MODAL SHIFT
Key points for the Barents region

1

Modal shift should not be pursued for the sake of it

It must be seen as a holistic transport system development work that improves logistical competitivity and brings added value to the transport customers. Many modal shift options are already in use in the Barents region, but there are still many other user cases available.

2

Modal shift is not to be exclusively regarded as an environmental action

Studies show, that even strong policy measures will only lead to relatively small emission reductions (few percentages). It has more to do with using each transport modes best qualities in each transport chain and maximizing the usage of infrastructure.

3

Modal shift requires infrastructure investments – EU Green Deal funding mechanisms should be used

From transport sector point of view, EU Green Deal is a funding mechanism focusing on TEN-T network. Most of TEN-T network in the Barents region belongs to the comprehensive network. In addition, there is a clear focus on multimodal transport systems, inland waterways and rail transport. All the investments must have clear climate benefits and digital reach. This approach offers a lot of opportunities for the Barents region because these support development of connectivity of the region.

4

Logistics hubs are critical nodes in multimodal infrastructure

Development of logistics facilities for terminal operations and transshipments are one key approach to promote modal shift in the Barents region. The region has a lot of potential for development of new transport solutions because there is an extensive rail network available between Scandinavia, Russia and Asia. Therefore, there are a lot of opportunities to construct new and alternative transport corridors to diverse directions by combining all the transport modes available in an effective way.

5

Modal shift needs a clear vision and target setting to form a competitive and sustainable transport system

Modal shift and intermodal transport systems must be seen from many perspectives and layers. Modal shift can be a political target which needs support and investments to proceed. Basically, a transport system has concrete product transport flows which have a product owner (or producer) and a customer. This transport system must be cost efficient with high service level and increasingly sustainable. Thus, a combination of looking at the big picture and local development is needed.

Chapter 4

Promoting new propulsion powers in the Barents region

EU SMART MOBILITY AND DIRECTIVE ON ALTERNATIVE FUELS INFRASTRUCTURE

EU Smart Mobility key points

The increased deployment and use of renewable and low-carbon fuels must go hand-in hand with the creation of a comprehensive network of recharging and refueling infrastructure to fully enable the widespread uptake of low- and zero-emission vehicles in all transport modes.

By 2025, the aim is to build half of the 1 000 hydrogen stations and one million out of 3 million public recharging points needed by 2030. The ultimate goal is to ensure a dense, widely-spread network to ensure easy access for all customers, including operators of heavy-duty vehicles.

The Commission will publish a strategic roll-out plan to outline a set of supplementary actions to support the rapid deployment of alternative fuels infrastructure, including in areas where persistent gaps exist. These would include recommendations on planning and permitting processes as well as on financing.

In the context of the upcoming revision of the Directive on Alternative Fuels Infrastructure (AFID), the Commission will consider options for more binding targets on the roll-out of infrastructure, and further measures to ensure full interoperability of infrastructure and infrastructure use services for all alternatively fueled vehicles.

Next to the revision of AFID, a revision of the TransEuropean Transport Network (TEN-T) Regulation and other policy instruments such as the recast Renewable Energy Directive and its accounting mechanism for electricity are prepared. The Commission will ensure alignment with the necessary grid investments under its initiatives under the EU energy system integration and hydrogen strategies.

Directive on deployment of alternative fuels infrastructure 2014 →

The Directive on the deployment of alternative fuels infrastructure 2014/94/EU introduces new EU rules to ensure the build-up of alternative refueling points across Europe with common standards for their design and use, including, for example, a common plug for recharging electric vehicles.

The revision of the Alternative Fuels Infrastructure Directive

The 2021 Commission Work Programme foresees the publication of the proposal in the second quarter of 2021. The Smart and Sustainable Mobility Strategy presented on 9 December 2020 lists the revision in its legislative action plan for 2021.

The required coverage by which the infrastructure must be put in place is shown in the table. The alternative infrastructure must be put in place by 2025.

Requirements in the Directive of alternative fuels infrastructure 2014

Mandatory	Fuels	Objectives/distance requirement
Yes	Electricity for vehicles	One recharging point per estimated ten electric vehicles (and for information purposes: at least every **60 km** on TEN-T Core Network)
Yes	CNG	At least every **150 km** on TEN-T Core Network and one CNG refueling point per estimated 600 CNG vehicles
Yes	LNG for vehicles	At least every **400 km** on TEN-T Core Network
Yes	LNG for maritime vessels	Coverage of maritime ports with mobile or fix installations to enable the circulation on TEN-T Core Network
Yes	LNG for inland waterway vessels	Coverage of inland ports with mobile or fix installations to enable the circulation on the TEN-T Core Network
No	Hydrogen	At least every **300 km** on TEN-T Core Network

ALTERNATIVE PROPULSION POWERS
- EFFICIENCY AND INFRASTRUCTURE

- BATTERY POWERED RENEWABLE ELECTRICITY
- HYDROGEN
- E-FUELS *Methane, methanol, dimethyl ether and ammonia*
- RENEWABLE DIESELS (HVO100 & BioVerno)
- BIODIESELS (E85,B100)
- BIOGAS (CBG & LBG)
- CNG & LNG

ENERGY EFFIENCY IN DIFFERENT STAGES

WELL → TANK | TANK → WHEELS

Vehicle type	Production efficiency	Delivery efficiency	Use efficiency	Total WTW (well-to-wheel)
BEV (Battery electric vehicle)	35...60%	81...84,6%	65...82%	18...42%
FCEV (Fuel cell electric vehicle)	23...69%	54...80%	36...45%	4...25%
ICEV (Internal combustion engine vehicle)	82...87%	99%	17...21%	14...18%

Source: Deloitte Fueling the Future of Mobility - Hydrogen and fuel cell solutions for transportation. Numbers for FCEV are based on a vehicle using hydrogen.

RESPECTIVE INFRASTRUCTURE

Battery electric vehicles (BEV)
- Charging infrastructure is required
- Fast charging is critical in public places, home charging can be slower

Fuel cell electric vehicles (FCEV)
- using hydrogen, new fueling infrastructure is required
- Also, fuel logistics is currently difficult and costly

Internal combustion engines vehicle (ICEV)
- New infrastructure is needed only for gasified products and liquid gases
- Existing infrastructure for can be used for e-fuels and renewable diesels

PROPERTIES OF DIFFERENT ALTERNATIVE PROPULSION POWERS

	Battery powered electricity	Compressed biogas (CBG) and compressed natural gas (CNG)	Liquefied biogas (LBG) and liquefied natural gas (LNG)	Renewable diesel (HVO)	Renewable diesel from forest industry	Green hydrogen	E-fuels (synthetic) methane, methanol, dimethyl ether
PROPERTIES	• Renewable or fossil energy stored in batteries that power an electric motor • Average range for electric passenger cars is around 300 km • Charging times depend on the charging current	• Made from waste and sewage water by digesting • Range for a semitrailer truck up to 500 km • Combustion engines can be altered to use CBG or LNG	• Liquid at -160C • Energy content 1:1,7 compared to diesel • Range for a semitrailer truck up to 1 000 km • Combustion engines can be altered to use LBG or LNG	• Hydrotreated vegetable oil • Made for waste and industrial residues	• Hydrotreated crude pine oil which is a residue from pulp production	• Made with renewable energy in electrolysis • In gaseous form in normal temperatures	• Carbon neutral and renewable fuels created with power-to-X process where renewable electricity, hydrogen (electrolysis) and captured carbon dioxide are used as inputs
ENGINE	Electric engine powered by battery electricity	Internal combustion engine	Internal combustion engine	Internal combustion engine	Internal combustion engine	Fuel cell powered electric engine	Fuel cells or internal combustion engines
LIFETIME CO_2 REDUCTION	-80%	CBG: -90% CNG: -15%	LBG: -90% CNG: -15%	-90%	- 80%	Nearly -100%	Depends if the carbon is captured from the air and if CO_2 is from bioindustry
POSSIBILITIES	• Best system efficiency • Enables smart electric grids • New battery technologies such as solid-state batteries could provide new opportunities	• Local and regional energy production (CBG) • Reduces energy waste (CBG)	• Good energy density • Long range with heavy vehicles	• Fit for all diesel engines • Burns purely • Local emissions are also reduced	• Fit for all diesel engines • Suitable for maritime • Eliminates sulfur oxide emissions, reduce nitrogen oxide emissions by 10% and fine particulate emissions by 50%	• Fueling is similar to current systems and it takes around 15 min to fuel a truck • Good energy density (1kg of H_2 = 1 gallon of diesel) • Production on site near wind power from excess energy	• Easier storage than for hydrogen • Easier integration with existing logistic infrastructure (e.g., use in gas pipelines, tankers, refuelling infrastructure)
CHALLENGES	• Not enough raw minerals to electrify all vehicles with current technology • Battery technology limits	• EU policies unclear • Limited amount of biomaterials • CNG is still a fossil-based fuel	• EU policies unclear • Limited amount of biomaterials • LNG is still a fossil-based fuel	• Limited raw materials and questions around palm oil plantations • Can't replace fossil diesel because supply is limited	• Supply limited to pulp production so volumes can't be increased without increasing deforestation	• Difficulties in transportation and storage due to gaseous form • Economical feasibility	• Carbon capturing and hydrogen production costs are still relatively high
OEMS	Wide range of companies in the battery electric vehicle value chain	Gasum, Scandinavian Biogas	Gasum, Scandinavian Biogas, Gazprom, Novatek	Neste	UPM	NEL ASA	At piloting stage

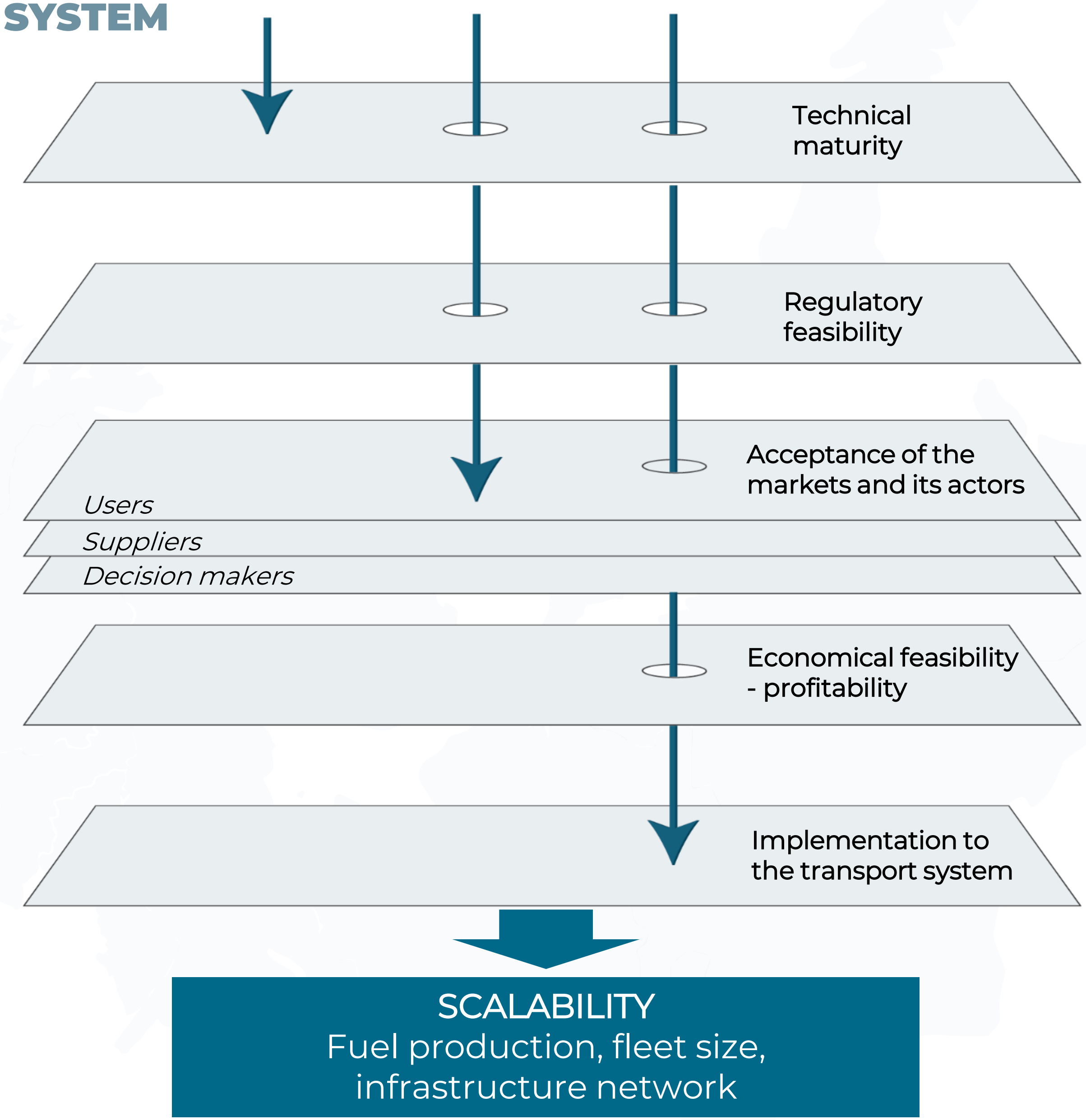
IMPLEMENTATION OF NEW TECHNOLOGIES AND PROPULSION POWERS IN THE TRANSPORT SYSTEM

All the forementioned propulsion powers are technologically feasible but their technical maturity varies

All the forementioned propulsion powers are generally accepted in different forms of regulation. But there is still development needed on different levels.

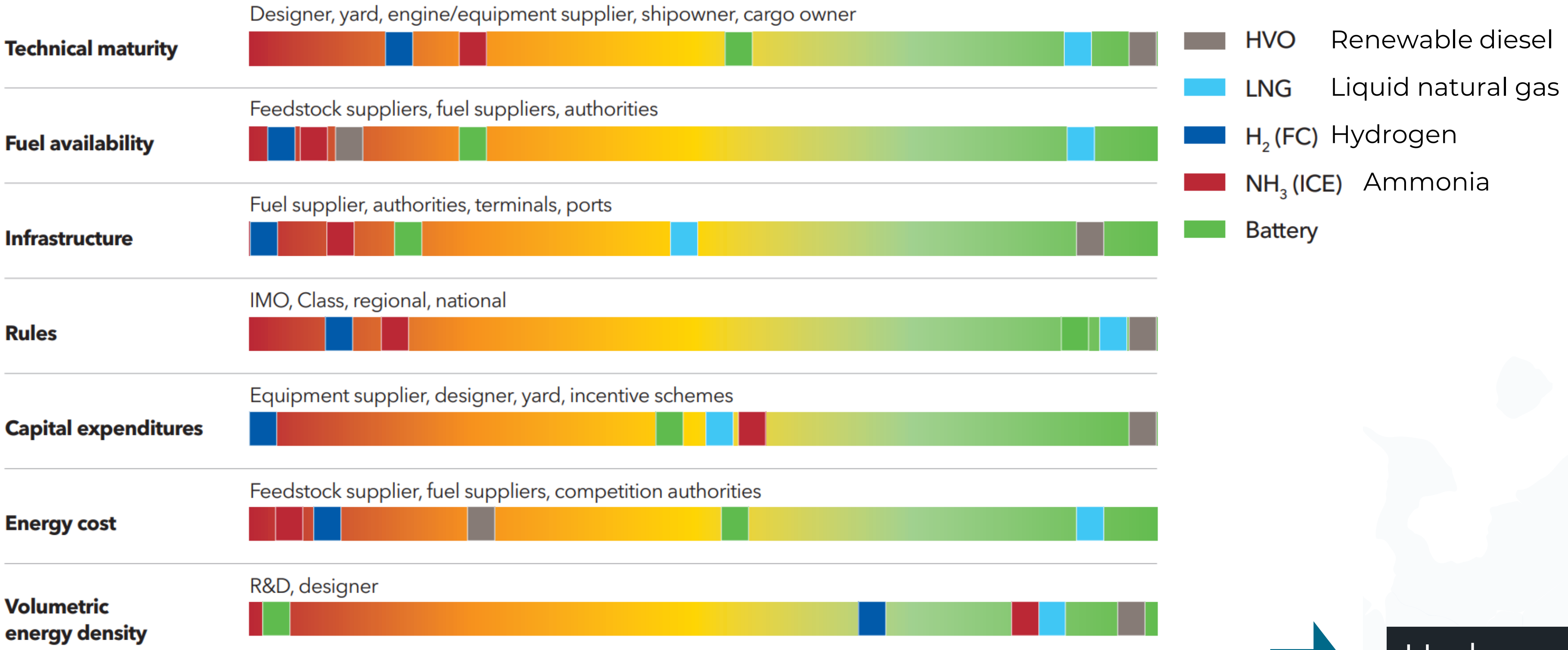
Renewable diesel is largely considered a good alternative. For BEVs, range anxiety and vehicle prices are still barriers in many cases. For hydrogen and e-fuels, the lack of scale and suppliers limits the notoriety.

BEVs are estimated to reach price parity with respective ICEVs by 2023. Hydrogen and e-fuels are in many cases still too expensive for large scale production.



CASE MARITIME

The Alternative Fuel Barrier Dashboard: Indicative status of key barriers for selected alternative fuels



Technical maturity – refers to technical maturity level for engine technology and systems.
Fuel availability – refers to today's availability of the fuel, future production plans and long-term availability.
Infrastructure – refers to available infrastructure for bunkering.
Rules – refers to rules and guidelines related to the design and safety requirements for the ship and onboard systems.
Capital expenditures (capex) – Cost above baseline (conventional fuel oil system) for LNG and carbon-neutral fuels, i.e. engine and fuel system cost.
Energy cost – reflects fuel competitiveness compared to MGO, taking into account conversion efficiency.
Volumetric energy density – refers to amount of energy stored per volume unit compared to MGO, taking into account the volume of the storage solution.

Source: DNV GL 2019

Hydrogen based fuels are still in early stages of development

PROPULSION POWERS FROM THE BARENTS AREA COUNTRIES POINT OF VIEW

NORWAY

Key strategies
- The Norwegian climate strategy for 2030
- National transport plan 2018-2029
- The Norwegian Government's hydrogen strategy 2020
- Handbook for infrastructure for alternative propulsion powers for transport 2019

BEV
- Largest charging network
- Over 50 % of current passenger car sales are EVs
- Electric vehicles are exempt from vehicle registration tax and VAT

Biogas
- Focus on heavier vehicles
- Enova's program for investment support for the establishment of biogas production will contribute to an increased supply of biogas. Enova also supports the purchase of heavier biogas vehicles and associated filling infrastructure.

LNG
- A good alternative in shipping

Hydrogen / E-fuels
- Lots of piloting focusing on shipping and heavy vehicles
- Fuel cell vehicles are exempt from vehicle registration tax and VAT.

SWEDEN

Key strategies
- Klimatklivet is an investment program supporting local and regional measures aimed at lowering GHG emissions
- Ladda bilen is an investment support program aimed at developing charging infrastructure administered by the Swedish environmental protection agency.
- National hydrogen strategy is being prepared (ready in July 2021)

BEV
- The bonus malus system is applied on top of the existing vehicle tax on vehicles registered after 1 July 2018. The system includes passenger cars and light trucks and buses up to 3.5 tonnes. Battery electric vehicles (BEV) and hydrogen vehicles receives the highest possible bonus set at SEK 60,000.

Biogas
- All gas vehicles receive a fixed bonus of SEK 10,000.

Biofuels in general
- The Swedish pump law states that filling stations that sell more than 1,000 m3 of gasoline and diesel a year are obliged to sell renewable fuels such as E85, biogas, HVO100 and B100. Charging infrastructure cannot replace the requirement to sell renewable fuel, however HVO100 can replace ethanol or B100.

FINLAND

Key strategies
- Fossil free transport roadmap 2020
- National Energy and Climate Strategy for 2030
- Distribution network for alternative propulsion powers in transport 2017
- National biogas program 2020
- National hydrogen roadmap for Finland 2020

BEV
- Incentives for battery electric vehicles (BEVs) are offered in the form of a €2000 purchase subsidy from the Finnish government (Traficom 2020).
- The Government offers incentives for building EV charging infrastructure. Grants for 16 public fast charging stations are offered up to 35 percent of investment costs

Biogas
- Available biogas for transport 2,5 TWh by 2030 and 10 TWh by 2045

Renewable diesel
- Finnish company Neste is one of the leading renewable fuels producer globally

Hydrogen / E-fuels
- By 2030 there will be 20 hydrogen fueling stations so that the distance between stations is 300km and each station's catchment area is 150 km.
- E.g. LUT, STI and Wärtsilä have studied the requirements for e-fuels in Finland

Biofuels in general
- Finland has a biofuel admixture policy, stating that fuel suppliers are obligated to blend their road transport fuels with at least 15% biofuels in energy content.
- A goal is set that 30% of the content of all fuels sold in 2030 will be biofuel energy

RUSSIA

Key strategies
- Russia's Energy Strategy to 2035.

LNG
- Russia has a lot of oil and gas production, and there are many LNG productions in operation or in construction phase in the Arctic. By far LNG provides the cleanest form of energy available from fossil fuels. LNG also meets mining and industrial production in the Barents region.
- Focus on LNG in maritime transport of NSR with increasing amount of LNG powered fleet in the Arctic. Replacing traditional fuels with more sustainable LNG. Advantages in availability in long term and also compliance with the IMO target settings.
- Russia has committed to Paris climate agreement and Russian Arctic is an area which is going to suffer most of climate warming causing huge costs for infrastructure. This is one reason why Russia is very active in development of new technologies in transition from fossil fuels to renewal propulsion powers. The sectoral plan for adaptation to climate change in the field of transport is being developed for a reduced carbon footprint.
- The rapid transition in global energy markets especially in Europe has changed plans and moves focus on ammonia production instead of LNG. For example, Novatek has announced plans for this kind of change in their Ob plant investment project. Natural gas remains the main energy source in Russia and significant change is not expected before 2040.

Hydrogen
- Hydrogen belongs to Energy strategy of Russia and there are studies done for hydrogen production plants.
- Piloting by gas industry and nuclear power plant site is targeted to 2023-24. Hydrogen export goals quite minor compared to other energy sources by 2035.

STATE FUNDING MECHANISMS FOR ALTERNATIVE FUEL DISTRIBUTION NETWORKS IN THE BARENTS REGION

NORWAY

Enova is the state-owned company that provides funding for Norway's transition to a low-emission society.

Support for charging infrastructure

Enova's purpose is to make it attractive for more people to use an electric car, by providing a basic offer of fast chargers in selected areas where there is still a need for public support and the network is not yet developed.

In 2020, commitments were made to 25 fast charging stations in Troms and Finnmark. The support was 65 MNOK in total. By the end of the year, 7 of these charging stations have already been established. In September 2020, a competition was announced for Nordland and Namdalen.

Enova can support up to 100% of approved investment costs within the minimum technical requirements. The application process at Enova is normally completed within 4-8 weeks.The charging infrastructure must be completed and in operation no later than 18 months after a decision from Enova.

Support for biogas production, infrastructure and vehicles

Enova has contributed to technology development to produce advanced biofuels and stimulated the further development of the value chain for biogas by supporting production facilities for biogas and the purchase of commercial vehicles with associated filling infrastructure. In 2020, NOK 98.2 million was given in support of two production plants for biogas. Support was also provided for a biogas filling station and 87 trucks, mainly tractors powered by liquefied biogas. The increasing number of projects on biogas trucks leads to more knowledge about the benefits and challenges of using the vehicles. The number of cars available in the market is increasing, and that the delivery of cars is no longer a barrier.

Support for hydrogen fueling stations

Since 2015, Enova has provided support to nine publicly available hydrogen filling stations. No aid has been granted after the year 2019. In addition to infrastructure support, Enova has also helped to realize innovative projects that use hydrogen.

Enova 2021

RUSSIA

The government of Russian Federation has decided investments and conducted action plans for increasing LNG delivery network for transport vehicles. Russia has also developed strategic planning documents for the increasing use of alternative fuels, for example a concept for the development of production and use of electric transport for the period up to 2030, a strategy for the development of transport production with a reduced carbon footprint and an action plan for development of the energy storage systems industry including measures to support the production and location of the minimally required infrastructure of electric charging stations.

Rosseti, a Russian power company, has been the most active in pursuing a charging infrastructure for electric cars, installing more than 250 stations since 2013. The company will not work without regional support, since there are big capital investments needed. Rosseti will build another 1,000 charging stations by 2025. The main difficulty is the problem of local electric capacities. Often the company finds that it's impossible to increase capacity in areas it wants to build stations, or that increasing capacity would be prohibitively expensive. (Bellona 2020)

FINLAND

Finnish Energy Authority regulates and promotes operation of the electricity and gas markets, emission reductions, energy efficiency and the use of renewable energy. It also provides support for alternative fuel infrastructure. Support can be given to gas fueling stations, local public transport electric charging stations and for fast and slow public charging stations.

Infrastructure support shall not exceed 35% of the eligible costs in the case of high-capacity vehicle recharging points, and otherwise up to 30%. The support can be granted if the investment wouldn't otherwise be done and municipalities that don't have existing infrastructure are prioritized.

Public charging infrastructure got 4,8 MEUR of funding between 2017-2019. In 2020, 3 MEUR was reserved for gas fueling stations and 1,76 MEUR for fast charging systems.

Infrastructure support for public charging stations and gas stations and for home and work charging stations are included also in the Fossil Free Roadmap's first phase that the government made a resolution on in May 2021.

Finnish Energy Authority 2021

SWEDEN

The Swedish Transport Administration offers investment support for the expansion of public fast charging stations for charging vehicles. The support applies to certain places in connection with major roads that do not have fast chargers. A network of fast chargers makes it possible for more people to drive on electricity.

The Swedish Transport Administration has SEK 150 million to grant to support the construction of charging infrastructure for three years, 2020 - 2022. It is possible to apply for up to 100 % of the investment cost. However, it is not possible to apply for support for the operation of the fast charging stations, only for the investment cost.

In 2021, the Swedish Transport Administration has granted investment support for 39 new public fast charging stations in connection with the major state roads, where such are lacking in Västerbotten, Västernorrland, Jämtland, Gävleborg and Norrbotten. Ten different players are granted SEK 45,350,899 million to establish 39 fast chargers.

Klimatlivet program also provides support for wide variety of carbon emission reduction projects such as biogas production and fueling stations.

Trafikverket 2021

One public CSS DC fast charger reduces yearly emissions in Sweden by 12 884 kg CO_2-ekv

OVERVIEW OF LOW EMISSION PROPULSION POWERS FOR TRANSPORT IN THE BARENTS REGION

Green Transport in the Barents region 2020 recommendations

Make electrification a top priority

Focus on passenger cars. For heavy trucks and buses, it is less clear what path to choose.

Set common goals for deployment of green transport infrastructure

To achieve a basic functionality in the green transport infrastructure (ensuring the possibility to get from point a to point b within the region), goals should be set for the primary road network. Based on average operating range of EVs and gas vehicles, standard requirements could be set. As an example, the Swedish national strategy on deployment of fast-charging infrastructure states that public fast charging possibilities should be available every 100 km along primary roads. Setting these target values also enables to identify where necessary infrastructure is absent, thus enabling a feedback to national levels on need of policy incentives

Implement public instruments that enable commercial infrastructure deployment

In order to provide favorable conditions to commercial actors constructing green transport infrastructure it is vital to identify the central needs of the commercial sector and implement relevant supportive measures throughout the Barents region.

Charging infrastructure plans for passenger vehicles. Heavy vehicles require alternative options.

Using EU regulations and existing transport corridors, the case studies are determined and required infrastructure is calculated

EU Green Deal and national funding sources are described

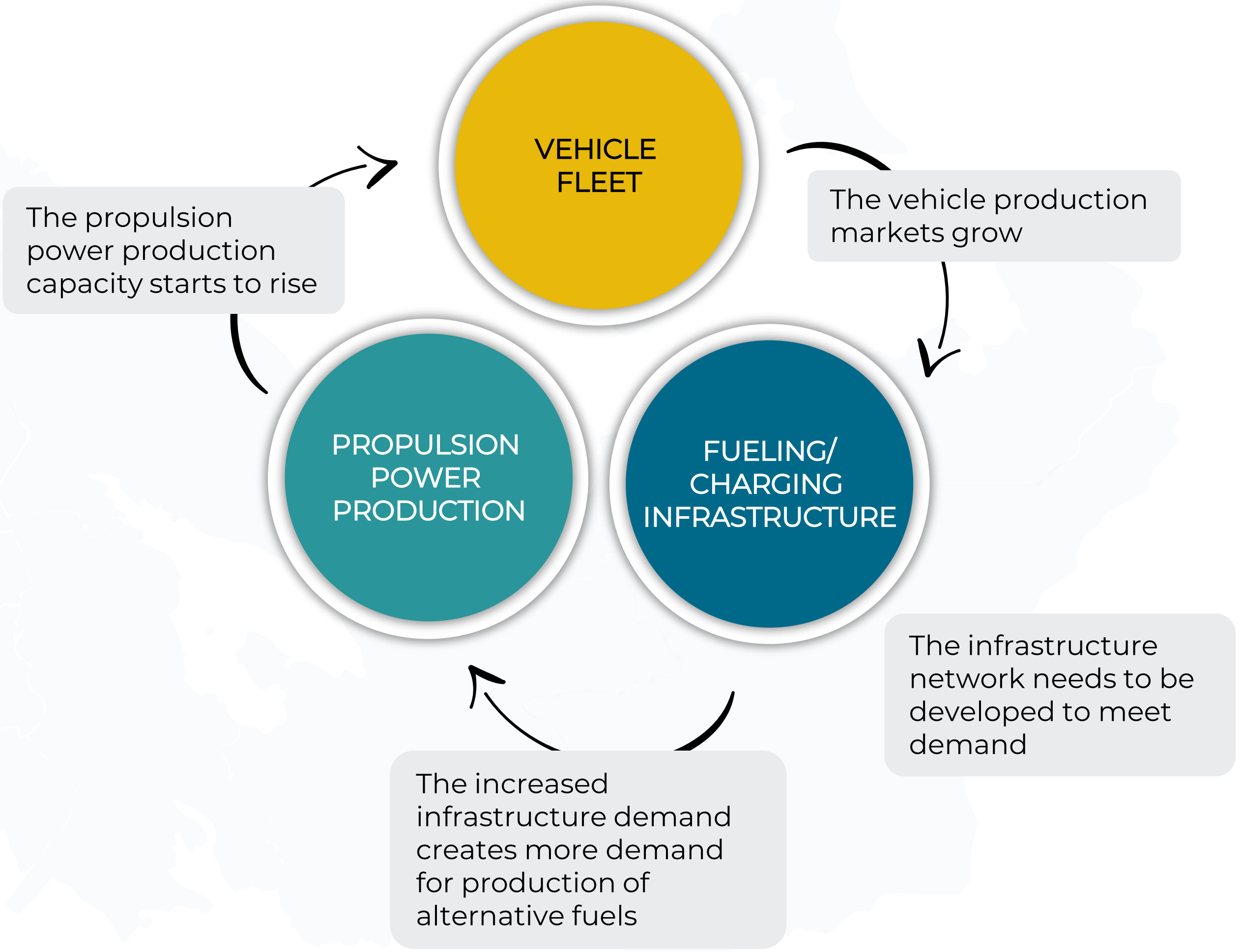
Updated in 05/2021. Most recent data available at: https://latauskartta.fi/

Updated 05/2021. Biogas stations include CBG/CNG and LBG/LNG fueling stations

WHAT PROPULSION POWERS
FOR THE BARENTS REGION TRANSPORT?

MODE OF TRANSPORT	PRIORITY FOR THE NEXT FEW YEARS	2030+
Heavy long-haul truck transport	• Renewable diesel • LBG/LNG	• Hydrogen • E-Fuel
Light short-haul truck transport	• Battery electricity • CBG/CNG • Renewable diesel	• Battery electricity • E-Fuel • CBG
Passenger vehicles	• Battery electricity • CBG/CNG • Renewable diesel	• Battery electricity • E-Fuel
Rail transport	• Electricity • Renewable diesel	• Electricity • Hydrogen
Shipping	• Hybrid battery electricity • LNG/LBG	• Ammonia • Hydrogen
Aviation	• Battery electricity • Sustainable aviation fuel (SAF)	• Hydrogen / E-fuels • Battery electricity

It is crucial to recognize that the Barents region or even the whole transport sector won't determine the future of transport fuels. The biggest decisions are made in the energy sector and from there the energy assortment will be carried on to the transport sector.



HEAVY TRANSPORT
PROPULSION POWERS IN THE BARENTS REGION

SHORT TERM	LONG TERM 2030
• Renewable diesel • LBG and LNG	• Hydrogen • E-Fuels

SHORT TERM
For heavy transport, the current alternative fuel options are limited. The vehicle producers are approaching the change with caution and are not going to choose one single approach. With the current situation, it is found that the best short-term options for heavy transport in the Barents region are renewable diesel and LBG/LNG. Battery electricity is currently not viable for long-haul transport as the batteries become too heavy compared to the energy density with the current technology. However, battery technology is developing towards solid-state batteries which could provide an opportunity for heavy vehicle producers to design new truck designs and integrate the batteries into the vehicle hull structure.

For renewable diesel, the existing infrastructure is sufficient, and no new investments are needed. For LBG and LNG, new fueling infrastructure is needed. LBG can both be produced and distributed in the Barents region and the distribution network should serve the largest transport demand corridors. For LNG, the Barents region has existing large production capacity but the fueling infrastructure is lacking.

LONG TERM
Near 2030, it is expected that new hydrogen-based fuels are nearly competitive with other fuels price wise. It is unclear whether heavy transport will use gaseous hydrogen or e-fuels. Hydrogen is difficult to transport and needs new fueling infrastructure. E-fuels can be liquid in normal temperatures, and they would not require new fueling infrastructure and fleet.

Picture: Posti

LBG AND LNG TRUCKS IN FINLAND
The Finnish postal company Posti owns 13 LBG trucks and 6 LNG trucks which are in operation around the clock. The new trucks can be built to correspond HCT-trucks weighing up to 68 tonnes with dollys and B-links. HCT has about 30% more transport capacity than a standard vehicle combination. The trucks are made by Volvo.

The vehicle investments are part of Posti's goal to be carbon neutral by 2030. The 13 LBG trucks reduce carbon dioxide emission by 2 000 tonnes each year. This corresponds to 11 million kilometers driven with a passenger car. The LBG fleet is designed so that the gas fueling stations are near terminals and along the operating routes.

Source: Posti 2021

Picture: ASKO

HYDROGEN TRUCKS IN NORWAY
In January 2020, ASKO started using the world's first hydrogen-powered trucks. The trucks have a range of 500 kilometres with a gross weight of 26 tonnes, and will deliver groceries to stores including those of NorgesGruppen, and will initially operate in Trondheim. ASKO has ordered a total of four trucks, all manufactured by Scania, with funding from agencies including ENOVA.

The hydrogen will be produced locally, using energy from 9,000 square metres of photovoltaic panels on the roofs of ASKO Midt-Norge's buildings. The refueling station, which is also on ASKO's premises, has been funded by Enova as an integral part of the truck project. The hydrogen produced will not only be used by the new trucks, but also by ASKO's cars and fork-lift trucks.

Scania is working with its electrification roadmap in the same way as with the combustion engine-technology; a multi-facetted approach with a broad range of solutions. The company has researched and developed different kinds of bio-fueled hybrid-electric technologies, as well as fully-electric vehicles.

Sources: Norway hydrogen strategy, ASKO and Scania 2020

COST ANALYSIS AND INVESTMENTS

LNG/LBG REFUELLING INFRASTRUCTURE

Currently there is only one LNG refuelling station in Barents region, located in Oulu, Finland. To reach TEN-T requirement (one refuelling station in every 400 kilometres) in all prioritized corridors in Barents, at least 19 new refuelling stations would be needed. **Stations are placed to map on the right side as reference purposes** and exact locations should be studied after reasonable distances between refuelling points are decided.

- LNG-trucks work with 1 000 km radius and considering the long distances and quite low heavy transport volumes in some routes in the Barents, it should be discussed whether TEN-T requirements are reasonable to be applied to all prioritized corridors.

LNG refuelling stations can fuel LNG as liquid (LNG), as gas (LNG-CNG) or as both (LNG and LNG-CNG). Same infrastructure can be used to LBG as well. Stations can be permanent, mobile or semi-mobile. Investment costs vary significantly between different station types and the ideal type depends on the demand and available technology.

Depending on the source, investment cost of one super saturated and saturated LNG refuelling station also selling CNG is somewhere between **1 million and 1.5 million euros**. Stations selling only saturated LNG or super saturated and saturated LNG without CNG option have lower investment costs. Also mobile stations benefit from lower investment costs. Gasum got investment aid from Swedish Klimatklivet in late 2019 for new LNG/LBG refuelling stations. Based on published information the investment cost of one station was estimated to be **1.3 million euros.**

The total investment cost of filling the TEN-T requirement for LNG infrastructure in the prioritised corridors would be roughly **19 to 28 million euros**, if 1 to 1.5 million euros is the investment cost of one station. If part of the stations would be mobil, or fuel only LNG without CNG, total investment would be lower.

As a part of EU “LNG Blue Corridors Project” cost analysis of LNG refuelling stations was made, and the operational costs were estimated. Based on this estimation, the yearly costs would be approximately 90 000 € in one super saturated and saturated LNG refuelling station also selling CNG. **100 000 € is used as an estimate**, since the study is from 2016.

In late April 2021, Nasdaq published article about price hikes in LNG and stated that the rate of about 175,000 to 180,000 cubic metres of LNG has risen to up to $70,000 to $80,000 from around $50,000 to $65,000. Average price is approximately same than what Wega expects for year 2021: **0.4 €/kg** .

In May 2021 (21.5.2021) tank price of LNG in Gasum’s refuelling station in Sweden was 17,4 SEK/kg **(1,7 €/ kg)** and price of LBG 18,65 SEK/kg (1,8 €/kg). Station price includes excise duties based on country’s taxation. For example, in Finland the excise duty of natural gas in 2021 is approximately **0,32 €/kg**, which is significantly lower than fossil diesel.

Smalja et al. 2019: Fuel Switch to LNG in Heavy Duty Traffic (2019); LSBT (2016), Techische Universität Kaiserslautern (2018); Klimatklivet resultat; Cost analysis of LNG reguelling stations (2016); Nasdaq; Gasum; Finnish tax authority; Wega;

Payback times with different monthly user rates are presented in the table below. Used VAT is 20 %, weigted average cost of capital 5 % and depreciation time 10 years.

Monthly LNG consumption (kgLNG)	20 000	40 000	60 000
Monthly refuels (á 115 kgLNG)	174	348	522
Payback time (years)	N/A	5	3

Will there be enough LNG trucks?

348 monthly refuels means 11-12 daily. Heavy duty traffic for example in Karesuvanto (number 6 in the map) was 169 vehicles daily. To reach 11 to 12 daily refuels, 7 % of the daily vehicles should refuel LNG at the station. LNG stations to be profitable, they should be located so, that usage rate is as high as possible, but sill so, that routes are drivable with LNG fuelled trucks.

NGVA expects that LNG vehicles would take up a 10 % share of the market by 2030, if this would be true for Barents area as well, the profitability could be secured.

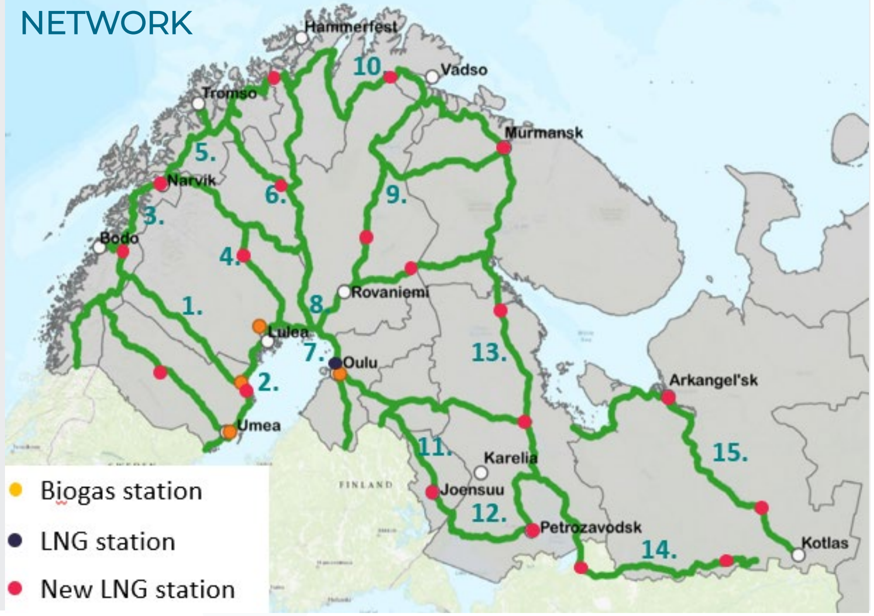
Chalmers University of Technology study concluded that “Studies suggested that for filling stations to be profitable, the filling ratio should be at least between 200 to 800.” In Finland, the expected share of gas-powered trucks is estimated to rise as presented in the table below. The share of LNG/ LBG-powered trucks is not specified.

Estimated amount of gas trucks in Finland (>16t)

2020	164
2025	1 100
2030	2 800
2035	5 200
2040	7 800

If 200 to 800 LNG trucks would make one refuelling station profitable, a major share of upcoming gas trucks should use LNG in addition to infrastructure to be profitable.

ROUGH ESTIMATE OF LNG/LBG TEN-T NETWORK



USING LBG&LNG HEAVY TRUCKS ON CURRENT TRANSPORT ROUTES IN THE BARENTS REGION

Potential locations for LBG/LNG fueling stations

Karesuvanto is a logistics node in many border-crossing transport chains in the North-West part of the Barents region. In the salmon transport system, it is also transshipment place of cargo between vehicles specially in wintertime. Therefore, Karesuvanto would be an ideal location for LBG/LNG delivery station serving transport chains in both south-north and east-west directions. To operate the Bodø-Kirkenes cargo transport route efficiently, LBG/LNG fueling infrastrucure is needed in Narvik and Kirkenes. This investment would enable utilization of LBG/LNG vehicles in many long-distance transport chains.

The Barents region contains LNG terminals for maritime vessels and industry purposes at least in Bodø, Narvik, Hammerfest and Kirkenes in Norway, and in Tornio in Finland. Would it be possible to utilize this LNG infrastructure to build facilities for road transport? The Barents region has already LNG production and terminal network for industrial and maritime needs. The most northern LBG/LNG fueling station is located in Oulu, Finland. Otherwise, the network is very sparse at the moment. LBG and LNG are one solution for the short term on the way towards carbon neutrality and therefore worth examining in the Barents region. LBG/LNG together with renewable diesel products are the only propulsion powers suitable for long distance road freight transport system without a need for dense distribution network for current propulsion power supply.

Route	Cargo	Distance	CO_2-emissions with diesel	Lifetime CO_2 emissions with LNG	Lifetime CO_2 emissions with LBG
Bodø-Kirkenes	General cargo (including goods)	1 170 km	1 013 kg CO_2	810 kg CO_2	101 kg CO_2
Narvik-Vuosaari	Salmon	1 270 km	1 100 kg CO_2	880 kg CO_2	110 kg CO_2
Skjervoy-Helsinki-Vantaa	Salmon	1 430 km	1 238 kg CO_2	990 kg CO_2	124 kg CO_2
Hammerfest-Helsinki-Vantaa	Salmon	1 370km	1 186 kg CO_2	949 kg CO_2	119 kg CO_2

EURO VI truck emissions: 866 g/km (VTT Lipasto). LNG emissions are 20% lower. LBG emissions are 90% lower.

NOTE: Operative emission of LBG are zero.

COST ANALYSIS AND INVESTMENTS

ELECTRIC CHARGING INFRASTRUCTURE

All corridors are drivable in Norway, Sweden and Finland but TEN-T requirements are filled only on some routes

All prioritized corridors located in Norway are drivable with electric cars and the longest distance between two chargers seems to be between Karasjok and Varangebotn chargers, and the longest distance between chargers is 200 kilometres. All routes in Sweden are also drivable and the longest distances between chargers in the prioritized corridors seems to be 100 kilometres. In Finland, the prioritized corridors are drivable with electric vehicles as well, and the longest distance between chargers seems to be also 200 kilometres. It should be noted, however, that there might be stations with only one slow charger. Prioritized corridors in Russia, e.g., from Murmansk to Petrozavodsk, are currently not drivable with electric vehicles.

Currently the market shares of electric cars (BEV) and plug-in hybrids (PHEV) are: **10 % in Norway, 4 % in Sweden, 2 % in Finland and less than 0,02 % in Russia.**In all countries the market shares of BEV and PHEV of all new cars are significantly higher than market share of all cars – from Norway's 75 % in 2020 to 0,14 % in Russia in 2018. (Elbil 2021, Trafikanalys 2021, Autoalan Tiedotuskeskus 2021, Bellona 2021, PwC & Autostat Info 2019).

The increasing number of electric cars is accelerating the development of chargerging infrastructure in all countries in the Barents region. For example, in Finland two supermarket chains announced in the beginning of May (2021) that they will increase the number of fast chargers in their locations "significantly". Norway and Sweden have set targets to phase out from cars with internal combustion engines – Norway in year 2025 and Sweden in year 2030. This will most likely increase the number of electric vehicles and consequently the needed infrastructure and number of chargers.

Investments to new chargers

As seen from the charging map on the right, new chargers are needed especially to eastern corridors, for example routes from Oulu to Joensuu and Petrozavodsk. Also routes from example Rovaniemi to Murmansk and from Murmansk to Petrozavodsk are lacking charging infrastructure currently.

Investment cost of new chargers vary significantly depending on the location and type of the charger. Based on approved Klimatklivet grants, investment costs to charging posts in Sweden start from as low as 2 000 € for slow chargers. Based on the same results estimated cost of fast charger start from 30 000 €.

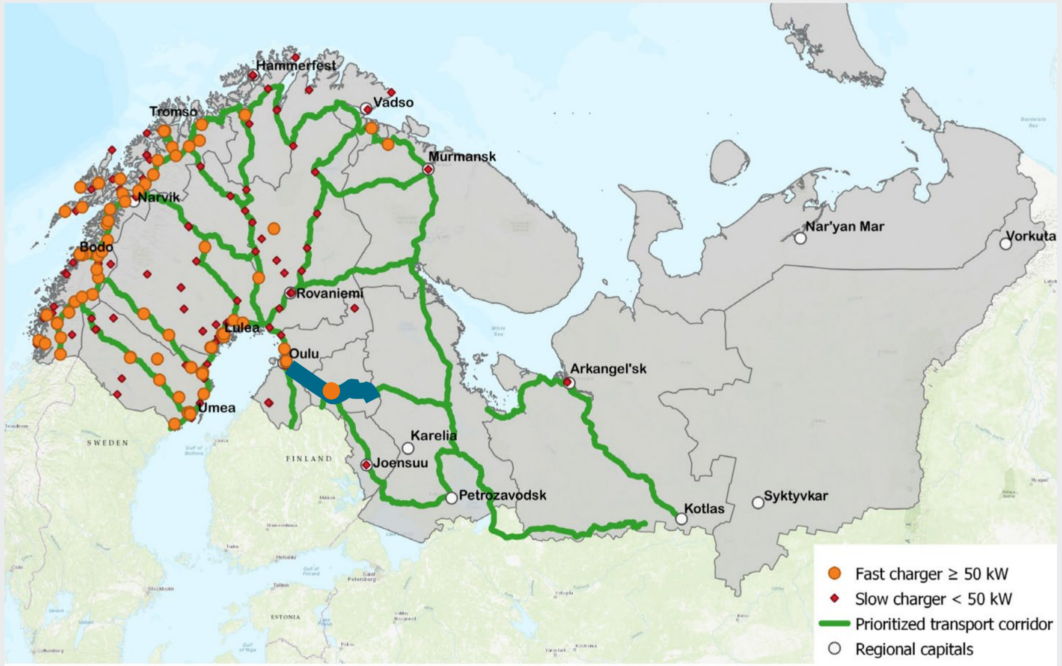
Based on information from Finnish charging station operator one fast charging operation along highway takes some 30 minutes, 16 kWh of electricity and costs roughly 5,5 €. From one single charging operation roughly 3 € is profit for the operator to be used to pay back the investment. In theory investment could be paid in three years with 400 monthly charging operations.

Directive 2014/94/EU proposes to have one slow charger for every 10 cars and one fast charger for every 100 cars, and TEN-T network proposes one charger in every 60 kilometre for every ten electric vehicles.

Amount of electric vehicles and chargers – Examples from Finland

Some dead points in the Barents' main corridors can be found for example in the route from Oulu to Russia via Kainuu (highlighted with blue in the map below). Traffic amounts on this route, as in every route, vary significantly in different parts of the route. But for example 313 daily vehicles were measured close to the Finnish-Russian border in 2020. To fill TEN-T network requirement four additional chargers are needed to be installed to the route as a whole: two chargers between Oulu and charging station in Kontiomäki and two between Kontiomäki and the Kuhmo-Vartius border crossing point.

Kainuu area as a whole has 19 charging points with 40 individual chargers and 8 fast chargers. There is 275 registered electric vehicles (electric cars and plug-in hybrids) in Kainuu. So if the Kainuu region is examined as a whole, the requirement of having one slow charger for every 10 cars and one fast charger for every 100 cars is currently fulfilled.
(Teknologiateollisuus 2021, latauskartta)



PASSENGER VEHICLE CASES

Case 1: Vadsø – Äkäslompolo

A Norwegian skier drives to Ylläs with an electric car to ski.

Route is currently drivable

However, there are no fast chargers between Varangebotn and Kittilä currently (distance 400 kilometres).

If the radius of electric vehicle is from 200 to 300 kilometres, electric car driver needs to stop at least once to charge with slow charger in this route.

Distances between chargers (km)		
Vadso	Between	Total
Varangebotn	50	50
Nuorgam	35	85
Utsjoki	43	128
Inari	125	253
Pokka	107	360
Kittilä	89	449
Äkäslompolo	50	499

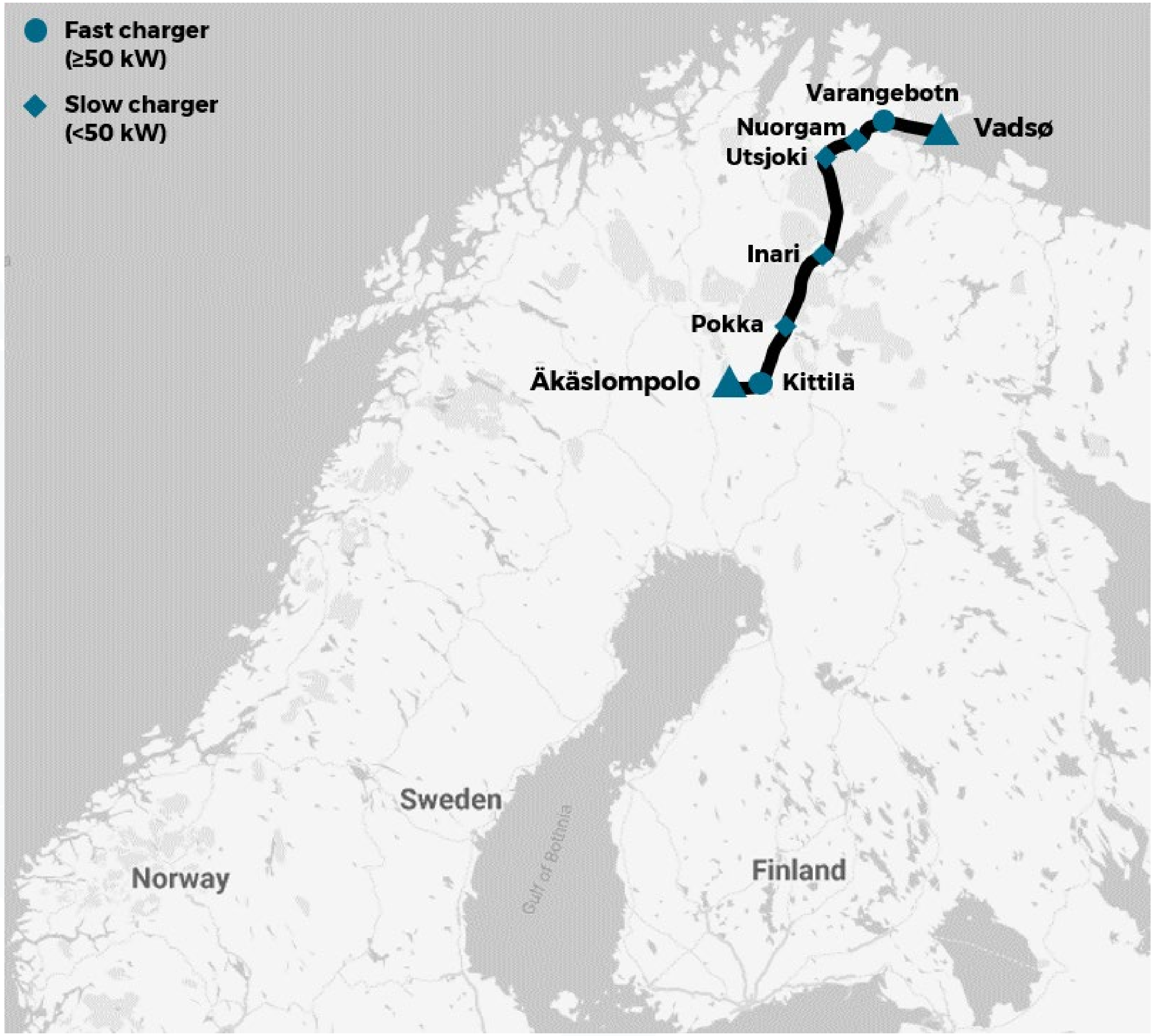
Possibility to increase the number of chargers in the Northern Lapland

The average amount of passenger cars daily in 2019-2020 between the longest distance in this case without chargers, Inari and Utsjoki, was 295 passenger cars daily based on Finnish Transport Infrastructure Agency.

In Finland the share of electric cars from all passenger vehicles in Lapland in the end of 2020 was 1 % based on Statistics Finland and Technology Industries of Finland. Using this as an estimate there were on average 3 electric cars daily at Inari-Utsjoki route. Since the charging infrastructure is currently quite poor, this might be too optimistic estimation at least in long-distance trips.

However, if the amount of traffic would stay the same, in the year 2030 there could be 17-40 electric passenger vehicles during one day on average. This would make from 510 to 1200 electric passenger cars monthly.

- Investment for a new charger would pay itself back in three years with approximately 400 monthly charges.
- If assumed that each electric car driver needs to charge in every 250 kilometres, then every driver having a long-distance trip between Kittilä and Utsjoki with electric vehicle would stop either at Inari or Pokka. If half of the drivers would drive long-distance, it would make from 250 to 600 charges monthly in these two locations. This might not fulfil the three years' payback time, but investments to chargers can still be potential to e.g. attract customers to shops or restaurants.



PASSENGER VEHICLE CASES

Case 2: Hammerfest – Oulu

Finnish salesperson drives from Oulu to Hammerfest to sell maintenance services. Which propulsion power is possible?

Electric vehicle

Route is drivable. However, between Pello and Kautokeino there is only slow chargers currently available (distance is 300 kilometres).

It is possible that electric car driver needs to use one slow charger in this route, depending on the radius of the vehicle.

Also, there is one distance of more than 100 km in this route, between Pello-Tornio in Finland (distance is 120 kilometres). Second longest distances are in Norway, between Skaidi and Alta and in Finland, between Muonio and Kolari. These don't exceed 100 km.

Traffic in this route is busier than in case 1, so new chargers are more likely to be installed in near future.

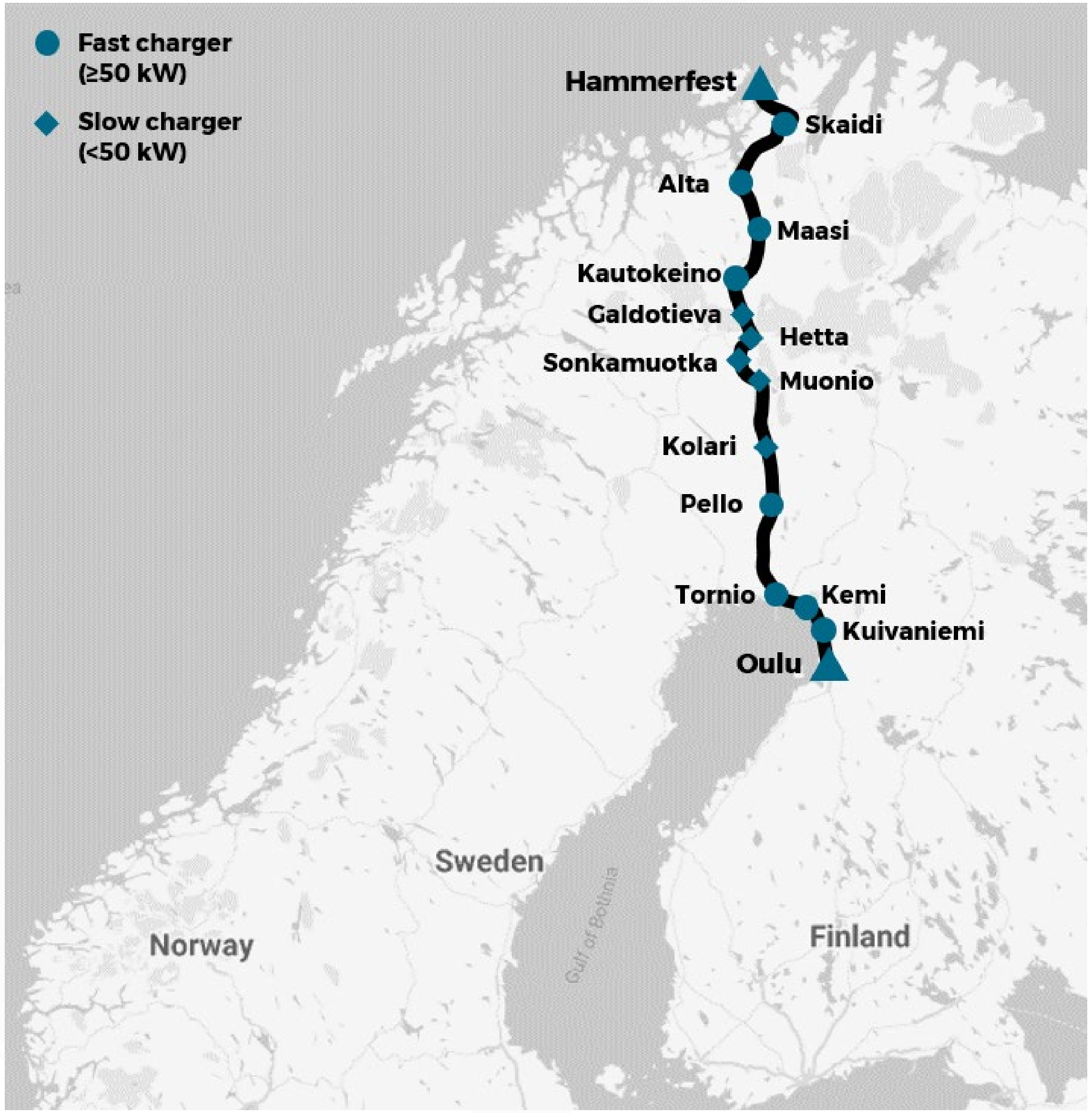
Distances between chargers (km)		
Hammerfest	Between	Total
Skaidi	55	55
Alta	85	140
Maasi	71	211
Koutokeino	62	273
Galdotieva	54	327
Hetta	27	354
Sonkamuotka	44	398
Muonio	33	431
Kolari	78	509
Pello	65	574
Ylitornio	60	634
Tornio	63	697
Kemi	29	726
Kuivaniemi	37	763
Oulu	71	834

CNG – not an option currently

CNG is challenging propulsion power for this route. There is currently only one CNG refuelling station, which is located in Oulu, Finland. Total distance of this trip is some 820 kilometres, so at least two additional refuelling points are needed to make round-trip drivable.

Some possible locations for new CNG refuelling station could be in Muonio, which is close to Finnish-Swedish border, or in Kivilompolo, close to Finnish-Norwegian border. Also, one station should be in Hammerfest to make round-trip possible.

Finnish gas operator Gasum is investing in the construction of around 50 gas filling stations for heavy-duty vehicles in Finland, Sweden, and Norway by the beginning of the 2020s.



PASSENGER VEHICLE CASES

Case 3: St. Petersburg – Saariselkä

A technology entrepreneur driving a Tesla from St. Petersburg decides to go downhill skiing and snowmobiling in Saariselkä. What route should he take to make the trip a success with his own car? Under what conditions could he drive through Niirala, for example, to Finland and continue the route 5 and then the route 4?

Two optional routes

3.1. Route viaNiirala-Vartius is not currently drivable (left picture). From Saint Petersburg driver would go first to Joensuu, but the distance is 400 kilometres without public chargers. There is fast charger in Joensuu, and after that next fast charger is in Kajaani. Distance from Joensuu to Kajaani is approximately 240 kilometres. In the middle there is Nurmes with a few slow chargers.

After Kajaani the next fast charger is in Sodankylä. The distance between Kajaani and Sodankylä is 493 kilometres, so in this route driver would most likely need to use slow charger one or twice.

For the route to be drivable at least one additional charger is needed to Niirala-Vyartsilya border crossing point. And in addition to make the route more pleasant to drive with electric vehicles, a few fast chargers would be needed between Kajaani and Sodankylä. Kuusamo area would be one potential location for fast charger(s): Kuusamo and Ruka attract many tourists to the area to ski or do other outdoor sports. Finnish supermarket chain Kesko is planning to install fast charger to Kuusamo in 2021.

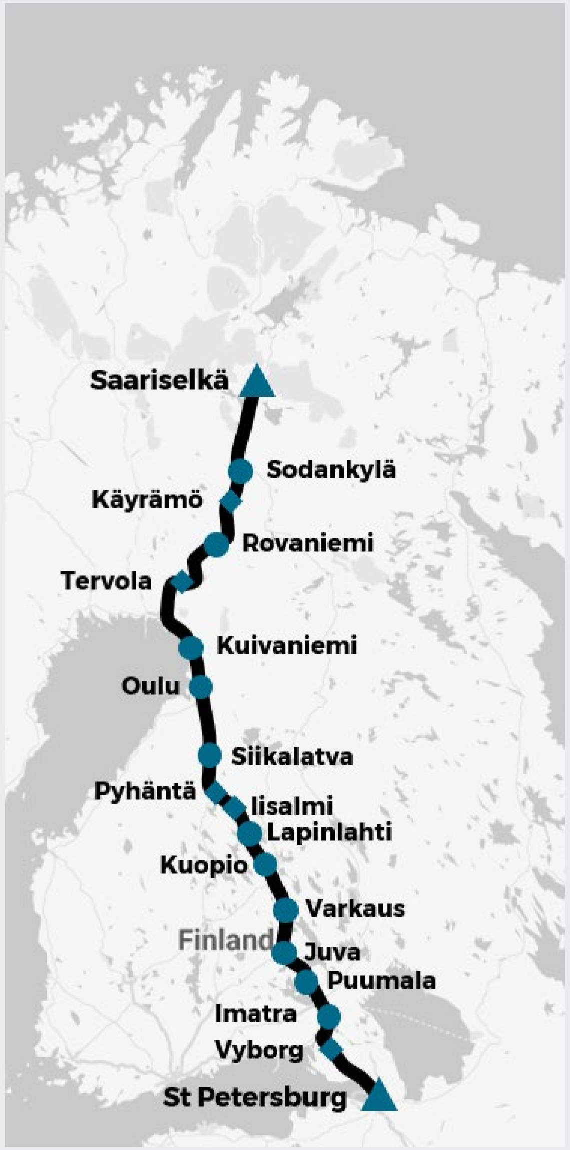
3.2. Fastest route from St Petersburg from Saariselkä would be the route via Oulu (right picture). This route is currently drivable with electric vehicles and includes multiple fast chargers. Longest distance, 137 kilometres, is from St Petersburg to Vyborg and the second longest, 128 kilometres, is from Sodankylä to Saariselkä.

3.1. Distances between chargers (km)

St Petersburg	Between	Total
Joensuu	403	403
Nurmes	127	530
Kajaani	112	642
Kontiomäki	25	667
Suomussalmi	85	752
Piispajärvi	55	807
Kuusamo	86	893
Ruka	27	920
Kemijärvi	116	1036
Sodankylä	99	1135
Saariselkä	128	1263

3.2. Distances between chargers (km)

St Petersburg	Between	Total
Vyborg	137	137
Imatra	63	200
Puumala	68	268
Juva	52	320
Varkaus	55	375
Kuopio	78	453
Lapinlahti	59	512
Pyhäntä	87	588
Siikalatva	33	621
Oulu	92	713
Kuivaniemi	72	785
Tervola	77	862
Rovaniemi	75	937
Käyrämö	67	1004
Sodankylä	61	1065
Saariselkä	128	1193



PASSENGER VEHICLE CASES

Case 4: Petrozavodsk to Bodø

Electric car route from Petrozavodsk to Bodo.

Electric – route is not drivable currently

Distance from Petrozavodsk to Joensuu is approximately 350 kilometers. It seems that there is no chargers in this route before Joensuu. After Joensuu, there is one slow charger located at Nurmes, and it also requires little detour. Distance between Joensuu and Kajaani is approximately 240 kilometers, and Nurmes is on the halfway

Distances in Finland from Joensuu to Oulu are long without chargers, for example, Kajaani-Oulu distance is 180 kilometers. There is one slow charger 20 kilometers from Kajaani to Oulu, and one "worksite socket" in between Kajaani and Oulu (charger output 11 kW).

From Luleå to Norway there is two chargers currently, first one is slow charger located in Advisjaur, 154 kilometers from Luleå. Distance from Luleå to the next fast charger in Arjeplog, Sweden, is approximately 240 kilometers.

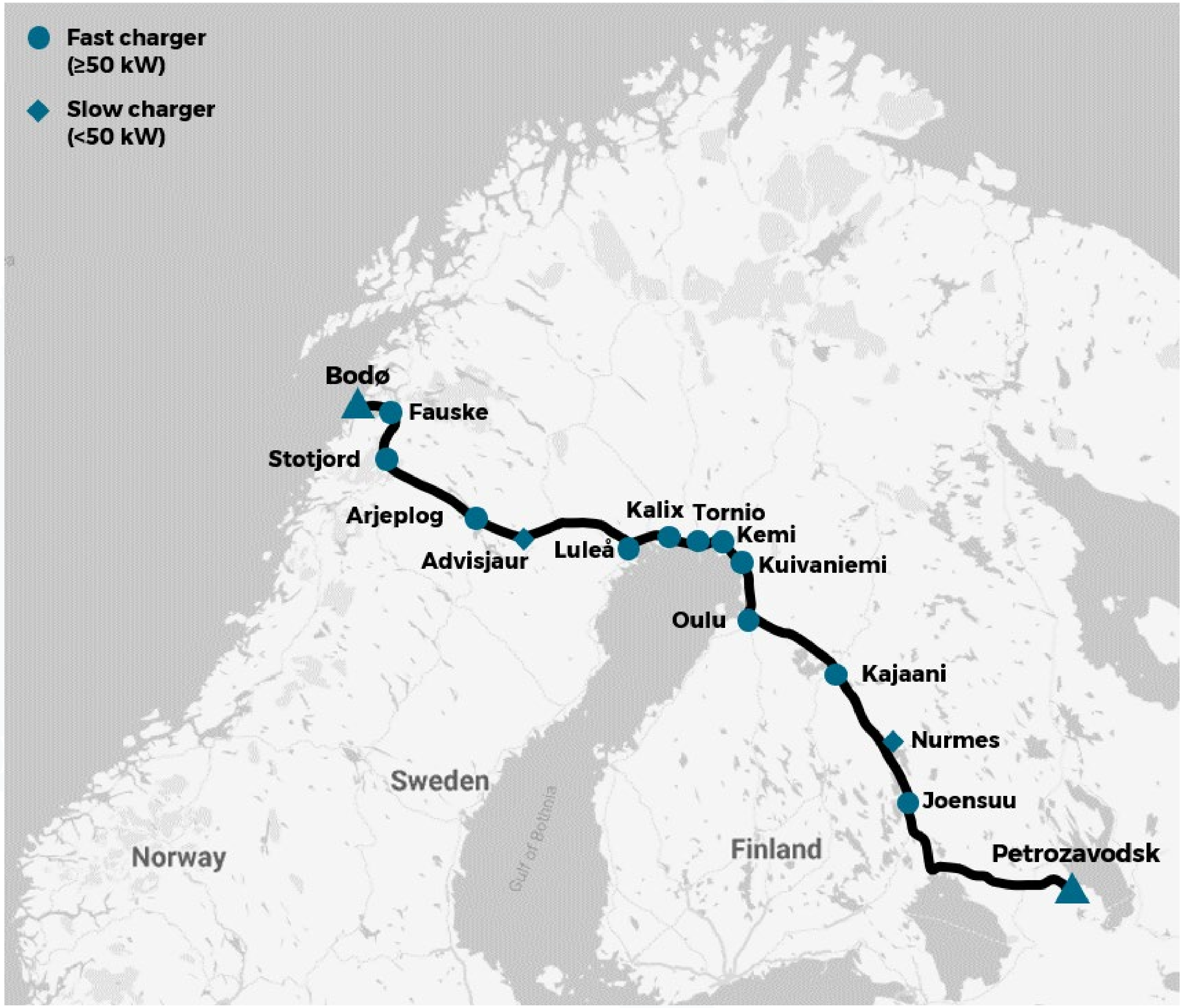
Based on information from Plugshare, there is two slow chargers under construction between Arjeplog, Sweden, and Stotjord, Norway (distance 162 kilometers). Currently there is no chargers between these cities.

From Stotjord to Bodø, the final destination, there is fast chargers in every 60 kilometers.

Between Oulu, Finland, and Luleå, Sweden, the fast charger network is adequate to even TEN-T requirements. Same applies to route from Stotjord to Bodø. All stations between Oulu and Luleå, as well as between Stotjord and Bodø are not presented in the map, since the purpose of this map is to present whether routes are drivable with electric passenger cars or not.

Distances between chargers (km)

Petrozavodsk	Between	Total
Joensuu	365	365
Nurmes	127	492
Kajaani	112	604
Oulu	183	787
Kuivaniemi	71	858
Kemi	42	900
Tornio	28	928
Kalix	52	980
Luleå	80	1060
Advisjaur	154	1214
Arjeplog	86	1300
Stotjord	161	1461
Fauske	63	1524
Bodo	53	1577



ALTERNATIVE PROPULSION POWERS

Key points for the Barents region

1

Future of road transport propulsion powers

In **passenger transport** there are many fuel alternatives available. Investments in the fleet are reasonable, technologies are already available and main solution seems to be towards hybrid and electric cars. Traditional fuels are moving to biofuels with larger amount of biocomponents. **Public transport** is focusing on electric buses in the city regions but in longer distances the problem-setting is quite similar as for heavy trucks.

Freight transport has many approaches. Light vehicles, mainly in regional distribution, are possible to electrify. In heavy vehicles there are ongoing testing regarding electric vehicles with diverse charging solutions. The Barents region is a large area with long distance freight transport demand and therefore renewable diesel and LNG/LBG are probably going to be the main propulsion powers completed with hybrid technologies to some extent.

The Barents region is a significant producer of LNG in Norway and Russia. Would it be **possible to utilize this production in the region's transport system**. Industries and shipping are utilizing LNG as an energy source and there are investments in LNG terminals in the region. But is it possible and what are preconditions to utilize LNG supply for heavy road transport? How to combine large scale production to small scale distribution?

2

Perspectives for investments

The Barents region is mainly a sparsely populated and geographically wide area. In addition, industrial structure consists of a few industrial centers. Otherwise, businesses are mainly SMEs spread like the population. This creates a challenge for investments in propulsion power distribution and charging networks.

If the energy networks are based on market-driven investments and operators, this special characteristics of the region must be considered. Utilization of present distribution networks of fuels as a basis for distribution of new propulsion powers is one robust approach. **New investments need careful consideration** as the energy sector is in a rapidly changing state

It's necessary to analyze main transport flows (conducted in BRTL World logistics market report) and **focus the investments on these main corridors**. Large transport volumes and energy demand makes the investment environment attractive in addition to diverse aids and public funding, which are available on state level and EU level (**CEF funding for modernizing the TEN-T network**). Investments should be seen at least at a regional perspective to improve the availability of alternative fuels by a larger margin, not just one station at a time.

3

Actions of vehicle manufacturers give signals to follow

Two of the worlds biggest truck manufacturers, Daimler AG and Volvo, are looking into hydrogen technology as one key propulsion power for heavy trucks in the future. They announced in 2020 to establish a joint-venture company Cellcentric to develop and produce fuel cell technologies for heavy vehicles.

Truck manufacturers are also developing battery electric trucks. E.g. Volvo has launched three different types of trucks using battery electricity. The fleet is designed for regional transport needs and the heaviest truck for city-to-city transport up to 300km. To summarize, **electricity will be one key propulsion power for both passenger and heavy transport** but the means to produce the electricity are still somewhat unclear and depend on the technological developments in electrolysis, carbon capturing and battery technology.

4

E-fuel infrastructure as a future solution?

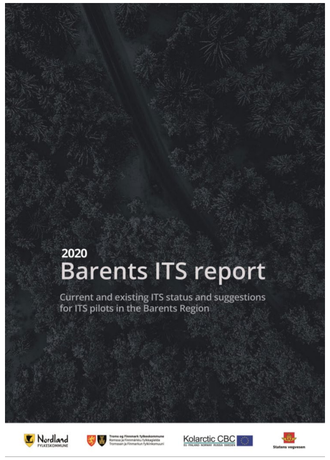
There are a lot of large-scale industrial plants in the Barents region which produce CO2-emissions. At the same time industries are planning development towards carbon neutral production processes. Is it possible to utilize emissions of these production units to produce e-fuels locally? **Could it be possible to form an own ecosystem for e-fuel and hydrogen production and distribution also utilized in the transport system of the Barents region?** Which preconditions would this kind on development require?

In addition to industrial production units there is a lot of LNG production and other energy production available for hydrogen production in the region. Are these industrial and energy production structures key drivers for Barents region to progress in the front line in utilization of new propulsion powers? Is it possible, that these approaches form a competitive factor as well for the Barents region?

Chapter 5

ITS solutions in winter maintenance

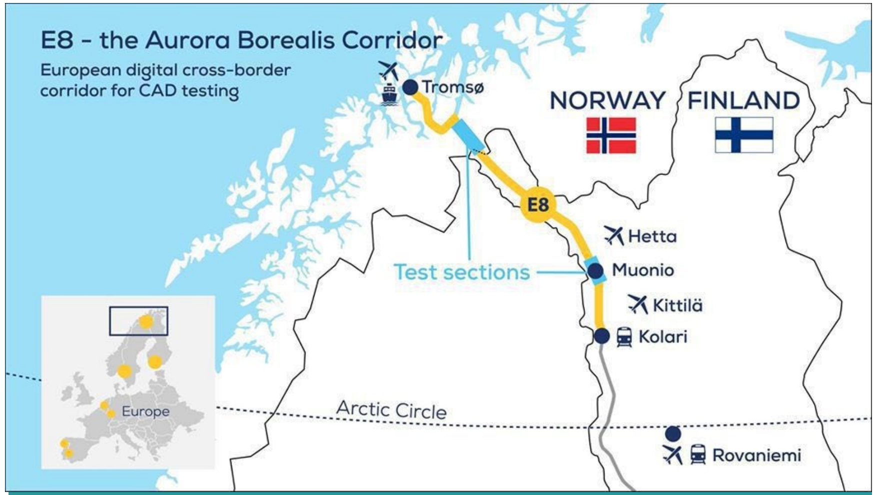
BACKGROUND FOR ITS
IN THE BARENTS REGION



Barents ITS report is a project report that focused on ITS pilots done in the Barents region. The report also lists possible pilots and project that might serve as demonstrations for cross-border ITS operations. Each of the pilots addresses some of the natural barriers that characterize the region, the anticipated increases in traffic volumes and the organizational/cultural barriers.

This study focuses on ITS solutions in winter maintenance operations on the road network.

Report ITS Pilot is a project report, that focuses on availability of real-time data regarding truck stops. There were two piloting locations for testing of camera and data applications, where truck drivers are capable to see in advance availability of space and services of truck stops. This is very important topic for long distance and also cross-border transport chains combined with requirements of driving and resting period legislation.



E8 - the Aurora Borealis Corridor as a test environment

Road E8 was in 2017-2019 a target for large ITS project both in Finland and Norway. In Finland there is a test road in Muonio, which is 15 km long. In addition to this test area, the project related to the whole E8 road up to Kilpisjärvi and further to Skibotn in Norway. This 46 km long extension to Norway was Borealis project. Target of these projects have been twofold. At first there were investments for road and ITS infrastructure, which enabled testing and piloting of autonomous vehicles, positioning technologies, road maintenance and platooning in challenging weather conditions.

On the other hand, these projects created an ecosystem around these research and development topics. The project have been successful, and piloting continues on these roads, although its not driven by public authorities and funding anymore. An open test laboratory for border-crossing transport to gather data and test future solutions in public road network has been formed. The instrumentation exist on these test roads and is available for development of ITS technologies and solutions regarding road transport in a wide extent. It is also important to maintain this kind of test environment for the future needs.

During the Aurora project, a drone hackathon in Enontekiö was organized which tested utilization of drone technologies for utilization in road maintenance. Thus, these projects caused a wide variety of testing and piloting in addition to target-setting of these projects itself.

Pilots carried out in the Barents region regarding winter maintenance

Borealis E8 PSI Group - piloted in 2019 The travel time prediction on road sections pilot from PSI Group will give commercial organisations greater predictability, enabling production and transport to be planned with higher precision and efficiency. By considering both weather forecasts and winter operations, more precise travel time forecasts with longer time horizons can be achieved.

WIRMA 2018-2020 The objective of the WIRMA project was to design, implement and test an IoT system for winter road maintenance in the north. The long-term vision was to overcome winter maintenance challenges using modern digital solutions — specifically, by providing more data, information and knowledge to the road maintenance and ITS domain with a focus on vehicle-based data and vehicle-mounted sensors.

ALASCA 2017-2018 The objective of the Automated Road Monitoring Pilot Using 2D Laser Scanning (ALASCA) regional pilot project was to develop and test a laser scanning unit that would enable crowd-sourced data collection from roads, especially by using large goods vehicles equipped with 2D laser scanning units. The idea was to create new solutions for road monitoring, especially for quickly changing winter conditions.

ITS GOALS FOR THE COUNTRIES OF THE BARENTS REGION

NORWAY

The National Transport Plan 2022-2033 states that rapid phasing in of ITS and technology is facilitated for all modes of transport by supporting knowledge development, R&D, experiments and pilots. ITS solutions reduce safety risks and help to detect and notify drivers (and eventually vehicles) of demanding conditions and low friction, as well as provide advice on the use of a chain or stop / pause in anticipation of plowing, spreading or salting, or alternative route / driving.

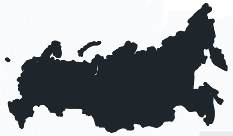
Sweden

"Leading the way by innovative transport solutions" is the vision for Sweden's ITS Strategy and Action Plan. It describes how and why Sweden should take a leading role in developing and introducing innovative transport solutions that are beneficial to citizens and industry. The ITS strategy encompasses all actors and modes and is based on strong collaboration and coordination between modes. The main focus areas are city logistics, C-ITS , Cooperative, Connected and Autonomous Mobility (CCAM), MaaS/public transport, micromobility, traffic management and regulation. The Strategy and Action Plan, serve as the national focus for ITS implementations.

Finland

The National Transport Plan includes strong focus on digital transport system. The full utilization of the physical infrastructure and the development of smooth passenger and freight transport services requires the construction of a digital data layer on top of the physical infrastructure. This includes digital twins. The goal is to promote automated transport and improve transport network maintenance. Finland has also publications on logistics digitalization, digital aviation and digital infrastructure.

The NTP states that the possibilities of a wider use of dynamic data collection and analysis utilizing communication networks in the maintenance of transport networks will be investigated and piloted by Finnish Transport Infrastructure Agency. The work takes into account, among other things, the needs of efficient asset management, winter maintenance, automation and logistics. Existing tools such as the Finnish Meteorological Institute's condition observations and data modeling can be utilized in the work.



Russia

The Finnish and Russian aim is that ITS cooperation will focus especially on the challenges of border crossings. Digitalization of logistics in particular is promoted in the Corridor as a Service approach.

Russia has a strong commitment to develop digital connectivity in the Arctic Regions. They have three approaches:

1) Arctic Connector, megaproject connecting Asia, Russia and Europe.
2) Support for industrial operations in the regions. Relating for example analysis and collecting data of geological structures. This can be used in discovering oil and minerals.
3) Arctic area as an ideal location for data centers. (solving heat problem)

ITS SOLUTIONS IN WINTER MAINTENANCE IN THE BARENTS REGION

Importance of the topic

Operations environment related to the topic consists of transport infrastructure, data connections, business and societal structures, and ITS solutions supporting business and transport operations. On the other hand, winter conditions may be challenging in wintertime and at the same time companies are expected to operate with punctual and reliable supply chains to global markets. *This requires predictability and reliability of the transport chains.* In addition, the Barents region is a wide and sparsely populated area. All these characteristics mean, that winter maintenance of road network and thus preconditions for functionality of transport systems must be based on predictable and on demand-based operations. This approach needs ITS to plan and direct necessary maintenance actions to right locations and timely accurate service supply.

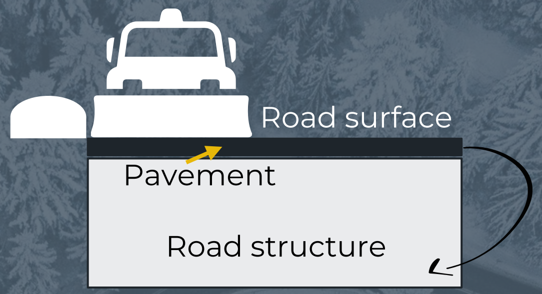
Data networks

Availability of data networks is a crucial precondition for business operations and one topical development area in the Barents region. Wide and sparsely populated area affects to data networks so that data networks are nor covering the whole region. For example forestry industry needs mobile data network for management of raw material transport. Business processes are planned and operated by real time information and lack of data networks, mobile or solid, may cause challenges for supply chains of the companies.

Another approach is a large scale development of data connections. Arctic Connector, which is the northern sea data cable from Asia to Europe is one example of a project that connects arctic areas to diverse markets with minimum latency. This offers a lot of opportunities to develop data ecosystems in the Barents region. Data server centres and high performance computing are examples of these opportunities.

WHAT IS TYPICALLY CONSIDERED WINTER MAINTENANCE?

- Antiskid treatment
- Snow ploughing
- Levelling road surfaces
- Removing snowbanks
- Cleaning of traffic signs
- Usually in winter maintenance, snow is ploughed first, and slipperiness is prevented after ploughing.



Winter maintenance should be seen as a tool to reduce road tear and infrastructure costs. *Insufficient winter maintenance weakens the road pavement and thus the lower levels of the road structure.*

PROBLEMS WITH CURRENT OPERATIONS

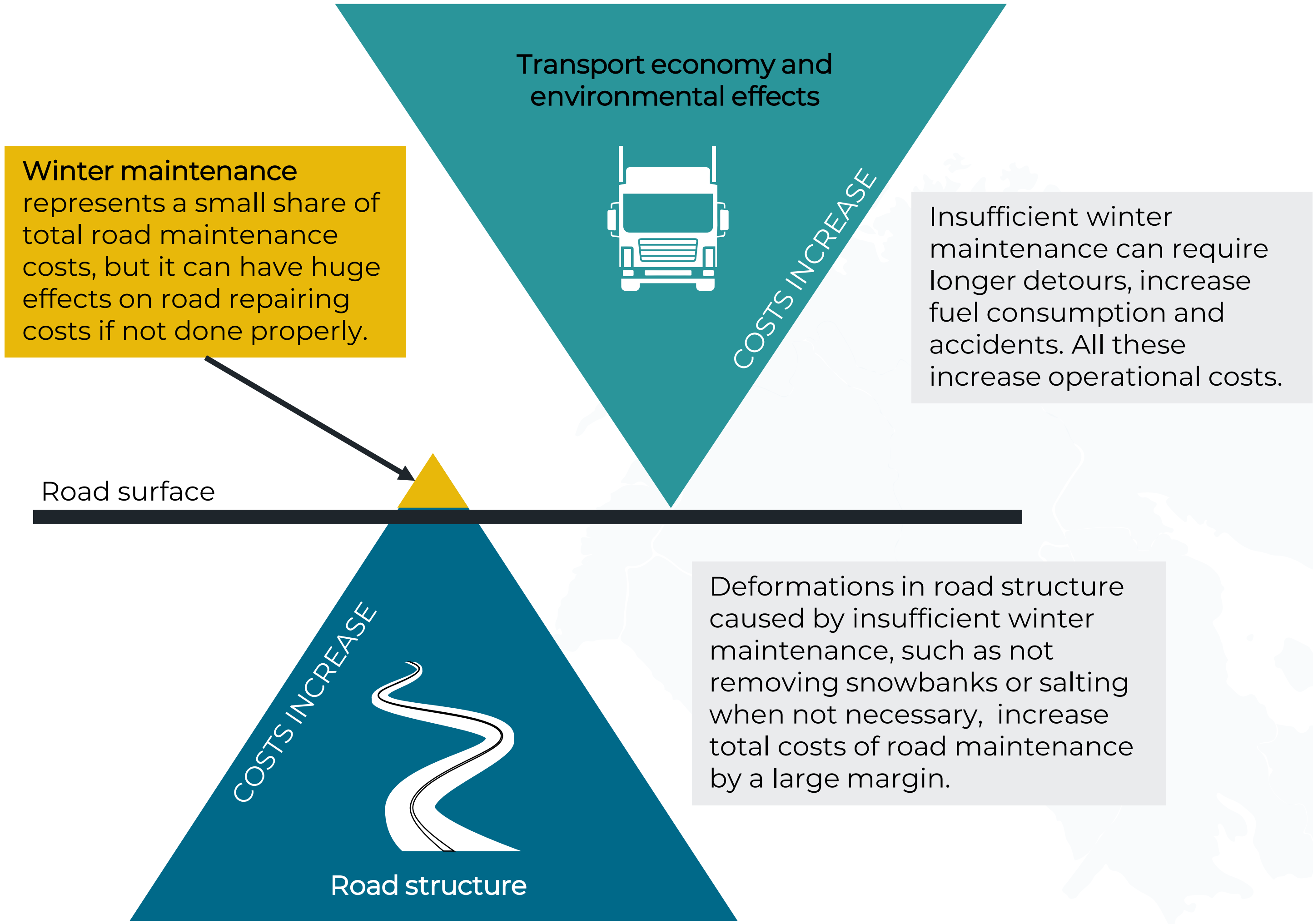
- Traditionally winter maintenance is seen as a treatment, which usually means providing a flat road surface for users.
- Shortcomings in winter maintenance typically consist of not overturning the snowbanks and slush ditches are made too late. This causes edge deformation and road safety problems. Eventually this weakens the road structure, increasing costs and safety risks. This problem will increase as a result of climate change.
- Excessive salt usage can cause exceptional rutting and increase safety risks and maintenance costs.
- Winter maintenance is divided between different contractors. This causes fragmented quality and eventually also reflects on the road structure
- Road network is classified in winter maintenance, which means that highly prioritized roads are operated first. In the Barents region there is a lot of heavy freight transport on the lower road network which are classified lower also from winter maintenance point of view. This leads to a situation where for example a timber truck is driving on a road network before winter maintenance operations, which in turn may cause severe problems to the road maintenance and road structure later.

Benefits of ITS solutions in road winter maintenance

- Winter maintenance operations are possible to direct more precisely according to challenging weather conditions combined with prioritized needs.
- Predictability of weather conditions is an important factor to take these into account both in road maintenance operations and for example in planning of supply chains.
- These approaches affects also to cost efficiency both in winter maintenance of roads and transport operations.

THE EFFECTS OF WINTER MAINTENANCE ON TRANSPORT ECONOMY AND ROAD STRUCTURE

Illustration of winter maintenance effects. The triangles represent increasing costs if winter maintenance is lacking.



Transport company

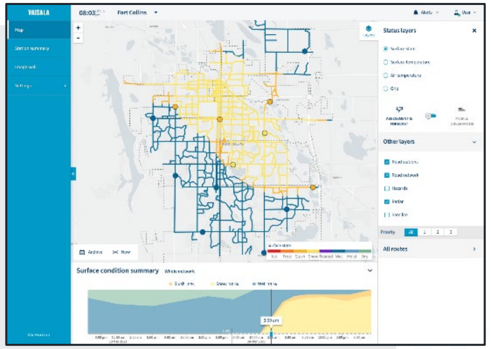
- Is the road in drivable condition? When will it be or are there alternative route options available?
- What should be optimized?
  - The whole supply chain
  - Operating routes and schedule
  - Staff

Road authority

- What is the road network's real time situation?
- What roads should be maintained first?
- What should be optimized?
  - Fleet size
  - Routes and schedules
  - Maintenance style: plowing or salting

ITS SOLUTIONS IN WINTER MAINTENANCE – BEST PRACTICES

Vaisala Wx Horizon for better winter maintenance decisions



Vaisala Wx Horizon decision support system helps road authorities, contractors and municipalities make roads safer with proactive working methods and save money due to precautionary winter maintenance actions. The service is suitable for road and airport winter maintenance in any country.

Data gathering methods

- Satellites, weather radars, weather stations and road weather stations
- Mobile data sensors installed on vehicles such as snowplows and heavy vehicles
- The model can also use road meta data, such as location of bridges, typical traffic flow, etc.

What is done with the data

- Realtime situation knowledge
- Simulations and forecasts
- Advanced Nowcasting technology fuses radar, satellite and ground-based observations every 15 minutes to create a fresh forecast of the next couple of hours for key markets.
- The road network is dynamically modeled for optimal resolution.

Who can benefit from the system?

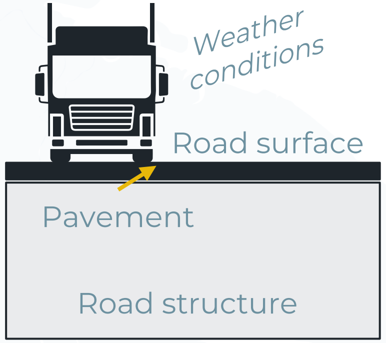
- Road and Airport authorities required to ensure safety despite adverse winter weather. The system can also help reduce the use of salt which provides both environmental and economical benefits.
- Svevia in Sweden utilizes such services in performing winter maintenance faster, more proactively and efficiently. Also cities can benefit, like the city of Espoo in Finland, who is a Vaisala decision support system customer.

Other road and winter maintenance services by Vaisala

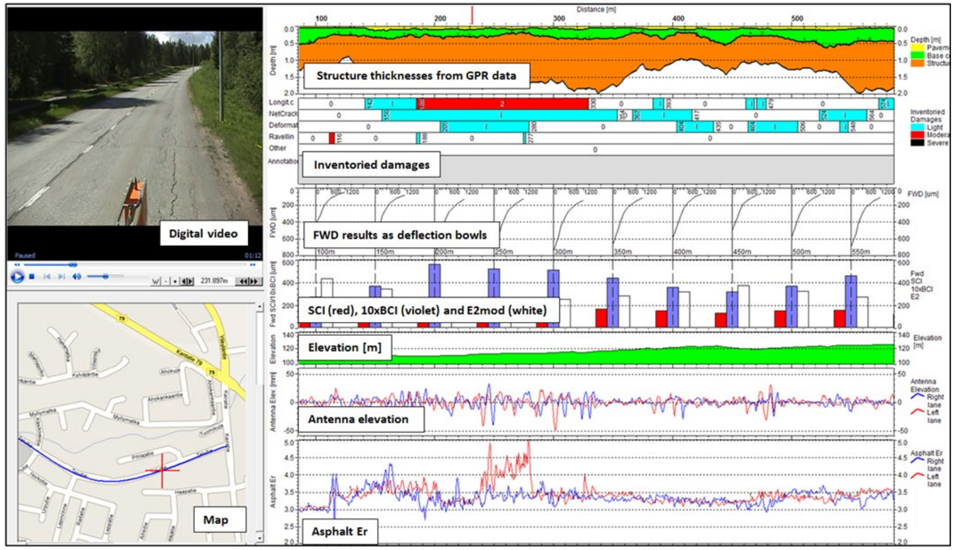
- Route Optimization is a bespoke consultancy service that specializes in the development of winter treatment routes in order to optimize resources and comply with best practice.
- RoadAI combines a user-friendly Artificial Intelligence (AI) tool, high-quality video data, and reliable methodology to visually assess pavement conditions quickly and accurately.

Source: Vaisala

Vaisala's services provide insight mainly on the things happening on and above the road surface



Roadscanners's services provide insight mainly on the things happening in and below the road surface



Roadscanners

Roadscanners operates on the interface of road structure and road pavement. Combining these two models by creating a digital twin is a core in the management of road maintenance, which can be used in winter maintenance planning and also maintenance of road structures. These two approaches have a close connection with each other.

Sub-optimization in winter maintenance above road surface affects the life cycle of road structures causing serious damage. Therefore, proactive planning is a key to secure good road condition. Scanning of road structures is one solution to support a proactive approach, as visual quality control focuses on existing road surface condition. Real-time monitoring is a crucial part of ITS solutions in road maintenance, including winter maintenance. This forms basis for intelligent asset management of road network.

Tools and services

- Road Doctor Maintenance Controller, which produces real-time monitoring of road conditions both in winter and summer time.
- Road Doctor Survey Van including a wide variety of scanning and measurement tools offers a complete system for road condition data collection, survey and analysis.
- Percostation, Instrumented station for real time monitoring moisture content, frost and temperature in the pavement structure and subgrade soil.
- Road asset management and a wide variety of specialized surveys.

Source: Roadscanners

A THEORETICAL TIMBER TRANSPORT CASE
TRANSPORT FROM FOREST TO SAWMILL

Timber transport to sawmills follow a strict timetable that has little room to maneuver. The process requires predictability from each part of the supply chain.

Timber load from a Finnish forest near Sodankylä

Timber load from a Swedish forest near the Finland-Sweden border

First part on a private gravel road

Regional road

Main road

Municipality road

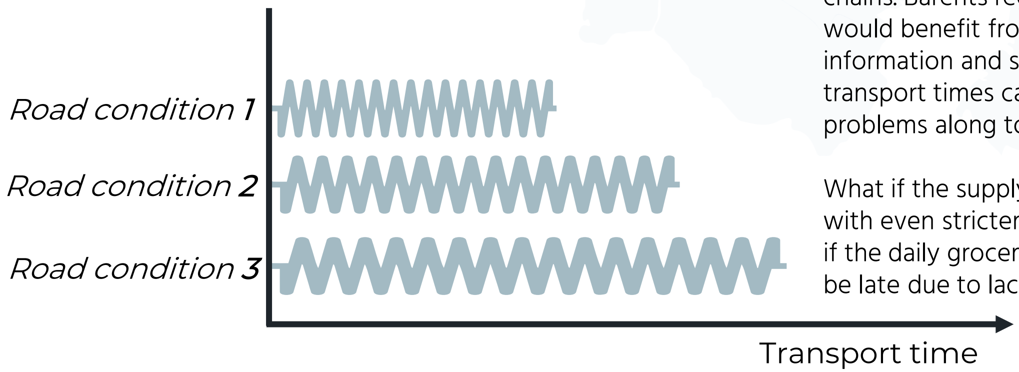
SAWMILL IN KEMIJÄRVI, FINLAND

1. The supply chain management **receives information** of a snowstorm from the winter maintenance platform. One part of the road will have very low standard of service due to weather conditions. The Swedish authorities confirm that this road can't be cleared in a sufficient time.

2. The supply chain management **reacts proactively** to the received information and reschedules a timber transport from Sodankylä to replace the timber load from Sweden. The Finnish authorities happen to have extra capacity and can provide winter maintenance for this route at an earlier time.

3. The sawmill can continue operations and there is no downtime in the process.

4. The end products can be shipped on time. The transport times are known by the road authority so it can make sure the road is in a drivable condition. The saw products reach the seaport and are shipped to customers on time.



Estimating transport times is critical for efficient supply chains. Barents region has a lot of export industry that would benefit from better road winter maintenance information and services. Longer than anticipated transport times can delay production and create problems along to supply chain.

What if the supply chain would be even more complex with even stricter schedules than presented here? What if the daily grocery transport in the Barents region would be late due to lacking winter maintenance?

ITS WINTER MAINTENANCE ECOSYSTEM

Illustration of the winter maintenance framework in the Barents region

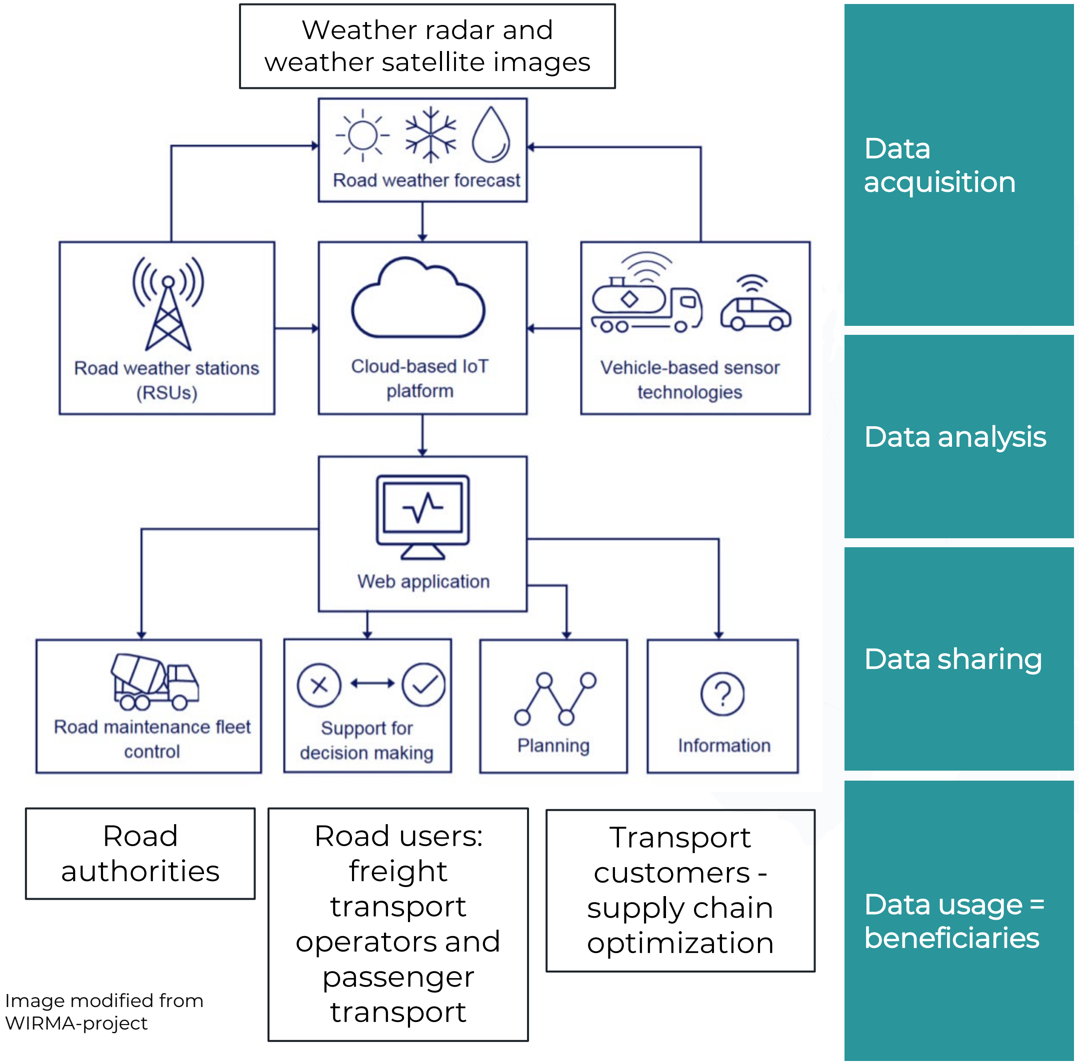


Image modified from WIRMA-project

Border-crossing approach for ITS solutions in winter maintenance

- The Barents region has challenging weather conditions for road transport system in wintertime. There are also a lot of border-crossing transport chains to all directions. When supply chains are border-crossing, also winter maintenance should be border-crossing supporting these supply chains with real time information and road maintenance.
- Each country in the Barents region has winter maintenance of their own and diverse ITS solutions, weather and monitoring systems. There is also piloting of ITS for various purposes (positioning, road weather stations, automatization and manoeuvring of traffic) with installed instrumentation. These ITS infrastructure pilots should be actively utilized and maintained for future purposes. The Barents region wide ecosystem for ITS solutions in winter maintenance would be one development path to support operations of transport system in the region.
- Road freight transport system needs forecasting of road conditions to operate in a punctual and safe way. All the technologies needed exist already for use and form a basis for a border-crossing ITS ecosystem. In addition to operational perspective of supply chains, there is also road maintenance point of view in offering real time information directly to the vehicles. Especially in frost heave situation, re-routing transport to avoid risky areas keeps road infrastructure in better operational condition.

Next steps – how to utilize existing ITS systems in winter maintenance?

- Development of an intelligent asset management system where information of real-time monitoring system is delivered through cloud services to supply chain management, heavy vehicles and road maintenance operators. Thus, it's possible to avoid serious damages in road structures and minimize the effects on road transport operations.
- ITS measurement systems brings uniform quality to quality control of road and especially winter maintenance.
- Forms preconditions to use higher total weight of heavy vehicles in wintertime, when road structure is on ice. Winter premium project (originally from Canada) is evaluating this approach. It would require changes in the legislation of total weight of heavy vehicles, but is an interesting opportunity from the Barents region point of view.

ITS SOLUTIONS IN WINTER MAINTENANCE

Key points for the Barents region

1

Winter maintenance should be linked to the structural condition of the roads

Winter maintenance quality has a long-lasting effect on road tear. Developing winter maintenance operating models to be more efficient and **consider the effects on road structure is vital to prolong the road network's age and reduce costs**. With ITS solutions, winter maintenance can be improved and effects on road pavement and structure monitored. Proactive measures will improve road conditions and provide efficiency with smaller total costs. This has also effects on service level of infrastructure, efficiency and costs of transport, and traffic safety.

2

Cross-border transport chains require cross-border winter maintenance

A Barents region wide ecosystem for ITS solutions in winter maintenance would support operations of the transport system. Barents countries should form nation wide winter maintenance ecosystems and collaboration between these would benefit the whole region. Recognizing key actors, data sources and required measures is a good way to start the process. Development of an intelligent asset management system where information of real-time monitoring system is delivered through cloud services to supply chain management, heavy vehicles and road maintenance operators. Thus, it's possible to avoid serious damages in road structures and minimize the effects on road transport operations. EU funding is available for modernizing the TEN-T network and for ITS, the Horizon Europe 2021-2017 (€95.5 billion) program is also a good opportunity for R&D projects.

3

Utilizing the Aurora and Borealis ITS road sections in Norway and Finland for living lab piloting

Aurora and Borealis projects are an example of border-crossing road corridor with focus on ITS applied to piloting and testing of new technologies in challenging weather conditions. The instrumentation exist on these test roads and is available for development of ITS technologies and solutions regarding road transport in a wide extent. It is also **important to maintain this kind of test environment for the future needs**. These projects created an ecosystem around ITS research and development topics including research institutes, technology developers, vehicle manufacturers and public organisations. Thus, there is a good basis for development of ITS ecosystem available.

4

Improving transport chain forecasting and integration into production planning

Companies require predictability and reliability of their supply chains and road transport chain is often a crucial part of the supply chain. The Barents region would be ideal for **piloting integration of ITS winter maintenance solutions to supply chain management of industrial companies**. There are some large-scale industrial production plants with large procurement and production flows. Thus, the number of companies for piloting is quite limited, but material flows are large. Forecasting of weather and road conditions for transport operations is an opportunity to increase punctuality in supply chains.

Chapter 6

Roadmap for smart and low-carbon transport in the Barents region

Proposed vision for the Barents Region transport system

Efficient and sustainable logistics system that uses all the transport infrastructures efficiently, uses more locally produced fuels and has intelligent properties to anticipate dynamic events.

THE ROADMAP CONSISTS OF FOUR WORKING PACKAGES

1.	**THE BIG PICTURE** *CREATE A SHARED VISION FOR THE DEVELOPMENT OF BARENTS REGION TRANSPORT AND LOGISTICS*	Sharing the findings and conclusions of the study to the national level	Cross-checking the findings and the vision with the Russian AC and Finlands BEAC Chairmanship's priorities	Deciding upon the shared vision in the Declaration of Barents Transport Ministers 14 Oct 2021	Creating national plans to meet the common vision	Aligning the Barents transport plan, the national transport plans and the shared vision

		PUT INTO ACTION OR PILOT	STUDY FURTHER	PROMOTE
2.	**MODAL SHIFT** *SUPPORT THE EFFICIENT USE OF THE TRANSPORT INFRASTRUCTURE & SOLVE CURRENT BOTTLENECKS*	Tacking bottlenecks by enabling cross-border rail transport with Haparanda-Tornio transshipment facilities and needed rail investments	Studying the needs of different industries in terms of the modal shift and identifying further bottlenecks to be solved	The extensions and development of railways in the region • Swedish ore railway and Finnish main railway • Norwegian extension from Fauske to Tromsø • Extensions based on the needs of mining industry in Finland Developing the national funding instruments to support modal shift
3.	**PROPULSION POWERS** *SUPPORT THE USE OF LOCALLY PRODUCED SUSTAINABLE FUELS*	Defining the specific locations for LNG/LBG fueling extensions, starting from Karesuvanto Building charging infrastructure based on TEN-T requirements to the main corridors Piloting long distance transport with hydrogen	Possibilities to utilize maritime vessels' LNG/LBG infrastructure for road transport Studying biogas and e-fuel production capacity and scalability in the area Follow the development and the actions in the market frequently	Promote the development of the charging and fueling infrastructure on a regional level in addition to the national level
4.	**ITS SOLUTIONS IN WINTER MAINTENANCE** *PROMOTE THE POSSIBILITIES AND VALUE OF THE SOLUTIONS TO LOCAL ACTORS*	Creating an ITS winter maintenance ecosystem: Border-crossing pilot to understand the value of further utilizing ITS solutions	Systemic approach to find most beneficial applications and implementation areas (industry, citizen usage in a wider network or supply chain) Analysing the financial and other benefits of further using ITS possibilities (eg, through forestry case)	Promote the continuous development and use of ITS solutions in the Region based on the findings of past projects

THE ROADMAP

The big picture | Modal shift | Propulsion powers | ITS solutions in winter maintenance

THE JOINT VISION

Efficient and sustainable logistics system that uses all the transport infrastructures efficiently, uses more locally produced fuels and has intelligent properties to anticipate dynamic events.

2021

Agreeing upon the shared vision

2022

Tackling bottlenecks by enabling cross-border rail transport with Haparanda-Tornio transshipment facilities and needed rail investments

Alternative propulsion power update study

Building charging infrastructure based on TEN-T requirements to the main corridors

Defining the specific locations for LNG/LBG fueling extensions, starting from Karesuvanto

2023

Studying biogas and e-fuel production capacity and scalability in the area

Analysing the financial and other benefits of further using ITS possibilities (eg, through forestry case)

2024

Creating an ITS winter maintenance ecosystem: Border-crossing pilot → value created to the parties calculated

Piloting long distance transport with hydrogen

2025

Renewing of the Joint Barents Transport plan

Studying the needs of different industries in terms of the modal shift and identifying further bottlenecks to be solved

Updating the national transport plans to correspond with the Joint plan

2026

Systemic approach to find most beneficial applications and implementation areas (industry, citizen usage in a wider network or supply chain)

Possiblities to utilize maritime vessels' LNG/LBG infrastructure for road transport

2030

POTENTIAL FUTURE PROJECTS & ACTIONS

Enabling cross-border rail transport with Haparanda-Tornio transshipment facilities

In order fo futher enable modal shift in the Barents Region, the focus should be put in solving the identified bottlenecks.

The Haparanda-Tornio hub has been identified as one of the key transshipment bottlenecks, and hence the actions should be directed into building the needed facilities and ensuring rail investments in the area.

Defining the specific locations for LNG/LBG fueling extensions

To meet with the future needs for the fueling infrastructure, the LNG/LBG fueling network for road transport should be extended.

The decisions to widen the LNG/LBG fueling network and the specific locations for the fueling stations starting from Karesuvanto should be made. In addition to the decisions, the financial calculations and concreate measures to implement the decisions should be done.

Building charging infrastructure based on TEN-T requirements to the main corridors

To meet with the future needs for the charging infrastructure in the Region, deciding upon the widening the charging network and the specific locations for the charging stations based on the TEN-T requirements should be put to the agenda.

Conducting financial calculations and taking concreate measures to implement the decisions are also needed.

Studying the local biogas production potential in the Barents Region

In order to fully understand the possibilities of biogas as a locally produced propulsion power, a study should be conducted to study the local biogas production capacity and demand in the Barents Region.

The study should also aim to unveil the potential use cases, users and new business models around locally produced biogas.

Creating an ITS winter maintenance ecosystem

In order for the actors in the Region to better understand the full potential and possibilities of the ITS solutions, a ecosystem pilot project should be developed.

In a cross-border pilot, an ITS winter maintenance ecosystem should be built and the value to the different parties calculated.

See page 71

POSSIBLE FUNDING ALTERNATIVES

Country specific funding mechanisms

Country-specific funding alternatives are possible for modal shift and new propulsion power promotion.

In **Norway**, Enova, the state-owned company provides funding for Norway's transition to a low-emission society including **charging infrastructure, biogas production, infrastructure and vehicles and hydrogen fueling stations**.

- Enova can support up to 100% of approved investment costs within the minimum technical requirements.
- Norway offers eco-bonus for railway and maritime companies to shift transport from road to sea or rail

In Sweden, The Transport Administration offers investment support for the expansion of **public fast charging stations for charging vehicles.**

- It is possible to apply for up to 100 % of the investment cost. However, it is not possible to apply for support for the operation of the fast-charging stations, only for the investment cost.
- **Klimatlivet program** provides support for wide variety of carbon emission reduction projects such as **biogas production and fueling stations.**
- Sweden has also eco-bonus schemes to support transfer of freight transport from road to rail or sea

In Finland, the Energy Authority provides support for alternative fuel infrastructure. Support can be given to **gas fueling stations, local public transport electric charging stations and for fast and slow public charging stations**.

- Infrastructure support shall not exceed 35% of the eligible costs in the case of high-capacity vehicle recharging points, and otherwise up to 30%.

In Russia, the government of Russian Federation has decided investments and conducted action plans for increasing LNG delivery network for transport vehicles. Russia has also developed strategic planning documents for the increasing use of alternative fuels, for example a concept for the development of production and use of electric transport for the period up to 2030, a strategy for the development of transport production with a reduced carbon footprint and an action plan for development of the energy storage systems industry including measures to support the production and location of the minimally required infrastructure of electric charging stations.

EU

European Union's funding mechanism

For larger development initiatives and low-carbon and digital innovation research

- EU's main strategic funding program for TEN-T development is CEF (Connecting Europe Facility) which supports modernization and expansion of the existing infrastructure.
- CEF funding can be applied for both domestic and border crossing development projects.
- In order to attract and utilize CEF funding, the Barents region must prepare a joint vision and strategy to be demonstrated in the EU, instead of promoting regional targets and development projects.
- For the regional development EU provides funding through EFDR, ESIR and Interreg Europe programs, which are managed by local regional councils. Regional funding mechanism can be gathered to support larger development initiatives such as required in the Barents region.
- In addition to CEF and other larger regional development funds, EU provides significant funding opportunities for digitalization and low-carbon research and development work through Horizon EU multibillion program. For emission reduction aiming projects Innovation Fund and smaller research-orientated smaller fund can be utilized as well.
- Lastly EIB (European Investment Bank) delivers large debt-based arrangements for infrastructure projects. EIB has communicated being in middle of transformation process towards climate neutrality. In the future EIB will focus more and more on digitalization and emission reduction related projects.

Both national and EU level strategic development initiatives and funding mechanism provide **opportunities to develop the Barents region**.

Nevertheless, Barents region must show why funding should directed to the region and demonstrate clear development vision and how development of the Barents region will benefit the entire EU economy area.

A JOINT DIRECTION IS NEEDED TO GET THE MOST OUT OF THE EFFORTS IN THE BARENTS REGION

SHARE INFORMATION

The European Union is pushing the area towards carbon neutrality and green transition where the transportation sector has a key role to play. Also, the natural conditions and resources in the Barents region are linked to many of the EU Green Deal targets. Norway has national goals related to both the environment and Russia is investing in creating more efficiency in its transport sector.

The national institutions can benefit from the insights from this report and other publications produced through the Barents collaboration as they provide concrete knowledge and answers to the big shared challenges the countries in the Barents region face at the moment.

ALIGN GOALS

In a complex world, resources should be directed to joint challenges in order to create both clarity and efficiency.

In the Barents Region the challenge in development comes from the multi-actor nature of the Region. In order to make the most out of the always limited resources, all the different actors, decision makers and organizations working in the area should be led towards the same direction.

The proposed vision for the development of the Barents Region transport system could act as a way to direct the efforts.

COORDINATE ACTIONS

In addition to the information and plans, the action taken in the Region should support the Region as a whole.

This requires for example better allignment between the Joint Barents Transport Plans and the national transport plans.

Sharing information supports in coordinating actions, yet in order to develop the area focusing on the long term, the coordination is needed also before actions are taken and projects begin.

This can support the participation of all right stakeholders in the development work within the Region.

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