists of four regions, Lapland, Northern Ostrobothnia, Kainuu and North Karelia. Total population of the Barents region in Finland is about 825 000 inhabitants of which about half live in Northern Ostrobothnia. The Finnish part of the Barents region is sparsely populated area with long distances. Biggest cities are Oulu (Northern Ostrobothnia), Joensuu (North Karelia), Rovaniemi (Lapland) and Kajaani (Kainuu). *(Ministry of Foreign Affairs of Finland, 2023; Statistics Finland, 2023)*

2.1 The TEN-T Network in Finland

Climate targets for transport are getting stricter. In the Finnish government program (06/2019), it was outlined that Finland must be carbon neutral in 2035, when also the transport emission reduction must meet this goal. The situation of other means of reducing emissions in transport also supports the tightening of the targets for alternative fuels. *(Liikenne- ja viestintäministeriö, 2020)*

Europe's comprehensive transport network TEN-T connects different regions of Europe, and it connects Finland to the rest of Europe's transport network. The TEN-T transport network consists of two levels:

1. the core network consisting of the most important connections and nodes, and
2. the comprehensive network.

The goal of the TEN-T network is a safe and sustainable EU transport system that promotes the seamless movement of goods and people. *(Valtioneuvosto, 2021)*

On the Finnish side of the Barents region the TEN-T core network of roads runs along the western coast via Oulu to Tornio. Biggest part of Lapland, Kainuu and North Karelia are not covered by the core road network in the AFI regulation. *(European Comission, 2022)*

According to the EU's decision, the ports of Kemi, Oulu and Raahe are included in the comprehensive network (Figure 3) in the Barents region. Tornio port is planned to be added to the comprehensive network. The railway networks run from Joensuu via Kuopio to Kajaani, from Oulu to Kajaani and to Rovaniemi. No railway terminals are located in the Barents region of Finland. The comprehensive network also includes road networks from Joensuu via Kuopio to Kajaani and Kuusamo, from Oulu to north and south of Kainuu, and in Lapland from Kemi via Rovaniemi to Ivalo and Norway. *(Traficom, 2022)*

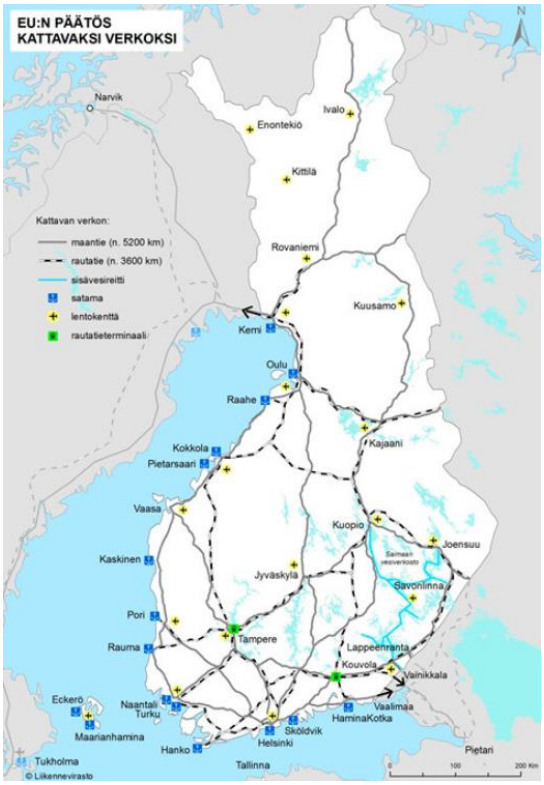

Figure 3. The EU's decision on the comprehensive TEN-T network in Finland. *(Traficom, 2022)*

2.2 Utilization of alternative fuels

The charging and refuelling infrastructure of alternative fuels is regulated in the Regulation of the European Parliament and the Council on the introduction of alternative fuel infrastructure in directive 2014/94/EU.

In Finland, the charging and refuelling infrastructure for alternative fuels directive has been implemented by the law on 'the distribution of alternative fuels used in traffic' (478/2017).

2.2.1 Current state

Working machines

Working machines used in infrastructure and building construction projects produce a significant part of carbon dioxide emissions outside of emissions trading. In recent years, public buyers have implemented the environmental requirements for equipment. In terms of the EU's emission reduction targets, the machines belong to the so-called burden sharing sector, which is outside the emissions trading system. There is no register information available on the quantities and characteristics of the machines. *(Väylävirasto, 2021)*

Emissions from trucks and mobile machinery are regulated on the EU level. Trucks are classified with Euro classes and working machines with Stage classifications, which limit the emissions, particles and smoke. Emission classes have certain inception year for the first registration. The latest emission regulation for engines of working machines is based on regulation (EU) 2016/1628 and the latest Euro VI class for trucks is based on regulation (EC) 595/2009. *(Väylävirasto, 2021)*

According to the survey conducted in spring 2021, majority of the Finnish working machines were Stage IV (inception year 2006). For trucks, the dispersion was slightly larger, and there are relatively old Euro III (inception year 2001) class trucks still in use. An increasing proportion of the equipment of machine rental companies already meets the Stage IV and V emission class requirements, as the reliability of the rental machines is primarily guaranteed by using new machines. There are more old machines used in infrastructure work than in the rest of the construction industry, especially in paving and track construction, where old equipment is used. The special machines

on the track side are expensive to renew. In addition, performance of special machines is small and thus also the total amount of emissions per working contract is small. *(Väylävirasto, 2021)*

Trucks, buses and vans

At the end of the 4th quarter of 2022, there were a total of 14 827 trucks, 1 714 buses and 58 360 vans in traffic use in the Barents region in Finland (Table 3). 98,0 % of the trucks were diesel-powered and 1,6 % petrol-powered. *(Traficom - Finnish Transport and Communications Agency, 2023)*

Table 3. Trucks registered in the Barents region in Finland at the end of the 4th quarter of 2022. (Traficom - Finnish Transport and Communications Agency, 2023)

Trucks	North Karelia	Northern Ostrobothnia	Kainuu	Lapland	Total
Petrol	41	110	24	65	240
Diesel	2571	6491	1319	4144	14525
Fuel oil	2	2	1	1	6
Electricity	1	-	-	-	1
CNG	1	15	-	1	17
Bensiini/CNG	-	5	-	-	5
Petrol/Ethanol	-	6	1	4	11
LNG	-	5	-	3	8
Diesel/LNG	2	2	4	-	8
Other	6	-	-	-	6
Total	**2624**	**6636**	**1349**	**4218**	**14827**

Table 4 illustrates the fuel used by the buses registered in the Barents region in Finland at the end of the 4th quarter of 2022. There is no charging infrastructure for electric buses in the Finnish Barents region. The infrastructure is currently concentrated only in the capital region of Finland. At the end of the 4th quarter of 2022 99,5 % of the buses in the Finnish part of the Barents region were diesel-powered. There were 5 gasoline-powered buses, 1 gas-powered and 3 natural gas-powered buses. *(Liikenne- ja viestintäministeriö, 2022; Traficom - Finnish Transport and Communications Agency, 2023)*

Table 4. Buses registered in the Finnish part of the Barents region at the end of the 4th quarter of 2022 *(Liikenne- ja viestintäministeriö, 2022).*

Buses	North Karelia	Northern Ostrobothnia	Kainuu	Lapland	Total
Petrol	1	2	-	2	5
Diesel	250	807	83	565	1705
Gas	-	1	-	-	1
CNG	-	3	-	-	3
Total	**251**	**813**	**83**	**567**	**1714**

Table 5 illustrates vans registered in the Finnish part of the Barents region at the end of the 4th quarter of 2022. 99,6 % of the vans were still powered by petrol and diesel. The number of electricity-powered vans has increased lately but they still represent only 0,2 % of the whole fleet.

Table 5. Vans registered in the Finnish part of the Barents region at the end of the 4th quarter of 2022 (Liikenne- ja viestintäministeriö, 2022).

Vans	North Karelia	Northern Ostrobothnia	Kainuu	Lapland	Total
Petrol	219	348	74	233	874
Diesel	11068	25125	5770	15295	57258
Electricity	46	53	5	39	143
CNG	4	30	1	2	37
Petrol/wood	-	1	-	-	1
Petrol/CNG	2	13	1	1	17
Petrol/electricity (plug-in hybrid)	2	7	1	10	20
Petrol/ethanol	-	-	1	-	1
Diesel/CNG	1	1	-	-	2
Diesel/electricity (plug-in hybrid)	1	2	1	3	7
Total	**11343**	**25580**	**5854**	**15583**	**58360**

Charging infrastructure in the Finnish part of the Barents region is presented in Table 6. Table does not show 22 kW business charging points, because distances traveled in Lapland are generally longer than elsewhere in Finland. This emphasizes the need for fast and high-power charging, as 22 kW charging power is not sufficient for charging a fully electric car on the road. *(Kotkansalo A., 2021)*

Table 6. Charging network by province in Q3/2022 *(Sähköinen liikenne, 2022)*.

Province	Fast Charging under 100 kW				High Power Charging over 100 kW			
	CHAdeMO		CCS		CCS		Tesla Supercharger	
	Location	Number of points	Location	Number of points	Location	Number of points	Location	Number of points
Kainuu	9	10	6	9	10	37		
Lapland	20	26	21	31	25	61	1	4
North Karelia	12	13	8	9	7	19		
Northern Ostrobothnia	29	32	26	33	17	62	1	4
Total	**70**	**81**	**61**	**82**	**59**	**179**	**2**	**8**

Northern Finland is characterized by a diverse range of livelihoods and long distances, which emphasize the importance of the functionality of travel, mining industry and transport chains. Seasonal changes affect the number of users of the transport system. The good condition of the road network and meeting the needs of the export industry is essential. For long transport distances, HCT (High-Capacity Transport, HCT) vehicles are more efficient than standard size trucks, but the proliferation of HCT vehicles requires infrastructure investments in road bottlenecks. *(Valtioneuvosto, 2021), (Vasara, Tie vähähiiliseen liikenteeseen, 2020)*

Regional conditions

Eastern Finland is characterized by taking into account the connections between residential centers, emphasizing the importance of international transport connections, especially in transport chains (road and rail connections to Russia and further to Asia, as well as commercial shipping through the Saimaa Canal and direct international air transport connections), long-distance travel and transport chains relying on rail transport, and the importance of heavy industry. *(Valtioneuvosto, 2021)*

There is concern about the condition of the lower-level road network in North Karelia, Lapland, and Kainuu. In North Karelia, the transportation system relies heavily on private car usage outside of Joensuu due to long distances, scattered settlements, and numerous waterways. Similarly, in sparsely populated North Ostrobothnia, long distances increase reliance on private car traffic and hinder the organization of public transportation. Lapland, North Ostrobothnia, and North Karelia all experience weak public transportation connections outside of urban centers. In Lapland, logistics face challenges due to long distances and the deterioration of road infrastructure. In North Karelia, maintaining and reducing the backlog in the transportation network, including the lower-level road network, is important for the forest industry. The growth of mining in Lapland requires investments in road connections to the mines and the deepening of the Kemi seaway. In Kainuu, improving the condition and coverage of the road network, along with continuous maintenance, is crucial for internal accessibility within the region. In North Ostrobothnia, the population growth in the Oulu region increases the pressure to develop sustainable urban structures and transportation systems, highlighting the importance of eliminating bottlenecks in the core network (National Road 4, Ostrobothnia railway). *(Liikennevirasto, 2018)*

Fuel regulation according to the distribution laws

Sustainability in freight transport has improved with the development of vehicle technologies, when there has been a shift to low-emission vehicles. The environmental harm caused by traffic has decreased and the risk of major accidents has decreased. The aim is to increase the number of energy-efficient and low-emission working machines through public procurement. *(Valtioneuvosto, 2021), (Väylävirasto, 2021)*

Emissions from transport and construction equipment are affected by fuel regulation at the EU level. In particular, carbon dioxide emissions are significantly affected by biofuel distribution obligations. *(Väylävirasto, 2021)*

According to the distribution obligation laws (2019/418 and 2007/446), fuel distributors have an obligation to put on the market annually increasing portions of transport biofuels and biofuel oil. If there is no demand for biofuels sold separately, distributors will have to raise the mixing ratio to meet the requirements of the legislation. *(Väylävirasto, 2021)*

The Government has decided to lower the distribution obligation to 12 percent by 2022 due to high fuel prices, as well as to relax the regulations regarding overages. The distribution obligation has been set to gradually increase so that in 2029 and thereafter, the energy content of biofuels must be at least 30% of the total energy content of motor gasoline, diesel oil and biofuels delivered by the distributor for consumption. *(Työ- ja elinkeinoministeriö, 2022)*

The required mixing ratios between the year 2021 and 2030 are presented in the Table 7.

Table 7. Transportation biofuels and biofuel oil distribution obligations, share of the total energy content of the fuels delivered for distribution. *(Väylävirasto, 2021)*

Year	Transport biofuels	Biofuel oil
2021	18,0 %	3,0 %
2022	19,5 %	4,0 %
2023	21,0 %	5,0 %
2024	22,5 %	6,0 %
2025	24,0 %	7,0 %
2026	25,5 %	8,0 %
2027	27,0 %	9,0 %
2028	28,5 %	10,0 %
2029	30,0 %	10,0 %
2030	30,0 %	10,0 %

In the national distribution infrastructure program for alternative means of transport, the goal was set that in 2030, all fuel distribution stations would have a high-blend biofuel in their product range (such as 100% renewable diesel, high-blend ethanol E85 or ethanol diesel ED95). E20/25 motor gasoline would be the dominant quality, for example. *(Liikenne- ja viestintäministeriö, 2020)*

The use of alternative fuels

According to previous studies, users of heavy vehicles and working machinery have experience with alternative fuels, mainly liquid biofuels such as HVO (Hydrotreated Vegetable Oil) diesel and fuel oil. Other well-known alternative fuels were electricity and bio or natural gas. The higher price of renewable fuels cause additional costs that can be priced into contracts. *(Väylävirasto, 2021)*

According to previous studies, companies had little or no experience with the use of electric working machines. Larger (mainly) electric equipment were not yet seen as realistic for the sites of the Norwegian Railway Agency or ELY centers. The number of electric machines will increase in the future, especially for small machines. On the other hand, in the interviews attached to the survey, it was estimated that there will not be a sufficient supply of electricity powered machines in the next few years. *(Väylävirasto, 2021)*

Machines that perform significant work, such as tracked and wheeled excavators, are relatively new in companies, regardless of the environmental impact. The machines are renewed regularly, as their utilization rate is high, and reliability is required in operation. The service life of the machines is long because the machines are sold on or kept as spare equipment. *(Väylävirasto, 2021)*

According to the conducted online survey and interviews of this survey the current use of alternative fuels is still low in the Finnish part of the Barents region. The organizations that reported use of alternative fuels still showed very little use compared to the fuel use in total, usually 0–10 %. HVO diesel was the most common used alternative fuel in heavy traffic. In addition to HVO diesel the use of electrical working machinery was also emphasized in the online survey answers. Electrical working machines are more commonly used in sites like factory areas and ports where moving long distances is not required and charging is easy to handle. For example, electrical machines are currently not used in wood harvesting according to the online survey and interviews.

Reaching the organization’s environmental goals was mentioned most often as the reason for the use of alternative fuels. Interviewees also emphasized that current use of alternative fuels depends a lot on the client’s requirements.

Availability of fuels

Public charging facilities in Finland are not geographically evenly distributed, but the vast majority have been built where most of the traffic is currently located. The charging infrastructure for electric buses is currently only concentrated in the capital region of Finland. *(Liikenne- ja viestintäministeriö, 2020)*

The network of biodiesel and bioethanol distribution stations built based on market conditions does not cover the eastern and northern part of the Finnish Barents region. In Lapland, the availability of biodiesel and bioethanol is limited to Rovaniemi. The distribution network of these biofuels does not reach the northeastern part of Northern Ostrobothnia. In Kainuu, the distribution network is concentrated in Kajaani, leaving out a large part of Kainuu. *(Liikenne- ja viestintäministeriö, 2020)*

According to the interviews done in the Finnish Transport Infrastructure Agency's report the availability of Neste HVO diesel is good only in large cities. Delivery of HVO diesel and fuel oil to the north requires a large order at once, and there is no normal distribution yet. Delimitation of the delivery area makes it difficult to demand renewable fuel in most of the country. *(Väylävirasto, 2021)*

Regarding the gaseous fuels, there is only one LNG terminal in the Finnish Barents region, in Tornio. There are 7 distribution points suitable for compressed gas CNG/CBG trucks in the Finnish Barents region. Of them the northernmost is located in Oulu. There is also only 1 distribution point suitable for liquefied gas LNG/LBG trucks in the Finnish Barents region, located in Oulu. *(European Union, 2021), (Gasum, 2022)*

In Finland's inland shipping, there are no alternative fuels available alongside fossil fuels. Currently, shore electricity is not available for ships in Finland's inland ports due to economic unprofitability. *(European Union, 2021)*

According to the online survey results if this survey in the Barents region HVO diesel had the best availability of the alternative fuels for heavy traffic and working machinery. Especially the respondents operating in ports, road building and maintenance agreed most with the claim that availability of HVO diesel is good from their organization’s perspective. However, it was also stated by a road building and maintenance company representative that

when the clients really start requiring the use of biofuels the demand will quickly exceed production volumes of HVO diesel while raw materials being the limiting factor.

2.2.2 Future prospects

In the Finnish distribution infrastructure program, the goal is to build a electricity distribution network for traffic use in Finland. The distribution network is supposed to meet the recommendations of the distribution infrastructure directive and to be built by 2020/2030. In proportion to the number of electric cars, this would mean at least 25 000 public charging points by 2030. No separate goals have been set for the charging infrastructure for heavy equipment. *(Liikenne- ja viestintäministeriö, 2020)*

Instead of one alternative fuel, the energy demand of the traffic could possibly be replaced with several different alternative fuels. For heavy trucks, in addition to electricity, other alternative biofuels are needed and their availability and distribution need to be secured. *(Liikenne- ja viestintäministeriö, 2020)*

In the development of the transport system, it is necessary to take into account, for example, the increasing use of alternative fuels and developing means of transport and technology in all modes of transport. Adapting to climate change also requires transport system operators, for example, to raise awareness of weather and climate risks. *(Valtioneuvosto, 2021)*

The vision for 2030 is that Lapland's network of charging stations will serve the needs of users throughout the province of Lapland. The goal is that charging point technologies offer a sufficient range of charging plug types to charge all vehicles, public charging stations geographically offer the possibility to charge electric cars in the entire region of Lapland, and the permit process for the implementation of charging stations is smooth and uniform throughout the entire region of Lapland. *(Kotkansalo A., 2021)*

In the future, hydrogen's role as an enabler of long-distance emission-free driving of heavy vehicles will require investments also in places where there is otherwise little traffic. *(European Union, 2021)*

The Bothnian Bay area has producers of carbon neutral steel, fuels and chemicals. The area inherently features industries for using renewable electricity, hydrogen and biobased CO_2 for sustainable methanol production. The area's wind power potential is sufficient to cover carbon-free steel production even in the peak estimate, in which case a significant part of the bio-based CO_2 emissions could be converted into e-fuels or chemicals with the remaining power capacity. Compared to electricity as a fuel, hydrogen fueled transportation is still in a very different life cycle phase, which makes electricity a safer option as an alternative fuel, at least from the risk management point of view. *(LUT School of Energy Systems, 2021)*

Regulation

The Euro classes set for trucks regulate emissions, but the emission classes do not reduce emissions linearly. Different levels of new emission limits have been introduced in different classes. With the distribution obligation, distributors have an incentive to sell biofuels also separately distributed, which can improve the availability of fuels in the future. *(Väylävirasto, 2021)*

It is estimated that diesel will still be used in heavy traffic at least in the 2020s and in buses until 2050. In lighter transports (from 3.5 t), electric and hybrid options are becoming more common earlier. The industry would be ready to use significantly more renewable diesel if logistics customers and biofuel producers would participate in cooperation and the availability and cost issues could be solved. *(Vasara, Tie vähähiiliseen liikenteeseen, 2020)*

Due to the Distribution Obligation Act, the share of renewable fuels will increase until 2030. It is estimated that the bio-share in diesel is 43,3 % in 2029 and ethanol mixing ratio in gasoline is assumed to be 6,84 % after 2029. *(Vasara, Tie vähähiiliseen liikenteeseen, 2020)*

TEN-T core network

The electrification of the train line between Kemi and Haaparanta connects Finland's railway network more closely than before to the Swedish railway network and further to Narvik in Norway. The project improves the cost-effectiveness of rail transport and the competitiveness of industry, strengthens the usability and functionality of land transport connections between Finland and Sweden as part of the TEN-T core network, and opens up potential for traffic. The connection enables, among other things, more comprehensive transport connections from Narvik to China with the developing container train traffic. However, the different track width between Finland and Sweden poses a significant challenge for cost-effective rail transport. (Valtioneuvosto, 2021)

Heavy traffic and working machines

The market of electrical working machines is expected to developed considerably from the current situation, where there is little suitable equipment, and the requirement of fossil-free fuels would mainly lead to a significant use of HVO diesel. *(Väylävirasto, 2021)*

The goal is that all new construction sites could be implemented fossil-free starting from 2030, when the permitted fuels for working machines and cars would be electricity, biogas, hydrogen and liquid biofuels. The goal for 2030 on selected sites is to increase the share of electricity, biogas and hydrogen-powered machines up to 20%. *(Väylävirasto, 2021)*

According to a survey conducted in the spring of 2021, there are not many obstacles to the use of biofuels for working machines. In almost all categories, there are machines for which the manufacturer has already officially approved biofuel use. Even small equipment can be largely used with renewable diesel. *(Väylävirasto, 2021)*

In terms of the promotion of alternative fuels, the fact that gasoline-powered machines have been tried to be replaced by electric and bio-oil-powered working machines in recent years can also be considered a potentially positive development. So far, there is no fossil-free drop-in fuel comparable to HVO diesel available for gasoline-powered machines. *(Väylävirasto, 2021)*

Future prospects were also brought up in the online survey and interview answers of this survey. According to the online survey results, the future targets of increasing the use of alternative fuels both in respondent's own organization and in the industry in general are mostly related to HVO diesel and electricity. This applies for both heavy traffic and working machinery. However, for working machinery electricity seems to play even bigger role than HVO diesel in the future.

In the interviews, the representatives of all organizations (mining, wood harvesting, transport logistics, road building and maintenance) showed clear interest in increasing the use of alternative fuels. Concrete plans of acquiring electrical machinery (cranes, forklifts) to the ports and LNG and electricity powered trucks to the transport logistics companies were mentioned as examples of the future progress. Larger plans of electrifying transport logistics and public transport sectors – especially urban traffic – were also mentioned.

In the interviews the following actions and future plans were described:

> Interviewed forestry company representative mentioned that they are willing to include usage of biodiesel in the contracts for wood harvesting subcontractors if they show interest in it. However, it's not required so far. In the forestry work biofuels are seen currently as the only viable solution. In wood terminals and production sites electrical wood handling machines are already commonly used and their usage is expected to grow heavily in the future. In the forestry related heavy traffic HVO diesel and biogas are currently used and the usage is expected to grow.
>
> Interviewed representatives of a large road building and maintenance company mentioned that one gas powered light road maintenance truck and several electrical vans are acquired by the company. More electrical vans and one small electrical truck will be acquired in the near future. In addition, all the company cars that can use renewable fuel already use it. Company has also developed an HVO diesel concept with a fuel supplier. In the concept the supplier delivers HVO diesel to the construction site in tanks. The concept is ready to be used in the whole Finland. The company is expecting to use HVO diesel in at least two projects this year. The target is to use over one million litres of HVO diesel this year. Company has also a plan for electrifying its whole fleet but will the plan be executed is not yet known.

Interviewed representative of a mining transport logistics operator told in the interview that the company is interested in electric powered working machinery (earth moving machines etc.) but there are still some things to be clarified, like fire risks related to electric powered machinery when working underground. Clients (mining companies) steer the use of alternative fuels and the progress regarding environmental issues in general. At the moment transport logistics operator is preparing for the future requirements. From the transport logistics operator's perspective cutting down the emissions is also a question of which kind of (safe) machinery is available. This is the case especially when mining is executed by tunnel excavation (not opencast mine).

Opportunities

Moving to 100 percent use of renewable diesel in heavy vehicles is a good opportunity for the truck fleet in Finland. In the coming years, the biodiesel and bioethanol distribution network will develop according to market conditions, according to demand, both for the distribution of HVO100 renewable diesel and E85 and ED95 fuels, according to demand. (Liikenne- ja viestintäministeriö, 2020)

Forecasting the development of hydrogen use is very difficult, because the production of heavy-duty hydrogen vehicles is about to begin. When the refueling infrastructure is in place, it can be assumed that the import of hydrogen trucks can begin. *(European Union, 2021)*

In addition to alternative fuels, it is worth considering new innovations, such as replaceable electric batteries. NIO, the smart electric car producer, designer and seller from China, has prepared battery exchange stations for trucks. With battery swapping infrastructure and compatible electric cars, long-distance travel should be possible at the same speed as in the case of combustion engine cars. NIO's replaceable battery pack is located behind the truck cab. The battery weighs 3.2 tons and has a capacity of 280 kWh. The battery gives truck a range of about 150-200 km with electricity. Changing the battery to a new one should take about five minutes. *(Insideevs, 2022)*

The purchase subsidy for heavy trucks lowers the purchase threshold but requires parallel measures to get the logistics chains electrified as a whole. A purposeful heavy transport electrification package gathers vehicle procurement, charging infrastructure and logistics operations into a competitive entity and transfers a significant number of transports to electric at once. *(Teknologiateollisuus, 2022)*

When switching to alternative power sources, the alternatives should be economically viable and attractive to companies, municipalities, and consumers. Through alternative fuels, low-emission technical solutions develop and become more common. Incentives are needed to switch to low-emission solutions. The total cost level of transportation and logistics should be kept as low as possible. In climate actions, all means should be taken into account. With the tax reform, we also have to invest in easily accessible and new types of digital services.

One industrial sector with huge potential for electric working machines is mining industry. By electrifying the working machines operating in mines it is not only possible to cut down emissions but to save in ventilation costs too. Cost savings apply especially to cases in which new mines are started. A Swedish company Sandvik for example is manufacturing electric working machines for mining in Finland. *(Tekniikka ja talous, 2022; Suomen Tieyhdistys ry, 2023; Sandvik AB, 2023)*

Also in wood harvesting, electrification of working machinery is seen as a solution in cutting down emissions. As an example of the latest development, a Finnish forestry machine manufacturer Ponsse has published a technical concept (not yet on market) of an electric forestry machine (forwarder). At this phase the batteries are still charged with a combustion engine, but the fully electric power line enables the use emission free energy sources in the future. *(Ponsse, 2022; Yle, 2022)*

Based on the online survey and the interviews conducted in this survey, emission reduction by increasing the use of alternative fuels is also seen as an opportunity to improve organizations' reputation. Some operators also named cost savings as a potential opportunity following the use of alternative fuels. However, profitability and additional costs were also seen as factors limiting the use of alternative fuels currently.

Limitations

Trucks

The proliferation of alternative biofuels in the western Barents region is a challenge due to long distances and market-based development. The AFIR requirements emphasize the importance of the centralization of charging points and stations. In sparsely populated Finland charging stations often do not form an entity meeting the power requirements of AFIR's pool so far. *(European Union, 2021)*

However, the AFIR requirements do not specify in more detail how big/large heavy vehicle must be used to reach the charging point. In general, one could assume that the driving connections of such a charging point intended for heavy equipment and the parking square at the charging point should be suitable for typical trucks. *(European Union, 2021)*

The Euro VI class requirements for trucks are ambitious. According to the sources, the moderate emission class requirements do not significantly increase the cost level. A more significant increase in costs can only be seen with the introduction of alternative fuels, especially electricity. *(Väylävirasto, 2021)*

Ports

The AFI regulation proposal obliges ports to provide shore power for container and passenger ships that stay in a seaport for at least two hours or that do not use another zero-emission energy source while in port. *(European Union, 2021)*

Onshore electricity investments are not currently financially viable for ports. If the provision of shore electricity becomes mandatory for the ports of the TEN-T network, it is important that ships also have the obligation to use shore electricity while at the berth. *(European Union, 2021)*

The obligations of the AFI regulation proposal for ports to provide shore electricity are planned in the FuelEU Maritime regulation proposal for shore electricity use obligations. In the supply of shore electricity in ports, it is essential that the supply is sufficient in relation to the demand and that the connections are suitable for the ships visiting the ports. To ensure sufficient supply, possible investment needs in the electricity grid must also be taken into account. From the point of view of Finnish ports, the financial profitability of onshore electricity investments must be ensured as the case proceeds, for example by securing sufficient CEF funding for the ports' onshore electricity investments. *(European Union, 2021)*

Working machines

In the purchase prices of individual machines, the difference can be, for example, double, but in the final costs of machine work, the differences remain smaller due to, for example, lower fuel costs. So far, however, the availability of electric equipment suitable for infrastructure construction is limited, and therefore the real cost effects can only be assessed after several years. The effects of the emission class requirements affect the increase in the use of fossil-free fuels, calculated carbon dioxide emission reductions, and bring socio-economic benefits. *(Väylävirasto, 2021)*

Fuel infrastructure

In the Finnish distribution infrastructure program for alternative means of transport, the goal was set to have a total of approximately 20 hydrogen refueling stations in Finland in 2030, so that the distance from station to station would be approximately 300 km and the radius of influence of each station 150 km. The stations would cover all major cities. *(Liikenne- ja viestintäministeriö, 2020)*

In addition, the goal has been set that in 2030, all fuel distribution stations will have a high-blend biofuel in their product range (such as 100% renewable diesel, high-blend ethanol E85 or ethanol diesel ED95). E20/25 motor gasoline would be the dominant quality, for example. *(Liikenne- ja viestintäministeriö, 2020)*

The municipality of Inari states in its statement that the municipality has been legally assigned obligations for the coming years, the implementation of which is not possible with the current technology. School transports can be up to 260 kilometers, in which case the battery capacity of an electric bus is not sufficient, when in winter the frost drops to under -45 ˚C in some places. The same challenge also applies to business traffic, where the distances are even longer, but not so strictly tied to the schedule. *(Inari, 2022)*

According to the online survey results the most relevant factors limiting the use of alternative fuels are their availability and lack of suitable technological solutions or the (physical) machinery/equipment. Profitability of the use of alternative fuels was also still seen as an issue.

The availability of all the alternative fuels except HVO diesel was considered low in the Finnish Barents region by the online survey respondents. In the interviews the opinions about alternative fuel availability were mainly related to HVO diesel. Its availability was considered good, meaning that the HVO diesel can be bought from many locations. However, the representatives of a road building and maintenance company stated that as soon as demand really starts to grow there will be shortage of HVO diesel due to shortage of raw materials. Some good experiences about use of LNG/LBG were reported though currently the only gas filling station in the Finnish part of Barents region is located in Oulu.

Lack of suitable technological solutions was brought up in the interviews by forestry operators (wood harvesting), a mining transport logistics operator and a road transport logistics operator. For all of them biofuels such as HVO diesel and LBG seemed currently the only suitable option to increase the use of alternative fuels. Electrical equipment seemed interesting for mining and road transport logistics operators but their characteristics didn't meet the needs in ability to carry big enough masses (road transport) and needs in safety (mining). For harvesting and forwarding logs electricity powered vehicles seemed still very distant due to lack of existing equipment and poor or non-existing charging possibilities. The poor availability of suitable equipment causes also long delivery times of alternative fuel-using vehicles. Representatives of a road building and maintenance company stated that this is the situation with electrical vans and light trucks at the moment.

In the interviews one strongly brought up view was that use of alternative fuels depends mainly on the customer's interests. If fossil free fuels are required by the client and they are willing to pay the additional fuel cost, it's easy for the contractors to choose HVO diesel instead of fossil diesel. Otherwise use of non-fossil fuels is usually not an option due to their higher price. One interviewee stated that the clients are more interested in alternative fuel use when they are located closer to the customer side in the supply chain.

Usage potential

The rise in costs weakens operators' willingness to invest and their ability to renew. Measures that increase the costs of companies, such as tax increases, are not necessary to reduce emissions. Excessive national lock-in to a certain technology is a risk, as the global automotive industry and the industry as a whole are undergoing a rapid change. *(Vasara, Tie vähähiiliseen liikenteeseen, 2020)*

A prerequisite for the wider popularity and continued growth of hydrogen use is that hydrogen would be a better or cheaper solution than battery electricity for a large part of users. In the case of hydrogen buses and heavy equipment, it is possible (departing from the basic forecast) that when distribution infrastructure and vehicles for sale start to be available and traffic starts to be cost-effective, the vehicle fleet will also start to grow, which could happen around in the middle of the decade. *(European Union, 2021)*

According to the online survey results the respondents considered the highest increase potential of alternative fuels for electricity and HVO diesel. However, the potentials for hydrogen and LNG were seen as relatively large too. The interviewees considered HVO diesel as a fast solution to start decreasing CO_2 emissions with current equipment. Electrification of fleet was seen as a suitable solution already for lighter vehicles and working machinery operating in small areas like factory areas. Still, in the future electrical equipment is expected to be in operation in heavy traffic and distant areas too. Interest towards hydrogen was clear but the topic seemed still rather distant from the contractors' point of view.

2.3 Natural gas, LNG, hydrogen user network in Northern Finland

Little information about current user network for natural gas, LNG or hydrogen was found during the surveying. There is no gas pipe network of natural gas or hydrogen in the Finnish part of the Barents region currently. *(Gasgrid Finland, 2023)* And according to the conducted online survey, interviews and other surveying *(Gasum, 2022)* the only filling station in the region for LNG/LBG for heavy traffic is located in Oulu. Some companies reported use of biogas/natural gas in their trucks. No hydrogen users were recognized in the Finnish part of the Barents region.

The port of Tornio has been featured in discussions on expanding the TEN-T network. LNG refueling points consisting of moving equipment, i.e. LNG bunkering, are expected to be expanded to the port of Oulu with the expansion of the TEN-T network. The share of LNG as an alternative fuel for gas trucks can be assumed to grow in the Sea-Lapland region in the coming years. *(European Union, 2021)*

In Finland, the distances are long, and the TEN-T network has a significant number of sections to which, due to the low traffic density, the most cost-effective way to deliver hydrogen is road transport, despite the high unit costs. However, this also strongly depends on other demand, i.e. the needs of industry in terms of hydrogen distribution. *(European Union, 2021)*

The AFI Regulation proposal proposes requirements for shore-based electricity and liquefied gas used by ships. Shore electricity is currently available in the Barents region from the seaports of the TENT-T comprehensive network in Oulu and Kemi for Ro-Ro vessels (6.6kV, 50Hz). (*European Union, 2021)*

3. Sweden

The Barents region of Sweden includes the two most northern county's Norrbotten and Västerbotten. The most populated areas in Västerbotten are Umeå and Skellefteå and in Norrbotten are Luleå, Piteå and Boden. This part of Sweden is currently the place to be for the large industry expansions. The industrial hold on the area has previously been dominated by the mining and steel industry but other sectors are now moving further up north, mainly related to the green industrial transition *(Karjunen, o.a., 2021)*. This region is favorable for large industries because of the supply of cheap and renewable electricity, the available amount of space, a favorable climate for some industrial applications and access to natural resources, iron ore and minerals etc.

3.1 Utilization of alternative fuels

3.1.1 Current state

Fuel use

The fuel use of registered vehicles in Norrbotten and Västerbotten are shown in table 7. Note that these numbers are showing the fuel that the vehicle is registered to use. Meaning that vehicles driven on HVO diesel for example does not have to be registered as a HVO diesel vehicle and will therefore not show in the statistics.

Electric light trucks (total weight ≤ 3 500 kg) represent currently about 1 % percent of the whole light truck fleet in Swedish Barents region. However, it is important to notice that during the 2022 their amount grew about 60 % to compared to year 2021. There was also about 40 % increase of ethanol-operated light trucks during the same time. Heavy trucks using alternative fuels are still rare and no significant change was noticed in their total number. Currently about 5 % of buses are electricity-powered and 8 % gas-powered but their share in increasing rather slowly.

From a global perspective, Sweden is in the lead regarding the consumption of biofuels as a fraction of the total fuel consumption. The share of renewables in the transport sector were 29,7% in 2018. Today, most of the biofuels are used as a fraction in fossil fuels in the existing vehicle fleet *(Fossil Free Sweden, 2020).*

Table 8. Vehicles and fuel in the Swedish part of the Barents region in 2022 *(Trafikanalys, 2023)*

(Number of trucks)	Petrol	Diesel	Electric	Hybrid	Ethanol	Gas	Other
Heavy trucks	47	6247	4	2	1	44	1
Light trucks	2931	33998	502	18	340	176	1
Buses	1	722	39	2	0	67	0

The forestry industry is accountable for around 17-19% of the total Swedish transport by trucks with an average travel length of 100 km. There are no regional specific statistics for transport and connection to specific industries or sectors. But the forestry sector is quite extensive in the north of Sweden, and therefore have a large contribution to these statistics.

Working machinery within forestry are still mainly using fossil fuels, but the companies within this industry are usually aware of their fuel use. One limitation for electrification within this industry are the long geographical distances. There are some ongoing pilot projects regarding electrification for forestry machines, these are to be tested during 2023 *(SMED, 2021)*. New technical solutions are missing for forestry, however, since Sweden is a large global player within the forestry sector, development will possibly take place here to a large extent *(Fossil Free Sweden, 2020)*.

For the mining industry there are talk about how to connect companies and organizations to make the logistics more effective. Making the links and coupling between different industries better so that the number of empty trucks can be substantially decreased. The mining industry has set a target for working machinery to be 50-95%

electrified by 2035. Electrification has benefits for the mining industry since it decreases the need for ventilation in the mines due to less emissions when the requirements for working environment are also increasing *(SMED, 2021)*. Also in the mines, there are possibilities to charge the machines either by cord or through trolley lanes when work is carried out. Today the machines are usually fueled with diesel when leaving its charging spot but developments to get the machines to work for longer without being constantly charging are ongoing (ibid).

For ports, electrification is not to be expected in the coming ten years, mainly due to the slow development regarding electrification of these working machines but also that the lifespan of the working machinery is longer than in both the mining and forestry industry *(SMED, 2021)*. So, the current machines must reach the end of their lifespan before it is viable to exchange them to fossil free options. One driver for development for the ports is that the large trucks used there usually come from the same manufacturers who are providing smaller electrified trucks which means that they have experience already (ibid).

For public transport and especially for local transport, short distance travel in highly populated areas, both biofuels and electrification are viable options and commonly used in the Swedish market. For regional, longer distance travel the transition to alternative fuels take a bit longer *(Fossil Free Sweden, 2020)*. In comparison with both personal cars and heavier trucks, buses have come a lot further regarding incorporating alternative fuels.

For public transport in the Barents region, biogas, HVO diesel and electricity are used today with a fraction of around 30-70% according to the executed survey. The utilization of alternative fuels is varying depending on municipality in the region according to the survey, in Piteå some of the urban traffic is electrified, Boden is using locally sourced biogas, and Luleå is planning on increasing its use of biogas and from 2030 transitioning to hydrogen. For regional traffic, HVO diesel is used if available, but the operators are increasing their use of biogas.

Availability of fuels

Biogas

The production of biogas in Sweden reached around 2.3 TWh in 2021 with a total number of 281 domestic producing facilities, with 132 being sewage treatment plants. Even though the largest part of produced biogas came from co-digestion facilities.

During 2021, a total of 87 GWh of biogas were produced in the Swedish part of the Barents region. In Norrbotten the production increased 3% compared to 2020 but the production in Västerbotten decreased 8%.

For local production of upgraded biofuels (LBG) there are currently 2 available upgrading facilities in the Swedish part of the Barents region, one respectively in Västerbotten and Norrbotten. The upgraded biogas is mostly used in heavy vehicles, but the industrial sector is increasing its overall usage. The access to fueling stations for 100% biogas is poor or nonexistent in the hinterland of Northern Sweden. In Table 9 the deliveries of gas to Västerbotten and Norrbotten are presented. Comparing to Sweden in total, the deliveries to Norrbotten and Västerbotten are limited.

Table 9. Deliveries of vehicle gas and liquid vehicle gas *(SCB, 2022)*

Region	CBG (1000 Nm^3)	LBG (1000 kg)	CNG (1000 Nm^3)	LNG (1000 kg)
Västerbotten	1 840	8	12	94
Norrbotten	533	-	63	-
Sweden	145 997	7 324	5 406	3 879

HVO and ethanol diesel

According to the survey, HVO diesel is perceived as one of the more accessible alternative fuels in the Barents region, but the higher costs compared to conventional diesel is seen as an issue. However, one company mentioned that even though they used HVO diesel a few years ago they had to go back to conventional diesel again because of problems with availability of HVO. According to the survey the availability of ethanol diesel is poor in both Västerbotten and Norrbotten.

Hydrogen

There are no official statistics regarding hydrogen use in Sweden today. The production and usage of hydrogen today are approximately 6 TWh annually, with only around 3% produced with electrolysis. The hydrogen produced is usually used close to the production, no hydrogen grids or other large scale distribution routes are in place today, the most common way to transport hydrogen in Sweden today is by trucks. Five fueling stations are currently available in Sweden today, one of these is in Umeå (in the Barents region) *(Energigas Sverige, 2022)*.

Electricity

The available charging infrastructure has increased in both Norrbotten and Västerbotten during recent years but charging stations for heavy vehicles are not as developed in the area. However, the survey respondents emphasize that infrastructure is still poor and concerns regarding the functionality of electrical vehicles and machines in a colder climate.

LNG and CNG

Sweden is dependent on imports of natural gas which is mostly used in various industrial processes in the Southern Sweden *(Energimyndigheten, 2022)*. As seen in Table 9, there are no deliveries of LNG to Norrbotten and only a rather small amount of CNG is delivered. In Västerbotten there are deliveries of both CNG and LNG but only rather small amounts are delivered. The responds to the survey also emphazised that the access to LNG and CNG in the Barents region is poor.

3.1.2 Future prospects

Sweden has the ambition to become one of the first fossil free welfare countries in the world. By 2045, Sweden shall have reached zero emissions of green-house gases to the atmosphere, and from thereon reach negative emissions.

Important to mention is that the Swedish national election was held in September 2022, that resulted in a change of government. There are therefore at the time this report is written some uncertainties of future changes in political priorities and regulations. The new government released the agreement Tidöavtalet that shall be the basis for the cooperation between the parties in the years to come. Compared to the previous government this one has a larger focus on favoring Nuclear Power and Swedish energy targets will be changed from “100% renewables” to “100% fossil-free” *(Tidöavtalet: Överenskommelse för Sverige, 2022)*.

The new government have decided that the reduction obligation of emissions from fuels (“reduktionsplikten”) and its planned raises shall be paused during 2023. Before, the plan was to continue to raise the reduction levels every year until 2030. The planned raise for 2023 was from 7,8% to 10,1% for petrol and from 30,5 to 35% for diesel, the lower levels will therefore continue to apply during 2023. The reason for the paus is a try to abate the price increases of fuel during recent years and to not increase, rather to keep, the bio fraction in fuels. Also proposed is a decrease of the reduction obligation levels to EU minimum by 2024 *(Tidöavtalet: Överenskommelse för Sverige, 2022)*.

The reduction obligation is a clear measurement that drives investments in biofuel production with a set out plan that determines the demand on the Swedish market. The industry emphasizes in the roadmap for petroleum and biofuels that the reduction duty is clear in its focus to support the transition of the transport sector *(Fossil Free Sweden, 2020)*.

The national initiative Fossil Free Sweden (Fossilfritt Sverige) combines plans for decarbonization of 22 sectors and industries, with the target to increase competitiveness by becoming fossil free and climate neutral. The plans include the possibilities, obstacles, and suggestions on solutions both through industry initiatives and political regulations and targets. Some industry plans to highlight in the aspect of this study are transport- heavy vehicles, petroleum and biofuels, heavy road haulage, forestry, and mining and minerals. All these plans are aligned to

the target, mentioned in the beginning of this section, a fossil free welfare nation by 2045 *(Fossil Free Sweden, u.d.)*

The roadmap for heavy vehicles is to summarize focused on electrification, biofuels, and efficiency. Emphasizing that the charging infrastructure for heavy trucks is essential with non-public, semi-public, and public charging options available. The same infrastructure focus also applies to biofuels together with support schemes *(Fossil Free Sweden, 2020)*.

In all road maps relevant for this study of the Swedish part of the Barents region is that the collaboration is central. Actors from different sectors and industries must collaborate with governmental stakeholders, researchers and international stakeholders to provide and develop the best solutions for a sustainable transition, which will be highly dependent on alternative fuels *(Fossil Free Sweden, u.d.)*.

The region of Norrbotten has set a few goals specifically applicable for heavy transport, these are:

- The public transportation shall increase with 25% to 2030
- The share of inhabitants that reach a central location within 60 minutes with car or public transport shall increase
- The share of loaded and unloaded goods transported on road shall decrease and be transferred to shipping

Also mentioned in the strategic plan is that the infrastructure for all kinds of transport must be improved *(Region Norrbotten)*.

The focus and plans for transportation in Västerbotten are to increase the safety, transfer transportation on roads to railway and create possibilities for sustainable travel locally with development in public transport, walking and cycle paths. The only mention of fuels in the transportation plan of Västerbotten is the plan to develop terminals along Inlandsbanan (railway) so that forest fuels can easily be transported to more populated areas *(Region Västerbotten)*.

For Sweden in general the plan for transport and especially for heavy traffic is to move as much as possible of transported goods to railway and shipping. For the Barents region, the most significant expansion of railway is Norrbotniabanan. A railway currently under development stretching the northern coast from Umeå to Luleå, with new travel centers in Skellefteå, Piteå and Luleå and several regional stations on the way. The new railway shall improve the opportunities for travel for inhabitants in the area and support the new industries to carry both goods and labor *(Trafikverket, 2022)*. The railway shall connect the north of Sweden more to the southern parts and to the rest of Europe and is partly financed by the EU's Connecting Europe Facility (CEF), which provides important financial support for projects within the TEN-T network.

Opportunities and Usage Potential

Companies in Norrbotten and Västerbotten are interested in increasing their usage of alternative fuels according to the survey. For heavy transport the focus is on biogas, HVO diesel, hydrogen, and electricity and for heavy machinery the focus is mainly on HVO diesel, hydrogen, and electricity. Organizations plan to increase their usage to improve the organization's reputation by decreasing emissions, to reach emission targets, and exploit the potential of locally available fuels.

Biogas

The production of biogas in Sweden is according to national plans planned to reach 10 TWh by 2030, consisting of 7 TWh of biogas produced through rotting and 3 TWh of biogas and other renewable gases produced using other techniques. The planned use of biogas in Sweden in 2030 is 15 TWh, 12 TWh for the transport sector and 3 TWh for the industrial sector. For Sweden to reach 12 TWh for the transport sector, the right incentives for heavy truck manufactures and a strong market are important. Since Sweden is home for two of the world's largest truck manufactures the Swedish market can also be used as a display for these trucks, and the possibilities should be utilized from all parties and possibly also for different alternative fuels *(Energimyndigheten, Energigas Sverige, 2022)*

HVO and ethanol diesel

No specific opportunities related to HVO, or ethanol diesel have been found.

Hydrogen

More than 100 hydrogen fueling stations projects are in the pipeline in Sweden today, which in the coming years shall be in full operation. This will change the landscape of hydrogen as transport fuel substantially *(Vätgas Sverige, 2022)*. Hydrogen refueling stations are under development in Arvidsjaur, Kalix and Piteå. A few stations for hydrogen and electricity have been given grants within the project regional electrification pilots, see Figure 4. Figure 4 Regional electrification pilot. These shall be in full operation during the fall 2023 (Ibid).

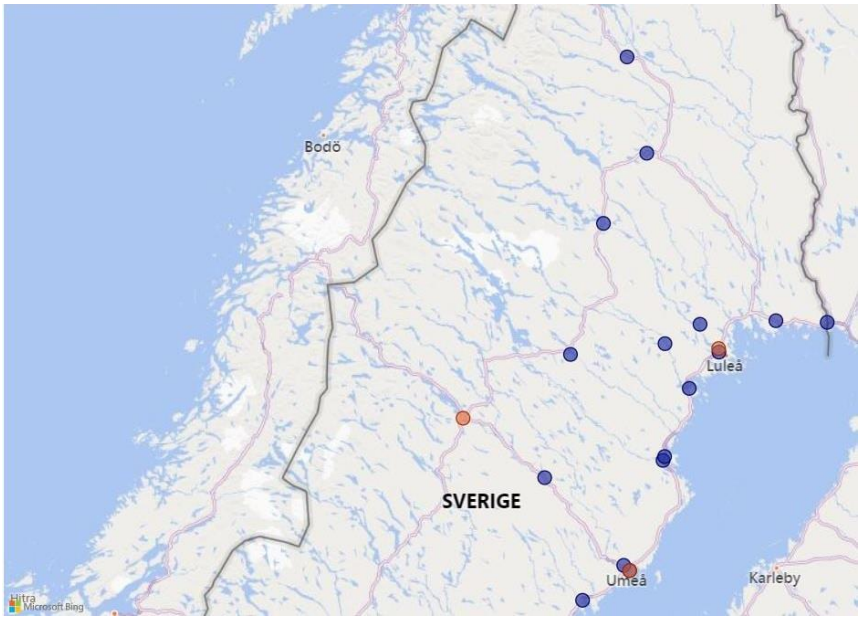

Figure 4. Regional electrification pilot *(Energimyndigheten, 2022)* (Blue = charging station, Orange= hydrogen refueling station)

In April 2022 Nordion Energy and Gasgrid Finland launched the Nordic Hydrogen Route, which is an infrastructure project that shall support the future hydrogen market. The project aims to develop a pipe network going around the Gulf of Bothnia, stretching to both the Swedish and Finnish coast of the Barents region. The plan is to start operation in 2030 and then provide the region with a secure transfer of hydrogen from producer to customer *(Nordic Hydrogen Route, 2022)*. In addition, the company OX2, in collaboration with Gasgrid Finland and Nordion Energy, communicated in December 2022 that they are also investigating the possibility for a hydrogen network, however further south in the Baltic Sea. This project is called the Baltic Sea Hydrogen Corridor and shall connect the Nordics and Baltics with central Europe *(OX2, 2022)*. The two projects are connected and shall together create an open and reliable market for hydrogen.

Electricity

Currently, the Barents region of Sweden, within electricity areas SE1 and SE2, usually have a surplus of electricity. Mainly due to the hydropower production in the area. These areas have in recent years had lower prices than the southern parts of Sweden (areas SE3 and SE4) where the demand is higher and production more limited. As seen in Figure 4, the amount of charging stations is increasing in the area, according to Regional electrification pilot some of this new infrastructure shall be accessible for heavier trucks as well.

LNG and CNG

There are no plans to set up LNG terminals in the Barents region of Sweden but the plans for LNG terminals in Northern Finland can possibly provide LNG also to Sweden *(Energimyndigheten, 2022)*.

Limitations

The largest issue at the Swedish market today is “who should go first”? Who will invest in production facilities or fuel stations for renewable gases when there are no vehicles using gas? And companies do not want to invest in gas driven trucks if they can’t fuel them up as needed. This requires strong cooperation between different sectors *(Energimyndigheten, Energigas Sverige, 2022)* The respondents to the survey also suggests that the alternative fuels infrastructure for heavy vehicles (such as biogas and electricity) is insufficient today. However, according to the survey the main limitations today for increased usage are concerns regarding profitability and the availability of alternative fuels. For both working machinery and vehicles one concern is also the investment cost. To invest in more expensive machinery or vehicles and then fuel them with fuels that they perceive as both unavailable and technically uncertain creates a difficult case for the companies.

Biogas

There is currently no gas grids available in Northern Sweden, and a market must be created without a grid to rely on. The gas pipeline infrastructure is limited to the south-western part of Sweden, that is connected to the European gas network. Other challenges are few vehicles driven on gas, long geographical distances *(Energimyndigheten, Energigas Sverige, 2022)* and according to the survey uncertainties regarding classification of vehicles fueled with biogas.

HVO and ethanol diesel

No specific limitations regarding HVO, and diesel were found other than what was mentioned above regarding availability. With no findings related to increasing the accessibility of these fuels it could be a limitation.

Hydrogen

The amount of hydrogen used in the area will most certainly increase, mainly because of the ongoing industrial developments undertaken by the fossil free steel projects, H2 green steel and HYBRIT. Both will use electrolysis to produce hydrogen to then use it in the steel production. In general, this creates demand for hydrogen in the north, which can then create spill-over effects on other industries. However, if industries, shipping, agriculture, and other sectors are all increasing its use of hydrogen and products with hydrogen origin, will transport and machinery be able to keep up?

Electricity

The electrification of heavy vehicles is limited due to the inadequate number of public charging stations for heavy vehicles in Sweden in general. According to Fossil Free Sweden’s roadmap for heavy vehicles (2020) there are only two public charging stations for heavy vehicles in Sweden today, one of these is in Luleå.

The surplus of electricity in Barents region of Sweden mentioned above will most likely change due to the large industrial expansions in the area, with the fossil free steel in SE1 and the giga factories in SE2. These new industries will require a lot of the today available electricity and create demand for new renewable production and grid expansions. To increase the amount of charging spots in the area at the same time will put even more pressure on the grid and demand more electricity.

LNG and CNG

Sweden’s dependency on import of natural gas creates limitations, especially during these geopolitical times when the supply of natural gas is more uncertain than before in Europe. Also as mentioned earlier, there are no plans for LNG terminals in the Swedish Barents region at the moment *(Energimyndigheten, 2022)*.

3.2 Natural gas, LNG, hydrogen user network in Northern Sweden

For CNG and LNG, the deliveries to the Barents region of Sweden are limited (Table 9). And according to the survey, companies are not planning on increasing their usage of either LNG or CNG and a few of them also express uncertainties regarding the development of vehicles driven on gas.

According to the survey, hydrogen is seen as a highly interesting fuel in the future even though the technology is still perceived by some as immature for both vehicles and working machinery today. According to the survey hydrogen are being evaluated for public transport. However, the usage of hydrogen in the region will increase, as mentioned earlier, the fossil free steel will potentially utilize enormous amounts of the gas. The companies involved in the HYBRIT project are mining company LKAB, steel producer SSAB and the energy company Vattenfall, the other steel project is conducted by H2 green steel together with various national and international partners and investors. These projects will not be using hydrogen as a fuel but rather as a component in their production processes.

No other findings regarding the user network of hydrogen were found in the Barents region of Sweden.

4. Norway

4.1 Utilization of alternative fuels

The Barents region of Norway consists of Nordland County and Troms and Finnmark County. The counties each have a population of around 240.000 people, in total making up approximately 10 percent of the Norwegian population. In Nordland County, the population is most densely concentrated in the Bodø region, as well as the Lofoten and Vesterålen island groups. In Troms and Finnmark, the highest concentrated area is the Tromsø region. Good access to natural resources as well as low energy prices make the northernmost counties of Norway favourable for a range of business areas. Both have long coastal lines, and fishery is one of the most important areas of business. Other important business areas are industry, mining, and energy production, including petroleum industries.

Our findings suggest there is little use of alternative fuels for transport purposes and in heavy-duty machinery in the Norwegian part of the Barents region. Supply is limited, as is also the demand for alternative fuels. This is also evident from the number of vehicles operating on alternate fuels, which is limited to a fairly low number of electrical vans and tractors *(Statistics Norway, 2022)*. While there is little statistics to document the number of working machines and heavy-duty machines, our document studies and interviews indicate that there is little use of alternative fuels for such machines as well, due to limited availability of technology, infrastructure and supply.

Table 10 shows the total number of registered vehicles in Nordland County and Troms and Finnmark County, by type of vehicle and fuel type in 2022. Of the alternative fuel-using vehicles only electricity-powered vans seem to represent at least a small share (1,5 %) of the whole fleet. It's also worth noticing that number of electricity-powered vans grew 40 % during the year 2022.

Table 10. The total number of registered vehicles in Nordland County and Troms and Finnmark County, by type of vehicle and fuel type in 2022 *(Statistics Norway, 2023)*. Passenger cars are not included.

Fuel	Buses	Vans	Combined vehicles	Trucks	Tractors
Bensin	9	1584	128	182	18553
Diesel	702	42350	2117	5179	23397
Gas	0	3	0	2	2
Electricity	0	679	0	1	7
Hydrogen	0	0	0	0	0

While there is little use of alternative fuels today, national and regional strategies and roadmaps, as well as specific projects and plans, suggest the usage and availability of alternative fuels in northern Norway will rise in the coming years. In the following sections, the current state of alternative fuels for heavy traffic and working machines, as well as the prospects, are discussed in further detail.

4.1.1 Current state

TEN-T network

As part of the European Economic Area (EEA), Norway is not part of the EU. Meanwhile, the AFI regulation will replace a regulation which incorporates 2014/94/EU into Norwegian Law, and AFI is therefore considered relevant for Norway *(The Norwegian Government, 2022)*. In the Barents region of Norway, the TEN-T network currently covers E10/E6 Riksgrensen/Bjørnfjell to Narvik (part of the core network), in addition to E6 southern Sweden to Kirkenes and E12 Riksgrensen/Umbukta to Mo i Rana (both part of the comprehensive network) (Figure 6).

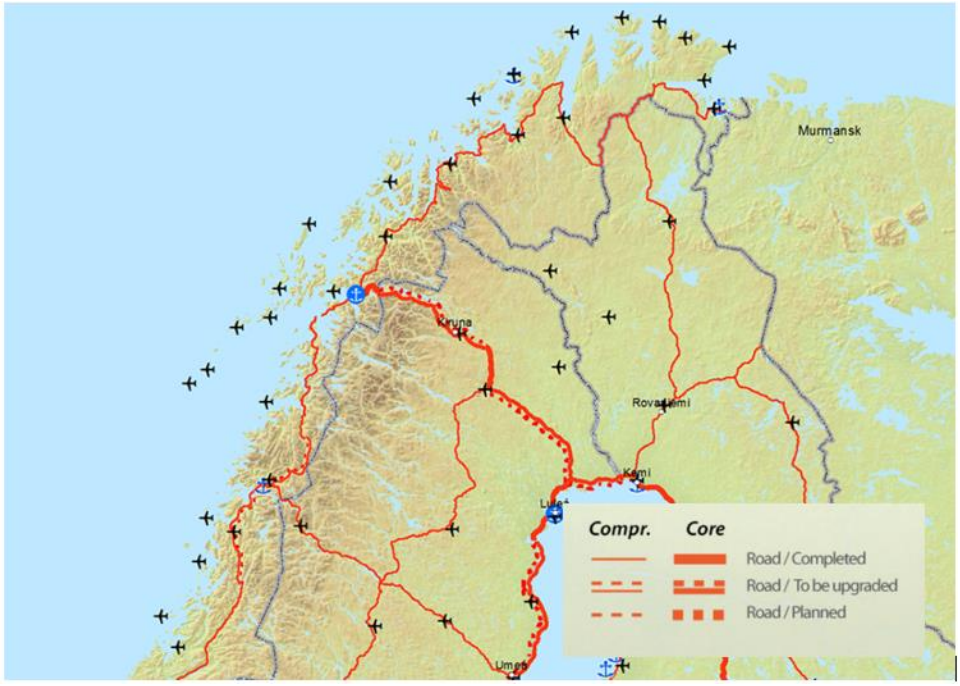

Figure 5. Norwegian TEN-T network. Illustration from *(European Comission, 2020)*

Fuel use

The usage of alternative fuels in Norway is primarily allocated to the transport sector. The usage of biofuels for transport is well developed in Norway, compared to other European countries, with fuel usage predominantly focused on advanced biofuels made from waste and residues *(Norwegian Environment Agency, 2022)*. At a national level, between 500 and 600 million liters of liquid biofuels are sold each year for road transport, of which up to 400 million liters is of advanced biofuels *(Miljødirektoratet, 2022)*. FAME and HVO diesel make up around 14 % of all diesel sales, while bioethanol makes up around 6 % of all gasoline sales *(Karlsen, Bratsberg, & Pelkmans, 2021)*. Meanwhile, the use of biogas is modest since there is almost no inland infrastructure of natural gas to households. While biogas is still limited in terms of volumes, it now makes around 20% of all gas products used in the natural gas fleet in the transport sector.

While there is a significant usage of biofuels in Norway today, is seems that both the usage and and the distribution of alternative fuels is not evenly spread across Norway in terms of geography. Our findings suggest there is no production nor distribution of scale of biogas in Nordland and Troms and Finnmark, and with no fueling stations for liquefied biogas *(Biogassbransjen, 2022)*. There seems also to be little use of liquid biofuels, when not considering biofuels blended with other fuels, following a national blend-in requirement.

The usage of biofuels in Norway is largely rooted in legislation aimed at reducing emissions from the transport sector. To lower the sectors emissions, the Norwegian Government in 2009 set legal requirement for fuel sales, mandating that for each unit of fuels that are sold for road transport a given share must be of biofuels *(Norwegian Environment Agency, u.d.)*. The share has gradually increased, and in 2022 is at 24,5 percent, of which 9 percent must be from advanced biofuels. Only liquid biofuels are eligible, meaning biogas is not covered by the requirement. To further stimulate the use of sustainable fuels, one liter of advanced biofuel counts as 2 liters, while conventional fuels are counted 1-to-1. A requirement is also set for aviation fuel sales, of which 0,5 percent of the volumes sold must be of advanced biofuels, and 2,6 million liters of advanced biofuels were sold for aviation purposes in 2021 *(Norwegian Environment Agency, 2022)*.

Meanwhile, almost all biofuels are mixed with other diesel and petrol products, and sales of pure biofuel are very limited. Biofuel production in Norway primarily uses waste products from forestry as feedstock, but biofuels are primarily imported from other European countries, as well as some imports from North America and Asia.

Table 11. Annual sales volumes (millions of liters) for liquid biofuels in Norway for road transport *(Norwegian Environment Agency, 2022)*.

Year	Total, liquid biofuels	Advanced liquid biofuels	Conventional liquid biofuels	Share, advanced liquid biofuels
2021	538	404	134	75 %
2020	500	330	168	66 %
2019	615	233	382	38 %

Electricity is a much-used alternative fuel source in Norway. Norwegian power prices have historically been lower than on the rest of the continent, largely due to Norway's extensive hydropower capacities. This makes electricity a favorable alternate fuel source across a range of sectors, including process industries and the transport sector. Most notably, Norway has a very large share of electric passenger cars, which is also due to the use of VAT exemptions and other subsidies which has stimulated demand for electric vehicles. Electric vehicles are also becoming increasingly common in light-weight freight truck segment, and many ferries for short vehicle and passenger transits use electric drivetrains as well.

Table 12. Electric vehicle share of all registered road vehicles *(Statistics Norway, 2023)*. By county and the national average.

Area	Passenger cars	Buses	Light transport vehicles
Nordland	8 %	0 %	1 %
Troms- and Finnmark	5 %	0 %	1 %
National average	16 %	4 %	3 %

While electricity is much used as an alternative fuel in Norway, our findings suggest the usage varies across geographies and is lower in Northern Norway. The share of electric vehicles in the Northern parts of Norway is much lower than in the rest of the country, both for passenger cars as well as for buses and light transport vehicles (Table 12). Finnmark and Troms and Norland also have a very low share of all registered charging points for electric vehicles in Norway (Table 13), and the lack of charging infrastructure is likely a significant barrier for potential users. Furthermore, there are no electric ferries in Northern Norway today.

Table 13. Number of charging points in Norway, by county, and share of charging points total in Norway *(Nobil, 2022)*.

	Norway total	Nordland	Troms and Finnmark
Charging points	23 407	822	516
Share	100 %	4 %	2 %

Availability of fuels

Liquid biofuels are available in Norway today but are primarily imported. The only known producers of biofuels in Norway today are Borregaard (bioethanol) and Adesso Bioproducts (FAME), both situated in southern Norway, and most biofuels are imported from Europe, North and South America, and Asia *(Berg, Harbo, & Lånke, 2017)*. Biofuels, including FAME, HVO Diesel and bioethanol, are distributed by the same companies distributing regular diesel and gasoline products. In this value chain, fuels are brought in by ship to terminals and distributions facilities and are then distributed by tank trucks directly to large consumers or to fueling stations.

Our findings suggest that biofuels are primarily brought ashore only in the southern parts of Norway, and that biofuels distributed in Northern Norway must therefore be transported by road for long distances, driving up the prices. Furthermore, our findings suggest there are no dedicated fueling stations for biofuels in Northern Norway, meaning fuels are likely distributed directly to consumers.

Our findings from interviews conducted in this survey with potential consumers of biofuels, suggest there are geographic variations in the availability of biofuels in Northern Norway. One of our interview subjects is in the building and construction sector, and the representative from the company noted they are already operating some of their machines on HVO diesel. The representative also noted that they found the availability of biofuels to be good, and that they have a standing contract with one or more suppliers that supplies them with HVO diesel, fueling their mobile tanks that the company uses on building sites. Meanwhile, a mining company situated in the far north was less happy about the supply. In our interview, they noted that they had been looking for alternative fuels,

but that the fuels had to be brought in by ship. However, the local port does not have the infrastructure needed to receive the volumes required for their operations, and this makes hard for the mining company to acquire biodiesel at a reasonable price.

Due to lower power prices, electricity is one of the most attractive alternatives for alternate fuels in Northern Norway. Meanwhile, availability is somewhat limited due to constrains in the power grid. Poor transmitting and local capacities across parts of the region limit the electric power users can extract. A representative from a mining company stated in an interview that due to the low electricity prices in their operating area, they would prefer to electrify their vehicles and machines, instead of turning to other fuel alternatives. However, the company is currently allowed to use only 20 MW because the grid operator has no available capacity. Meanwhile, the company would need another 60 MW to further electrify their operations. According to Norwegian TSO Statnett, existing plans for electrification and new business means there is no capacity for new applicants, and the grid must be expanded and upgraded to meet new demand in the coming years *(Statnett, 2022)*.

There are currently only two biogas production plants in Northern Norway *(Biogas Oslofjord, 2022)*. One is located in Steigen in Nordland County. The plant is owned and operated by Cermaq, which also owns fish farms and uses waste products from its farms to produce gas *(Cermaq, 2017)*. The gas is then used for heating purposes inside of Cermaq's facilities and production lines. The second plant is Liholmen Biogas in Båtsfjord in Troms and Finnmark county, which was constructed in 2020 and converts waste to biogas, which is then supplied to local business and used for heating purposes *(Antec Biogas, 2020)*.

There are currently no fueling stations for either compressed (CBG) or liquid biogas in (LBG) in Nordland and Troms and Finnmark *(Biogas Norway, 2022)*. There are no filling stations for natural gas (CNG/LNG) either (NGVA Europe, u.d.).

4.1.2 Future prospects

The Norwegian Government has high ambitions for reducing the emissions from hard-to-abate sectors, including the industry, construction, and transport sectors. There are no specific targets for heavy duty machinery and working machinery, but for road transport, the government has defined several targets in its national transport plan *(Ministry of Transport, 2021)*:

- In 2025, all new passenger cars and light road transport vehicles should be zero-emission vehicles.
- In 2025, all new city buses should be zero-emission vehicles or utilize biogas.
- By 2030, all new heavy road transport vehicles, 75 percent of new long-distance buses, and 50 percent of new trucks should be zero-emission vehicles.
- By 2030, the distribution of goods in large cities should be handled with close to zero emissions.

immature in terms of production and usage of alternative fuels. Meanwhile, the Norwegian government, in its national transport plan, has defined several key policies, and is has taken several steps to speed up the implementation of low-emission vehicles and machinery and to create demand for alternative fuels across Norway. Most notably, the government plans on using CO_2-taxes, blend-in mandates and other regulations to strengthen the demand for alternative fuels. Also, The Norwegian Ministry of Transport have also provided feedback on the proposed AFI regualtion, where they expressed their support for the proposal. The ministry also noted the ambitions in the AFI regulation align well with Norways ambitions for the transport sector, and that most of the proposed criteria will be met within 2030 regardless of the new regulation following national plans for the transport sector.

In addition to regulatory steps, the Government plans to contribute with funding for both pilot and commercial scale projects to support the development and implementation of new production technologies, vehicles, machinery and infrastructure.

Following these developments, a range of projects are currently being planned and developed, which are likely to contribute to both supply and demand of alternative fuels in the northern parts of Norway.

In the following subsection, some key policies, future projects and drivers for important alternative fuels are discussed.

Biofuels

Based on our findings, we find it likely that the demand for biofuels will continue to grow all across Norway. A major driver will be the blend-in legislation. The blend-in requirement, which today only covers road-transport, is set to gradually increase *(The Ministry of Finance, 2022)*. This should increase the usage of biofuels, but the total volumes may vary as conventional biofuels are replaced with advanced biofuels that are double counted. Furthermore, the government has decided that from 2023, the requirement will also cover fuels for non-road machinery, whereas 7 percent of all fuel sales must be of biofuels. This will lead to blending of plant diesel with biofuels, as is currently being done for road diesel. We expect blending with HVO diesel will be the preferred alternative. HVO can be used directly in most new diesel machines and vehicles without additional modifications and is easily stored *(Oslo Economics, 2021)*. Meanwhile, FAME must be stored in appropriate tanks because it reacts to water, making condensation a potential issue. FAME is therefore not used in utility diesel today, as most consumers have their own storage tanks, that are designed only for regular diesel.

While a blend-in requirement could increase the use of biofuels, a barrier for the usage of pure biofuels is cost. Biofuels are more expensive than regular diesel, and construction firms typically only use biofuels when there is a requirement to do so *(Berg, Harbo, & Lånke, 2017; Oslo Economics, 2021)*. In separate interviews, two representatives from building and construction firms noted that they would use HVO diesel, but only in projects where this was a requirement or there were bonuses for reducing CO_2-emissions. According to them, the price of HVO diesel is typically double the price of regular plant diesel, and they have no chance of competing with other firms if they are using HVO, but the other firms are not, and there is no financial reward for using zero-emission fuel.

To solve this issue, the Norwegian Government has proposed a new legislation which will mandate all public procurements to a climate and environment criteria. The government has suggested the criteria should have a weight of 30 percent when contracts are to be decided, which would then increase machine operators' incentive for using alternative fuels, for example in public building and construction projects. Despite favorable electricity prices, we expect biofuels will often be the preferred option due to poor grid capacity and infrastructure in many parts of northern Norway. As such, the requirement is likely to significantly increase the demand for biofuels, which could also lead to further development of supply chains and infrastructure for biofuels in Northern Norway. This again could make biofuel a more viable, accessible option for several applications. The proposal is currently being reviewed in a public hearing process, ending March 2023, and a legislation is expected within 2030 *(The Norwegian Government, 2022)*.

Biogas and LNG

While there is little biogas production in Northern Norway today, many plans for new production has formed in the past years. Former studies have concluded that there is a large untapped potential for producing biogas in the Barents region of Norway, based on waste products from citizens, and waste products from the fish, farming, and forestry industries in the region *(SINTEF, 2017)*. Troms and Finnmark and Nordland County have also developed a joint bioenergy strategy, which targets biogas production *(Molvig, et al., 2022)*.

In Skibotn in Troms and Finnmark, a range of actors, including waste management companies Remiks and Avfallsservice, and transport company Asko, have come together to form Rå Biopark *(Rå Biopark, u.d.; Remiks, 2021)*. Inside this plant, the actors intend to build a biogas production plant capable of producing 5 million liters of biogas annually, equivalent to 50 GWh. As its feedstock, the plant will use almost 50.000 tons of organic waste from 41 northern municipalities. The companies behind Rå Biopark have also received public funding to build biogas fueling stations in Alta, Tromsø and Bjerkvik, in addition to funding for the purchase of 16 biogas trucks and other heavy-duty vehicles running on biogas.

Other plans for biogas in Northern Norway include the establishment of a biogas production plant on Senja island in Troms and Finnmark *(SenjaBio, u.d.)*, Sømna biogas plant which is under development and has received 100 MNOK in grants and loans from Innovation Norway and 60 MNOK from Enova *(Norwegian Innovaton, 2022; Enova, 2023)*, and a potential biogas production plant in Troms and Finnmark based explicitly on waste products from fishing industries *(Sterner, 2021)*.

For LNG, the proposed AFI regulation mandates the countries must ensure there are sufficient infrastructure and fueling stations for LNG, as to meet demand. Meanwhile, we find no evidence of demand of scale for LNG in

Northern Norway. Therefore, we expect the regulation will not have significant impacts on LNG infrastructure and fueling stations in the short term.

Hydrogen

The Norwegian government has ambitions of building a hydrogen value chain in Norway and has developed a hydrogen strategy and a roadmap. The strategy describes how the building of value chain will contribute both as to reduce emissions from hard-to-abate sectors, specifically targeting the industry and heavy transport sectors, but also to building new areas of business, with the intention of exporting hydrogen and hydrogen technology to Europe *(The Norwegian Government, 2020)*. The roadmap describes a range of measures to achieve these goals. Most notably, the government will contribute to the development of a hydrogen value chain through the development of legislation, and by contributing to research and bilateral collaboration, in addition to supporting projects that will contribute both to the supply and demand of hydrogen *(The Ministry of Petroleum and Energy, 2021)*.

Several large-scale projects have so far received funding, including a green hydrogen connection point in Glomfjord in Nordland County, where a production plant with an annual production of 300 GWh will supply hydrogen for local ferries *(Glomfjord Hydrogen, u.d.)*. There is also dialogue between the project committee and other public and private actors for establishing a hydrogen fueling station for passenger cars, buses and trucks in Bodø. Many other projects located in Northern Norway are currently being developed or are at a conceptual phase, including hydrogen plants in Berlevåg *(Varanger Kraft, u.d.)*, Mo I Rana *(Statkraft, 2020)*, Sandnessjøen *(Gen2-Energy, 2022)*, Mosjøen *(Gen2Energy, u.d.)*, and Hammerfest *(Horisont Energi, 2021)*, in addition to a green ammonia plant at an unspecified location in Finnmark *(St1, 2021)*, and a green methanol plant in Finnfjord *(Carbon Recycling International, u.d.)*. The projects primarily focus on offtake from the maritime sector and from energy-intensive industries. However, we believe new value chains could form, following the establishment of new production facilities, with potential demand also from road transport and for heavy machinery in the sectors investigated in this report.

To support the development of a hydrogen value chain, Troms and Finnmark County has developed its own hydrogen strategy. In it, the county argues hydrogen is key to decarbonize various sectors in the northernmost part of the county because of the low temperatures, which makes battery technology less suitable *(Troms and Finnmark County Municipality, 2021)*. The county's main ambition is to reduce emissions and increase value creation in Troms and Finnmark by establishing a hydrogen value chain in the region. One of the objectives in the strategy is therefore to establish at least one large-scale production plant for green or blue hydrogen. Additionally, the county will focus on attracting new regional business to settle and build or use hydrogen infrastructure and its by-products (O_2 and heat), expecting infrastructure to first be developed in the larger cities. Another objective is to develop at least two national hydrogen-hubs in the region, contributing to a regional market and simultaneous development of both supply and demand, as to solve the hen and egg problem.

Troms and Finnmarks hydrogen strategy does not focus on personal cars, but instead targets taxis and buses as first-movers due to long distances in the region and cold conditions. In a feasibility study, the county estimates 5-15 percent of all taxi and bus traffic will be fueled by hydrogen in 2030 *(Troms and Finnmark County Municipality, 2021)*. The county also focuses on hydrogen-driven trucks, which may follow hydrogen-driven buses as they then can use the same infrastructure. However, most demand for heavy road transport is expected to occur in the southern parts of the region, and the county therefore believes the share of hydrogen among trucks will be lower than for buses. A reason here is that if the logistics are not built up outside of bus-transport lines, the needed infrastructure for hydrogen-driven trucks may not be sufficient to support truck operations across all parts of the region. In its possibility study, the county therefore estimates only 2-5 percent of trucks will run on hydrogen by 2030.

While there are currently few hydrogen fueling stations in Norway, and none in Northern Norway, the AFI regulation is expected to mandate fueling stations are built along corridors of both the core and comprehensive network by 2030 (every 150km), as well as within defined city areas *(The Norwegian Government, 2022)*.

Electricity

Electricity is already a much-used source of energy for vehicles in Norway, particularly so for passenger cars, and we expect electricity will continue to play an important role in the years to follow. Tax reliefs and other benefits

have fueled a tremendous growth in the number of electric passenger cars in Norway, and electric cars up to 500.000 NOK (approximately 50.000 EUR) are still exempt from VAT. Technological advancements in battery technology has also led to more affordable alternatives in other segments as well, including buses and small trucks. State owned Enova is also offering funding support for charging infrastructure and vehicles, trucks, and machinery for businesses, to support the electrification of both road and non-road transport. Meanwhile, we expect poor grid infrastructure will continue to be a limitation for the usage of electricity as an alternative fuel in Northern Norway in the short term.

The grid capacity in Northern Norway is mostly reserved and must be expanded in order to meet new demand. Lack of capacity is therefore likely to cause a bottleneck for major electrification initiatives in Northern Norway. Meanwhile, Norwegian TSO Statnett has several plans to strengthen the grid, including a two 420kV transmission lines from Skaidi to Hammerfest and from Adamselv to Varangerbotn, both in Finnmark and Troms County *(Statnett, 2021)*. Furthermore, Statnett will continue its work on 132kV lines, and has several stations and line renewals planned. Statnett will also consider a new 420kV in Mo I Rana, depending on the development of new demand. Meanwhile, the developments and expansions of the power grid in Northern Norway is expected to take many years, and we believe it is likely that poor grid capacity will continue to be a bottleneck for electrification in the years to follow.

While the grid capacity could be a major limitation for electrification in Northern Norway, the government has already taken steps to increase the infrastructure for electric chargers in Nordland and Troms and Finnmark. Enova has targeted the northern parts of the country in application processes for its grants for charger stations. As a result, many new charging stations have already been established, and many more are expected to come online in 2023 *(Ministry of Transport, 2022)*.

Following the governments focus on establishing charging infrastructure, most of the Norwegian roads that are part of the TEN-T network already meet the proposed distance requirements for charging infrastructure for light vehicles (i.e. charging stations every 60km) *(The Norwegian Government, 2022)*. Meanwhile, there is currently no charging infrastructure for heavy road transport vehicles, and the regulation is therefore likely to have significant impacts. The scope is likely to be limited in the short term (2025) given the small scale of the Norwegian TEN-T core network where public chargers must be withing 60km, but implications are likely to be much larger in the medium term (2030) to meet the requirement of public chargers every 100km for the comprehensive network (i.e. the E6 corridors in the Barents region).

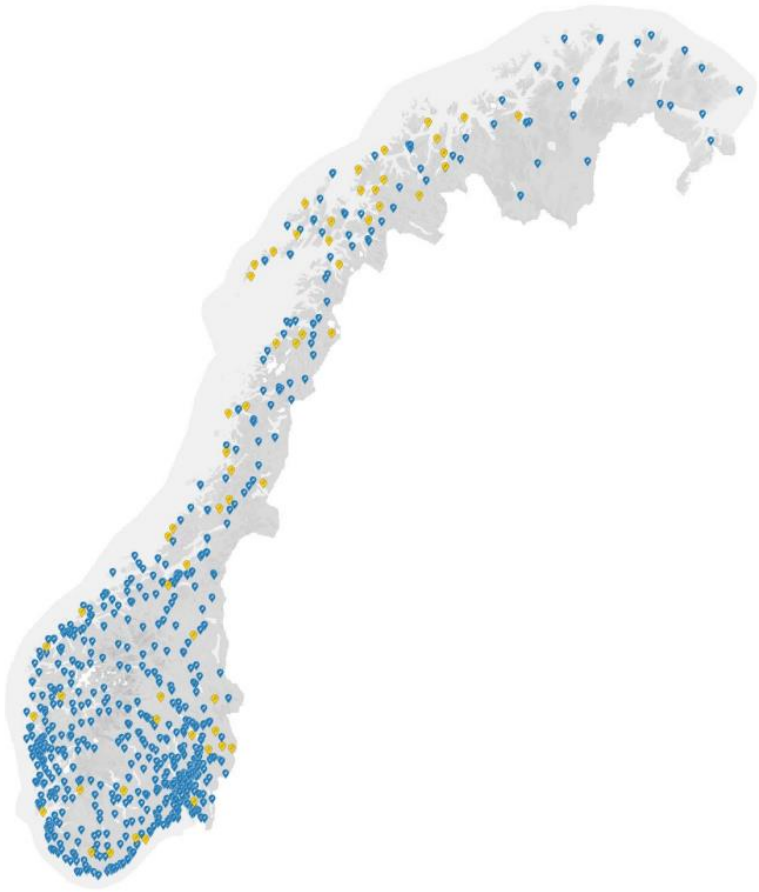

Figure 6. Overview of charging stations in Norway. Blue symbols are online stations, and yellow ones are stations that has received funding from Enova and will be online no later than June 2023. Illustrations collected from *(Ministry of Transport, 2022)*

4.2 Natural gas, LNG, hydrogen user network in Northern Norway

We have found little information regarding the users of alternative fuels in Northern Norway from our surveys and document studies. This strengthens our overall impression that the usage of alternative fuels is immature in Nordland and Troms and Finnmark counties. Our findings suggest that usage of liquid biofuels is very limited, partly due to lack of infrastructure and poor distribution, but also due to higher prices than for conventional fuels. Meanwhile, it its evident from our interviews, that potential users are looking for alternative fuels, mainly motivated by their own sustainability targets, and to meet increasingly sustainability focused consumers.

We expect user networks and supply chains will develop rapidly in the years to come. The development will follow a range of projects on the supply side, with several hydrogen and biogas projects currently being planned and developed. Additionally, we expect increased usage of liquid biofuels and other alternative fuels, following new policies and legislation, including a strengthening of the existing blend-in mandate for road transport fuels, a new blend-in mandate for non-road transport, as well as the introduction of environmental and sustainability criteria in public procurements.

5. Online workshop

In addition to the conducted literature review, interviews and online survey also an international online workshop was organized as part of the project. In the workshop the survey results were presented and further processed. Several Finnish, Swedish and Norwegian experts were invited to the event. The list of invitees included representatives from road administration, regional administration, largest cities, chambers of commerce etc.

Despite this, the number of participants was relatively small. All together 6 attendees (5 from Finland and 1 from Sweden) were present in the workshop.

The online workshop was executed utilizing Mural platform. During the workshop attendees were asked to comment the results and to bring out new ideas and solutions related to the use of alternative fuels in the Western Barents region. Later the comments, ideas and solutions were categorized and located under different topics. Following types of comments were made at the workshop:

Functionality of the Charging Network

- 24/7 operation of charging stations should be guaranteed.
- It is important that the information about mobile apps for charging/re-fueling is easily available. It is very important that the information is easy to reach also when charging is needed abroad. Several apps might be needed when moving between countries.
- Will there be enough electricity for traffic and industry when the green transition goes forward?

Purposes of Different Fuels

- Not all alternative fuels suit for all uses. For example, electricity is not a viable solution for heavy duty and long-distance transport currently. Hydrogen and bio-based fuels might be viable solutions for that purpose in the future.
- Synthetic fuels made of hydrogen and CO_2 or N_2 (methane, methanol, ammonia) could solve many problems related to storage and transfer of energy in mobility sector.
- Mining industry has high potential for electric equipment and vehicles since they operate on limited areas.
- Electric forestry equipment is also being developed.

Internal Operating Methods and Conditions for Heavy Traffic

- Long distance and heavy transportation are challenge for electric vehicles now and for many years still. Long-distance transport requires a comprehensive charging network or a re-fueling network for alternative fuels.
- Which should come first: demand or supply? The challenge is long distances and refueling/charging stations. Locally, it is easy to implement the use of electric buses and the use of work machines, if desired. But long-distance transport requires a comprehensive charging network or a refueling network for alternative fuels.
- New fuels effect to the entire logistics systems: route planning, resting times, loading times, weight regulation, working time regulation.
- Differences in Euro class regulation between countries can cause problems when crossing the border, for example from Finland to Sweden.
- Regarding alternative fuels and long distances: demand and supply do not meet? In which direction are the development of heavy traffic (manufacturers) headed and are we talking about alternative fuels as the right alternatives for future transport fleets? Is there enough predictive information to support decision-making?
- How will the standard for heavy equipment charging effect the situation?

Safety

- Some alternative fuels need strict land use measures due to safety issues (for example gaseous fuels).
- Hydrogen is a safety risk.

Production of Fuels

- Enormous amount of electricity is needed in the future as the traffic and industry switches to electricity.

Availability of Fuels

- A lot of attention needs to be paid on planning to ensure a 24/7-working charging/filling network.
- Existing infrastructure might not be suitable for all future uses, e.g. current charging infrastructure might not have enough space for heavy vehicles.
- The charging infrastructure requires a lot of space. Land use planning has an important role in building it.
- Information about charging and alternative fuel infrastructure needs to be easily available also when abroad.
- There is a lot happening in Sweden regarding the charging infrastructure development and alternative fuel-operated vehicle purchases.

After categorizing the comments attendees were asked to place the category topics on a coordinate grid with the importance of the topic on the horizontal axis and the realistic timeframe of its implementation on the vertical axis (Figure 7).

All the topics were clearly seen to have high importance. Most of them were also considered very acute. Only safety, availability of fuels and production of fuels were located on the timeframe so that their realistic realization time is not immediately.

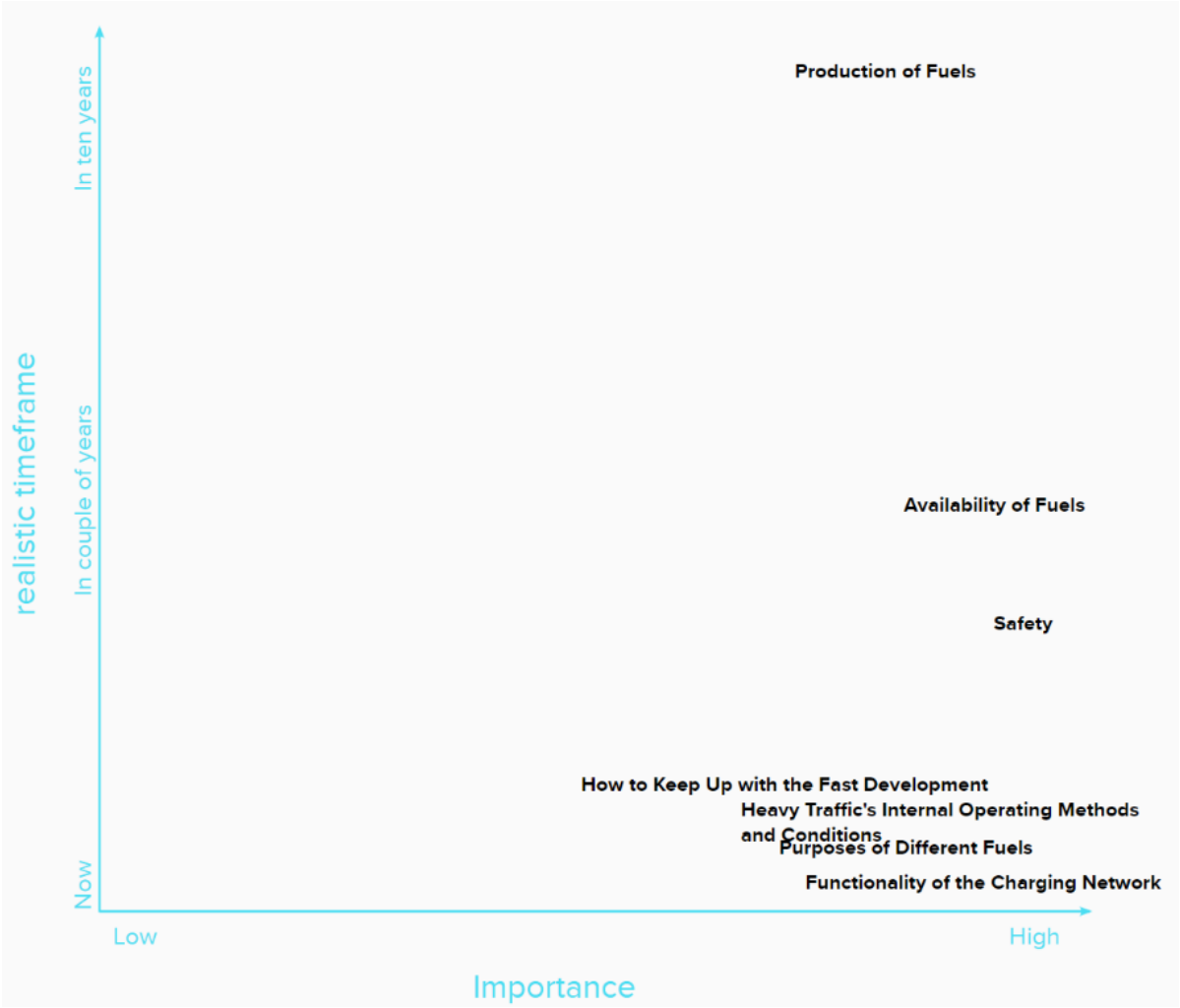

Figure 7. Comment categories on a coordinate grid with the importance of the topic on the horizontal axis and the realistic timeframe of its implementation on the vertical axis.

Due to the small amount of online survey answers received the participants expressed doubts about the correspondence of the results with the current situation, especially in Sweden. It was also suggested that the rapid change in the use of alternative fuels was not sufficiently reflected in the results.

As a summary of the online workshop, it can be said that there are still doubts about viability of electricity as an alternative fuel. Doubts are especially related to the applicability of electricity in heavy and long-distance transportation but also related to sufficiency of electricity for all purposes when the green transition goes forward. Bio-based and other alternative fuels are seen more suitable for heavy and long-distance transportation currently and in the near future.

It also became evident that switching to alternative fuels doesn't mean only technical changes but also extensive changes in working manners like working and resting times and in route planning. Land-use planning has also an important role in this shift since not all of the old charging/re-fueling infrastructure can be utilized and large areas are needed for the new infrastructure.

6. Conclusions

The use of alternative fuels is currently on a low level in the westerns Barents region. Seems that most of the current use is due to the existing biofuel blend-in requirements of road-transport (Finland, Sweden and Norway). The use exceeding the blend-in requirements is still marginal. The use of alternative fuels in working machinery is not covered by the blend-in requirements.

Despite the current low level of alternative fuel use, a lot of effort is being put in supporting its future growth. One example of this is EU's Alternative Fuels Infrastructure Regulation (AFIR) that will increase the charging and distribution infrastructure of electricity and hydrogen remarkably along the TEN-T road network starting from the year 2025. The results of the online survey and interviews conducted in this project also suggest that there is a clear interest in decreasing emissions by increasing the use of alternative fuels among the operators in the surveyed industries.

Still, there are currently several factors limiting turning this interest into actual use. In some industrial areas there is lack of existing suitable technology for alternative fuels. This is the case for example for electrical equipment and charging infrastructure in forestry and heavy transport logistics. Some organizations also reported about long delivery times for products like electricity-powered vans and light trucks that are already in the market. Some concerns on relying on new technologies were brought up in the interviews too. Concerns were related for example to cold climate operation and safety issues of electricity powered equipment.

The prices of the fuels and the equipment were also seen as a major limiting factor currently. Regarding the fuel prices several transport and machine work operators stated that it is not really up to them to decide whether the alternative fuels are used. They claimed that due to strict competition they can't afford to use non-fossil fuels unless it's required by the client. This is the case especially with HVO diesel that can be used in the existing diesel-powered equipment.

The availability of alternative fuels was in general considered poor in the western Barents region due to lack of charging and filling station infrastructure for heavy traffic. Exception to the above was HVO diesel that was in general considered as a rather accessible fuel.

In general, with other alternative fuels than HVO diesel (that can be used with existing equipment) many players seem to be waiting, what's going to happen next and who should go first? Will there be enough charging infrastructure and filling stations and which technologies will be the "winners" in the competition. Bold actions are needed.

According to the surveying done in this project currently the most interesting and most accessible alternative fuel for heavy traffic is HVO diesel since it's rather well available in the western Barents region and it can be used with the existing equipment. There is a lot of interest in electric vehicles but for heavy and long-distance transport they are not considered as a viable solution so far. However, number of registered lighter electric vehicles like vans/light trucks has increased during the past couple years in all the surveyed countries, especially in Sweden.

For working machinery electricity is already a viable and even more potential solution than HVO diesel. For example for mining industry there are electric working machines already on the market and a huge electric leap is expected. On the other hand, there are also sectors, like wood harvesting, where electricity is not seen as an option (as primary energy source) currently or in the coming years.

There is also a lot of interest in hydrogen but it's potential is seen to be further in the future. It is also yet to be seen will the industrial hydrogen projects in the western Barents region be executed and how will they affect heavy traffic and working machinery.

In the online workshop it was commented that due to the low amount of survey answers the "big picture" in the report does not reflect the current actions related to alternative fuels, especially for Sweden. Despite the criticism, it can be stated that the registration statistics show that alternative fuels in heavy traffic are still mainly in the marginal in the western Barents region. However, it seems that the situation is changing, and the speed of change may be high.

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