Alternative propulsion sources in public transport in the Western Barents region

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Contents

1 Introduction

1.1 Background

The aim in the Western Barents region is to promote concrete cooperation in the transport sector and cross-border traffic. This report is a part of a larger project called *Markets, infrastructure, and distribution of alternative transport fuels in the Western Barents region*, which is connected to the Finnish presidency (2021–2023) of the Barents Euro-Arctic Council BEAC. The larger project carries out preliminary studies and analysis related to potential, capacity needs and availability of alternative forms of energy in transport, as well as the required infrastructure in the Western Barents region. The region consists of the northern parts of Finland, Sweden, and Norway, and is characterized by for example long distances, sparse land use, difficult winter conditions, limited domestic market and limited public transport options.

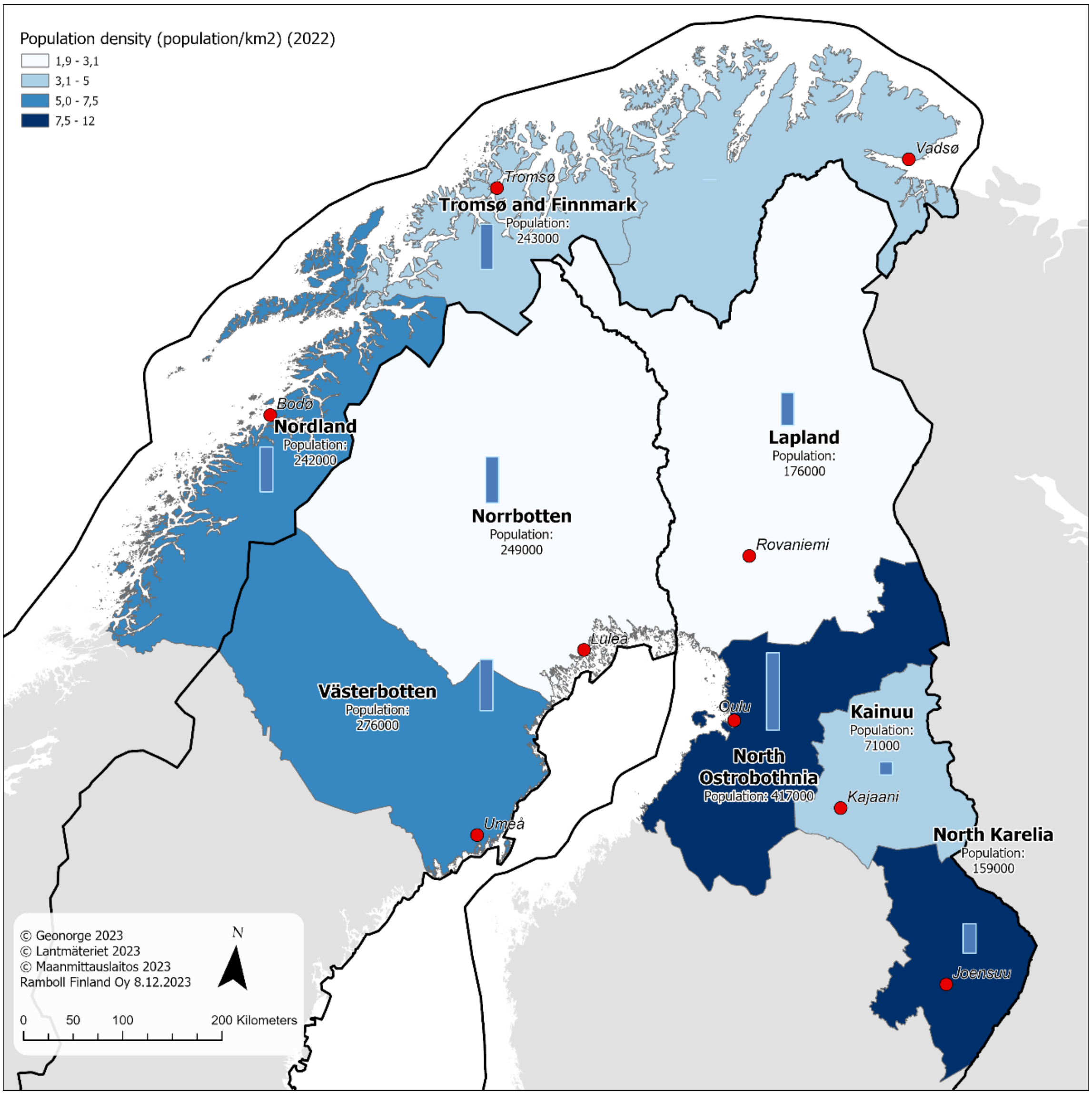
There are many reasons why non-fossil propulsion sources are topical in the Barents region: the most important ones being the green transition and climate policies. In addition, cross-border international traffic and growing tourism require a sufficient charging and refueling network. Uniform standards, for example at charging stations, are needed in the future. When promoting the use of alternative propulsion sources, the latest information is needed on operators and distribution networks, current development plans, as well as the availability and future potential of new fuels.

The purpose of this report is to analyze possibilities for alternative propulsion sources in public transport services in the Western Barents region. The project has been implemented with funding from the Baltic Sea, Barents and Arctic region cooperation granted by the Ministry of Foreign Affairs of Finland.

1.2 Scope of the report

Western Barents region consists of Finnish, Swedish and Norwegian parts of the Barents region. Included regions in Finland are Lapland, North Ostrobothnia, Kaiju and North Karelia, in Sweden Norrbotten and Västerbotten, and in Norway Finnmark, Troms and Nordland. The population of the area is 1,8 million, which consists of 823 000 Finnish residents, 525 000 Swedish residents and 485 000 Norwegian residents. The average population density in the region is 5,4 residents per square-kilometer so the area is very sparsely populated. Average population density of Finland is around 16/km^2, Sweden 25/km^2 and Norway 14/km^2. The most populous city in the area is Oulu in Finland with over 200 000 residents. Other biggest cities are Swedish Umeå with over 100 000 residents, and Tromsø (Norway), Luleå (Sweden) and Joensuu (Finland) all three almost 80 000 residents.

Figure 1. Counties of the Western Barents region, including population and population density.



Alternative fuels are compared to the most used public transport fuel: fossil diesel. Alternative fuels researched in this report are:

- **Electricity.** Electricity refers to full battery electric buses and e-buses which might use (renewable) diesel for heating of the cabin.
- **Biogas (CBG/LBG).** By biogas we mean renewable gaseous fuel which is produced from organic matter, such as food and animal waste. Biogas can be compressed (CBG) or liquefied (LBG) which makes transporting and storing easier.
- **Renewable diesel (HVO).** Renewable diesel refers to HVO (hydrotreated vegetable oil) which is a second-generation biofuel and is produced from 100 % renewable waste materials. First-generation biodiesel is not addressed since it has poorer attributes and would be problematic in cold winter weathers. Since all three researched countries have distribution obligations set for the distributors, fossil diesel can include renewable diesel. When talking about renewable diesel or HVO in this report, we mean using 100 % HVO.
- **Hydrogen.** Hydrogen fuel cell buses are kind of e-buses which instead of electricity stored in batteries, produces electricity in the vehicle's fuel cells using hydrogen as a fuel.
- **Synthetic fuels**. Synthetic fuels or e-fuels are liquid or gaseous fuels such as synthetic diesel produced using electricity, and usually hydrogen is involved in the process.

The report focuses on the public transport operated by buses and coaches, and includes local, regional, and long-distance transport. The biggest focus is in publicly procured transport by public transport authorities (PTAs). The description of what's considered as local, regional, and long-distance public transport differs a bit in the three countries mainly because of the differences in the system how public transport is organized. In Finland transport is considered local when it's procured by cities and city regions and operated by city buses with low floor (category M3, classes I and A). The difference between regional and long-distance transport in Finnish case is understood in this report as follows: regional transport is procured by ELY-centers (mostly operated by buses of category M3, class II) and long-distance (category M3, class III) is market based. Sometimes the usage of different vehicle types is not so straightforward, and ELY-centers can procure routes which by their length could also be considered long-distance.

In Sweden and Norway, where only regions procure public transport, the categorization follows mainly the vehicle types: local is operated by city buses with low floor (category M3, classes I and A), regional is class II and long-distance is class III. The situation in both countries is the same as in Finland: for example, sometimes regional transport can use classes I and A, so the descriptions are not binding.

Smaller vehicles are considered if those are part of publicly funded passenger transport. There are many connections in the Western Barents area where smaller vehicles are used instead of buses due to low demand. Sprinter-minibuses are quite common but sometimes even passenger cars are used if the demand is very low. Taxi services are not discussed in this report.

Vehicle categories included in the report:

- Buses and coaches (focus of the report):
    - Category M2: More than eight sears in addition to the driver's seat, a total mass maximum of 5 tons.
    - Category M3: Same as above, but a total mass over 5 tons.
    - Class I: Constructed with areas for standing passengers.
    - Class II: Constructed principally for seated passengers, standing passengers only in the gangway and/or in an area which does not exceed the space provided for two double seats.
    - Class III: Constructed exclusively for seated passengers.
    - Class A: Designed to carry standing passengers.
    - Class B: Not designed to carry standing passengers.
- Passenger cars (when used in public transport services):
    - Category M1: Not more than eight seats in addition to the driver's seat.

1.3 Methods and involvement of the interest groups

The analysis included four focus areas: 1) current state analysis, 2) availability and cost of the fleet, 3) current distribution and charging networks and 4) costs of procured transport services. The information has been collected from written materials, statistics, knowledge of the expert group and by interviewing relevant interest groups operating in the Barents region. Since the report includes three countries, similarities have been addressed and kept in focus while also keeping the differences in mind. Based on the analysis results, goals and roadmap have been set for the region.

Public transport authorities and their roles in general and on the promotion of alternative propulsion sources have been analyzed in chapter 2. EU-level, national and regional targets, and strategies which PTAs must follow when procuring public transport are discussed in chapter 3. This chapter also includes analysis of the future changes in the operating environment.

Chapter 4 discusses the status of using alternative propulsion powers in the Western Barents region. Current usage of alternative propulsion powers in the transport procured by PTAs and in market-based services is analyzed, as well as availability and cost of the fleet of different propulsion powers. Situation with distribution and charging networks in all three countries is analyzed keeping in mind that refueling and recharging of buses has some differences compared with for example passenger cars or trucks. Finally, how alternative propulsion powers affects the costs and service level of procured transport services is analyzed in an upper level.

Based on the current state analysis and existing requirements, goals are set for the whole Barents region. Possible actions to help achieving the goals are created with a roadmap. Roadmap includes proposals for possible pilot projects.

The project was guided by the steering group which met in three meetings during the project via Teams. The third meeting was organized as a workshop where goals, roadmap and pilot projects were discussed. The participants in the steering group were Mikko Tervo, Juha Tapio, Sanna Kolomainen, Jaakko Ylinampa, Heino Vasara, Juuso Puurula and Jussi Huotari from ELY-center of Lapland (Mikko Tervo representing Council of Lapland from December 2023 onwards), Kirsi Ylipiessa from the PTA of Sea Lapland, Mats Aspemo from the PTA of Norrbotten of and Lars Engerengen from the PTA of Troms and Finnmark. The consultant's project team consisted of experts from Ramboll Finland, Sweden and Norway: project manager Tytti Viinikainen (until November 2023) and project manager Pekka Vähätörmä (from November 2023) who also acted as a senior public transport specialist during the whole project, project secretary and main designer Juulia Hyvärinen, senior public transport specialists Hans Cats and Emma Eriksson, energy specialist Jaakko Takala and quality control by transport system specialist Markku Kivari. Consultant organized three internal round tables during the project to discuss and brainstorm the contents of the report.

1.3.1 Interviews

Besides desktop analyses (literature, earlier reports, statistics) the expertise of the project team and interviews of key stakeholders were used to collect information and experiences in the Barents region. Interviews were conducted via Teams during October and early November 2023. Interviewees were public transport authorities, operators and vehicle manufacturers or importers. They were asked about the current situation of the usage of alternative propulsion powers, views and plans, possibilities and good experiences and possible challenges and limitations. Full question lists can be found in annexes.

The stakeholders interviewed are listed below:

Finland:
- Public transport authorities
    - City of Oulu
    - Sea Lapland
    - ELY-center of Lapland
    - ELY-center of North Ostrobothnia
- Operators
    - Koiviston Auto Oulu Oy
- Vehicle manufacturers and importers
    - YES-EU Oy / Yutong Eurobus (interview covered Finland, Sweden, and Norway)
    - Volvo Finland Ab

Sweden:
- Public transport authorities
    - Region Norrbotten
    - Region Västerbotten
- Operators
    - Luleå Lokaltrafik
- Vehicle manufacturers and importers
    - Scania Sverige

Norway:
- Public transport authorities
    - Region Nordland
    - Region Finnmark (including Troms at the time of the interview)
- Operators

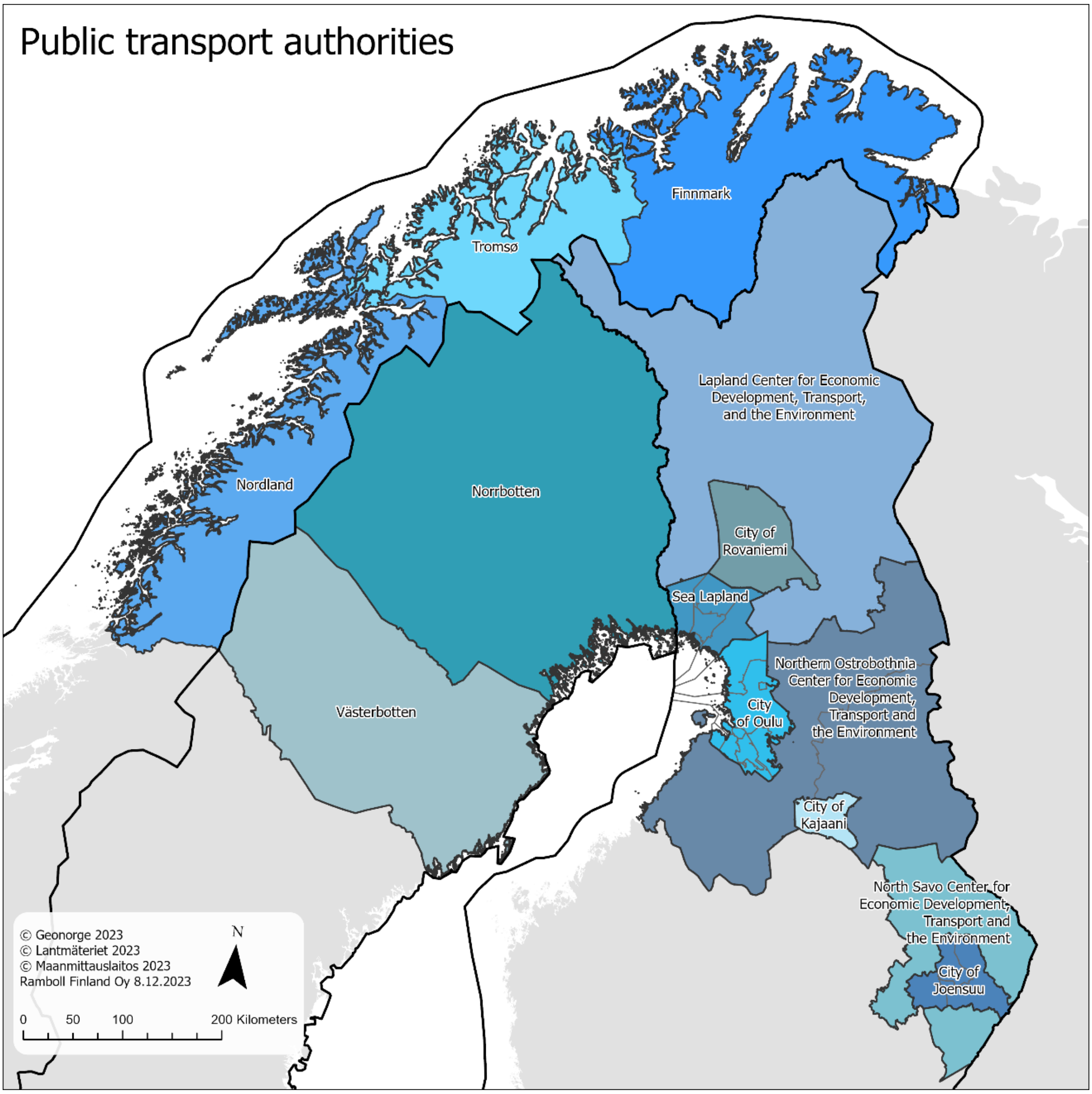
    - Boreal Norge AS
    - Connect Bus AS
    - Tide AS
- Vehicle manufacturers and importers
    - Scania Norge

Regarding the capacity of electricity grid and the charging infrastructure, additional interviews were conducted with the operators and energy companies.

2 Public transport authorities and their roles in the Western Barents region

Public transport in Finland, Sweden and Norway is organized by public transport authorities (PTAs) or it is operated market based. In Norway and Sweden, there are only regional PTAs which means that regions are responsible of all the transport in their own area. In Finland, there are both regional and city PTAs, so the responsibilities are more divided. PTAs in Finland are ELY-Centers of Lapland, North Ostrobothnia and North Savo, and cities or city-regions of Rovaniemi, Sea Lapland, Oulu, Kajaani and Joensuu. Swedish PTAs are regions of Norrbotten and Västerbotten, and Norwegian PTAs regions of Finnmark, Troms and Nordland.

Figure 2. Public transport authorities of the Western Barents region.



This chapter introduces the Finnish, Swedish and Norwegian PTAs. Subchapters are constructed differently between the countries to suit the local system. The chapter about Finland is sectioned based on the overview and characteristics, since the number of PTAs is higher. Chapters about Sweden and Norway are sectioned based on the PTAs since each country has only two or three. In the summary and discussion, we'll compare the systems and analyze the roles PTAs have when promoting alternative fuels.

2.1 Finland

2.1.1 Overview

Local and regional public transport in Finland is organized by competent public transport authorities (PTAs) which are specified in the Act on Transport Services (320/2017). The PTA can be either a city, city region or ELY-center.

Cities and city regions are responsible of the local public transport in their own area which can be only one municipality or several. For example, a city of Rovaniemi is a PTA only inside of their city borders but city of Oulu is responsible also in several smaller municipalities around Oulu.

ELY-centers as regional entities are responsible of the public transport in other small municipalities and regional transport between municipalities in their own region. Sometimes ELY-centers have divided responsibilities between themselves so that one ELY-center is responsible in several regions: for example, North Ostrobothnia ELY is responsible in their own region and in Kainuu region, and North Karelia's regional transport is organized by the ELY-center of North Savo. All authorities of the Finnish Barents region and their responsible areas are listed in table 1.

Table 1. Finnish PTAs in the Western Barents region and their responsible areas

Public transport authority (PTA)	Area (and type of transport) they are responsible of
City of Rovaniemi	Rovaniemi (local)
Sea Lapland	Tornio, Kemi, Keminmaa, Simo and Tervola (local and regional)
Lapland Center for Economic Development, Transport, and the Environment	Region of Lapland (regional)
City of Oulu	Oulu, Ii, Kempele, Liminka, Lumijoki, Muhos and Tyrnävä (local and regional)
North Ostrobothnia Center for Economic Development, Transport, and the Environment	Region of North Ostrobothnia (regional)
City of Kajaani	Kajaani (local)
North Ostrobothnia Center for Economic Development, Transport, and the Environment	Region of Kainuu (regional)
City of Joensuu	Joensuu, Kontiolahti and Liperi (local and regional)
North Savo Center for Economic Development, Transport, and the Environment	Region of North Karelia (regional)

In addition to connections organized by public transport authorities, long-distance transport is organized market based by public transport operators. Typically, long-distance buses have long routes which travel between major cities and stop by the smaller municipalities on their way. Tourist buses are typical for Lapland and there are connections between larger cities and for example the ski resorts. In ski resorts, such as Levi, there are also ski buses which operate between the slopes and accommodations.

Public transport organized by the PTAs in the Western Barents region includes only buses, and if demand is low, sometimes minibuses and even passenger cars. In other parts of Finland, PTAs can also be responsible of trams or light rail (Helsinki and Tampere areas), metro (Helsinki area), commuter trains (Helsinki area) and some ferries (Helsinki and Turku areas). Long-distance train connections are either market based or nationally subsidized.

2.1.2 Roles of the PTAs

The roles of the PTAs in Finland include a variety of responsibilities regarding the organization of public transport services. The main roles are:

- assigning the targeted service level of public passenger transport,
- procuring the operation of public transport,
- planning the routes and timetables,
- procuring the ticket and payment system,
- deciding the ticket types and fares,
- marketing of the public transport and offering passenger information, and
- selling tickets and giving customer service.

The roles differ a bit between cities and ELY-centers. For example, ELY-centers usually don’t organize ticket selling, and tend to have a smaller role in marketing aspect while city and city region PTAs might have their transport branded (for example JOJO in Joensuu).

The operation of the transport is handled by private bus operator companies; purchaser-provider model is the most common. Operators own the vehicles, employ the drivers and are responsible of organizing the depots for vehicles. The size of the operators varies: small PTAs usually have small local companies while bigger PTAs in dense areas usually have also bigger nationwide companies. The size of the PTA and operators affects the possibilities and limitations using alternative propulsion powers as discussed later in the report.

In addition to before mentioned roles, municipalities are also in charge of the public transport infrastructure (for example bus stops) on the street network, while ELY-centers have the same responsibility on the public road network.

2.1.3 Procurement systems and funding

Public transport authorities procure the operating services of public transport locally and/or regionally. Public transport services can be organized using contracts based on the procurement legislation (gross model) or concession agreements based on the EU’s Public Service Contract Regulation (1370/2007).

When using gross model, PTA buys a route or regional transport entity with certain timetables and quality level. PTA is responsible of planning the transport service and has the box office risk. The price the operator offers in their tender includes all the operating costs. When using the concession agreements, on the other hand, the operator has the box office risk. Most of the transport cities procure is operated using gross model and ELY-centers in the Barents region use mostly concession agreements. PTAs can do joint acquisitions when they procure for services together. These can be for example between city PTA and ELY-center when they procure route which crosses the borders of the city PTA, but instead of just serving regional transport, the route is very useful for passengers inside the city borders as well.

In practice, PTAs organize a competitive tendering process where they publish a call for bids, and operators send their offers. The most economically advantageous tender is chosen. When choosing, not only the price is evaluated but also the quality of the offered service using criteria told in the call for bids. Regarding propulsion powers, demands about emission levels of the fleet are included most often. Besides requirements, PTAs can also have a scoring system where different kinds of vehicles are given points which affects the choice of the operator.

The operation can be procured in one package or separated into several. Most common is to procure in several packages. This means that one PTA can have several contracts which include services for example in different parts of their responsible area and/or different kind of services. Based on the size of the PTA, one package can include only one or two vehicles or several dozens. If the amount of traffic is low, PTAs can also procure vehicles which only serve schools and commuting during morning and afternoon, and for the rest of the time the operator uses the vehicles in for example charter services.

The lengths of the contracts vary. Cities and city regions use mostly longer contracts of up to 7-10 years and ELY-centers shorter contracts of about 1-3 years plus option years. ELY-centers typically use shorter contracts since they usually procure complementary transport which is not offered market-based. The situations can change quickly and commitment to longer contracts can be difficult.

City PTAs fund public transport services using ticket sales, taxes collected from the citizens of the municipality/municipalities and the state subsidies. ELY-centers use mostly only funding they receive from the state but sometimes also ticket sales if the transport is organized using gross model contracts. State subsidies are paid from the national budget (Ministry of Transport and Communications). Usually maximum of 50 % of the costs can be covered with state subsidies.

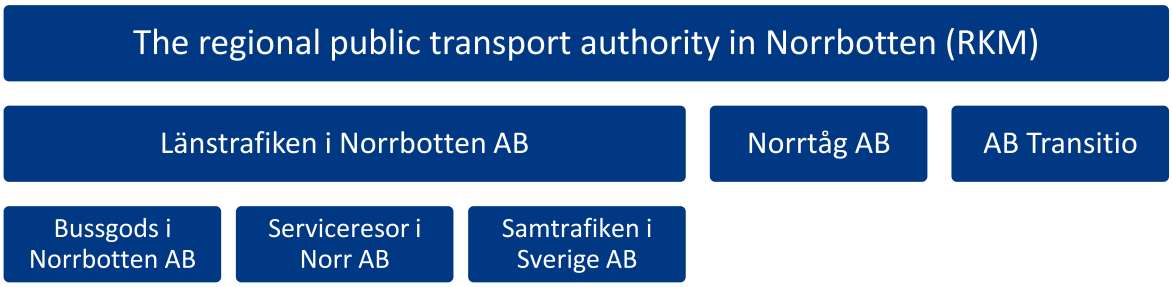
2.2 Sweden

In Sweden there are two PTAs in the Western Barents area: Region Norrbotten and Region Västerbotten. The roles of the PTAs are described below.

2.2.1 Region Norrbotten

The Regional Public Transport Authority in Norrbotten (RKM) handles local and regional public transport in the county. Regional public transport refers to public transport within one county or extending over several counties. RKM is organized as a municipal association with Region Norrbotten and the county's 14 municipalities as members. RKM is coordinating, streamlining, and developing public transport in the county. The authority also takes part in local, regional, and national networks that create conditions for continued development and rational management of public transport. RKM handles permits for transport services and national transport services in the twelve of the county's 14 municipalities in Norrbotten that have transferred the exercise of authority to the regional public transport authority.

Figure 3. Organization of the public transport in Norrbotten.



The Regional Public Transport Authority in Norrbotten, RKM is responsible for the strategic planning of public transport as well as for transport services and national transport services. Länstrafiken Norrbotten AB is owned by RKM Norrbotten. Länstrafiken assists RKM with planning, procurement, and follow-up of bus traffic in Norrbotten County. The company's operations also include planning, procurement, execution and coordination of community-paid bus and taxi trips in Norrbotten. Norrtåg AB is owned by the Regional Public Transport Authorities in Norrbotten and Västernorrland, Länstrafikbolaget Västerbotten and Region Jämtland Härjedalen. Norrtåg is the procurer and client of the regional train traffic. AB Transitio is jointly owned by 20 county councils/regions and public transport authorities from Skåne to Norrbotten. Transitio purchases, finances, and manages rail vehicles for its owners. Bussgods in Norrbotten AB is a wholly owned subsidiary of Länstrafiken i Norrbotten AB. Bussgods transports goods for the members of RKM, private individuals and companies in Sweden and Finland, mainly with regular bus traffic. Serviceresor in Norr AB is a wholly owned subsidiary of Länstrafiken which performs medical trips and transportation service trips with special vehicles in Kiruna municipality. Samtrafiken in Sverige AB is owned by

Länstrafiken and 37 other transport companies. Samtrafiken is responsible for good cooperation between the owners regarding tickets, timetables, and traffic management, but also for accompanying people with disabilities.

Roles and responsibilities

Regional Public Transport Authority in Norrbotten

- Works strategically for the development of public transport.
- Decides on Norrbotten's traffic supply program based on the County Administrative Board, the Swedish Transport Administration's, the municipalities, and Region Norrbotten's traffic plans.
- Conducts broad consultations.
- Decides on public service obligations and fares.
- Responsible for and monitors the county's public transport costs.

Länstrafiken in Norrbotten AB

- Manages operational activities on behalf of the Authority.
- Plans trunk line traffic in dialogue with Region Norrbotten
- Works out an action plan linked to the traffic supply program.
- Procures and drives traffic.
- Calculates costs and establish budget for traffic.
- Engages in dialogue with entrepreneurs.
- Produces statistics for travel, traffic costs, etc.
- Develops marketing and traffic information.
- Promotes coordination of ticketing and payment systems.

Municipalities in Norrbotten and Region Norrbotten

- Plan intra-municipal traffic and trunk line traffic (the municipality finances the intra-municipal traffic and region Norrbotten finances the trunk line traffic).
- Establish intra-municipal transport plans.
- Pay for the operation of the authority and traffic costs to Länstrafiken.

Swedish Transport Administration

- Supports and consults in the development of the transport supply program.

2.2.2 Region Västerbotten

The PTA of Västerbotten region acts as a public transport authority but also as a financier of the public transport. The municipalities are also important financiers because they finance the public transport within their municipality. PTAs fund public transport services using ticket sales, taxes collected from the citizens of the municipality and the state aids.

The region is the county's public transport authority, and is responsible for regional public transport by road, rail, and water overall, both its own procured traffic, municipal procured traffic and commercial traffic. The region is responsible for, among other things, transport supply programs, decisions on public service obligations and procurement. A traffic supply program is therefore something that Region Västerbotten' s council decides on as an authority. Just as the program's goals and strategies concern Region Västerbotten' s own traffic and its own efforts, the program also affects other actors' efforts and traffic. However, Region Västerbotten has a special responsibility for initiating and coordinating the work of different actors to achieve the goals.

Region Västerbotten is the owner and co-owner of the contracting units:

- Länstrafiken i Västerbotten

- Norrtåg

Regional bus services in the county and Umeå city traffic are procured by Länstrafiken. Several different operators operate regional bus services under the Länstrafiken brand in Västerbotten and city traffic under the Ultra brand. City transport in Skellefteå has the brand Skellefteå Buss, operated by the company with the same name on behalf of the municipality. The traffic Norrtåg is run by the train company Vy with the brand Norrtåg.

In cooperation with each other the public transport authority, municipalities and traffic operators develop the routes and timetables and markets the public transport. The municipalities are also responsible for infrastructure for the public transport.

Region Västerbotten finances the procured regular traffic and some demand-responsive traffic with the main traffic between municipal centers, including Norrtåg' s traffic (as well as medical trips). This model is being investigated at the time. In addition, Region Västerbotten finances the common costs, such as Länstrafiken's operations. Each municipality finances lines and demand-responsive traffic within the municipality (as well as transport services and school transport). Regions Västerbotten, Umeå and Skellefteå are the largest financiers of public transport, and the other municipalities finance in relation to their populations. In addition, there are commercial bus and train services to and from the county after Bothnia - the line, Inlandsbanan, E4 and to ski resorts.

When procuring transport services, PTAs can add requirements on the fleet used. Regarding propulsion powers these most often include demands about emission levels of the buses. Besides requirements, PTAs can also have a scoring system where different kinds of vehicles are given points which affects the choice of the operator.

2.3 Norway

Responsibility for public transport in Norway is divided among the state, county municipalities, and municipalities. They contribute to varying degrees to infrastructure, planning, and the purchase of economically unprofitable public transport services. The state has overall responsibility for transport policy and sets the framework conditions. The state is also responsible for national highways and the national railway network, while the county municipalities are responsible for local public transport within each county.

The main roles for the county municipalities are:

- assigning the targeted service level of public passenger transport,
- procuring the operation of public transport (buses, ferries, and express boats),
- planning the routes and timetables, supplying information to Entur[1] ,
- following up on operators,
- procuring the ticket and payment system,
- deciding the ticket types and prices,
- selling tickets and giving customer service, and
- marketing of the public transport and supplying passenger information.

In the Barents region there are three county municipalities; Nordland, Troms and Finnmark (Troms and Finnmark county municipality was split 1.1.2024). The county council in each county municipality decides on budgets and political guidelines for the public transport offering.

In Norway, depots and services in depots (such as charging) can be owned and organized by the PTA or the operator. The trend is for the PTA to offer depots in new contracts. In Nordland it is the operator that is responsible for the charging equipment, maintenance, etc. In Finnmark it is the PTA which is responsible for both the depots and the charging infrastructure, including maintenance.

[1] Entur is a government-owned transportation company in Norway. Owned by the Norwegian Ministry of Transport and Communications. It was created to offer sales and ticket solutions for the railways and travel planner for public transport throughout Norway.

2.3.1 Nordland

Reis Nordland is the brand used by Nordland County Municipality for public transport in the county and is organized as part of the transportation department in the county municipality. The PTA is responsible for school lines, regional lines, and city buses in Bodø, as well as 19 ferry connections in Nordland and two express boat connections (ferries and express boats are not discussed in this report). Bus services are procured through 9 different contracts.

When evaluating tenders Nordland uses their own evaluation model when evaluating fuel/emissions. Nordland is currently preparing tenders for four contracts covering 49 % of the county buses (40 % of the production).

2.3.2 Troms

Troms fylkestrafikk is the brand used by Troms County Municipality and is organized as part of the transportation department in the county municipality. The PTA is responsible for school buses, regional lines, and city buses in Tromsø and Harstad. They also have responsibility for 12 ferry connections and six express boat connections. Bus services is procured through 11 different contracts.

Troms is currently preparing a tender for the contract Nord-Troms, covering about 45 buses (11 % of the production). There are additional six contracts (total 308 buses) with contract ending in 2027-29, all running on diesel.

2.3.3 Finnmark

Snelandia is the brand used by Finnmark County Municipality and is organized as part of the transportation department in the county municipality. The PTA is responsible for school buses, regional lines and city buses in Alta, Hammerfest and Nordkapp, Vadsø and Kirkenes. They also have responsibility for 8 ferry connections and 5 express boat connections. Bus services is procured through 3 different contracts.

The Norwegian Public Transport Association publish an overview on bus contracts and ferry/express boat contracts.

2.4 Cross-border services and tourism

Western Barents have cross-border services which are organized mostly market-based. PTAs though organize some of the cross-border services or cooperation. The cross-border services have been affected by the COVID-pandemic starting from spring 2020 and the Russian war in Ukraine starting from spring 2022. There were more cross-border routes before and some of the routes have been cancelled. The situation is ongoing and some of the cancelled routes are still not running.

Finnish town Tornio and Swedish town Haparanda are situated right next to each other on both sides of the national border. Due to the proximity, municipalities have a shared travel center which is situated on the Swedish side just about 100 meters from the border. Along the Swedish buses, the city buses of Tornio, organized by PTA of Sea Lapland, and most of the Finnish long-distance buses travelling to and from Tornio use this travel center on the Swedish side.

Examples of border-crossing public transport services are:

- Bus service from Norway's Tromsø to Narvik, to Sweden's Björkliden, Abisko, and Kiruna. The bus routes are operated by Länstrafiken Norrbotten (route 91)
- The Arctic Route:
    - Train service from Norway's Narvik to Sweden's Kiruna. Train is operated commercially by Swedish VY

    - Bus route from Finland's Rovaniemi to northern Norway's Tromsø during wintertime: collaboration commercially between Bussring (Norway) and Eskelisen Lapin Linjat (Finland)
- Bus service from Finland's Oulu and Rovaniemi to Norway's Nordkapp during summer, operated by Eskelisen Lapin Linjat

Especially northern parts of both countries also have transport services specifically for tourism. For example, regional PTAs procure bus routes between major cities and towns, railway stations and the tourism centers. There are also a variety of commercially organized bus routes which mainly serve tourists, and bus operators offer charter services which can be bought straight from them. Tourism-related services might operate seasonally only during winter when the tourism season is livelier. Some of the commercially operated bus routes can be very long: for example, buses from southern Finland to Lapland's skiing resorts cover over 1000 kilometers. In the tourism centers itself, there are internal bus services which operate between the main slopes and the major accommodation areas. Ski buses have similar characteristics than urban transport in cities: running quite short routes with frequent headways.

2.5 Summary and discussion

The biggest difference between PTAs in three researched countries is the organization of them. Finnish system separates the cities from the regions and biggest cities acts as a PTAs themselves while regional ELY-centers are responsible of the other towns and the whole region. Swedish and Norwegian systems are based on the regions: counties are responsible of all the transport within the county borders. Swedish and Norwegian PTAs are responsible of train connections as well but in Finnish Barents area the PTAs have only buses, minibuses, and some passenger cars. One difference affecting the organization of different propulsion powers is that in Norway the bus depots can be owned by the PTAs, but always in Finland and mostly in Sweden, the operators handle their own depot services.

Otherwise, the responsibilities of the PTAs are similar in all three countries: PTAs assign the service level, they procure the transport service and plan routes and timetables. Operator companies handle the execution of the transport operation. In Sweden, the PTA can be an owner or co-owner of the operating companies while in Finland and Norway operating companies are most often fully independent.

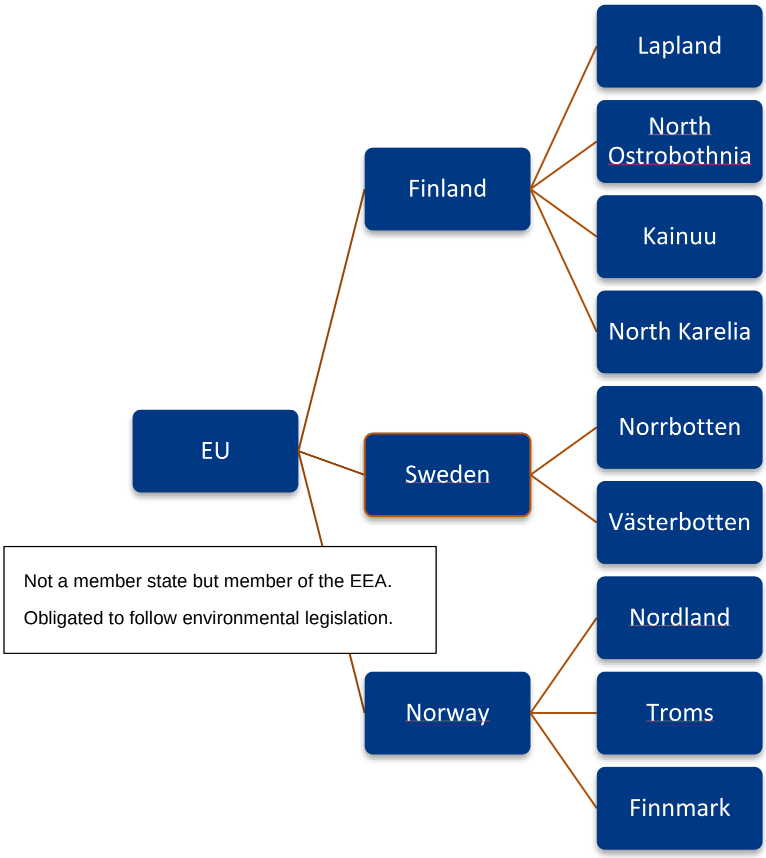
PTAs have a very big role in promoting alternative propulsion powers in the Western Barents region. PTAs place the fleet requirements and scoring systems while procuring transport and this significantly affects which propulsion powers the operators offer. They can also require that the operation is run using alternative fuels. The procuring processes affects operators' possibilities to invest in new vehicles and infrastructure needed to charge and fuel the fleet. Longer contracts make it possible to invest but shorter ones do not. Also, the length of the contracts affects the cycle how fast the fleet changes. If long contracts are made now with requirements and conditions guiding towards fossil fuels, the fleet can change next time only after the contract period has passed. Simply said, PTAs are the key actor when talking about publicly procured transport.

Public transport authorities act as enablers and examples. If PTAs require alternative propulsion powers, this might offer possibilities for also market-based actors. If the usage of for example biogas or hydrogen in publicly procured transport is certain, distribution companies may see this as a possibility to invest in the area.

3 Legislation and strategies

The development of the usage of alternative propulsion powers is affected by the legislation and strategies. Requirements and targets are mostly derived from the sustainability and climate challenges the European Union and the countries must tackle.

Figure 4. Requirement and target hierarchy from the EU level to national and regional level.



This chapter examines the legislation and strategies which aim to increase the usage of alternative propulsion powers in the Western Barents region. The legislation and strategies can be on different levels: from the upper-level climate and emission goals to the specific goals about the public transport fleet or the charging and fueling infrastructure.

3.1 EU-level requirements

Requirements and strategies implemented by the European Union define the legislation and goals each member state must adopt. Finland and Sweden are member states of the EU and follow their legislation and rules. Norway is not a member state, but still usually adopts large part of the legislation and policies since as a member of the EEA (European Economic Area) it is obligated to follow the environmental legislation.

A European Green Deal is the EU's strategic growth agenda for 2021-2027. The aim of the Green Deal is to transform EU into a modern, resource-efficient, and competitive economy which have no net emissions of greenhouse gases by 2050. Before that, goal is to reduce greenhouse gas emissions by at least 55 % by 2030 comparing to 1990 levels. Transport sector's goal is to reduce the emissions 90 % by 2050.

To specify how the mobility and transport sector should be developed, European Union has published a **Smart Mobility strategy**. The strategy has following goals, which affect the propulsion powers of public transport:

- By 2030:
  - At least 30 million zero-emission vehicles will be in operation on European roads.
  - Scheduled collective travel of under 500 km should be carbon neutral.
  - Zero-emission vessels will become ready for the market.
- By 2050:
  - Nearly all cars, vans, buses as well as heavy-duty vehicles will be zero-emission.

One of the flagships to reach the goal of zero emissions is to boost the uptake of zero-emission vehicles, renewable and low-carbon fuels and the infrastructure related to those. For road transport, for example investing in battery-electric and hydrogen fuel cell vehicles is one of the solutions. Since the vehicles need charging and fueling infrastructure, goal is to ensure a dense, widely spread network. The European Commission will also investigate ways to support cities procuring zero-emission vehicles and associated infrastructure.

European Union has also approved of the general approach regarding CO_2-limit values for heavy vehicles. The emissions of new buses used in urban transport should have zero net-emissions from 2030 onwards. The negotiations over the regulation will continue later between European Council, Parliament, and Commission.

Two of the most important legislations regarding propulsion powers in public transport are the Clean Vehicles Directive (2019/1161/EU) which regulates the fleet and Alternative Fuels Infrastructure Directive (AFIR) (2014/94/EU) which regulates the public charging and fueling stations.

Clean Vehicles Directive (CVD)

Clean Vehicles Directive was adopted in EU in 2019 and has been transposed into national laws by August 2021. The aim of the regulation is to promote clean mobility solutions in public procurement tenders, and it applies to cars, vans, trucks, and buses which are publicly procured.

Light-duty vehicles are considered “clean” when until 2025 they emit carbon dioxide (CO_2) no more than 50 g/km, and up to 80 % of applicable real driving emission limits for nitric oxide and nitrogen dioxide (NOx), and particle numbers (PN). From 2026 onwards only zero-emission vehicles are considered clean. These are applicable for vehicles of classes M1, M2 and N1: vans, passenger cars and light buses. Vehicles of class M2 are considered buses when they are used in public transport services.

Clean heavy-duty vehicles are trucks and buses which use hydrogen, battery-electric (including plug-in hybrids), natural gas (both CNG and LNG, including biomethane), liquid biofuels, synthetic and paraffinic fuels, and liquefied petroleum (LPG). There is also a separate definition for zero-emission heavy duty vehicles.

The directive excludes coaches meaning vehicles of category M3 other than Class I and Class A. In other words, regarding buses, it includes categories M2 and M3: vehicles of more than eight seats, total mass of M2 maximum 5 tons and total mass of M3 over 5 tons. Classes I and A mean buses which are constructed with areas for standing passengers. Other classes, which are excluded from the directive, are principally or exclusively designed for the carriage of seated passengers.

The Directive sets national targets for each member state. Each member state must make sure that the minimum percentage of clean vehicles is reached during the procurement period. The procurement periods mean that the percentage must be reached in tenders which are published during that period: not the vehicle fleet altogether. The national goals are discussed in chapter 3.2.

Alternative Fuels Infrastructure Directive (AFIR)

The original Directive on Deployment of Alternative Fuels is from 2014, and the revision of the directive will enter into force during autumn 2023. The aim of the regulation is to promote the transition to the alternative fuels. The regulation lays down mandatory minimum targets for the deployment of publicly accessible recharging and refueling infrastructures for road vehicles, which might help the conditions for the long-distance buses. It also sets out general technical requirements for the recharging and refueling stations.

Main deployment targets are:

- Along TEN-T core network by 2025: pool of 1400 kW output power and a high-power charging point (350 kW) every 60 kilometers. Along TEN-T comprehensive network the same power but every 100 km.

- Along TEN-T core network by 2030: pool of 3500 kW output power every 60 km. Along TEN-T comprehensive network this should be by 2035.
- Along TEN-T core and comprehensive network by 2030: hydrogen refueling stations every 150 km.

Recharging pool means one or more recharging stations at a specific location. Station on the other hand means a physical installation, consisting of one or more recharging or refueling points which are interfaces for the transfer of electricity, liquid, or gaseous fuel to one vehicle.

TEN-T network means Trans-European Transport Network, and core network in the Western Barents area are roads E75 and E8 from southern parts of Finland to Oulu and continuing through Tornio to the Swedish side. In Sweden, core network is the E4/E10-road following the Bothnian border and E10 from Töre through Kiruna to Narvik in Norwegian side.

3.2 National and regional legislation and strategies

Countries have national requirements and targets which are applicable in the Western Barents region, and which should be considered when analyzing the situation in the area. Regions and cities can also have their own goals which usually follow the goals set up on the upper level.

3.2.1 Finland

National level

Finland has a national goal to reach carbon-neutrality by 2035, and a roadmap to fossil-free transport has been constructed to support that goal. Goal is to replace fossil fuels with a variety of alternative transport fuels: fossil fuels should in the longer term be terminated.

Finland's **National Transport System Plan** for 2021-2032 is a strategic plan for developing the transport system. According to the vision, in 2050 transport will function in emission-free manner. Environmental damage caused by transport will have decreased and people will be able to use fossil-free propulsion powers throughout the country. The central and local governments will promote the construction of a distribution network for alternative fuels.

Law on environmental and energy efficiency requirements for vehicle and transport service procurement (740/2021) is a Finnish national implementation of the Clean Vehicles Directive. The directive has set out national goals for Finland to reach, which Finland has implemented as basic goals in the national law (table 2).

Table 2. Basic goals for clean vehicles in Finland during two procurement periods (share of clean vehicles in the contracts awarded during the period).

	2.8.2021-31.12.2025	1.1.2026-31.12.2030
Light-duty vehicles	38,5 %	38,5 %
Buses	41 %	59 %

The goals of buses apply to the PTAs of Rovaniemi, Sea Lapland, Oulu, Kajaani and Joensuu. In addition, city of Oulu has stricter requirements on zero-emission buses: during the first procurement period 5 % of the procured bus fleet should be emission free and during the second period 10 %. This means electric, hydrogen or e-fuels buses. The law is applicable only for city buses (M3-category, classes I and A) but not for coaches which are meant to serve regional and long-distance transport (M3, II and III). Regional ELY-centers mostly use the bus types which are excluded from the law but if they procured city buses, the law would apply to them. The minimum goals by PTA are in table 3.

Table 3. The minimum goals of Finnish PTAs regarding the clean buses (share of clean vehicles in the contracts awarded during the procurement period).

	2.8.2021-31.12.2025	1.1.2026-31.12.2030
Oulu	41 % zero-emission: 5 %	59 % zero-emission: 10 %
Rovaniemi	41 %	59 %
Sea Lapland	41 %	59 %
Kajaani	41 %	59 %
Joensuu	41 %	59 %
ELY-Centers	41 % mostly not applicable since the usage of vehicle classes excluded from the law	59 % mostly not applicable since the usage of vehicle classes excluded from the law

Light-duty vehicles (passenger cars, class M1) requirements are stricter for bigger cities, so during first procurement period Joensuu, Oulu and Rovaniemi should have 50 % of the vehicles clean. In other municipalities 20 % of the vehicles should be clean.

A distribution infrastructure programme for new fuels in road transport (Ohjelma tieliikenteen uusien polttoaineiden jakeluinfran kehittämiseksi Suomessa vuoteen 2035) was published in 2023 and the purpose is to promote the green transition in the transport sector. It includes the examination of the current state of the infrastructure distributing electricity, methane, and hydrogen for transport use. The programme is also intended to promote the implementation of the EU Regulation on the deployment of alternative fuels infrastructure (AFIR Regulation). Goals derive from the AFIR-directive but there are also some national goals.

Table 4. The minimum goals for the number of recharging pools and methane/hydrogen stations in Finland. The recharging pools and hydrogen stations are based on AFIR, methane based on the national vehicle goals.

	2025	2030	2035
Electricity, passenger cars and vans	25 on TEN-T core network	min. 60 on core and comprehensive network	increase in the power requirements
Electricity, heavy vehicles	min. 8 on core network	min. 60 on core network	increase in the power requirements
Liquefied methane (gas)	40	90	180
Compressed methane (gas)	100	-	-
Hydrogen	-	min. 7–30	-

Programme also sets out some goals regarding the number of vehicles using alternative propulsion powers in Finland.

Table 5. Vehicle goals of the Finnish distribution infrastructure programme. Table includes only vehicles that are relevant to this study.

	2025	2030	2035
Electric cars	213 000 PHEV 177 000 BEV	330 000 PHEV 550 000 BEV	352 000 PHEV 1 072 000 BEV
Electric buses	570 BEV	1600 BEV	2800 BEV
Methane buses	150 (LBG+CBG)	400 (LBG+CBG)	600 (LBG+CBG)
Hydrogen buses	10	100	200

PHEV = hybrid, BEV = full electric, LBG = liquefied methane, CBG = compressed methane

Regional level and cities

Finnish regions and cities have set goals mostly about carbon neutrality and strategic guidelines. Goals are based on the national requirements. The goals were collected from the regions' transport system plans and regional plans.

Lapland

- Lapland aims for carbon neutrality by 2035.
- Strategic focus points of developing Lapland include e.g., restraining climate change including green transition and good accessibility.
- Transport's emissions must be considered in all development. This includes for example alternative propulsion powers and energy efficiency.
- Development of the charging and fueling networks of alternative propulsion powers will be supported, and e.g., park-and-ride facilities and tourism centers will be considered as locations.
- Lapland has their own Green Deal roadmap which includes transition to electricity and other renewable propulsion powers in transport sector.

North Ostrobothnia

- North Ostrobothnia heads towards carbon neutrality.
- Goal is to be e.g., easily accessible and to grow sustainably.
- In transport sector, there are goals to promote clean transport vehicles and renewable propulsion fuels.
- One goal of the transport system is to be able to answer to the emission reduction goals. Charging and fueling networks will be promoted and considered when planning the land use.

Kainuu

- Kainuu plans to reduce their carbon emissions 80 % by 2040.
- Region heads towards a wide network of charging and refueling points for alternative propulsion powers.
    - 3 biogas stations in 2025, 6 in 2040
    - Low-emission cars 100 %
- Goal is to develop the transport system towards more sustainability. One way to do that is to consider clean vehicles and renewable propulsion powers when planning and making decisions.

North Karelia

- Main goal is to promote the accessibility and to restrain climate change.
- Low-emission public transport will be available to use in daily trips to work and school and in tourism sector.
- Plans to develop the charging and fueling networks and enhance low-emission fleet in public transport.

3.2.2 Sweden

National level

Sweden must have no net emission of greenhouse gases into the atmosphere by 2045 at the latest. In the transport sector, Sweden's goal is to reduce transport sector's emissions by 70 % between 2010 and 2030. The goal includes emissions within Swedish borders.

European Union's Clean Vehicles Directive has set national targets for Sweden. The directive has been implemented in Sweden through **the Act on Environmental Requirements for the Procurement of Cars and Certain Services in the Road Transport Sector** (2011:846). Sweden hasn't distributed the effort differently across contracting entities, and all follow the same minimum targets shown in table 6. Half of the target set out for clean buses must be fulfilled by procuring zero-emission buses.

Table 6. Basic goals for clean vehicles in Sweden during two procurement periods (share of clean vehicles in the contracts awarded during the period).

	2.8.2021-31.12.2025	1.1.2026-31.12.2030
Light-duty vehicles	38,5 % zero emission: 19,25 %	38,5 % zero emission: 19,25 %
Buses	45 % zero emission: 22,5 %	65 % zero emission: 32,5 %

Sweden has an **Action program for charging infrastructure and tank infrastructure for hydrogen** (Handlingsprogram för Laddinfrastruktur och tankinfrastruktur för vätgas) which sets out goals for charging pools based on the AFIR-regulation. By 2025, there should be charging pools every 120 km for 15 % of the TEN-T network, and by 2027 for 50 % of TEN-T network. By 2030 there should be charging pools every 60 km on core network and every 100 km on comprehensive network. The total capacity per charging pool and direction increases every goal year.

Regional level and cities

Swedish regions of Norrbotten and Västerbotten have set goals and strategic aims based on national ones. Counties have transport plans set for 12 years. Besides transport plans, the goals are collected from the climate strategies.

Norrbotten

- Norrbotten will have no net emissions of greenhouse gases in 2045.
- The region plans to promote to create a county-wide infrastructure for renewable fuels and charging points.
- In Norrbotten, there are good opportunities for transition to electricity and renewable fuels in transport sector.

Västerbotten

- Västerbotten follows national goals and will have no net emissions of greenhouse gases by 2045, and greenhouse gas emissions of domestic transport must be reduced by at least 70 % by 2030.
- A goal of transition to sustainable mobility means changing modes of transport and switching to less polluting vehicles and propulsion powers.
- According to the climate strategy, the focus for work on fossil-free land transport must be on the traffic that the region pays for: meaning for example public transport.
- The Trafikförsörjningsprogram för Västerbotten stipulates the following goal: "The proportion of vehicle kilometers that use renewable fuel in procured public transport will amount to 100% by 2030. Interim target for 2025 is 75%".

3.2.3 Norway

National level

Norway’s national goal is to reach carbon-neutrality by 2030 if emission cuts are made by other countries and by 2050 regardless of international emission cuts. The zero-growth goal is a national requirement for urban areas: "The goal for urban areas is to reduce greenhouse gas emissions, congestion, air pollution, and noise through efficient land use and by shifting the growth in personal transportation to public transport, cycling, and walking."

The transport sector accounts for approximately one-third of Norway's greenhouse gas emissions, and roughly 60 percent of non-quota emissions. The CO_2 tax and the blending mandate for biofuels are the primary measures for reducing emissions from the transport sector. However, additional and more detailed measures are required to contribute to technology development and emission reduction. In recent years, the share of electric city buses has increased. In 2022, two out of three city buses sold were electric, and by December 2023, 17 percent of all public procured buses are electric and about 5 percent run on biogas.

The regulation on emission requirements for publicly procured road transport vehicles (Forskrift om utslippskrav til kjøretøy ved offentlig anskaffelse til veitransport) mandates zero emissions for all buses with standing room from January 1, 2024 (the requirement was moved from 2025 to 2024). This means that from 2024 all procured new buses must be zero-emission in urban transport. 75 % of the new long-distance buses must be zero-emission by 2030.

Regional level and cities

The county municipalities develop regional transport plans, including strategies and action programs. The County Council approve these plans. Some goals and measures from the regionals plan are shown under:

<u>Nordland</u>

It is a recurring theme in the inputs from the Nordland community to facilitate the reduction of greenhouse gas emissions from the transport sector. There is a need to adopt new environmentally friendly propulsion technologies in the transportation sector and develop a robust charging and refueling infrastructure throughout the county. It is also of great importance to facilitate walking, cycling, and public transportation in cities, towns, and rural areas.

Goals and strategies to achieve the goal in Nordland:

- Facilitating climate-friendly transportation systems in Nordland.
    - Working towards public transportation services that rely on eco-friendly solutions and contribute to reducing car usage.
- Reducing total greenhouse gas emissions by 60% by 2030, compared to 2016.
    - Implementing low- and zero-emission solutions in the public transportation sector through public procurement
    - Developing a strategy for transitioning to the green shift for ferries, fast boats, and buses.
    - Initiating and participate in projects aimed at developing new knowledge and expertise in low- and zero-emission technology in the public transportation sector.

<u>Troms</u>

The county municipality is tasked with facilitating the sustainable development of urban areas in Troms. As the transport authority, it will facilitate the achievement of the zero-growth goal and improve transportation networks, with responsibilities for public transport and key road connections within and between cities and centers.

City packages and urban growth agreements entail binding cooperation between state, regional, and local actors for sustainable transport in the largest urban areas. This framework guides the development and efforts to create attractive cities, reduce climate emissions, and improve transport networks in urban areas. City packages are action plans for urban areas. Measures are financed through a joint effort, including user fees and funding from municipalities, county municipalities, and the state. The measures mainly involve transport infrastructure and, to some extent, the operation of public transport. The reward scheme is an incentive program aimed at achieving the zero-growth goal. The scheme aims to stimulate better mobility, environmental sustainability, and health in major urban areas by curbing the growth in private car transport and increasing the number of public transport trips.

Goals and strategies to achieve the goal in Troms:

- Reducing the transportation sector's emissions of greenhouse gases and minimize its impact on the natural environment.
    - Advocating for the state to fully finance mandates and transfers of responsibilities.
    - Facilitating increased use of more environmentally friendly technology.
    - Contributing to ensuring access to climate-friendly fuel solutions.

Finnmark

The land-based public transportation system aims to offer an attractive mobility service that enhances quality of life. The introduction of zero-emission buses, improved information systems, and optimization of route paths aim to make cities feel modern and attractive for residents at all stages of life.

The towns and settlements in Finnmark should be connected within a comprehensive public transportation network that provides access to regional centers through public transport. This integrated public transportation network consists of express and regional buses, with a particular focus on safety, road conditions, travel time, and passenger comfort. In rural areas, a combination of regular routes and school transport is a crucial prerequisite for the public transportation service.

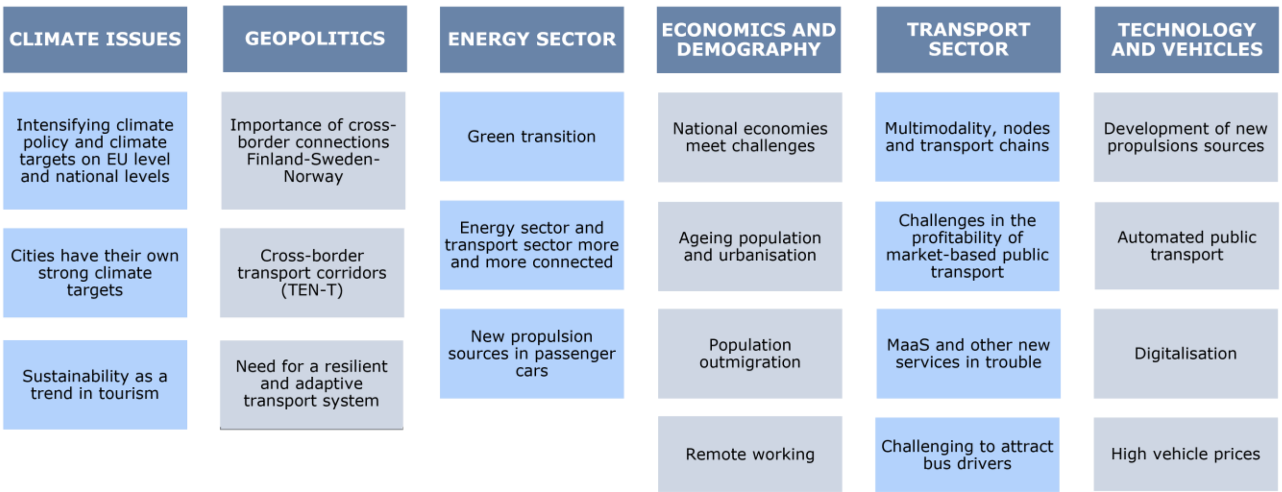
Strategies to achieve goals in Finnmark:

- Implementing zero- and low-emission solutions for all public transportation.
- Facilitating a dedicated public transportation service alongside commercial routes within the county and extending across the borders to neighboring counties/countries.

3.3 Changes in the operational environment

Changing operating environment influences the transport sector. This includes global megatrends and major global phenomena which change the society's functions and the environment where public transport operates. Changes in the operating environment are behind the need to shift from fossil fuels to the alternative propulsion sources and the operating environment affects how non-fossil fuels can be adopted in certain areas. Some of the most relevant changes here are seen in the themes of climate issues, geopolitics, energy sector, economics and demography, transport sector itself and technologies and vehicles. The changes in the operating environment are similar in the big picture in Finland, Sweden, and Norway but there might be small nuances which differ between the countries.

Figure 5. Changes in the operational environment.



Climate change is one of the major global megatrends and due to that intensifying climate policy and climate targets on the EU and national levels have introduced a wide variety of needed measures to tackle the targets. Cities also have their own strong climate targets, and urban public transport is increasingly being electrified. Climate and other sustainability issues have made sustainability one of the growing trends in tourism.

Geopolitics have changed the situation in Nordics fast during the latest years. Especially the situation with Russia caused by the Russian war in Ukraine has affected the connections and economics of Finland which have very long Russian border. Geopolitical changes increase the importance of cross-border connections between Finland, Sweden, and Norway. Geopolitical changes and climate change also both have increased the need for a resilient and adaptive transport systems. Cross-border transport corridors (TEN-T) are gaining EU-financing.

Energy sector and transport sector are getting more and more connected since new clean energy (electricity, e-fuels, and hydrogen) is used more and more in transport. There is a green transition of industries and energy production in the North underway, and this affects the possibilities there are to promote alternative propulsion powers. New propulsion sources in passenger cars have possible impacts on public transport since the share of electric and other clean cars is growing.

Economics and demography have influence in the transport sector. National economies meet challenges which have led to strained public budgets. Ageing population and urbanization have impacts on the demand of public transport. Population outmigration have happened due to less economic opportunities. Remote working has increased after coronavirus pandemic which have changed the demand for public transport.

Transport sector itself is going through some changes. Multimodality, nodes, and transport chains have been elevated as an emphasis in transport policies. Challenges in the profitability of market-based public transport especially in rural areas affect the supply of public transport. MaaS and other new services are in trouble if strong public transport to rely on is not offered. Public transport sector also has had challenges to attract bus drivers.

Technology have changed the society's functions during the latest decades and will continue to do so. Development of new propulsion sources like hydrogen affect the supply of vehicles and needed infrastructure in the future. Automated public transport especially in cities and as last-mile solutions and high vehicle prices similarly affect the possibilities in developing transport services. Digitalization still is changing the customer experience and possibly bringing new players to the field.

3.4 Summary and discussion

European Union chases carbon neutrality by 2050. Transport sector's goal is to reduce emissions 90 % by the same year of 2050. European Union also has a goal that by 2030 scheduled collective travel of under 500 km should be carbon neutral and by 2050 nearly all buses should be zero-emission. To help reaching the goals, EU has set up for example Clean Vehicles Directive (CVD) and Alternative Fuels Infrastructure Directive (AFIR). CVD regulates the development of vehicles in publicly procured transport and AFIR regulates the infrastructure used to fuel alternative propulsion powers. New general approach about CO2-limits of heavy vehicles suggests that from 2030 onwards new buses in urban transport should have zero net-emissions.

CVD and the similar goal in Norway are the ones which are the easiest to follow-up and can be considered as the most important goals public transport sector must fulfill in the Western Barents region. It's possible to calculate and assess, how many clean or environmentally friendly vehicles are required and what kind of characteristics gives possibilities or limits reaching those goals. These goals are collected in the following table 7. The requirements are for buses of classes I and A, so only vehicles meant to carry also standing passengers are included.

Table 7. Shares of public transport vehicles, which should be clean or zero-emission. The percentages refer to the share of the vehicles procured during the time period via competitive tendering processes. It does not refer to the share of all vehicles which are operating.

	2021–2025	2026–2030
Finland	41 % (Zero emission: Oulu 5 %)	59 % (Zero emission: Oulu 10 %)
Sweden	45 % (Zero emission: 22,5 %)	65 % (Zero emission: 32,5 %)
Norway	All zero emission from 2024	All zero emission from 2024

The law does not require alternative propulsion powers to be used in transport of longer distances and regional transport where low floor buses are not used. Norway is an exception: there is a goal to have 75 % of the new long-distance buses zero emission vehicles by 2030.

All three countries have national goals of carbon neutrality: Finland is reaching towards carbon-neutrality by 2035, Sweden by 2045 and Norway as early as by 2030 (if emission cuts are made by other countries and by 2050 regardless of international emission cuts). The Finnish, Swedish and Norwegian counties in the Barents region also have their own carbon-neutrality goals which usually follow the goals of the state.

Norwegian goals for the development of the vehicles are strict and clear. All city buses must be zero-emission as soon as from 2025, and 75 % of new long-distance buses from 2030. This means that the vehicles must be electric or hydrogen vehicles. Finnish and Swedish goals currently allow more possibilities to be considered.

4 Present state of alternative propulsion sources in public transport

This chapter discusses the present state of alternative propulsion sources in public transport in the Western Barents region. It includes analysis of the usage of alternative propulsion sources, situation of fueling and charging infrastructure, availability and cost of the fleet, and costs of procured transport services.

4.1 Usage of alternative propulsion sources

The current usage of alternative propulsion sources in public transport in the Western Barents region has been analyzed. This chapter discusses the situation in all three countries separately. National statistics and interviews were used as sources when collecting the information. In Finland, a short email questionnaire was sent to the PTAs due to the limitations in public sources.

4.1.1 Finland

In whole Finland, 93 % of the registered bus fleet were diesel buses as of Q2/2023, and 6 % of the bus fleet were electric buses. Most of the rest of the remaining 1 % were gas buses. The share of diesel buses includes buses which are fueled with 100 % renewable diesel required in the public transport contracts or otherwise. There are not any hydrogen fuel cell buses in Finland. Altogether in 2022 fossil diesel covered 54 % of the energy consumption in the road transport sector (including all passenger cars, trucks, buses, etc.). Shares of the alternative fuels in energy consumption were renewable diesel 12 %, biogas 0,7 % and electricity 1 %.

Even though the usage of alternative propulsion sources in public transport is still not very high in Finland, electrification has advanced fast and continues to grow in urban transport. The number of electric buses registered in Finland has grown from 62 buses in 2019 to 550 buses in 2022 nationwide.

The national statistical institution of Finland (Tilastokeskus) tells that there are not any electric, gas or hydrogen buses registered in the regions belonging to the Barents area. The total of 1293 buses are diesel buses, 4 uses gasoline and 4 gas. There are some serious limitations using these statistics. The buses can be registered elsewhere than where they are used (for example headquarters of the operator), so not all buses operating in the Barents area are visible in the statistics. Also, it cannot be separated which diesel buses are fueled with 100 % renewable diesel.

Other sources have been used to tackle the above-mentioned limitations. Finnish Transport and Communications Agency (Traficom) has clarified that all the electric and gas buses are used in public transport in cities and procured by the city PTAs. Based to that, it can safely be said that there are not any gas or electric buses operating elsewhere than in cities. Market-based operators might sometimes fuel their tanks with 100 % renewable diesel but there aren’t any statistics available to check that.

PTAs were asked via email about their share of different propulsion sources. All the PTAs in the region answered the questionnaire or the situation was clarified in the interview. Only PTAs of Oulu, Joensuu, and Sea Lapland currently (winter 2023-2024) have vehicles using alternative propulsion powers in their transport services. Answers are collected to table 8.

Table 8. Vehicles using different propulsion powers procured by the Finnish PTAs in the autumn of 2023. (Source: survey send to PTAs).

PTA	Electric buses	Diesel buses (HVO)	Gas buses (biogas)	Diesel buses (fossil diesel)	Total
Oulu	15 (class I)	18 (class I) 18 (minibuses)	4 (class I)	95	150
Joensuu	13 (class I)	5 (class I)	0	19 (class I)	59

		8 (minibuses)		14 (class II)	
Rovaniemi	0	0	0	19 (class I) +1–3 added during winter	19
Sea Lapland	0	1 (class I)	0	6 (class I) ~10 (class II)	~17
Kajaani	0	0	0	9 (class I) 12 (class II) 6 (minibuses)	27
Lapland	0	0	0	~26–30	~26–30
North Ostroboth-nia and Kainuu	0	0	0	~60	~60
North Karelia (ELY of North Savo)	0	0	0	30 (class II/III) 6 (minibuses)	36
Total	28 (7 %)	50 (13 %)	4 (1 %)	~312–316 (80 %)	~394–398

Finnish PTAs in Barents region are still dependable on fossil diesel, but cities have started to move towards more sustainable propulsion sources. Altogether 80 % of the fleet uses fossil diesel, 13 % renewable diesel, 7 % electricity and 1 % gas. Oulu is the biggest PTA in the region with 150 buses and has started the electrification of urban transport in the summer of 2023. The number of electric buses will increase by 57 vehicles in 2024. In summer 2024 48 % of their fleet will be electric, and when gas and renewable diesel are added, 75 % will use alternative propulsion powers.

In Joensuu, 22 % of the buses run by electricity and 22 % by renewable diesel (HVO). City of Rovaniemi, which currently have only diesel buses using fossil diesel, clarified that their current contract is valid until summer of 2025, and in the new procurement process PTA will take the law (740/2021) into account. Sea Lapland has one bus using renewable diesel, and the rest are fossil diesel. In Kajaani all the buses use fossil diesel. All the transport procured by ELY-centers are diesel buses and there are no obligations to fuel them with renewable diesel. All the interviewed PTAs had positive view towards alternative propulsion sources but there are limitations affecting which propulsion powers are realistic options.

New buses procured into cities are mostly electric nowadays. In general, the number of first-time registered diesel buses has decreased in last years while the share of electric buses has grown. The development has been much faster than predicted as discussed in the interviews. In bigger cities the operators tend to offer electric vehicles even if those aren’t required or the tender hasn’t been built to especially favor e-buses. Electricity has been the most preferable propulsion power among alternative powers due to the market situation favorable towards electricity, and for example insecure price development of renewable diesel and poor refueling infrastructure of gas.

Outside urban transport in cities, smaller and regional PTAs have challenges that make it more difficult to swap fossil diesel to electricity. Main limitations are the small amount of transport services which limits the possibilities to invest in infrastructure, long distances, and cold climate during winter. Where electric buses are not suitable, renewable diesel is seen as most potential alternative propulsion power. HVO has limitations due to the fueling network and price, and how PTAs can monitor the usage of fuel.

4.1.2 Sweden

In Sweden altogether 76 % of the registered buses were diesel buses in 2022. Second most used propulsion power is gas, since 17 % of the bus fleet in the country were gas buses. Sweden has been focusing on promoting the usage of gas buses much more than Finland and Norway where the gas usage is lower. Electric buses took a bit over 5 %. Usage of alternative propulsion powers in Västerbotten and Norrbotten are discussed separately.

Region Västerbotten

Region Västerbotten is the owner of Länstrafiken Västerbotten and Norrtåg. The regional buses and Umeå's city traffic are procured by Länstrafiken Västerbotten. In the rest of the region several different traffic operators are procured by the municipalities. Because of the divided responsibility, each one also decides what kind of propulsion they use. When they procure, they can demand prices for several different propulsion and then the PTA chooses which one they want to have.

There is a target for the proportion of renewable fuels in the procured transport (75 % of vehicle kilometers by 2025, and 100 % by 2030). The proportion of vehicle kilometers increases when procured operators switch – through agreements or voluntarily – to renewable fuels, and report this in the vehicle database FRIDA. Today's share of propulsion can be seen in table 9. 81 % of the vehicles uses alternative propulsion powers: the share of HVO is 66 %, electricity 7 % and CNG 8 %. Only about 20 % of the Västerbotten' s public transport use fossil diesel.

Table 9. The share of different propulsion powers in Västerbotten. The source of the number is FRIDA-system which includes all the public transport vehicles registered in the system.

	Number of vehicles	Share of vehicles
Electric buses	32	7 %
Diesel buses (renewable diesel (HVO))	293	66 %
Gas buses (CNG)	35	8 %
Diesel buses (fossil diesel)	87	20 %
Total	447	100 %

The biggest challenges for the region are the infrastructure for the alternative propulsions, the cold climate and that the regional buses often drive long distances. It is also a challenge to procure HVO and CNG in some of the municipalities. The increased demand of alternative propulsion fuels can also be a challenge. In Västerbotten, there is relatively good grid capacity, which will facilitate electrification.

Region Norrbotten

Region Norrbotten mainly has the same structure of organization as Västerbotten which makes that each procuring organization is responsible for their own traffic and choosing the propulsion that will be used in the future. Both regions want to procure traffic with more electricity, HVO and biogas. The Region do not today have any "added value" in the procurements if the traffic operators offer a certain propulsion.

Today Norrbotten only procures buses with either diesel or HVO, the share of 44% is HVO and the rest diesel buses. This is for the buses that Region Norrbotten is responsible for, about 200 buses. In the future the Region want to procure both biogas and electric buses mainly. The other alternative propulsions have challenges that must be solved. Today they do not have any regional buses with electricity, especially due to the long distances and cold climate in the region. But they have city buses with electricity in the cities of Luleå and Piteå.

Table 10. The share of different propulsion powers in Norrbotten. The source of the number is FRIDA-system which includes all the public transport vehicles registered in the system.

	Number of vehicles	Share of vehicles
Electric buses	2	0,3 %
Diesel buses (renewable diesel (HVO))	46	6 %
Gas buses	82	11 %
Diesel buses (fossil diesel)	652	83 %
Petrol buses (fossil petrol)	3	0,4 %
Total	785	100 %

In some of the municipalities there are challenges to be able to find biogas as propulsion due to the distribution network. The same situation is sometimes with HVO, and due to that there are challenges for PTAs to get tenders that could offer this propulsion. The biggest challenges for the region are the infrastructure for the alternative propulsions, the cold climate and that the regional buses often driving long distances.

4.1.3 Norway

In Norway as a whole 87 % were diesel buses out of all the registered buses in the country, 6 % electric buses and 5 % gas buses in 2022. Rest were petrol vehicles or diesel hybrids. Altogether in 2022 fossil diesel covered 55 % of the kilometers in the road transport sector (including all passenger cars, trucks, buses, etc.). Shares of the alternative fuels in energy consumption were gas 0,2 %, electricity, 18 % and hydrogen 0,01 %. Big share of electricity is explained by the amount of electric passenger cars in Norway: over 20 % of Norwegian registered passenger cars are electric.

The most used fuel in public transport in Nordland, Troms and Finnmark is fossil diesel. The region is huge, with large areas with low population density. Managing large areas with many locations and varying needs is challenging. Historically all public transport was done by using diesel as fuel. This was predictable, and there were few changes between each contract – same fuel, same drivers, same depots but with newer buses (usually from the same supplier). Currently, market is in a technological shift to zero-emission technologies.

Counties in Norway do not mandate the use of renewable diesel (HVO) in their operating contracts. The rationale behind this is linked to the distribution obligation, which compels all fuel distributors to vend a specified proportion of HVO. This obligation is fulfilled by blending fossil and renewable diesel. For instance, if a Public Transport Authority (PTA) demands 100% renewable diesel, distributors can opt to blend a lesser percentage. Consequently, insisting on 100% HVO becomes economically unviable, as it would incur higher costs, without yielding any discernible difference in climate impact in the long run.

PTAs in the region view electric vehicles as the primary solution due to their cost-effectiveness in terms of running expenses. The operational costs of biogas are comparatively high, coupled with low local production. Additionally, hydrogen is still significantly more expensive than electric buses. Consequently, PTAs exclusively request electric buses and diesel buses in their contracts. The county municipalities switch fuels when changing contracts. The number of vehicles is described in table 11 and the current contracts in table 12.

Table 11. The number of buses using electricity and fossil diesel in the Norwegian Barents in the transport procured by the PTAs (December 2023).

	Electric buses	Diesel buses (fossil diesel)	Total
Nordland	32	373	405
Finnmark	35	94	129
Troms	0	351	351
Total	67 (8 %)	818 (92 %)	885

Table 12. The status of Norwegian Barents' PTAs' contracts with more than 5 buses.

PTA	Area	PTO	No. Buses	Technology/ Propulsion	Contract start	Contract end
Nordland f.k.	Ofoten	Boreal Buss AS	25	Diesel	25.03.2018	24.03.2026
Nordland f.k.	Søndre Salten	Nordlandsbuss AS	24	Diesel	01.01.2018	31.12.2025
Nordland f.k.	Indre Helgeland	Boreal Buss AS	120	Diesel	01.10.2017	30.09.2025
Nordland f.k.	Søndre Helgeland	Connect Bus Nord AS	30	Diesel	01.07.2017	30.06.2025
Nordland f.k.	Ytre Helgeland	Nordlandsbuss AS	27	Electric from 2026	01.04.2023	31.03.2033
Nordland f.k.	Lofoten og Vesterålen	Boreal Buss AS	84	Diesel	01.01.2021	31.12.2030
Nordland f.k.	Salten	Nordlandsbuss AS	95	32 e-busses, rest Euro6 fossil diesel	01.07.2021	30.06.2031

TFFK - Snelandia	Finnmark Øst	Boreal Buss AS	40	15 e-buses + rest Euro6 fossil diesel	01.10.2023	30.09.2033
TFFK - Snelandia	Finnmark midt	Tide Buss AS	53	10 e-buses, rest Euro6 fossil diesel	01.10.2023	30.09.2033
TFFK - Snelandia	Nordreisa kommune (Nord Troms)	Connect Bus Nord AS	36	10 e-buses + rest Euro6 fossil diesel	01.10.2023	30.09.2033
TFFK - Troms fylkestrafikk	Nord-Troms	Connect Bus Nord AS	43	Euro6 fossil diesel	01.08.2019	31.07.2025
TFFK - Troms fylkestrafikk	Midt-Troms og region	Tide Buss AS	90	Euro6 fossil diesel	01.08.2019	31.08.2028
TFFK - Troms fylkestrafikk	Tromsø-området	Tide Buss AS	171	Euro6 fossil diesel	01.08.2019	31.07.2027
TFFK - Troms fylkestrafikk	Dyrøy kommune (Midt Troms)	Bussring AS	2	Euro6 fossil diesel	01.11.2019	31.08.2028
TFFK - Troms fylkestrafikk	Målselv kommune (Midt Troms)	Connect Bus Nord AS	2	Euro6 fossil diesel	01.11.2019	31.08.2028
TFFK - Troms fylkestrafikk	Bardu kommune (Midt Troms)	Furuly Turbuss AS	3	Euro6 fossil diesel	01.11.2019	31.08.2028
TFFK - Troms fylkestrafikk	Sør-Troms og Harstad	Connect Bus Nord AS	40	Euro6 fossil diesel	01.05.2020	30.06.2029

County municipalities reported during interviews that some operators inquire about the possibility to voluntarily transition from old diesel buses to new electric buses in the middle of contract period. The county municipality interprets this as operators finding it economically viable to make the switch if they see a potential for reusing the zero emission buses after the contract ends (e.g., using the buses in another contract).

There are many bus operators providing market-based long-distance and international bus connections. In this project, Boreal, a significant operator is the market, was interviewed regarding their operations in the Barents region. Their fleet undergoes continuous changes to align with market demands. A snapshot in the autumn of 2023 reveals that about 25% of their fleet is battery-electric buses. Boreal is at the forefront of the technological shift, so it should be expected that the percentage is lower when considering all operators in the market.

Operating with gas (biogas or hydrogen) is entirely different from operating with electricity. Gas is demanding on the infrastructure. Hydrogen could be a good fuel in the region but has higher costs than electricity. The public sector must drive this change as it comes at a higher cost for the operators. At the same time hydrogen could have positive ripple effects on other parts of the transport sector, and across borders.

Norway has experience of piloting hydrogen buses. There was a pilot in Oslo from 2011-2019 which showed that hydrogen market was still in early development phase. The pilot had problems with production and delivery of hydrogen, operations, maintenance, and spare part sourcing.

4.1.4 Summary and discussion

Fossil diesel is the most common fuel used in public transport in the Western Barents region. In all three countries there is of course a long history and habit of using fossil diesel. Also, for example challenges with the long distances, sparse population, and limited public transport supply affects the conditions of alternative propulsions. The usage of different propulsion powers is shown in table 13 by the number of vehicles. Fossil diesel is used in 69 % of the vehicles, and 100 % HVO in 19 %. 6 % of the fleet are electric, and as well 6 % are gas buses.

Table 13. Shares of vehicles using different propulsion powers in the Western Barents area in PTA-procured transport.

Country	Electric vehicles	Diesel vehicles (HVO)	Gas vehicles	Diesel vehicles (fossil diesel)
Finland	7 %	13 %	1 %	80 %
Sweden	3 %	28 %	10 %	60 %
Norway	8 %	0 %	0 %	92 %
Total	6,3 %	19,1 %	5,9 %	68,7 %

In all three countries distribution obligations require that the distributors distribute a certain share of the fuel as renewable. Due to this, the fuel used in diesel vehicles can be a blend between fossil diesel and renewable diesel. Share of diesel vehicles using HVO include only buses which are required by contracts to be fueled with only HVO. Norway do not require 100 % HVO to be used due to the distribution obligations, which explains why Norway do not have any HVO reported. Sweden uses gas as a propulsion power much more than Finland or Norway, and they also require HVO more often than Finnish PTAs. The share of electric vehicles is expected to be growing during upcoming years due to the fast electrification of the urban transport.

4.2 Fueling and charging network

Refueling and recharging of public transport differs a bit from other road transport. Public transport vehicles are most often refueled and recharged in the depots where there is suitable infrastructure installed. Public refueling and recharging stations can be used to support depots in long-distance transport and for smaller vehicles but those can also sometimes be used by small operators which do not have invested in their own fueling systems. This is how the fueling of fossil diesel is also organized currently. When transitioning from fossil fuels to alternative propulsion powers, the availability of fuel must be analyzed but also the costs which are caused by the possible new storage and fueling or charging systems of the new propulsion powers. This chapter discusses the situation in Finland, Sweden, and Norway separately.

Fueling and recharging of vehicles used in public transport differs based on what kind of vehicles are used, what kind of routes are operated and what kind of operator is the one operating. In table 14, the situation of whether public or private recharging or refueling stations are used is explained by distributing the type of the service or vehicles and propulsion power. The table is simplified. Hydrogen or e-fuels are not used currently in public transport in the three countries, so those are not included in the table, but fueling those follows the same basic principles as HVO or gas.

Table 14. The way different propulsion powers are recharged or refueled in different kinds of public transport.

	Passenger cars	Urban and shorter regional transport (city buses)	Long-distance Note: long-distance only uses fossil diesel currently
Electricity	Public and can be private	Fully private (depots, terminals or stops) Public possible	Private (depots) Public needed to support
Renewable diesel (HVO)	Public	Mostly private (depots) Public possible	Private (depots) Public
Biogas (CBG and LBG)	Public	Mostly public Private possible (depots)	Mostly public Private possible (depots)

In Finland and Sweden, the bus depots are always owned and managed by the operators. If the infrastructure is in the depots, the operator is responsible in organizing both the infrastructure and buying fuel or electricity from the distributors. In Norway, there is no uniform practice for how the responsibility of the charging components is distributed between the PTA, operator, or the facility owner. The situation differs a bit between different PTAs and areas.

4.2.1 Finland

Electricity

City buses, which use electricity as propulsion power, are recharged in depots where the operator invests in the charging infrastructure. Electric buses can also be charged using faster opportunity charging in terminals or stops, and if those are used, the operator or the PTA is the one to invest in the infrastructure. E-buses in Oulu and Joensuu use only depot charging. During the interviews, possibility to consider opportunity charging in bus stops or terminals came up: this would help supporting the depot charging and the range in northern areas.

In Finland, there isn't long-distance transport which uses electricity currently. If there were, there should be choices made by the operator whether the vehicles should use public charging stations or if the operator should invest in the infrastructure in their depots. Due to the operating range being shorter with electricity, opportunity charging on the road would be needed in most cases. Challenge is organizing the charging so that it would not increase the travel times for the passengers. Charging should be done when the passengers aren't onboard or using fast charging in terminals. Anyhow, charging at the endpoint of the long route would also be needed.

The private charging stations are not mapped in this report but those can be found at least in Oulu and Joensuu where the operators have invested in the charging infrastructure in their depots. Since the charging of e-buses in cities is mostly done in depots or otherwise organized separately, the public charging network do not affect the possibilities. There are over 50 public charging stations of high capacity (150 kW or more) in the Barents region in Finland. Most of them are in or close to the cities or along the main roads. Some are in the tourism centers. Passenger cars and other small vehicles have the best coverage of charging stations. In whole Finnish Barents region, the closest one is always under 100 km away, and mostly under 50 km away.

Renewable diesel

The refueling of buses with diesel fuels can be organized in depots or operator can choose to use public stations. Especially in cities where the operators have many vehicles, most common is to have the refueling infrastructure in the depot and buy the fuel from distributors. If the operator has very small number of vehicles, only cost-efficient choice would be using the public stations. This is the case with both city buses and coaches. Coaches might need fueling on the way or at the endpoint of the route to support fueling in depots if distances are very long. Since some of the vehicles used in the Barents region's public transport are passenger cars, those are easiest to fuel in the public stations.

There are few public refueling stations serving renewable diesel (HVO) in the Finnish Barents region. HVO stations suitable for heavy transport can be found in Oulu, Ii, Kempele, Kärsämäki, Ylivieska and Raahe in North Ostrobothnia, Rovaniemi, Kemi and Keminmaa in Lapland, Kajaani and Paltamo in Kainuu. The network for passenger cars and other small sprinter type vehicles has much better coverage.

If renewable diesel is fueled in the depots, it's possible to order it from the distributors. Delivery of HVO diesel requires a large order at once which means that the operator should be able to use all the order if there aren't other users nearby. If the same operator uses both fossil diesel and 100 % HVO in their vehicles, there needs to be different tanks for both fuels.

In Finland there is a mandatory distribution obligation for fuel distributors. That means that annually certain percentage of the fuel distributed must be renewable fuels. The obligation for 2023 is 13,5 % and due to law, it would originally have been increased to 28 % in 2024 and increased slowly after that so in 2030 it would be 34 %. Due to a legislative proposal, the obligation was kept in 13,5 % also in 2024. Distributors can organize this in several ways. The obligation can be fulfilled for example by selling renewable fuels cleanly as 100 % themselves or blending renewable fuels with fossil fuels. Since producing renewable fuels is more expensive than fossil fuels, this increases the prices of fuels altogether.

Biogas

The refueling of biogas can be organized either in depots or the operator can choose to use public stations. Situation is quite the same as with renewable diesel: the investing costs of the infrastructure and the size of the fleet affects if it's possible to have the refueling in the depot. If gas is used, there needs to be gas infrastructure built in the depot.

In October 2023, Finland had 83 fueling stations for compressed natural gas (CNG) and biogas (CBG). 33 of those focus only on biogas. At the same time, there were 16 fueling stations for liquefied natural gas (LNG) and biogas (LBG). Most of the stations are situated in the southern parts of Finland where there is more usage. The most northern CBG-stations are in Oulu where there is also a production plant. There is one in Limingantulli close to the city center, and two located in the outskirts of the central areas of Oulu. North Ostrobothnia also has CBG-stations in Liminka, Haapavesi and Pyhäjärvi. In North Karelia there are two CBG-stations: in Joensuu and Kitee. Liquefied biogas is only available in Oulu. Gasum is currently building a gas station suitable for heavy vehicles in Keminmaa, and investigating if there could be one built in Rovaniemi. The refueling possibilities of biogas or gas in general are therefore very limited in the Western Barents region, especially above Oulu.

Hydrogen

There isn't public distribution infrastructure of hydrogen for transport usage in Finland. Hydrogen is produced in Finland mostly using fossil energy but used mostly to refine oil and biofuels. New hydrogen projects are planned. Earlier there were hydrogen stations in Vuosaari and Voikoski (both in Southern Finland) but those have been closed due to low usage. Based on Council of Europe, Finland should make sure that there is public hydrogen station in every 200 km along TEN-T core network in 2030. This would mean at least seven stations since the length of core network is 1 100 km. According to AFIR, 30 hydrogen fueling stations would be needed in 2030.

There is a will to build hydrogen production in the Barents area. For example, the BotH_2nia network is a cooperation network which aims to build a robust hydrogen industry cluster around the Gulf of Bothnia. The goal is to attract investors in the area.

Synthetic fuels

Synthetic fuels or e-fuels could be used in transport which is hard to electrify. Those aren't used in public transport in Finland currently, and there isn't refueling capacity for synthetic fuels.

4.2.2 Sweden

Electricity

City buses which use electricity as propulsion power are recharged in depots where the operator invests in the charging infrastructure. There isn't yet long-distance transport in Sweden using electricity. If there were, there should be choices made by the operator whether the vehicles should use public charging stations or if the operator should invest in the infrastructure in their depots. Due to the operating range being shorter with electricity, opportunity charging on the road would most likely be needed. Challenge is organizing the charging so that it would not increase the travel times for the passengers: charging should be done when the passengers aren't onboard or using fast charging in terminals.

Since the charging of e-buses in cities is mostly done in depots or otherwise organized separately, the public charging network do not affect the possibilities. The private charging facilities are not mapped out in this report. The public charging infrastructure of high capacity (over 150 kW) is concentrated into the Bothnia side of Norrbotten and Västerbotten regions where also the population has concentrated. There are over 40 existing stations, and new are planned. Most of them are in cities and some in between.

Renewable diesel

The refueling of buses with diesel fuels can be organized in depots or operator can choose to use public stations. Especially in cities where the operators have many vehicles, most common is to have the refueling infrastructure in the depot and buy the fuel from distributors. If the operator has very small number of vehicles, only cost-efficient choice would be using the public stations, but then renewable diesel cannot be used, if it's not available. The most common way in the two Swedish regions is to use the public stations.

The refueling network of liquefied fossil-free fuels is concentrated on the Bothnian side of Norrbotten and Västerbotten where most of the population and usage is also situated. Otherwise, the network inland is very sparse. 100 % HVO is available in for example Umeå, Skellefteå, Piteå, Luleå and Haparanda in the coast, and Övertorneå, Jokkmokk, Boden, Arvidsjaur and Storuman inland. The most northern station is in Kiruna.

Sweden has a mandate (Lag (2017:1201) om reduktion av växthusgasutsläpp från vissa fossila drivmedel) to reduce the greenhouse gas emissions of fossil fuels and fuel suppliers must increase the biofuel blend in their gasoline and diesel. The emissions must be reduced by 30,5 % from 2022 to 2023, and 6 % yearly from 2023 to 2026.

Biogas

The refueling of biogas can be organized either in depots or the operator can choose to use public stations. Here also the investing costs of the infrastructure and the size of the fleet affects if it's possible to have the refueling in the depot. For the smaller traffic operators, it generates an expensive cost to have their own tanks at the depots, so they often refuel at local gas stations. Having infrastructure in depots is mainly for the bigger traffic operators. In some of the municipalities it is a challenge to be able to find biogas as a propulsion, this due to no production and the long distances to the fueling stations.

Sweden has altogether around 200 gas stations for compressed biogas (CBG) and 30 for liquefied biogas (LBG), and those are very heavily concentrated on the southern parts of the country where there is more usage both in public transport and passenger cars. The gas infrastructure is very sparse in Norrbotten and Västerbotten. Skellefteå has a biogas plant. The only stations are in Umeå, Skellefteå and Boden.

Hydrogen

There are a few innovation projects on going in Sweden regarding the use of hydrogen in public transport. Hydrogen is especially interesting in the northern Sweden due to the cold climate and that they do not need a heater that runs on for example diesel.

Hydrogen stations are planned at least in Luleå, Umeå and Storuman. There is one hydrogen station existing in Umeå.

Synthetic fuels

There isn't public capacity to refuel synthetic fuels in Sweden currently.

4.2.3 Norway

Electricity

In Norway, public transport buses are charged in depots or along the route in terminals. There is no uniform practice for how the responsibility of the charging components is distributed between the PTA, operator, or the facility owner. The situation differs a bit between different PTAs and areas.

Since the charging of e-buses in cities is mostly done in depots or otherwise organized separately, the public charging network do not affect the possibilities. The private charging stations are not mapped in this report. The public charging infrastructure of high-capacity chargers is available in the area. There are 377 high-capacity chargers in Nordland and 254 in Troms and Finnmark.

Electricity itself is available at most places, but there are some areas with power limitations due to constraints in the regional grid. Finding a solution for power and depot placement leads to compromises. It's becoming more critical to find power than space, which is a new perspective, and one should be aware of how the energy solution will govern and operate a public transport contract. Also, transporting buses (to a new area) is a challenge when there are few public charging stations available that have the space to charge buses.

The contractual framework in Norway is straightforward, where a customer reports their needs to the grid operator and pays a connection fee. The connection fee is calculated based on the investment requirements. The customer enters into a development agreement with the grid operator and the grid operator handles the investments and grid expansion. Problematic has been enough land which is needed to arrange the charging facilities.

In Norway, cost of charging equipment is around 250 000 – 500 000 NOK for a depot charger (21 000 – 43 000 €), 1,5 million NOK (130 000 €) for a fast charger (150 kW with 12 outlets) and a pantograph costs about 4 million NOK (343 000 €).

Renewable diesel (HVO)

In Norway as well, there is a mandatory blending requirement for biodiesel. That is a sustainable practice to promote the use of biodiesel and reduce fossil fuel consumption. At the same time, it makes requiring 100 % renewable diesel in bus contracts expensive, since renewable diesel is more expensive than fossil diesel. The climate effect of requiring HVO is also considered to be zero because the distributors are required to sell only a certain share of HVO. As mentioned before, due to this in Norway PTAs do not require 100 % HVO. Due to this, PTAs accept fossil diesel in their contracts since in the end the same amount of renewable diesel will be used in transport altogether.

Distribution network of HVO in Norway has not been studied in this report because of this practice.

Biogas

Public transport buses are fueled in depots, and gas is not used in the Norwegian Barents region to fuel public transport. The low temperatures and long winters affect the efficiency and reliability of the biogas production and utilization processes. The high transportation costs and limited infrastructure makes biogas a less practical fuel compared to HVO and electricity.

There is only low-level local production of biogas in the region: in Steigen in Nordland and in Båtsfjord in Finnmark. There aren’t any fueling stations of biogas in Nordland, Troms or Finnmark.

Hydrogen

Regarding hydrogen production, there isn’t any production in Nordland or Troms, but it is expected to change in 2025. In Finnmark, there is local production in small volume. There are currently no hydrogen fueling stations available in the region. The limited infrastructure and high production and transportation costs (compared to electricity) limits the use of hydrogen in the transport sector.

Synthetic fuels

Currently, there is insufficient public infrastructure for refueling synthetic fuels in Norway.

4.2.4 Connecting electricity grid and bus fleet electrification

Electrification of bus fleet requires things from the electricity grid, and this view is worth considering in future development of bus fleet electrification. Especially in Norway it has been noticed that the capacity of the electricity grid may hinder the electrification process and cause problems. The issue of connecting electricity grid and bus fleet electrification were studied by a case example of one city in the Western Barents region. A bus company and a local distribution system operator were interviewed.

The bus company envisions it being possible in the near-term to operate bus traffic with electric buses similarly as with diesel buses. Two years ago, electric buses were charged twice daily during operations. The upcoming bus generation will be equipped with approximately 700 kWh batteries, which allows only overnight charging to sustain fleet operations. The estimated practical battery capacity ranges from 500-600 kWh, requiring a 100-kW charger for a 5–6-hour charging window between 23:00 and 06:00. Buses are preheated for about half an hour using grid power before departure, optimizing battery capacity for actual operations. This is a simplified scenario for discussion purposes; in reality, charging times may vary based on bus size, battery capacities, return times to the depot, other maintenance work and seasonal fluctuations in battery capacity needs. The electricity connection sizes mentioned do not consider other on-site consumption besides bus charging. It is likely that the terminal will require a slightly larger connection than the maximum bus fleet charging power.

In the local electricity grid, connections exceeding 3 MW must be directly linked to the substation, which serves as the contractual connection point. This implies that the connecting customer must construct and own the connecting line from the substation to their premises. This threshold could be reached with 30 electric buses with the next generation buses. Upon reaching this limit, constructing a dedicated line to the substation becomes necessary, incurring costs of approximately 100 000 € per km, plus a 30 000 € cable element from the substation. Additionally, when connecting, a capacity booking fee for the medium-voltage electricity connection must be paid. The 3 MW limit varies across distribution networks.

The specific rules and regulations for grid connections in Sweden and Finland vary depending on factors such as the size of the connection, location, and the grid operator. The specific rules and regulations for grid connections in Norway are the same regardless of the size of the connection, location, or grid operator. In Norway, grid connection costs are around 1000 NOK/kW (85 €).

In the scenario of a 10MW consumption (100 electric buses), the grid company might need to invest in an additional transformer for the substation, especially if there are additional consumption rises in the substation's vicinity. The existing 10MW capacity is likely unavailable, which causes a network company investment of approximately 800 000 € for the substation. If a new transformer investment is required, the connection time is estimated to be between 2 to 3 years. If it is enough that an old and smaller transformer is replaced with a new bigger transformer it could go in 1 to 2 years. Given the extended delivery time, each city should proactively engage with the local distribution system operator when planning to transition its tendered bus routes to electric buses. When the electrification speeds up the electricity infrastructure upscaling might need longer time than the tenderers have been used to.

An essential consideration is the security of the power supply to the depot. When a bus company constructs its cable from the substation, it may be laid along a road or in an area where a road might be built in the future. In such cases, permit conditions may mandate cable disconnection during street construction, rendering the depot without power. An alternative is to build a second cable (doubling the cost) from a different route from the same substation or, to ensure power supply, construct a second cable from another substation, albeit at a significantly higher cost. Another choice for security in exceptional situations is for the depot to invest in a back-up power generator. The bus company must also get or maintain updated cable location information and be capable of indicating the cable's location in the ground when needed or asked. The important thing with electric buses is to notice that the charging is critical infrastructure for the operations. With diesel buses the power source was easy to move and available from several locations. In the electric bus case if there is no power at the depot during the charging hours, it is not possible to drive the routes.

From the grid's standpoint, nighttime bus charging is favorable, considering that daytime consumption typically exceeds nighttime usage. The power grid benefits when significant loads are connected or disconnected at different times, and evenly distributing the load over an extended period is preferred. In the case of electric buses, the slow charging speed over 7-8 hours makes additional battery storage less suitable for the case to smoothen the consumption peak. While batteries effectively can smooth short fluctuations, a shipping container-sized battery storage unit, costing between 2,5 million € to 4 million €, could store approximately 3-4MWh of power, covering the energy needed for charging 5-7 buses. However, the considerable cost of batteries, doubling the expense of some buses' most valuable equipment, may outweigh the business's ability to absorb it. Therefore, a detailed analysis, considering the depot's load profile, is necessary to decide if investing in batteries for depots to save on electricity connection fees is financially viable.

The example case is from an urban environment and grid capacity in more sparsely populated areas can be even more problematic. This depends on the location of the depot but operations to the electricity grid are probable every time charging of e-buses is planned in a new depot. In very sparsely populated areas, the electricity grid might need very extensive measures and end up being impossible. It's important that the electricity grid companies know in beforehand when new electric buses will be procured and there's enough time to set up the needed infrastructure. In some cases, the capacity and cost of the infrastructure limits the possibility to have electric vehicles.

4.2.5 Summary and discussion

Vehicles running public transport are mostly charged and fueled in the depots. Sometimes public charging and refueling stations can be used if the operator chooses to act so because for example the number of vehicles is so small that it's not economically viable to invest in the fueling or charging facilities in the depot. If the same operator uses multiple propulsion powers in their vehicles, own infrastructure is needed for each. Depots are owned and organized by the operators in Finland and Sweden, but in Norway the trend is that PTAs offer the depots to the operators in new contracts. Infrastructure costs must be considered when considering the transition from fossil fuels to alternative propulsion powers.

Refueling infrastructure of renewable diesel is much more limited than fossil diesel. In some areas where the population is more dense, renewable diesel is more commonly offered in public stations. It's also possible for operators to buy renewable diesel from the distributors in the same way they can buy fossil diesel in their tanks in the depots. If the public distribution network is limited, it can cause difficulties to get HVO delivered.

Biogas is considerably harder to get in the Western Barents region since the public refueling infrastructure is very sparse in the northern parts of all three countries. In Finland and in Sweden the capacity is highly concentrated in some cities while in Norway, there isn't any biogas stations in Nordland, Troms or Finnmark. This is a limiting factor for the possibilities to use biogas as an alternative in the area since the transportation distances of the fuels would be long.

There aren't basically any refueling possibilities of hydrogen or synthetic fuels in the Western Barents region. In Sweden, there are a couple of hydrogen stations. This – among other things – limits the possibilities to currently start using hydrogen or e-fuels as an alternative for fossil fuels for example in long distance transport.

Electricity charging for buses is organized in depots or along the routes of public transport so currently it is always separately organized and planned with a certain transport structure in mind. Electricity is available in most places, but the capacity of the grid has been noticed to be a challenge. Charging of e-buses needs very high capacity in the depots and usually simultaneously during the night which causes situations where the grid capacity must be upgraded. This is both costly and takes time.

The production of fossil-free fuels and energy is of course a base for the possibility to use alternative propulsion powers. If there isn't enough of the produced fuel, it cannot be used in public transport. In some cases, it has been noticed that the growing demand of for example renewable diesel or biogas can cause shortages.

4.3 Availability and cost of the fleet

Availability of the vehicles affects the possibilities PTAs have when trying to increase the number of vehicles using alternative propulsion powers in the Barents region. Nordics are a small market in a global scale. The availability of vehicles is mostly similar in all three examined Nordic countries, so Finland, Sweden and Norway are considered here together. The availability and price estimates are collected from the interviews and websites of bus manufacturers and importers.

Besides what kind of vehicles are offered by manufactures and importers, availability is also affected by delivery times. Delivery times, in general, are about a year for every type of new buses bought from the manufacturers. Some of the manufacturers can deliver the vehicles in under a year but mostly 1,5 years between the decision of the operator and starting the operation is hoped. Delivery times consists of the design process of the vehicles to meet the client needs, the manufacturing, and the transportation of the vehicle from the factory to the client. If the timetable of the procuring processes is too tight, it affects the availability and limits the possibilities operators have.

Prices of the vehicles varies. Price is determined for example by the vehicle type, size of the vehicle, size of the batteries and charging systems (if e-bus), client needs and requirements, and the number of buses bought. The bus can be for example normal 12-meters long bus or 18-meters articulated which naturally affects the price. Also, even though two buses delivered to two clients would be similar from the outside, the interiors of the vehicles are designed specifically based on the client needs. The costs of designing and the project altogether are lower per bus when more vehicles are bought. The price levels of different buses are compared to each other in general level in the following subchapters. Prices have been affected by the rising inflation due to the Russian war in Ukraine, which have had an impact to for example the prices of material and components. Covid-19 pandemic also led to higher prices because of higher prices of logistics.

The different vehicle requirements every PTA has affect the deliveries of the vehicles. The situation is similar with every propulsion power. For example, in Finland and Sweden every PTA has their own vehicle requirements which means that every version must be designed separately. This makes the processes longer compared to the situation where every PTA would use same requirements. Sometimes the requirements can even cause concrete problems: if for example the space between seats is asked to be a centimeter longer than normally, the needed number of seats might not fit into the vehicle, and the requirement cannot be fulfilled. Different requirements in different regions leads to less probability of smaller or not already established operators to take part in tendering processes.

Manufacturers are interested in to discuss about the vehicles and vehicle requirements even when there aren't open tendering processes ongoing. This would be very good time to have discussions about the possibilities of different types of vehicles in certain areas, since it would support the upcoming tendering processes. Manufacturers are also very open to market dialogues.

4.3.1 Diesel vehicles

Regarding alternative propulsion powers, availability of diesel vehicles affects the possibilities to use renewable diesel or later synthetic diesel fuels as an option. As discussed in other parts of the report, renewable diesel could be a functional substitute for especially electricity if the conditions make using renewable diesel possible (distribution network, production of HVO). In the future, synthetic fuels could be possibility in long-distance transport where electricity might never be a solution in every case, and diesel coaches are needed.

City buses (class I) are offered widely in different sizes; for example, 12- and 18-meters long options are available. Challenge here might be in the future that city buses are rarely manufactured as diesel buses anymore and the market has shifted strongly towards electricity. For example, Yutong and BYD sell only electric buses and Volvo has just stopped manufacturing their diesel low-floor city buses. Other manufactures still have diesel city buses in their selection, but the options are getting more limited. This might be a problematic development in the close future for small PTAs which use city buses, but the number of vehicles is very small. For example, Finnish PTA of Sea Lapland has contracts of only a couple of buses operating urban transport in cities of Kemi and Tornio. The number of vehicles and service level is so low that investing in electric infrastructure is not very cost-efficient. The PTA has noticed that nowadays it's been challenging for the operators to find diesel buses since those are not manufactured as much anymore and the aftermarket has slowed down.

Vehicles of classes II and III (regional buses and coaches) are still widely available with diesel engines. Also, the availability of sprinter vehicles and passenger cars is good. The availability of those vehicles thus does not limit the possibilities to use HVO as an alternative for fossil diesel.

Delivery times of diesel buses are mostly a bit over a year. The prices of diesel buses are lower than otherwise similar electric, gas, or hydrogen buses.

4.3.2 Electric vehicles

Electric city buses (I) are widely available since the manufacturers have followed the market demand. City buses are more and more offered as electric buses, and basically every bus vehicle manufacturer offers electric city buses. Vehicles are available in various sizes: for example, 12-, 15- and 18-meters long options, longer ones being articulated. Passenger cars are also widely available.

Other types of vehicles are noticeably less available as electric since the technology is not yet fully compatible with all applications and conditions. Availability of electric regional buses (II) and coaches (III) is very limited: only Chinese manufacturers offer e-buses suitable for regional traffic and long-distance. Challenge with these buses is the operating range which needs to be long enough to serve long-distance transport. The energy consumption and batteries need to develop for long-distances to be possible to operate.

The availability of small sprinter type buses is limited as well. For example, Yutong has these in their selection. Difficulty with small vehicles is the size of the vehicle contra size of the batteries needed to operate public transport.

Chinese manufacturers have the widest selection of electric vehicles available compared to other manufacturers since China has been the forerunner in electrifying the bus fleet. They also have the capacity to deliver the fastest. Mostly the delivery times of electric buses are over a year, but Yutong can deliver their vehicles in under a year. Due to this, some of the interviewees mentioned that there is a risk that the market is getting too concentrated. If the timetables of tendering processes are too tight, this limits the selection of manufacturers the operators can choose from. In general, manufacturers and importers hoped that PTAs should do the decision of the chosen operator at least 15 months or 1,5 years before the contract and operating starts. This would give the operators possibility to choose from several manufacturers and give the manufacturers realistic timeline to design, manufacture and import the vehicles. Manufacturers also noted that there can be a problem if the process is too long: during a couple of years a lot can happen technology- and marketwise so if the process is extended too much, it starts to be difficult to predict the prices and available solutions.

Electric vehicles are more expensive than diesel buses. Approximately the price of an electric vehicle is about double of an equivalent diesel bus. What differs from diesel buses is that the price of the vehicle is determined mostly by the size of the batteries, and the vehicle and its energy capacity is designed to be suitable for the specific operating environment. The battery covers 50 % of the cost of the electric buses, so the price development of batteries dictates the price development of the electric buses. The capital needed to buy electric buses might be barrier especially for smaller operating companies to invest in new vehicles.

Hybrid buses are not used much. Those are available but are more expensive in both purchase and total costs perspective.

4.3.3 Gas vehicles

The selection of gas buses is limited. Those are of course available and can be used and purchased but the selection is more limited than the selection of diesel or electric vehicles. The limited availability of gas buses and especially the sparse distribution network are a limitation for the usage of gas as a propulsion power. The usage and favorable market situation for electric city buses has taken over gas in urban transport. Due to that most manufacturers are focusing on electric vehicles and do not have or intend to have gas vehicles in their selections. For example, Scania and Solaris have gas city buses, and Scania gas buses also for regional and long-distance usage.

The price of a gas vehicle is approximately 10-15 % higher than an equivalent diesel bus.

4.3.4 Hydrogen vehicles

The availability of hydrogen fuel cell vehicles is still very limited since only a couple of manufacturers offer those.

The manufactures noted that hydrogen buses available are currently not very profitable compared to electric buses. Price range of the vehicle itself is double of electric buses but at the same time the operating costs are also higher. The market-readiness of hydrogen buses is not sufficient, and this does not support the production and usage of hydrogen buses.

4.3.5 Summary and discussion

To sum it up, availability of diesel and electric vehicles are the most adequate. Diesel vehicles, which affects the possibilities to use HVO and e-fuels, are offered in every type of vehicles. The availability of city buses might get limited since city buses are more and more manufactured as electric buses. This limits the possibilities to use especially HVO in smaller cities, where HVO could be an easy alternative to electricity.

In electric bus field, availability of city buses is the most diverse and adequate, but availability of coaches and small sprinters is more limited due to the challenges with range and battery sizes. This limits the possibilities to use electric vehicles when operating long-distance transport and for example service lines in cities.

The availability of gas and hydrogen vehicles is limited with every vehicle types. Hydrogen vehicles are more less offered than gas vehicles. This limits the possibilities to use biogas as an alternative but of course does not make it impossible since gas buses are available, and the price is only a bit higher than the price of diesel equivalent. With hydrogen buses, the cost-efficiency of hydrogen technology currently limits the possibilities and does not support the production of hydrogen buses.

The summary of availability of different vehicles is listed in table 15.

Table 15. Availability and price level of different vehicles.

	Diesel vehicles	Electric vehicles	Gas vehicles	Hydrogen vehicles
Availability	Good availability Availability of city buses might get limited	City buses: good availability Coaches and sprinters: limited	Limited availability	Very limited availability
Price level	The lowest	Double of diesel vehicles	10-15 % higher than diesel vehicles	Double of electric vehicles

The situation of technology development and demand among other reasons define which vehicles and which propulsion powers the manufacturers offer. Even if the situation is now how it is, it can of course change based on how the market develops. For example, if hydrogen at some point becomes cost-efficient solution for long-distance buses and the technology develops to be more reliable, the production of hydrogen coaches might of course increase.

The general availability as in what kind of vehicles are manufactured is of course the main limiting factor but the procuring processes also may limit possibilities. The delivery times of the vehicles affect the availability if the procuring process has not been started early enough. Especially, if PTAs wish to get new alternative propulsion powers offered, the process must be started early enough.

4.4 Cost of procured transport services and the procurement process

Using alternative propulsion powers in public transport affects the costs of the transport services PTAs procure and causes changes that must be considered during the procuring processes and planning of the operation. This chapter examines the costs of public transport and the effects on procurement processes. Additionally, possible effects on service level are addressed.

4.4.1 Costs of public transport

The cost PTA pays for publicly procured transport is determined by the bids operators give based on the call for tender PTA has sent out. Here we'll focus on the effects alternative propulsion powers have on the costs. The prices of the vehicles itself and the needed infrastructure are discussed also in the earlier chapters.

The cost indexes have been used when comparing the costs of public transport organized using different propulsion powers and the development of the prices. The cost index describes changes in prices of cost factors compared to the selected base year. It describes the cost changes caused to entrepreneurs from acquisition of inputs for a contract. So, it describes the costs operators pay for organizing the traffic, and the costs transfer into the costs PTAs must pay for the transport they procure. The cost indexes are calculated with a method where different cost factors are weighted together by their proportions of total costs. All the researched countries have cost indexes for public transport divided by propulsion powers.

The cost structure of practicing public transport consists of various factors, and can be divided into personnel costs, fuel costs and other costs. The more precise factors are wages of bus drivers, fuels, tires and spare parts, maintenance and repairing, capital depreciation of vehicles (and infrastructure), interest rates of investments, insurances, and other overhead costs. When deploying new propulsion powers, the infrastructure and vehicle investments and the cost of the fuel change compared to diesel.

Wages of bus drivers is the biggest factor affecting the costs of public transport when discussing urban and regional transport. The personnel costs cover about half of the total costs. Fuels include the propulsion source used to power the vehicles, and it can be either diesel (fossil or renewable), electricity, gas, or hydrogen. Capital depreciation includes the price of the vehicles which are calculated to depreciated during the contract period. Other overhead costs include things like the wages of other personnel in the operating company, costs related to the buildings and office spaces the company uses, training, communication, etc. In Sweden, around 50-60 % of the costs are the wages of the staff, 10-25 % fuels, 5-20 % new vehicle acquisitions and 10-20 % other general costs depending on the situation and used fuel.

The cost structure is a bit different when using different propulsion powers. In table 16, it can be seen how different cost factors are weighted in the Finnish cost index of bus and coach transport. This means that different factors cover different shares of the total costs based on the propulsion power used. Finnish index does not have this kind of index/shares solely for diesel buses: overall index in the table includes all the propulsion powers, but since fossil diesel has the biggest share, overall index can be used to compare electric and biogas to a service mostly operated with diesel buses.

Overall, the share of fuels in the cost structure is higher when using other propulsion sources than electricity. This leads to a conclusion, that using electricity as a fuel is relatively cheaper than using diesel or biogas. On the other hand, capital depreciation is higher when using electric buses since the purchasing price of electric vehicles is higher than diesel and gas buses as discussed in earlier chapters. What should be noted is that the wages of bus drivers or other costs do not differ between different propulsion powers.

Table 16. Weighting of different cost factors in Finnish cost index of bus and coach transport. (Source: Tilastokeskus, 2020)

	Overall index	Electric bus	Biogas bus
Wages of bus drivers	49 %	54 %	50 %
Fuels	14 %	8 %	17 %
Maintenance	11 %	6 %	12 %
Capital depreciation (vehicles)	8 %	17 %	7 %
Other costs	18 %	15 %	13, %
Total costs	100 %	100 %	100 %

In Norway, it has been calculated that even though the purchase prices of electric buses still remain significantly higher than diesel buses, the lower operating costs compensates the total level of costs. This depends on the annual mileage and the expected lifespan of the vehicle: if one vehicle is used for more than one contract period, the total costs of operating with electricity will be lower per kilometer than when operating with fossil diesel (Miljødirektoratet, 2022). The new contracts with electric buses in Finnmark region have not had any significant price differences compared to the earlier contracts. Fuel prices have been estimated per kWh after the efficiency loss in Norway (Nordland fylkeskommune, 2021). Operating with electricity is the cheapest option since the cost is 0,56 NOK/kWh (0,05 €). HVO is 3,88 NOK/kWh (0,34 €), liquefied biogas 3,86 NOK/kWh (0,34 €), compressed biogas 4,42 NOK/kWh (0,39 €) and hydrogen 6 NOK/kWh (0,53 €). Based on the same report, for example normal 12 meters long city bus consumes 1,1, kWh/km by driving (+ 0,2 kWh/km if heating is used).

Helsinki Region Transport (HSL, the PTA of the capital area of Finland) has estimated that operating with electric buses has been 9 % cheaper than with diesel buses. Investing costs have been compensated with cheaper operating costs when the mileage of electric buses has been maximized. This is at least the case in bigger cities where electric vehicles operate a lot. For example, in Oulu, there are some cases where operating with an electric vehicle is not cost-efficient since the mileage is too low. In smaller cities and in sparsely populated areas, the cost-efficiency of electric buses might not be that clear since the mileage is smaller, and the cost-efficiency of the fuel won't end up compensating the investing costs.

Renewable diesel is more expensive than fossil diesel which increases costs if 100 % renewable diesel is required. This has been noticed in Sea Lapland, where requiring HVO has increased the costs: though it was mentioned, that the general increase of all the fuel prices (see table 18) and the redesigning of the traffic makes it difficult to compare. In Sweden, biogas has been a little cheaper than diesel because of the local production, and gas is used much more than in Finland and Norway.

In table 17, cost factors caused by using alternative propulsion powers are summarized. Mainly using other fuels than traditional fossil diesel affects the costs of the fuel itself, costs of the vehicles and causes costs of investing in new charging and fueling infrastructure.

Table 17. Cost factors caused by different alternative propulsion powers.

	Fuel	Vehicles	Infrastructure
Electricity	• cheaper than fossil diesel	• more expensive than diesel buses	• new charging infrastructure needed (including chargers and grid connections) • might need grid upgrading
Renewable diesel (HVO)	• more expensive than fossil diesel	• same buses than used with fossil diesel	• additional fueling infrastructure needed if used alongside fossil diesel
Biogas (CBG and LBG)	• more expensive than fossil diesel	• more expensive than diesel buses	• new fueling infrastructure needed
Hydrogen	• significantly more expensive than fossil diesel	• more expensive than diesel and electric buses	• new fueling infrastructure needed.
E-fuels	• More expensive than fossil diesel	• same buses than used with fossil fuels	• additional fueling infrastructure needed if used alongside fossil diesel

The price development of different fuels and different vehicles is an uncertainty factor which affects how the total operation costs compare to each other. The indexes can be used to compare how the prices of different propulsion have been developing over the couple of last years. The development of the latest years does not of course talk about the upcoming years. Finnish indexes are presented in the table 18. The index numbers of different fuels cannot be compared to each other: the table tells how the price of different fuels have been developing compared to the price level in 2020. What can be interpreted from the table is that the price of fossil diesel has increased 70,6 % from 2020 to 2022. The prices of other fuels have also increased between 2020 and 2022: electricity 47,6

% or 19,1 % based on how big the consumption is, and biogas 32,4 %. Almost all the prices have decreased from 2022 to 2023. HVO-diesel only have index number for 2023, and between 2020 and 2023 the price has increased 47,6 %. The development has been similar in Norway where the prices of all mentioned fuels have increased between 2021 and 2022 but decreased again between 2022 and 2023.

Table 18. Cost indexes of public transport operated with different propulsion powers. 2020=100. (Source: Tilastokeskus, 2020)

	Fossil diesel	HVO-diesel	Electricity (consumption 2000-19999 MWh/year)	Electricity (consumption 500-1999 MWh/year)	Biogas (CBG)
2020	100	100	100	100	100
2021	123	-	91,4	90,4	98,5
2022	170,6	-	147,6	119,1	132,4
1-7/2023	151,3	147,6	133,1	121	122,4

4.4.2 Effects on the service level

Strict goals about alternative propulsion powers can in current situation possibly lead to effects on service level. This is case especially in Norway where there is very strict requirement to have all the vehicles in urban transport zero-emission by 2025 and long-distance vehicles later. Thus, all the vehicles procured from now on must be electric. Since costs of charging infrastructure and the grid upgrading are high and investments in new vehicles are needed, this may lead to the need for the PTAs to lower the service level to cover the costs.

In Sweden and Finland, the effect is not so probable. The Finnish and Swedish goals still allow more possibilities regarding alternative propulsion powers and there aren't currently very close requirements to have all or almost all vehicles using alternative propulsion powers. In the long run, if the goals are made stricter, there might be effects on the service level.

4.4.3 Procurement processes

Since public transport authorities procure the transport services, tender and contract documents have a big role when promoting the usage of alternative sources in public transport sector. Alternative propulsion powers have been considered when PTAs procure their services. The PTAs, which operate with alternative propulsion powers, have used either scoring systems or requirements to get offers with electric buses, gas, or renewable diesel.

- Scoring systems
    - Biggest points are given to the vehicle types hoped to be offered: for example, Oulu gave 1 point for electric vehicles, ½ points for other alternatives and 0 points for fossil fuels.
- Requirements
    - It is required that a certain number of buses should be offered using alternative propulsion powers: for example, Sea Lapland required one bus to use renewable diesel.

Altogether some Finnish PTAs have increased the share of quality points in their calls for tenders, while the share of the price points has been decreased. The scoring and requirements must be in good balance with what's possible to achieve in current situation. The criteria should also be considered to still be relevant in the new situation, and it's important to understand how different criteria affects the possibilities of the operators: for example, contract length might make investing in electric vehicles impossible even though the criteria otherwise would be favorable towards those. This affects how different propulsions can be used, since for example electric buses may require different requirements than diesel buses. One example of the criteria that may cause difficulties are the average and maximum ages of the offered buses. The lifetime of electric bus is considered to be longer than the one of diesel bus.

Finnish regional ELY-centers have not had any requirements or scoring systems in their tenders which would promote the usage of alternative propulsion powers. The CVD or the national law does not include the bus classes ELY-centers usually use, so sometimes the vehicle class asked is decided in a way that the law would not concern the procurement process yet.

One main difficulty when promoting alternative propulsion powers have been the timetables of the procuring processes. Operators need enough time between the operating decision and starting the operation. The time is needed to buy the vehicles and organize the charging or fueling of the vehicles. Vehicle manufacturers and operators hope for 15 months - 1,5 years gap between the decision and operation which would ensure enough time for the operators, manufacturers and, if electric buses are bought, grid companies to react and organize things smoothly. This also makes it possible for the operators to use more vehicle manufacturers since then the delivery times would not be one of the main deciding factors.

Especially in Finland, the lengths of the contracts may also be a barrier to invest in new vehicles. If the contract is too short, operator cannot depreciate the investment during the contract period which makes investing risky. This problem is well-known within Finnish ELY-centers. They mostly procure “additional” routes meaning routes that are not profitable to operate market-based and other mandatory routes to ensure the very basic service level. Situations change quickly and it has been difficult for ELY-centers to commit in long contracts. Also, the funding is only decided for a year or so in advance.

4.5 Main barriers and development needs

Development needs were collected during the project based on the interviews and earlier reports and research. Those needs and barriers are divided into six categories: long distances and the scale of traffic, climate, expertise, procuring processes, vehicles, and fuels. The first two are basic challenges and realities of the operating environment that must be considered. Most of the development need and barriers are relevant for all three countries but there are also some country-specific issues.

4.5.1 Long distances and the scale of the traffic

Long distances and sparse population are basic challenges of public transport in the Western Barents region. This isn’t a barrier which can be solved by transport sector, but it is a reality which affects the possibilities of different propulsion powers outside of the biggest cities of the region. The routes can be very long: PTAs can procure routes of even 200 kilometers long and market-based routes are even longer. This is a challenge for especially electric buses which still have more limited operating range than others. When HVO or biogas are used there must be enough refueling infrastructure to make it possible to refuel at the end of the route.

Due to sparse population, volume of tendered transport might not be very big, headways infrequent and there may be small number of vehicles running. It is very costly to invest in for example charging infrastructure if it is used only by a small number of vehicles. For example, when talking about electricity, e-buses have been lowering prices in densely populated areas, but it might not do the same in sparsely populated areas: little amount of transport as opposed to very frequent headways and big numbers of buses in bigger cities.

Small local operators are typical for the Western Barents region. For small operators, investing in new vehicles and charging or refueling infrastructure is costly, and affects how they can compete in the tendering processes. Small operators also tend to refuel their vehicles in public stations, so the public distribution network also plays a role.

Development needs and barriers of long distance and the scale of the traffic are:

- Long distances are challenge for operating range and the charging and refueling infrastructure.
  - Energy consumption and batteries of electric buses need to develop.
  - Refueling infrastructure needs to be dense enough to support refueling and charging widely.
- Sparse population makes the demand of public transport low which is resulting to small volume of transport.
  - Conditions not sufficient for some of the propulsion powers.
- Small local operators operating the transport have smaller resources.

4.5.2 Climate

Just like long distances and the scale of traffic, climate is a reality that must be considered when promoting alternative propulsion powers in the northern regions. Cold temperatures and snowy or icy conditions decrease the range of electric buses since batteries run out faster in cold and more electricity is used due to the increasing rolling resistance in snow or ice. Cold temperatures also demand indoor heating which is a challenge especially in urban transport where the doors of the bus are opened often letting the heated air outside. Heating is organized either with electricity or using diesel to heat the indoors. Possible snowstorms cause also challenges. As opposed to very low temperatures in winter, the temperatures may also get very high during summer which can mean over 70 degrees of temperature differences between winter and summer. The vehicles need to be suitable for the climate conditions.

Cold temperatures must also be thought when using renewable fuels. Renewable diesel must be 2^{nd} generation HVO which is suitable for low temperatures.

Development needs and barriers of climate are:

- Cold temperatures and icy or snowy conditions decrease the range of electric buses.
- Heating of indoors decrease the range of electric buses.
- Cold temperatures must be considered when choosing the fuel.

4.5.3 Expertise

Expertise relates to the development needs of the knowledge and skills. It also means collaboration and knowledge-sharing between actors in the field. Without sufficient knowledge of different possibilities and quite detailed knowledge of needs and possible obstacles of each propulsion power, it's harder to promote the usage of them. Sometimes, the issue of alternative propulsion power has not yet been topical. Even the resources of the PTA affect the possibilities: if there's barely resources to run the basic operations, there may not be enough resources for thinking of the propulsion power issues.

More collaboration is needed especially between PTAs both nationally and internationally, but also with operators and vehicle manufacturers, to support this. Every actor needs to individually carry out extensive information gathering if the knowledge is not shared. The operating environment and issues are in the end the same between PTAs and operators in one country but also quite similar between Finland, Sweden, and Norway – considering of course the differences of for example the size of the PTAs and legislation.

Development needs of expertise are:

- Insufficient relevant expertise and knowledge
  - Limited knowledge of the possibilities of different alternative propulsion powers.
  - Insufficient relevant expertise and knowledge sharing in charging infrastructure design and electric bus operation.
  - Insufficient relevant expertise and knowledge sharing in hydrogen infrastructure design, hydrogen bus operation and ripple effect of the use of hydrogen in public transport.
- Collaboration and knowledge sharing between PTAs, operators and vehicle manufacturers needed.

4.5.4 Procuring processes

Public transport authorities procure the transport from the operators. When promoting alternative propulsion sources in PTA's transport, procuring processes can cause limitations but also enhance the possibilities. This can be divided into three themes: tender criteria, timetables of the tendering processes and contract durations. First two concern all three countries and the last one is mainly a Finnish issue.

Tender criteria define which propulsion powers the operators offer, and it can be done with requirements or scoring systems. What should be noted is that very many criteria added to the procuring and contract documents may be limiting or, on the contrary, making possibilities. The criteria used in tenders should be relevant in the new situation and provide incentives for long-term resource use. How tendering is done and what is asked has been adapted based on the long history of diesel buses, and other propulsion powers might need different criteria. It is important to understand how different criteria affects the outcome and understand the consequences of certain requirements.

Each PTA tend to have somewhat different vehicle requirements, which causes difficulties for manufacturers and reselling vehicles between PTA-areas. This does not only mean just the outside color schemes etc. of the vehicles but PTAs may also have different requirements for the interiors.

The amount of time between the operator decisions during the tendering processes and the starting date of the operation can cause difficulties. This affects both the availability and delivery of the vehicles and building the needed charging or refueling infrastructure. In the interviews, minimum of 15 months or 1,5 years between the decisions and operation were hoped to ensure that it is possible for the operators to use various manufacturers, for manufacturers to design, build and deliver the vehicles in time and for operators and grid companies to take care of the charging or refueling infrastructure and strengthening the grid capacity if needed. When talking about the Western Barents region, ground is in frost for long during the spring and this affects the possible time period to construct new infrastructure. Too long time between the procuring process and the start of the operation can on the other hand be also problematic because then getting the correct component prices for the vehicles might be hard since the price levels develop over time.

Contract periods should be long enough to make it possible for the operators to invest in new vehicles and infrastructure. The vehicle should be able to be depreciated during the contract period. This is not a problem in cities and regions where contract durations are already 7-10 years. Short contract periods are a well-known limitation within Finnish ELY-centers.

Development needs of procuring processes are:

- Tender criteria are adapted based on the long history of diesel buses and needs to be updated to be relevant in the new situation.
- Too short time between the tendering processes and decisions and starting the operation is problematic for both the delivery times of the vehicles and getting the needed charging/refueling infrastructure ready.
- Contract durations might not provide incentives for long-term resource use, thereby raising the threshold for investing in new technologies.

4.5.5 Vehicles

Vehicle selection which manufacturers offer improves and limits the possibilities PTAs and operators have. City buses are offered as electric, diesel, gas, and hydrogen but the availability of the latter two is more limited. There are also limitations with the availability of electric long-distance buses and minibuses. In coaches, the challenge is the sufficient operating range and battery capacity and in minibuses, the size of the battery contra the size of the small vehicle. The delivery times of the vehicles also limits the selection if there is too short time between the decision of the operator and the commencing of the operation.

The prices of the vehicles can also be a limiting factor. Capital is needed to purchase and the prices of other than diesel buses may be too high for the smaller operators. This might lead to a situation where smaller companies cannot compete, so PTAs have been carrying out their tenders in a way which supports the competitive situation. Operators also use used vehicles, and it has been noticed that there have started to be a problem to get used low-floor diesel buses: most of the new low-floor buses are bought as electric. In the near future, even the selection of new diesel city buses may get more and more limited due to the transition to electric urban transport.

Cold climate demands heating of the vehicles, which affects especially the usage of electric vehicles. Range of electric buses decrease by 25 % if the indoor air is heated with electricity. Electricity usage increases in urban transport where the bus doors are opened many times and the heated indoor air escapes again and again. This can be resolved by using diesel to heat the air.

Development needs of vehicles are:

- Availability of the vehicles of different alternative propulsion powers.
    - Limited availability of especially hydrogen vehicle and electric long-distance and minibuses, and smaller selection of gas buses
- Delivery times of the vehicles must be considered when procuring.
- Prices of the vehicles limiting for especially small PTAs and operators.

4.5.6 Fuels and infrastructure

Regarding fuels and the recharging or refueling infrastructure for those, many development needs and barriers were noticed.

One of the main challenges is the access to alternative fuels in general since coverage of the public refueling stations has shortages when talking about HVO and gas. Due to this urban and regional transport has limitations: if public stations are used, the sparse network can mean that the stations are in difficult places for the routes. Or there might not be refueling possibilities at all which is the case of for example biogas in Finland above Oulu and in Norway altogether. This can also cause problems to have fueling in the depots if there aren't other usage in the area. The operator must then buy a huge amount of the fuel. Long-distance is difficult with current sparse refueling possibilities.

Electricity is generally available anywhere, but the capacity of electricity grids is one of the main limiting factors when electrifying public transport. Upgrading the energy transmission network takes time and can be expensive, which is why ensuring the adequate energy capacity might end up being problematic both in and outside of cities.

Funding of refueling and charging infrastructure have been a challenge due to the high costs. There is a lack of unified funding mechanisms and responsibility allocation for charging infrastructure at bus facilities. In Finland and Sweden, this has been the responsibility of the operators and in Norway the trend has been lately that the PTA owns the depots and the infrastructure. State funding is needed especially in Norway where the requirements from the state and the speed of the development are very high. Investments into public infrastructure might also be needed to support transition both with smaller PTAs and market-based transport. If public transport uses public charging and refueling stations, buses cannot generally wait very long so booking systems might be needed. There can also be shortages of space for charging and refueling facilities in urban areas where there is a need to organize the charging and fueling.

The prices of renewable fuels are still higher than the most used fossil diesel. This does not encourage voluntary changes of the market-based actors and makes it more expensive for PTAs to require renewable fuels.

Climate in the Western Barents region is challenging for some of the fuels. Cold winters and snowy or icy conditions affect the energy consumption of the electric vehicles and shorten the operating range. HVO must also be suitable for low temperatures to be useful.

Hydrogen and e-fuels could be solutions in the future especially in long-distance, but currently there are serious lacks in hydrogen refueling infrastructure and production. Funding mechanisms and responsibility allocation are also un-unified at bus facilities.

Development needs of fuels and infrastructure are:

- Coverage of the charging and refueling infrastructure of especially HVO, gas and hydrogen is insufficient in the northern areas and outside of the main cities.

- Capacity of electricity grid is insufficient: upgrading the capacity takes time and is costly.
- Funding of refueling and charging infrastructure.
- The prices of the renewables are still higher than fossil diesel.

4.6 Summary and discussion

One of the main prominent challenges of promoting alternative propulsion fuels in the Western Barents region is the geographical and demographical environment. The area is wide and sparsely populated which leads to long distances and low traffic volumes. Cold and snowy climate during winter also causes challenges. The public transport supply is low due to low demand but there are exceptions. Cities have better conditions for alternative propulsion sources, and the usage of electricity is widely growing in urban transport also in the northern parts of Finland, Sweden, and Norway. For electricity to be practical solution in longer distances, energy consumption and batteries need to develop further. The seasonal peaks due to tourism also provide possibilities.

Two main challenges of the availability of the propulsion sources are wider than public transport sector. The lack of refueling capacity and lack of electricity grid capacity cannot be solved only by the actions taken by the public transport actors but those are to be solved together with transport sector in general and the energy sector. Heavy transport vehicles such as trucks face the same kind of challenges than long-distance public transport so the development of the logistics sector should be monitored.

Currently, public transport is using mainly fossil diesel in Finnish Barents region. The situation is moving towards electricity especially in cities, and some 100 % HVO is used. Regional and long-distance is still using fossil diesel. Gas is not very widely used in Finnish public transport services. Sweden uses electricity and HVO which are seen as the main options. Gas is also seen as workable option in Sweden if the access to it would be better. Norway uses fossil diesel and electricity and is planning to electrify most of the fleet. Norwegian PTAs do not see HVO as a practical option due to distribution obligation making it unprofitable.

Main possibilities and challenges of each propulsion power options are combined in table 19. The possibilities and challenges include issues discussed in the earlier chapters.

Table 19. Main possibilities and challenges of different alternative propulsion powers.

	Main possibilities	Main challenges
Electricity	• Cheap running cost (cost pr km) • Good vehicle availability (city buses)	• Grid capacity • High infrastructure costs • High vehicle costs • Limited vehicle availability of other than city buses • Battery capacity in long distances • Cold temperatures reduce the capacity of the batteries
Renewable diesel (HVO)	• Easy transition from fossil diesel (same vehicles and infrastructure) • Good alternative for long-distance already	• Distribution obligation: not profitable to require 100 % HVO • Sparse distribution network in places • Low local production volumes • Expensive running costs (cost pr km) • Fuel must be suitable for cold temperatures
Biogas (CBG/LBG)	• Good vehicle availability • Good alternative for long-distance already	• Sparse distribution network • Expensive running costs (cost pr km) • Low local production volumes
Hydrogen	• Potential in long-distance	• Expensive running costs (cost pr km) • High vehicle costs and limited availability • Low energy efficiency

		• Sparse or no distribution network • Low local production volumes, limited supply • Maintenance / aftermarket issues • Safety issues of hydrogen
Synthetic fuels	• Potential in long-distance • Same vehicles and infrastructure than with diesel buses	• Low energy efficiency • Sparse or no distribution network • Low local production volumes, limited supply

Since the situations are different and the limitations of different types of public transport are different, the overall perspective should be to find the right solution suitable for each case. The used solution does not have to be electricity which have become the most common solution in urban transport. A range of factors should be considered when discussing about the most possible and sustainable solution for each case: availability of the propulsion source in the area, suitability of it for the certain routes, climate impact and emissions.

PTAs have significant role when promoting the usage of alternative fuels since they are responsible of a huge share of the public transport operating in the area. Reaching the national goals set for the procurement of transport services is possible in all three countries in the Western Barents region. It demands that in Finland and Sweden the right solution for each one of the PTAs must be found and in Norway especially the funding must be secured due to the strict requirements.

5 Goals and roadmap

Based on the analysis of the current situation and possibilities and limitations, the goals and roadmap were created for promoting alternative propulsion sources in public transport in the Western Barents region. Goals are set for the introduction of alternative propulsion powers by comparing the main development needs with the existing national and regional goals. Road map is a compilation of necessary concrete actions needed to help achieving the goals. The roadmap includes especially actions for public transport authorities in all three countries but introduces also needed actions for other actors in the field to support the transition. An overall compilation of the funding possibilities is introduced.

5.1 Goals

The main goal in deploying alternative propulsion powers in the Western Barents region is to fulfill the existing goals. All three countries have national goals of carbon neutrality: Finland is reaching towards carbon-neutrality by 2035, Sweden by 2045 and Norway as early as by 2030 (if emission cuts are made by other countries and by 2050 regardless of international emission cuts). The Finnish, Swedish and Norwegian counties in the Barents region also have their own carbon-neutrality goals which usually follow the goals of the state. To help reach the carbon-neutrality goals, European Union and countries have set legislation to regulate the share of alternative propulsion powers in public transport (table 20).

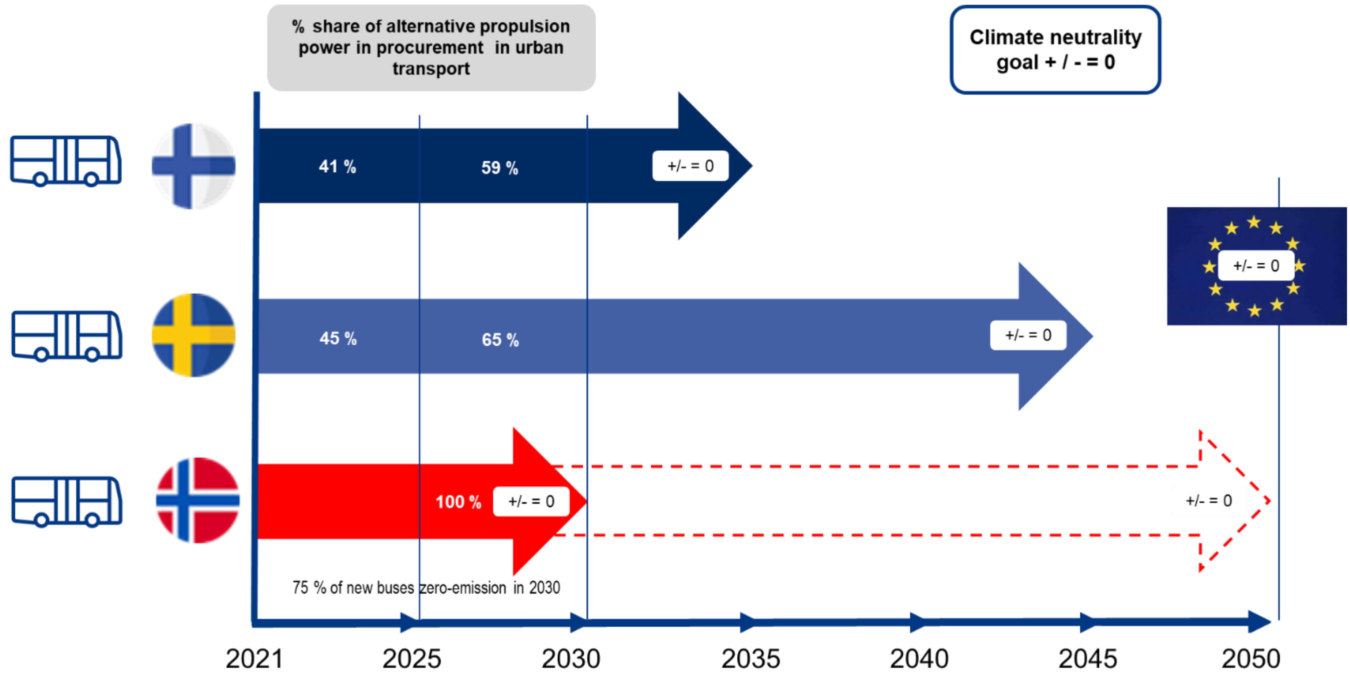
Table 20. Shares of city buses, which should be clean or zero emission. The percentages refer to the share of the vehicles procured during the time period via competitive tendering processes.

	2021–2025	2026–2030
Finland	41 % (Zero emission: Oulu 5 %)	59 % (Zero emission: Oulu 10 %)
Sweden	45 % (Zero emission: 22,5 %)	65 % (Zero emission: 32,5 %)
Norway	All zero emission from 2024	All zero emission from 2024

The goals include only buses which are meant to carry also standing passengers (classes I and A). This means that the laws do not require alternative propulsion powers to be used in transport of longer distances and regional transport where low floor buses are not used. Norway is an exception: there is a goal to have 75 % of the new long-distance buses zero emission vehicles by 2030.

The goals of carbon-neutrality and bus fleet are combined in figure 6.

Figure 6. Goals in Finland, Sweden, and Norway.



Since the requirements to use alternative propulsion powers differ between the three countries and there are different possibilities, it is aspirational to find the right solution for each case. Same solution and propulsion power does not fit every country, region, city, and transport structure. Regardless, it is important to make some fuels priority so investments and funding can be concentrated.

In Finland and Sweden, urban transport in cities can mostly be operated with electric buses. Electricity suits regional transport too, if transport structure is concentrated around the city and the charging can always be organized in the depot just like in urban transport. If electricity is not possible, HVO or gas are the best options if the fuel distribution can be solved. Gas is especially practical option in Sweden where gas is already used much more than in Finland. In long-distance and charter services, HVO or gas are currently the most viable options, and hydrogen or e-fuels might be potential in the longer run. Currently, especially market-based long-distance still runs with fossil diesel due to the limitations in technology and market.

In Norway, electricity is the only choice in urban transport due to strict and clear national requirements. In long-distance where the requirements are lower, fossil diesel blended with renewable diesel is still the most viable option, but hydrogen or e-fuels are potential in longer run.

5.2 Actions and roadmap

Roadmap includes actions which are needed to promote the usage of alternative propulsion powers in public transport in the region. There aren't any easy single solutions, so the action package focuses on the collaboration and building knowledge. The actions focus to the close future and continuous actions since the development of the market is very hard to foresee.

Actions are divided into five subcategories: cooperation, procuring, infrastructure, vehicles, and funding. Action groups and actions are described in the subchapters more precisely. Lastly, indicative timetable for the actions is given.

Since public transport authorities have been the focus in the study and the requirements by laws mostly concern PTAs, the actions focus on the procedures which are possible for the PTAs to do. Actions are meant to help the PTAs to find the most suitable propulsion power to fulfill the requirements or if that's already clear, to help with conducting the tendering processes, to ensure the possibilities of propulsion powers and to share best practices.

Structure of the action plan:

- Cooperation
  - 1A. Launching a new cross-border public transport collaboration forum.
  - 1B. Information sharing via market dialogues and other collaboration sessions.
  - 1C. Promotion of interests.
- Procuring
  - 2A. Propulsion power analysis
  - 2B. Procuring guide for the PTAs.
  - 2C. Following the development and market situation
- Infrastructure
  - 3A. Collaboration regarding charging and fueling networks.
  - 3B. Following plans of local production of non-fossil fuels
- Vehicles
  - 4A. Vehicle requirements guide for the PTAs.
  - 4B. Testing area for electric buses
- Funding
  - 5A. Ensuring funding.
  - 5B. Facility and service sharing

5.2.1 Cooperation

The geographical and demographic situation of the Western Barents differ from other parts of the countries for example related to the population density and climate. Working together and cooperating cross-border and inside the country-borders is needed as a base to promote the usage of alternative fuels. Sharing knowledge and best practices between the PTAs but also with operators, vehicle manufacturers, fuel distributors and energy companies ensures that everyone has the needed knowledge of the situation. Operating environment is of course different between for example Finnish city of Oulu and Norwegian small town in far north, and the cooperation should mind the differences but focus on the similarities.

Table 21. Actions related to cooperation.

Action	Description	Who should act	First steps
1A. Launching a new cross-border public transport collaboration forum	A new cross-border public transport collaboration forum helps to coordinate the development and especially share information and experiences between PTAs. Group should invite members from all the PTAs operating in the Western Barents region. It would also be helpful to have separate national forums for experience sharing between the PTAs in each country. The topics of the forum could include issues covering fuels, vehicle requirements and procuring to help with the transition towards alternative propulsion powers. Of course, other relevant topics of organizing public transport could be discussed. Multinational forum helps to share know-how and experiences between the countries where for example the usage of different propulsion powers is in different stages (for example Norwegian experiences with electricity in far north and Swedish experiences with gas).	• PTAs	Inviting members and launching the forum

	There are multinational public transport forums between Finland, Sweden, and Norway, but their focus is on the capital regions or other big cities. Since conditions in the more sparsely populated northern are quite different, forum focusing on these issues would be beneficial. Collaboration forum is referred to in other actions as an actor who should act.		
1B. Information sharing via market dialogues and other collaboration sessions	Commercial actors hold valuable information for PTAs and vice versa. Information sharing between PTAs and other actors can be done in market dialogues or other forms of collaboration meetings or workshops. Market dialogues are organized as a part of procuring processes for public transport operators. Otherwise, for example vehicle manufacturers, fuel distributors and energy companies are beneficial stakeholders for a successful deployment of alternative propulsion powers, and a collaboration workshop with those actors could be fruitful. Collaboration seminars or workshops can be organized nationally.	• PTAs • Collaboration forum • Stakeholders: operators, vehicle manufacturers, fuel distributors	Organizing market dialogues and initiating a broader collaboration workshop
1C. Promotion of interests	The geographical and demographic situation of northern regions differ from other parts of the countries (distances, population, climate). It is important to ensure communication within existing bodies and processes in national and EU level to ensure that the northern view is considered in the national contexts. This includes promotion of interests in public transport sector, transport sector as a whole and in energy sector. Promotion of interests require that the whole region combines forces and acts in cooperation to move things forward.	• Regions and municipalities • Collaboration forum • PTAs	Keeping the message from the northern regions up in different contexts.

5.2.2 Procuring

Procuring is one of the main instruments PTAs can use when promoting the usage of alternative propulsion powers themselves. Of course, the overall situation and market-readiness of different propulsion powers affect the possibilities PTAs have and those must be considered. PTAs can set requirements and scoring in tender materials, construct their tendering processes and write contracts in a way that most efficiently support the usage of alternative propulsion powers suitable for each case. To do this, knowledge is needed and of course cooperation between different actors is essential.

Table 22. Actions related to procuring.

Action	Description	Who should act	First steps
2A. Propulsion power analysis	Suitable propulsion powers differ between each city and county in the Western Barents region. Researching possible propulsion powers for each specific operating environment and transport structure helps to identify correct solutions for each case. Studies should include synergies between PTAs and market-based actors operating in the area.	• PTAs	Initiating propulsion power analysis project if found needed
2B. Procuring guide for the PTAS	Since the PTAs play significant role in promoting the usage of alternative propulsion powers, ensuring the expertise to conduct successful procurement processes is crucial. Guide should include instructions how to tender transport services with alternative propulsion powers: contract lengths, procuring processes, charging, and fueling systems, operating, etc. Guide answers to question, how ten-	• Collaboration forum • PTAs	Initiating a study to construct the guide

	der materials and processes and contracts should be constructed to attract alternative propulsion powers and how each choice made in the process affects the possibilities. Guide can be done nationally but, if possible, cooperating with other two countries. Procuring guide supports when promoting the implementation of the guidelines set in the propulsion power analysis.		
2C. Following the development and market situation	Technical maturity and economic feasibility of alternative propulsion powers develop fast, and development has proven to be quite difficult to foresee. Market situation of the fuels and vehicles should be followed closely and reacted accordingly. In the longer run, especially market maturity of hydrogen and e-fuels should be monitored as possible solutions for long distance transport.	• Collaboration forum • PTAs	Selecting the person(s) responsible of the monitoring

5.2.3 Infrastructure

Charging and fueling is mostly organized by the public transport operators due to the nature of public transport services. Distribution network or electricity grid and production must be sufficient for the propulsion power to be possible to be deployed. Infrastructure-related issues are mostly in the hands of other actors than PTAs. For this reason, once again, cooperation and collaboration are the keys. Available public infrastructure also affects the possibilities of market-based long-distance transport transitioning from fossil fuels to renewables.

Table 23. Actions related to infrastructure.

Action	Description	Who should act	First steps
3A. Collaboration regarding charging and fueling networks	Public transport actors, municipalities and regions benefit from monitoring the development of charging and fueling infrastructure. The services itself are mostly organized by private sector, but public entities can monitor and coordinate the plans to build refueling and charging capacity and research the demand of the operators and supply from fuel distributors and energy companies. Coordination helps to ensure that infrastructure is developed in a strategic manner and meets the needs of the entire region and its different actors. Public entities should also consider charging and fueling needs in land use planning, help find suitable locations and streamline the permit processes.	• Collaboration forum (PTAs) • Municipalities and regions • Stakeholders: service providers, energy companies	Keeping up with the plans Identifying and communicating the needs of the region
3B. Following plans of local production of non-fossil fuels	Non-fossil fuels are most easily deployed if the transportation distances of the fuels are short. Local production plans should be monitored to try to find possibilities to use the infrastructure and/or fuel. Local production of biogas, HVO, hydrogen or e-fuels increases the possibilities for public transport. Synergies with logistics could be used to promote the transport use besides industries.	• Regions and municipalities • PTAs	Keeping up with the plans and discussions concerning production in the operating area

5.2.4 Vehicles

Selection of vehicles develops together with the demand, technological development and market-readiness of each of the propulsion powers. PTAs can ensure the vehicle availability by making sure that the requirements set in their documents are favorable for alternative propulsion powers. The technological characteristics of different vehicles and fuels or electricity affect for one's part in which situations each fuel is a viable solution. In the Western Barents region, climate and long distances are the main issues which may hinder the conditions.

Table 24. Actions related to vehicles.

Action	Description	Who should act	First steps
4A. Vehicle requirements guide for the PTAs	Vehicle requirements guide is related to procuring guide since both are meant to help with the preparation of tender requests and contract documents. Guide answers to question how vehicle requirements affect the possibilities to offer different kinds of vehicles and what each propulsion power demands to be considered. Guide helps to unify the requirements. Vehicle guide can be included in the procuring guide but since vehicle market develops fast, this part of the guide must be possible to be updated more regularly.	• Collaboration forum • PTAs • Stakeholders: vehicle manufacturers	Initiating a study to construct the guide
4B. Testing area for electric buses	Conditions in the northern regions of Finland, Sweden and Norway are different than in the rest of the countries. Testing area for electric buses helps to test the suitability of electric buses in the northern climate conditions.	• Collaboration forum • Regions and municipalities • Stakeholders: vehicle manufacturers	Initiating a project to plan the testing area

5.2.5 Funding

Transitioning from fossil fuel to alternative propulsion powers requires funding. Funding is needed for example for the expansion of the charging and refueling network, investing in charging and refueling infrastructure in depots, investing in new vehicles and covering the operation costs if those increase due to the propulsion power change. Funding is especially crucial if the requirements are set so strict that the transition must be done even though it'll increase the costs significantly. The cooperation and promotion of interest nationally and internationally is important to make sure that the situation in the northern regions is heard.

Table 25. Actions related to funding.

Action	Description	Who should act	First steps
5A. Ensuring funding	Funding is needed for relevant stakeholders regarding the charging and fueling infrastructure, vehicle investments and grid upgrading. Existing funding possibilities should be used when applicable and new ways of financing should be actively monitored. There are country specific funding mechanisms and for example EU opportunities: • Finnish Energy Authority, Norwegian Enova, and Swedish Transport Administration to construct charging/fueling infrastructure. • CEF-funding for strategic investment in transport, energy, and digital infrastructure, also for cross-border issues.	• Regions • Municipalities • Collaboration forum • Chambers of Commerce	Collaboration forum identifies opportunities to apply for funding and keeps the matter on the agenda in the region

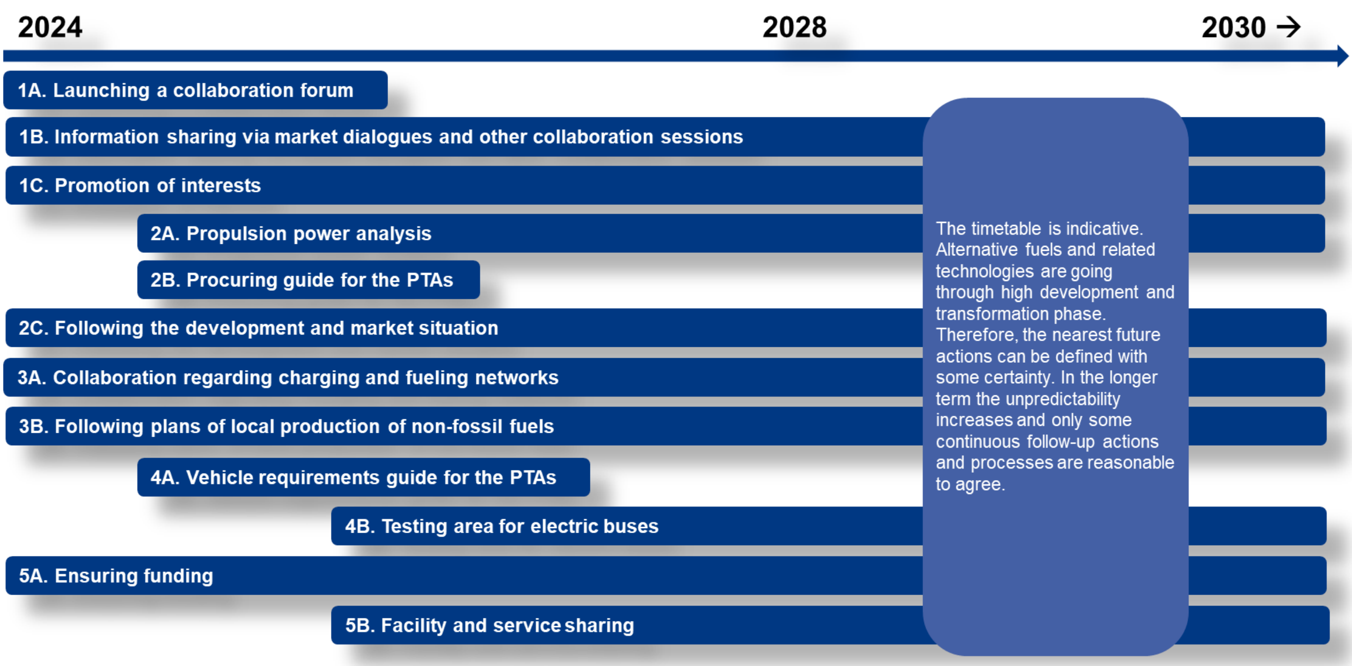
5B. Facility and service sharing	Investigating possibilities of facility/service sharing could help find ways to fund infrastructure, broaden the demand and level the usage of the infrastructure. Charging capacity in depots could be used by other heavy transport during the day, for example by placing the charging capacity at the border of the depot making it possible to use the capacity outside of the actual depot. Synergies of fueling and charging capacity of public transport and logistics should be utilized and investigated. Especially synergies are useful regarding transitioning long-distance buses from fossil fuels to alternative propulsion powers.	• Service providers • Public transport operators • Logistics operators	Identifying facility sharing possibilities

5.2.6 Timetable of the actions

Most of the actions are based on the collaboration of the actors in the region. A new cross-border public transport collaboration forum acts as a base to the collaboration of the PTAs. It also makes base for actions which include information sharing and building consensus. Some actions are continuous. Information sharing, promotion of interest, collaboration, following the development and ensuring funding should be on the focus continuously to ensure that the public transport market can adapt to the developing situation. Propulsion power analysis should be done in the PTAs when transitioning to alternative propulsion powers stars to be topical and well in advance before the procuring needs. Procuring and vehicle requirements guides are done once to help the PTAs, and it is important to keep updating those when the market develops.

Timetable of the actions is presented in figure 7. The timetable is indicative. Alternative fuels and related technologies are going through high development and transformation phase. Therefore, the nearest future actions can be defined with some certainty. In the longer term, the unpredictability increases and only some continuous follow-up actions and processes are reasonable to agree.

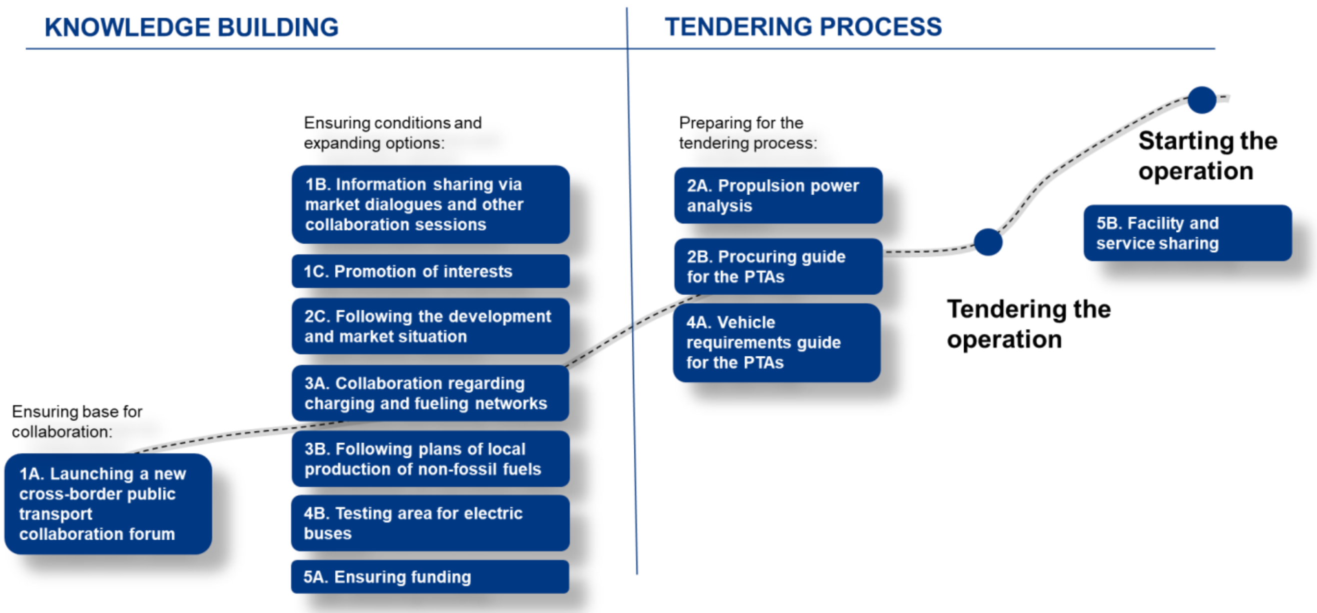
Figure 7. Indicative timetable of the actions.



When comparing actions to the process of PTAs tendering public transport services, some actions are needed beforehand, and some are related to the actual process. Well before tendering process, in a continuous manner, it is crucial to ensure conditions of alternative propulsion powers and expand options. Distribution network and market-readiness of fuels and vehicles must be developed first so that it is possible to deploy them. Development needs funding, so it needs to be secured. Based on the assessed local conditions, PTAs need to choose which propulsion power is the best choice and built the tendering and contract documents accordingly.

What's needed for each propulsion power to be a real option ready to be deployed in public transport in certain regions is more closely analyzed in chapter 6.1.

Figure 8. Placement of actions in relation to the tendering process.



5.3 Proposals for pilot projects

Based on the roadmap and other good practices noticed during the project, ideas for pilot projects are proposed for the region. Pilot projects can be used to test different ideas and services for the shorter period to get first-hand experiences and learn what still needs to be developed.

Since tourism is a big business in the Western Barents region and causes needs for transport services, it is a very attractive case to pilot and deploy alternative propulsion powers and other new innovations in the transport sector. For example, connections inside tourism centers could be operated with electric buses and even pilot autonomous transport services, and first and last mile connections from bigger cities, airports and railway stations could be operated with electricity or other alternative powers.

Table 26. Proposals for pilot projects.

Pilot project	Description	Who should act
6A. Electric ski buses in tourism centers	Tourism is marketed in north by using image of nature and cleanliness. Clean and zero-emission transport would suit that very well. Ski centers have ski buses that operate with dense headways and are kind of an urban transport between hotels, accommodation areas and ski slopes. These are operating environments where electric buses would be suitable. The vehicle currently used is a normal city bus. In longer run, autonomous buses could also be piloted in suitable ski bus routes. One example case for a pilot project could be Levi ski center if Finland. During the season, there are two ski bus routes that meet at the Zero Point -house at the Front Slopes. Both routes are about 10-12 km long and operate daily every 30 minutes. Piloting electric buses	• Buyers and operators of the ski-bus services

	would be suitable also in other tourism centers (such as Ylläs and Ruka in Finland and Hemavan-Tärnaby in Sweden).	
6B. Tornio-Haparanda as a twin-city	Tornio-Haparanda are a unique border “twin-city”, consisting of the Finnish town Tornio and Swedish town Haparanda which are directly connected on each side of the border. This unique operating environment has potential for even closer cooperation. It could be an interesting case to pilot or deploy alternative propulsion powers together. There are for example a joint travel center which bus transport of both cities use just at the Swedish side of the border. PTAs responsible of the public transport in both cities have already connections and ideas to develop the cooperation which enable a good base for the discussions about propulsion powers.	• PTAs of Sea Lapland and Norrbotten
6C. First clean long-distance public transport to and from tourism centers	Public transport between bigger cities and tourism centers offers cases where alternative propulsion powers could be piloted in routes serving longer distances. Alternative fuels are more commonly available in bigger cities and tourism centers where the demand for those is larger for passenger cars. Also, connections from airports and railway stations to tourism centers could be offered with clean fuels. This enables that the fuel is available in both ends of the route.	• Collaboration forum • Public transport operators

6 Conclusions

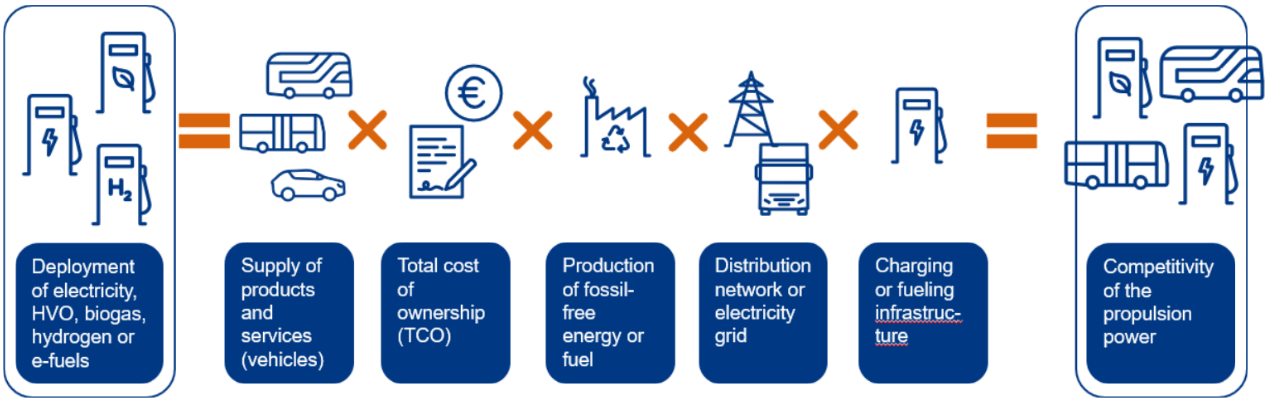
6.1 Deployment of alternative propulsion powers

For the propulsion power to be competitive in the public transport sector – and transport sector in general – the market conditions need to be at a good level, some competition and alternatives available, and it should be technologically reliable. These issues need to be considered when PTA starts planning the transition from fossil fuels to alternative propulsion powers or when market-based operator starts to think about their possibilities to do the same transition.

For the successful deployment of electricity, renewable diesel, biogas, hydrogen, or synthetic e-fuels the fuel must fulfill the following variables (also shown in picture 9):

- Supply of products and services (vehicles)
- Total cost of ownership (TCO)
- Production of fossil-free energy or fuel
- Distribution network or electricity grid
- Charging or fueling infrastructure

Figure 9. Variables defining the deployment of the propulsion powers (after Volvo / Magnus Björklund, Electrification of heavy transport 28.11.2023).



When all of these are in a good level, the propulsion power can be considered to be a competitive option. On the other hand, if even one of the variables is not as developed, the deployment is much harder, less economically viable or even impossible. What should be noted based on the variables is that the future of each transport fuel is determined on a big part outside of the Western Barents region, public transport sector and even outside the whole transport sector. For example, energy sector has main impact on how the production of fossil-free energy or fuels develop.

For public transport service to be able to be transitioned to alternative propulsion powers, suitable vehicles must be available. For example, to electrify the urban transport in cities, the availability of vehicles is very good. In addition to vehicles, the route or transport service structure needs to be suitable for the characteristics of the propulsion power.

Total cost of ownership (TCO) means all the costs which are needed to deploy the propulsion power. This includes for example costs of energy or fuel, infrastructure and vehicle investments, maintenance, and labor. The total costs should be economically viable for the fuel to be true alternative to produce transport services.

Of course, energy or fuel must be produced for it to be available to use. In some cases, the production is sufficient but, in some cases, it can be very limited. For some fuels, the production should be close-by to decrease the difficulties and costs of transporting the fuel (for example biogas and hydrogen) but in some cases the location of the production does not matter as much (for example fossil-free energy).

Energy or fuel must be distributed to the public or depot-based charging and fueling stations. Distribution of some fuels is technologically easier, and the distribution network affects how widely the fuel is available. If for example HVO is distributed already widely to stations meant for passenger cars, the distribution to for example depots in the same area is much easier. When talking about electricity, the capacity of electricity grid can be limiting issue. Charging and fueling infrastructure must be available, or in the context of public transport built to the depots. This also includes the storing of the fuel, such as diesel or gas tanks.

When all the above-mentioned variables are combined, it is possible to analyze the situation where each propulsion power is in their readiness to be deployed in public transport sector. Situation of the variables divided by propulsion power in each of the three countries are analyzed in the following tables 27, 28 and 29. Tables are indicative expert assessments which are based on the current situation in the Western Barents region analyzed in the report in the earlier chapters.

Colors and symbols mean:

- **Green and +**: Market conditions are at a good level, competition and alternatives are available, and technology is reliable. All the criteria should be fulfilled.
- **Yellow and 0**: The market is inadequate; the supply is somewhat limited, or technology is unsettled. If even one of the criteria set for the green is not fulfilled, the situation is marked with yellow.
- **Red and -**: Piloting phase. The market is undeveloped, there is none of close to none supply or technology is undeveloped.

Table 27. Maturity of technologies: state of the key variables in Finnish part of the Western Barents region.

FINLAND	Supply of products and services (vehicles)	Total cost of ownership (TCO)	Production of fossil-free energy or fuel	Distribution network or electricity grid	Charging or fueling infrastructure	"Total"
Electricity	+	+	+	0	0	0
HVO	+	+	0	+	0	0
Biogas	0	0	0	0	0	0
Hydrogen	-	-	-	-	-	-
E-fuels	+	0	-	0	0	-

Electricity, HVO and biogas are all possible solutions in the Finnish part of the Western Barents region. The deployment of electricity or HVO is easier in most cases while biogas has some difficulties related to especially production and distribution in the region. Hydrogen technology is still in pilot phase, so it does not currently provide many possibilities. E-fuels are otherwise in better level – mostly because of the vehicles and infrastructure using the same as fossil diesel – but the production is very limited.

Table 28. Maturity of technologies: state of the key variables in Swedish part of the Western Barents region.

SWEDEN	Supply of products and services (vehicles)	Total cost of ownership (TCO)	Production of fossil-free energy or fuel	Distribution network or electricity grid	Charging or fueling infrastructure	"Total"
Electricity	+	+	+	0	0	0
HVO	+	+	0	+	0	0
Biogas	0	0	+	+	0	0
Hydrogen	-	-	-	-	-	-
E-fuels	+	0	-	0	0	-

Main difference between Finland and Sweden is the deployment of biogas in the transport sector. Gas is much more used in Sweden which is for example due to the more distribution around the counties but mainly because of the political and operational decisions made. In Finland, gas is not much used in public transport even nationally. Otherwise, situation and possibilities to deploy the propulsion powers are quite similar in both countries.

Table 29. Maturity of technologies: state of the key variables in Norwegian part of the Western Barents region.

NORWAY	Supply of products and services (vehicles)	Total cost of ownership (TCO)	Production of fossil-free energy or fuel	Distribution network or electricity grid	Charging or fueling infrastructure	"Total"
Electricity	+	+	+	0	0	0
HVO	Not used as 100 % in public transport, political decision.					
Biogas	0	0	-	-	-	-
Hydrogen	-	-	0	-	-	-
E-fuels	Not used in public transport, same reason than with HVO.					

Main difference of Norway compared to Sweden and Finland is the view PTAs have on HVO. Since 100 % HVO is not seen as an option, the state is not analyzed in the table. Otherwise, the situation is quite similar than in Finland and Sweden, but biogas distribution network in northern Norway is much more limited than in other two countries.

6.2 Funding possibilities

Since funding was noticed as one of the key issues, EU-level and national funding possibilities are listed below.

EU

- Connecting Europe Facility (CEF)-funding for building infrastructure of alternative propulsion powers along TEN-T network for organizations building distribution infrastructure.
    - For example, in 2024 the first round is accepting applications for the infrastructure of alternative propulsion powers (first phase from February 2024 to September 2024, expected to have three rounds of which two of the latter ones in 2025).
- Invest EU -funding.
- European Regional Development Fund (ERDF) tor regional development initiatives through regional councils.
- European Fund for Strategic Investment (EFSI) for strategic development initiatives.

Finland

- Propulsion power studies and plans:
    - Ministry of the Environment: Grant for the promotion of green transition investment projects for municipalities and regional councils.
    - Ministry of the Environment: Municipal climate projects -grant for municipalities, regions, and regional councils.
- Constructing fueling and charging networks:
    - Finnish Energy Authority: Investing aid for charging and refueling (gas and hydrogen) infrastructure for organizations building distribution infrastructure.
    - ARA: Aid to build charging infrastructure for electric cars to residential buildings and workplaces for owner organizations of residential buildings and employers.
- Others:
    - Business Finland: Energy aid to replace the energy-system with a low-carbon one. Projects related to the production of renewable energy, energy saving or energy audit.
    - EAKR (ELY of North Ostrobothnia): Green transition, themes of energy efficiency and reducing greenhouse gas emissions.

Sweden

- Constructing fueling and charging networks:
    - The Swedish Transport Administration: Investment support for expansion of public charging infrastructure.
    - Klimatlivet -program is funding carbon emission reduction projects widely: for example, charging stations, hydrogen filling stations, production of biogas, biofuels, and e-fuels.

Norway

- Infrastructure and vehicles:
    - Enova: State-owned company providing funding for transition to a low-emission society. Funding can be granted for hydrogen vehicles and infrastructure and locale/flexible grid systems.
- Knowledge and pilot studies:
    - The Research Council of Norway: Norwegian government agency that funds research and innovation projects. Collaborative project to address challenges in society and business. Research organizations collaborating with relevant societal and business stakeholders to develop new knowledge and build research expertise essential for addressing key societal challenges.

6.3 Fulfilling the national and regional goals

Main national and regional goals of the countries and regions in the Western Barents are the climate neutrality goals which should be achieved in the upcoming decades. Transitioning public transport from fossil fuels to alternative propulsion powers is one instrument in the wide selection. Governments of the three countries have set minimum shares of public transport vehicles which should be procured in the present decade.

The Western Barents region, especially the northern part of it, is more challenging operating environment for the alternative propulsion powers than the rest of the three countries. The climate and the demography are different. Long distances and sparse population cause problems for public transport services already when it's operated with well-known fossil diesel. It is likely possible to achieve the national goals set for public transport vehicles, but it demands that a right solution is found to fit every situation. Electricity is a good choice in urban transport but when the driving distances get longer, organization of electric operation gets more difficult. It is also good to notice that in Finland and Sweden, not all vehicles have to use alternative propulsion power just yet. Norway has stricter goals and electricity is basically the only option currently in urban transport.

Urban transport is the easiest case to replace fossil fuels with alternative options. Urban transport is procured by PTAs and the operating conditions are suitable to most of the fuels and electricity. Regional transport has limitations due to the longer routes but still the transition can be made with careful planning and if conditions are favorable. Market-based long-distance transport is challenging, and it is most likely the last one to swap from fossil fuels to the alternatives. For example, in Finland, long-distance operates with fossil diesel in the whole country, so in the Western Barents region, it is likely still best to continue to monitor the development.

Fulfilling goals requires enough funding and knowledge of the market situation regionally, nationally and internationally. The roadmap helps with building the knowledge. Since challenges in northern regions are similar, collaboration between the cities, counties and countries is crucial. One of the main learnings is that working together towards the goals is needed and collaboration needs to be cross-border and between PTAs, operators, vehicle importers, municipalities, and other actors and between public transport sector, transport sector and energy sector.

7 Literature

Antikainen, J., Hovi, S., Sinerma, J., Ilomäki, R., Auerma, R. & Nazarov, D. 2022. Barents Region Transport and Logistics (BRTL) – Current Status. https://kainuunliitto.fi/assets/uploads/2022/11/BRTL-Current-Status-report-February-2022.pdf

Drivmedla. n.d. Gasinfrastruktur. https://drivmedla.se/kartor-och-statistik/gasinfrastruktur

Drivmedla. n.d. Infrastruktur med flytande fossilfria drivmedel. https://drivmedla.se/kartor-och-statistik/infrastruktur-med-flytande-fossilfria-drivmedel

Etelä-Karjalan liitto. 2023. Etelä-Karjalan vaihtoehtoisten käyttövoimien jakeluverkko. Ohjekirja jakeluverkon kehittämistä edistämään. https://liitto.ekarjala.fi/wp-content/uploads/2023/08/Vaihtoehtoisten-kayttovoimien-jakelu-infrastruktuurin-kehitys-ohjekirja-kuntatoimijoille.pdf

European Commission. n.d.: Delivering the European Green Deal. https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal/delivering-european-green-deal_en

European Commission. n.d.: Sustainable & Smart Mobility Strategy. Putting European transport on track for the future. https://transport.ec.europa.eu/system/files/2021-04/2021-mobility-strategy-and-action-plan.pdf

Ilomäki, R., Kivari, M., Käsnänen, S., Takala, J. & Vähätörmä, P. Raskaan liikenteen ajoneuvojen latausinfra. Tarveselvitys. Liikenne- ja viestintäministeriö. Helsinki. http://urn.fi/URN:ISBN:978-952-243-917-8

Jääskeläinen, S. (toim.) 2022. Liikenteen vaihtoehtoisten käyttövoimien jakeluinfra. Kansallisen ohjelman seuranta 2022. Liikenne- ja viestintäministeriö, Helsinki. http://urn.fi/URN:ISBN:978-952-243-909-3

Korkia Consulting & WSP Finland Oy. 2020. World Transport Market and Logistics Project. KO1029 Barents Region Transport and Logistics. https://kainuunliitto.fi/assets/uploads/2020/11/World-Transport-Market-and-Logistics_ENG.pdf

Korkia Consulting & WSP Finland Oy. 2021. Barents Region Transport and Logistics. Case Studies. https://kainuunliitto.fi/assets/uploads/2021/10/Barents_case_studies_raportti_final_RUSupdate_part1.pdf and https://kainuunliitto.fi/assets/uploads/2021/10/Barents_case_studies_raportti_final_RUSupdate_part2.pdf

Korkia Consulting & WSP Finland Oy. 2022. BRTL – Barents Region Transport and Logistics. Action Plan. https://barents-council.org/document/Barents-Region-Transport-and-Logistics-Action-Plan-March-2022.pdf

Korri, J., Takala, J., Helve, M, Fält, E. & Vaet, E. Preliminary survey on alternative fuels for heavy traffic and working machinery in the Western Barents region. Center for Economic Development, Transport, and the Environment of Lapland.

Handberg, Ø., Hagman, R., Bruvoll, A., Ørving, T. Dombu, S. & Ulstein, H. 2019. Kostnader ved overgang til fossilfri kollektivtransport. Rapport. https://www.menon.no/wp-content/uploads/2019-4-Kostnader-ved-overgang-til-fossilfri-kollektivtransport-1.pdf

Miljødirektoratet. 2022. Barrierer for elektrifisering av bussdrift i kollektivsektoren. Observasjoner fra intervjuer med bransjeaktører. https://www.miljodirektoratet.no/publikasjoner/2022/mai/barrierer-for-elektrifisering-av-bussdrift-i-kollektivsektoren/

Nordland fylkeskommune. 2021. Analyse av lav- og nullutslippsløsninger for buss, ferge og hurtigbåt i Nordland. https://www.nfk.no/_f/p1/i206c8b5f-d870-47ab-86c9-5e4574c36724/rapport-dnv-gl-analyse-av-lav-og-nullutslippslosninger-i-nordland.pdf

Oulun kaupunki. 2019. Oulun linja-autoliikenteen käyttövoimaselvitys. Raportti.

Regeringskansliet. Sveriges rapport enligt direktiv om utbyggnad av infrastrukturen för alternativa bränslen 2019. https://alternative-fuels-observatory.ec.europa.eu/sites/default/files/documents/2022-12/2019%20Sweden%20NIR.pdf

Tilastokeskus. 2020: Linja-autoliikenteen kustannusindeksi 2020=100. Menetelmäseloste. https://www.stat.fi/media/uploads/tup/kustannusindeksit/linja-autoliikenteen_kustannusindeksi_2020100_menetelmaseloste.pdf

Traficom, 2023: Liikennekäytössä olevat linja-autot - käyttövoimat, päästöt ja keski-ikä. https://tieto.traficom.fi/fi/tilastot/liikennekaytossa-olevat-linja-autot-kayttovoimat-paastot-ja-keski-ika

Traficom, 2023: Linja-autojen käyttövoimat viranomaisten järjestämässä joukkoliikenteessä. https://tieto.traficom.fi/fi/tilastot/linja-autojen-kayttovoimat-viranomaisten-jarjestamassa-joukkoliikenteessa

Tyréns AB. 2020. Green Transport in the Barents Region. Final Report. https://kainuunliitto.fi/assets/uploads/2020/11/Grona-transporter_Final_Report_200331.pdf

Statistics:

Statistikmyndigheten. 2022. Körsträckor med svenskregistrerade fordon. https://www.scb.se/hitta-statistik/statistik-efter-amne/transporter-och-kommunikationer/vagtrafik/korstrackor-med-svenskregistrerade-fordon/

Statistisk sentralbyrå. 2022. Euroklasser, drivstofftyper og kjøretøygrupper. https://www.ssb.no/statbank/table/11823/

Statistisk sentralbyrå. 2023. Cost index for passenger transport by bus. https://www.ssb.no/en/transport-og-reiseliv/landtransport/statistikk/kostnadsindeks-for-buss

Tilastokeskus. 2023: Liikenteen energiankulutus. https://pxdata.stat.fi/PXWeb/pxweb/fi/StatFin/StatFin__ehk/statfin_ehk_pxt_12sz.px

Traficom, 2023: Liikennekäytössä olevat ajoneuvot neljännesvuosittain 2008–2023. https://trafi2.stat.fi/PXWeb/pxweb/fi/TraFi/TraFi__Liikennekaytossa_olevat_ajoneuvot/040_kanta_tau_104.px/

Law:

Directive (EU) 2019/1161 of the European Parliament and of the Council of 20 June 2019 amending Directive 2009/33/EC on the promotion of clean and energy-efficient road transport vehicles. https://eur-lex.europa.eu/eli/dir/2019/1161/oj

Laki ajoneuvo- ja liikennepalveluhankintojen ympäristö- ja energiatehokkuusvaatimuksista (740/2021). https://www.finlex.fi/fi/laki/ajantasa/2021/20210740

National plans and strategies:

Det Konglige Samferdselsdepartement. Nasjonal transportplan 2022–2033. https://www.vegvesen.no/fag/fokusomrader/nasjonal-transportplan/nasjonal-transportplan-2022-2033/

Finnish Government. 2021: The National Transport System Plan for 2021-2032. Publications of the Finnish Government 2021:77. Helsinki. http://urn.fi/URN:ISBN:978-952-383-804-8

Jääskeläinen, S., Ojala, T., Simonen, E. & Kola, H. 2023: Ohjelma tieliikenteen uusien polttoaineiden jakeluinfran kehittämiseksi Suomessa vuoteen 2035. Liikenne- ja viestintäministeriö, Helsinki. http://urn.fi/URN:ISBN:978-952-243-933-8

Regional plans and strategies:

Kainuun liitto. 2021. Kainuu-ohjelma. https://kainuunliitto.fi/assets/uploads/2022/11/Kainuu-ohjelma-web-final.pdf

Kainuun liitto. 2018: Kainuun liikennejärjestelmäsuunnitelma. https://kainuunliitto.fi/assets/uploads/2020/08/kainuun_liikennejarjestelmasuunnitelma.pdf

Lapin liitto. 2021: Lappi-sopimus. Maakuntaohjelma 2022–2025. https://www.lapinliitto.fi/wp-content/uploads/2022/02/Lappi-sopimus-2022-1.pdf

Lapin liitto. 2021: Lapin liikennejärjestelmäsuunnitelma 2040. https://www.lapinliitto.fi/wp-content/uploads/2021/06/Lapin-liikennejarjestelmasuunnitelma-2040-1.pdf

Lapin liitto. 2021.: Lapin Green Deal -tiekartta. https://www.lapinliitto.fi/wp-content/uploads/2021/09/VALMIS_Lapin-Green-Deal-tiekartta_290921.pdf

Länsstyrelsen Norrbotten. 2019: Norrbottens klimat- och energistrategi 2020–2024.

Pohjois-Karjalan liitto. 2020: Pohjois-Karjalan strategia 2040. https://pohjois-karjala.fi/wp-content/uploads/2022/03/Pohjois-Karjalan-strategia-2040.pdf

Pohjois-Karjalan liitto. 2020: Pohjois-Karjalan liikennejärjestelmäsuunnitelma 2030. https://pohjois-karjala.fi/wp-content/uploads/2022/03/198-Pohjois-Karjalan-liikenneja%CC%88rjestelma%CC%88suunnitelma-2030.pdf

Pohjois-Pohjanmaan liitto. 2022: Pohjois-Pohjanmaan maakuntaohjelma 2022–2025. https://www.pohjois-pohjanmaa.fi/wp-content/uploads/2022/03/PPL_maakuntaohjelma_2022-2025_WEB-2.pdf

Pohjois-Pohjanmaan liitto. 2020.: Pohjois-Pohjanmaan liikennejärjestelmäsuunnitelma 2040. https://www.pohjois-pohjanmaa.fi/wp-content/uploads/2020/09/A60.pdf

Region Norrbotten. 2021: Länstransportsplan 2022–2033. Norrbottens län.

Region Västerbotten. 2021: Länstransportplan 2022–2033. Västerbottens län.

Region Västerbotten. n.d.: Miljö- och klimatstrategi.

Appendices

Appendix 1 Question lists of the interviews

Public transport authorities

Background

- What kind of role does your organization have, concerning a) public transport and b) alternative propulsion sources in public transport?
- How is your own work connected to these issues?

Current situation

- How would you describe the current amount of public transport that uses alternative propulsion sources, in your country / geographical area / county / region / city?
    - What is the share of diesel/electricity/gas/others?
- How would you describe the current distribution networks (electricity/gas/others) available for buses? Do they have a good coverage (in Western Barents / in your own region)? Where are the biggest shortages, if any?
- Are there any regional or city-level strategies / roadmaps /targets for alternative propulsion sources in public transport? How are those considered when developing and procuring transport services?
- Where are the buses charged/fueled? Who is responsible of:
    - the depots?
    - charging/fueling infrastructure?
    - providing the electricity/fuel?

Tendering PT operation

- What kind of experiences do you have on alternative fuels when tendering public transport operation? How are the propulsion sources considered when tendering? What kinds of requirements do you have for the fleet? Or how does the scoring of the offered fleet work?
- Have there been tenders / winning tenders where vehicles using alternative propulsion sources have been offered?
- How have alternative propulsion sources affected the outcome of the tendering processes? How about the public costs of procuring PT operation? Could you estimate the price differences between different kinds of fleet? Any examples?
- What kind of experiences do you have regarding the availability and cost of the fleet when tendering? Have the delivery times of the vehicles caused any problems?
- Have the alternative propulsion sources affected the service level overall? (Considering e.g., the changing cost structure and the availability of the distribution / charging networks)
- Are there any problems in the tendering process that you'd like to point out (considering alternative propulsion sources)?

Larger picture and the future

- In your opinion, what are the biggest obstacles for usage or promotion of alternative propulsion sources in public transport (in Western Barents / in your own region)?
- Which actions would be needed to overcome the above-mentioned obstacles? Who needs to act?
- What do you think about the future of public transport that uses alternative propulsion sources, in your country / geographical area / county / region / city?

- How will the share of diesel/biodiesel/electricity/gas/others change in next 5 years? What about the next 10 years?

Public transport operators

Background

- How big is your company? Where do you operate? What kind of transportation (city, long distance, other)?

Current situation

- Tell about your fleet in the Barents area: how may vehicles do you have? Which propulsion sources are used? Why these?
  - The share of diesel/ biodiesel/ electricity/ gas/ others? (Concrete numbers needed!)
  - Any differences in the usage?
  - When did you buy the electric/gas/other vehicles?
  - What made you decide to buy them instead of fossil diesel, or use biodiesel in the diesel vehicle?
- What kind of experiences do you have on using alternative propulsion sources? Good, bad?
- How is the availability of the fleet using alternative propulsion sources? Have the delivery times of the vehicles caused any problems?
- How about the costs of these vehicles? Could you estimate the price differences between different kinds of fleet?
  - Vehicles itself?
  - Operating costs?
  - Costs of the fuels/electricity
- Do you have an idea about the above-mentioned issues for other operators - which propulsion sources are used? Why? Is there a difference between city public transport and long-distance public transport?
- Where are the buses charged / fueled? Who is responsible of:
  - the depots?
  - charging/fueling infrastructure?
  - providing the electricity/fuel?
- How would you describe the current distribution networks (electricity/gas/others) available for buses? Do they have a good coverage (in Western Barents / in your own operation routes)? Where are the biggest shortages, if any?

Tendering PT operation

- What kind of experiences do you have on alternative fuels when PTA's tender public transport operation? How are the propulsion sources considered when tendering? How should they be considered?
- How have alternative propulsion sources affected the outcome of the tendering processes?
- Are there any problems in the tendering process that you'd like to point out (considering alternative propulsion sources)?

Larger picture and the future

- In your opinion, what are the biggest obstacles for usage or promotion of alternative propulsion sources in public transport (in Western Barents / in your routes)?
- Which actions would be needed to overcome the above-mentioned obstacles? Who needs to act? How could PTAs promote the usage of alternative fuels?
- What do you think about the future of public transport that uses alternative propulsion sources, in your country / geographical area / county / region / city / routes?
  - How will the share of diesel/biodiesel/electricity/gas/others change in next 5 years? What about the next 10 years?

Vehicle manufacturers / importers

Background

- Tell about your company, e.g. how many buses do you deliver to Sweden/Norway/Finland per year?

Current situation

- What kind of vehicles that use alternative propulsion sources do you offer now?
  - electric, gas, diesel, (hydrogen)
  - capacity, passenger seats
  - long-distance buses (coaches), city buses, smaller vehicles
- What are the prices of said buses? How are the prices determined?
  - electric, gas, diesel, (hydrogen)
- How is the delivery time of said buses? If the bus is ordered today, how long it will take to receive it?
  - electric, gas, diesel, (hydrogen)

Tendering PT operation

- What kind of experiences do you have on PTAs tendering processes and delivering buses for the operators (alternative fuels and e-buses)?
- Are there any problems in the tendering process that you'd like to point out (considering alternative propulsion sources)?

Larger picture and the future

- In your opinion, what are the biggest obstacles for usage or promotion of alternative propulsion sources in public transport (in Western Barents / in your own region)?
- Which actions would be needed to overcome the above-mentioned obstacles? Who needs to act?
- What do you think about the future of public transport that uses alternative propulsion sources, in your country / geographical area / county / region / city?
  - How will the share of diesel/biodiesel/electricity/gas/others change in next 5 years? What about the next 10 years?
- How do you see the potential of hydrogen and e-fuels in Finland/Sweden/Norway?

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