

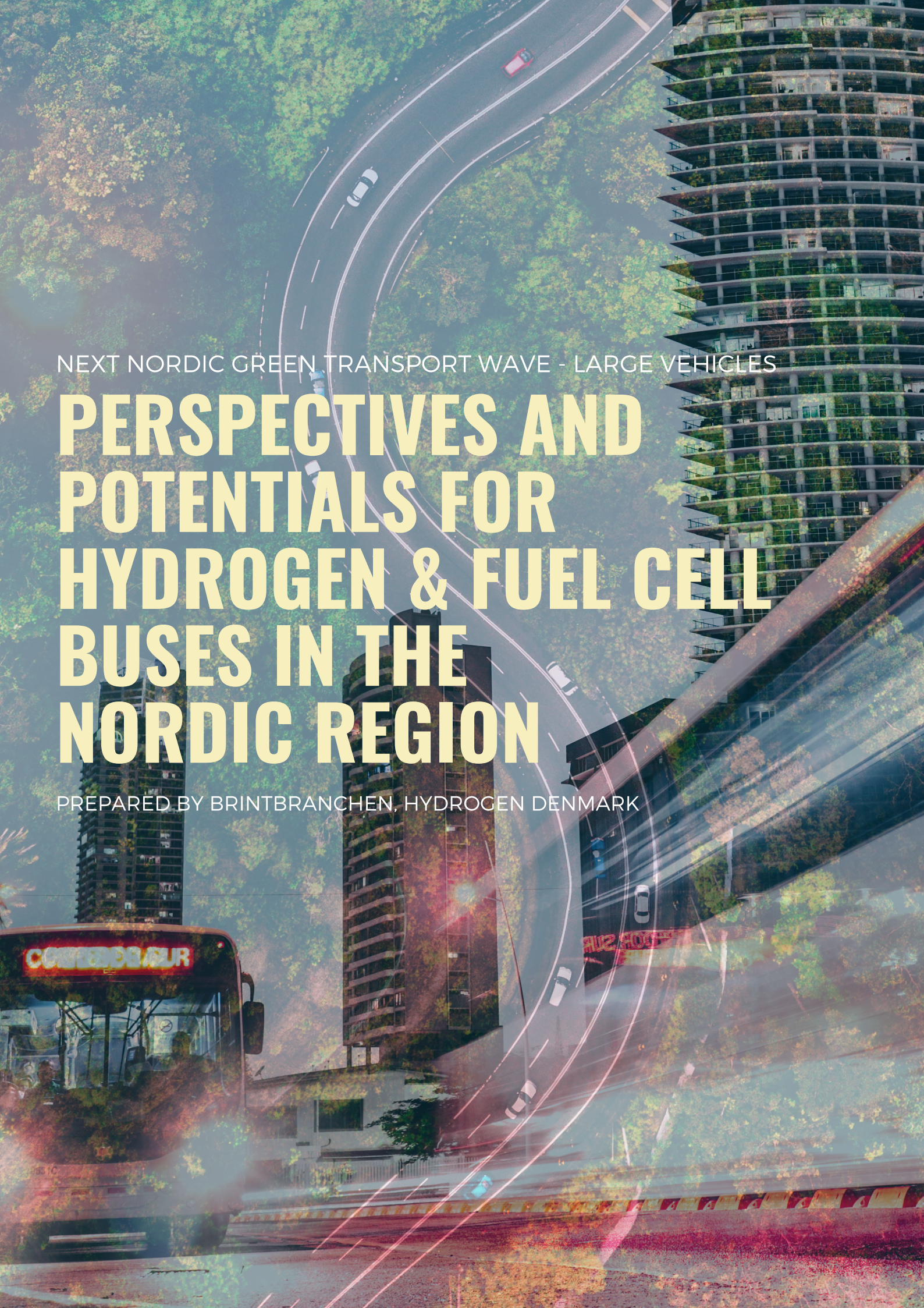
Next Nordic Green Transport Wave - Large vehicles

Perspectives and potentials for hydrogen & fuel cell buses in the Nordic Region

Prepared by Brintbranchen, Hydrogen Denmark



Nordic
Innovation

An aerial, top-down view of a city street. A red bus is visible in the lower-left corner, moving along the road. The street is flanked by lush green trees and modern, multi-story buildings with balconies. The overall scene is vibrant and urban.

NEXT NORDIC GREEN TRANSPORT WAVE - LARGE VEHICLES

PERSPECTIVES AND POTENTIALS FOR HYDROGEN & FUEL CELL BUSES IN THE NORDIC REGION

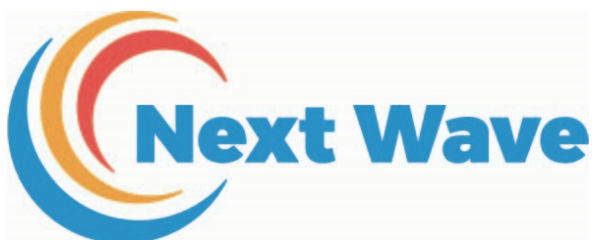
PREPARED BY BRINTBRANCHEN, HYDROGEN DENMARK

Next Nordic Green Transport Wave - Large Vehicles

September 2020



Perspectives and Potentials for Hydrogen and Fuel Cell Buses in the Nordic Region



CONTENT

04

Partners and contributors

05

Executive summary

06

Why hydrogen?

07

About Next Wave

08

Paris Agreement

10

Eu Hydrogen Strategy & Clean Hydrogen Alliance

11

Recommendations - overview

12

01 Multipurpose Infrastructure

13

Spill over effect

14

02 Comprehensive Strategies

15

03 Investments

16

04 Scale & Volume

17

05 Nordic Collaboration

Partners in Next Wave

The Next Wave consortium consist of hydrogen associations from Denmark, Finland, Iceland, Norway and Sweden.

The Next Wave project is cofunded by Nordic Innovation.



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EXECUTIVE SUMMARY

As a part of the Next Wave project Hydrogen Denmark has been responsible for conducting an analysis describing the innovation and business potential for a roll-out of hydrogen and fuel cell buses in the Nordic region. All project partners have participated in this analysis and provided data and information about the current status in these countries regarding hydrogen as a means for decarbonizing the transport sector in general and in relation to buses in particular.

While there are not a great number of hydrogen and fuel cell buses on the streets in the Nordic Region currently and the hydrogen infrastructure is not yet sufficiently constructed, the potential for a roll out of hydrogen buses is vast.

This analysis has boiled down to five recommendations going forward with initiatives for implementation of hydrogen and fuel cell buses: infrastructure, comprehensive strategies, investments, scale and a strengthening of Nordic collaboration.

Hydrogen and fuel cell technologies not only represent a means of decarbonizing the transport sector but also great business opportunities, that can create jobs, new industries, and export markets. The Nordic Region is a world leader in renewable energy and green hydrogen and fuel cell solutions are a natural next step. These new solutions present the Nordic Region with opportunities for future economic growth that is both sustainable and viable.

Why Hydrogen?



The world is at a threshold. The devastating consequences of climate change are becoming ever clearer and more present. The need for transitioning energy systems are obvious not least in the transport sector. Transportation is vital and mobility imperative in an increasingly interdependent world. But the heavy dependency on fossil fuels in transport must soon be a thing of the past. This does not, however, mean that we have to cease moving. We need to be able to travel and to commute in order to function in a modern world. It simply means that we must find new and sustainable ways of maintaining our mobility.

Renewable energy and electrification are the way forward – in the entirety of an energy system. But electrification can happen in more ways than one. There are many instances where direct electrification or batteries are inefficient, uneconomical, or impossible to implement. This is where liquid electricity in the form of renewable hydrogen will play a key-role in the green transition of transport.

Utilizing renewable energy to produce hydrogen by electrolysis widens the portfolio of applicability significantly. Not only does hydrogen make the transitioning of transportation easier it also creates large-scale storage for renewable energy, thus enabling electrification of transportation independently of the immediate energy production.

The need for energy storage becomes increasingly important as we move towards fossil independence. Basing entire energy systems on fluctuating sources has inherent vulnerabilities, and large-scale storage will ensure the stability and resilience necessary for a successful transition.

The Nordic Region leads the world in renewable energy production and sustainable innovation. Whether wind, hydro or geothermal power the Nordic Region has succeeded in harnessing the natural energy that surrounds us. This part of the world has some of the most lucrative conditions for renewable energy and subsequent green hydrogen production.

The green tradition, the innovative heritage makes the Nordic Region not only the natural leader in the green transition but also in the development and export of sustainable solutions. The hydrogen and fuel cell value chain already exists in many parts of the region and this represents massive business and export opportunities. The Nordic Region can pave the way for new businesses, new jobs and an economic growth that is both viable and sustainable.



ABOUT NEXT WAVE

Electrification of the transport sector has already begun and the Nordic countries, specifically Norway and Iceland, have taken major steps resulting in battery electric vehicles (BEVs) already accounting for a substantial percentage of the total sales. The world is looking towards the Nordics as they are providing global examples for success. However, little is happening regarding larger vehicles as battery solution still are not able to provide heavy-duty users (e.g., buses, trucks and lorries) the mobility they need.

Fuel cell electric vehicles using hydrogen as a fuel can solve this. The project focuses on providing infrastructure for a large scale deployment of trucks, buses and lorries. The goal is to further stimulate the global technological lead, which the Nordic countries have by stimulating the very first hydrogen infrastructure roll-out for larger vehicles while at the same time map how the infrastructure build-up needs to be done, so that the transition to hydrogen vehicles can happen smoothly. Such roll-out will also benefit the use of hydrogen for trains and the maritime sector. Furthermore, in addition of sourcing the hydrogen as a by-product from the industry, in the Nordic region we have the unique opportunity to produce the hydrogen in a green manner exploiting renewable electricity production.



ABOUT NEXT WAVE

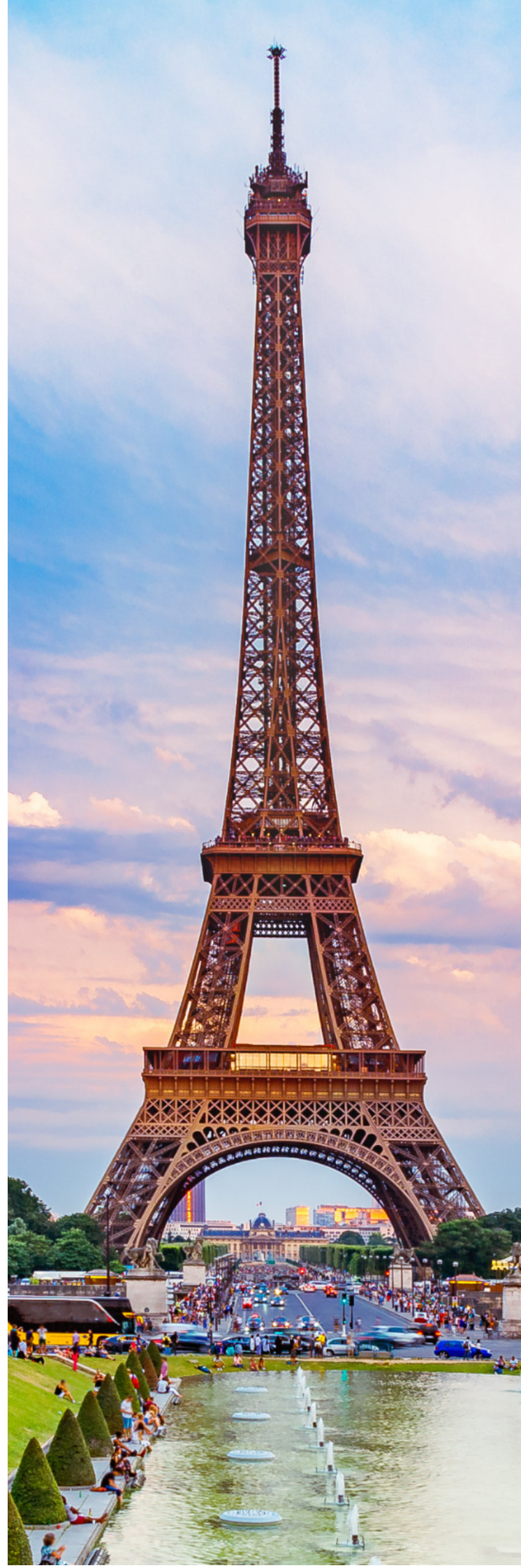
Already Nordic industries have taken international lead in the field of hydrogen and fuel cells and a unique cooperation exists between “hydrogen companies” via the Scandinavian Hydrogen Highway Partnership (SHHP) cooperation. Jointly they have marketed the Nordic platform for hydrogen and, at the same time, paved the way for vehicle manufacturers to deploy such vehicles in the Nordic countries. When it comes to hydrogen, the Nordics have globally leading companies both within the infrastructure and the fuel cell business. The project therefore sets forward four key activities in a unique project where technical innovation and deployment strategies are intertwined.

The project will deliver an analysis on large-scale transport of hydrogen with mobile pipeline, a description of the innovation and business potential for a roll-out of FC-buses in the Nordic region, as well as a coordinated action plan for stimulating the FC truck demand and a prospect for utilising hydrogen in heavy-duty equipment. Finally, the project will contribute to national and Nordic hydrogen strategy processes, even providing input to a possible Nordic Hydrogen Strategy.

The Paris Agreement

Denmark, Finland, Iceland, Norway, and Sweden have all signed and ratified the Paris Agreement.

The Agreement acknowledges the threat of climate changes and commits signatories to reduce greenhouse gas emissions, strengthen sustainable development and holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing a limit of 1,5°C.



EU Hydrogen Strategy

The EU Commission has made it clear that hydrogen will play a crucial part in the transition of the European energy systems. Emphasizing hydrogen as one of the ground pillars in the transition the Commission presented a dedicated hydrogen strategy in the summer of 2020.

The strategy contains the ambitious goals of 6 GW electrolysis capacity in 2024 and 40 + 40 GW in 2030 along with a hydrogen market of 140 billion Euro. At the core of the strategy is the commitment to the green transition as well to the creation of new jobs and sustainable industries.

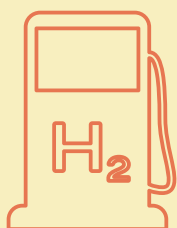
Clean Hydrogen Alliance

The Clean Hydrogen Alliance was launched to gather member states, industries and other relevant actors that are key in implementing the Hydrogen Strategy. The purpose of the Alliance is to expand the hydrogen industries, roll out infrastructure and strengthen both the supply and demand side of the hydrogen economy. Several partners in the Next Wave project has joined the Clean Hydrogen Alliance.



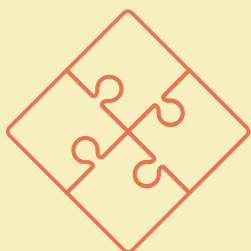
Recommendations

for roll out of hydrogen and fuel cell buses in the Nordic Region



01

Multipurpose Infrastructure



02

Comprehensive Strategies



03

Investments



04

Scale & Volume



05

Nordic Collaboration

INFRASTRUCTURE

Multi purpose stations

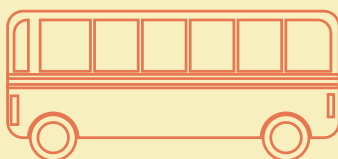
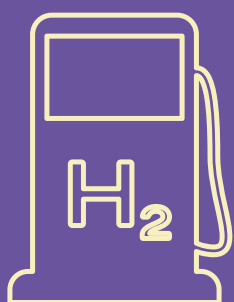
Infrastructure and bus roll out go hand in hand

This analysis has shown that there is great potential for hydrogen and fuel cell busses in the Nordic Region. The transitioning of public transport is vital to cutting emissions, fossil dependency and combating air and noise pollution. The implementation of battery electric busses is ongoing in several places but the efforts in rolling out hydrogen and fuel cell busses are happening at a slower pace.

The experiences drawn from past and present projects conclude that constructing and expanding the hydrogen refueling infrastructure depend completely on the volume of guaranteed consumption pull for the stations. The efforts to roll out hydrogen and fuel cell buses must entail the infrastructure as part of the same project.

Recommendation 01

It is a great advantage if the stations have a capacity to fuel different types of vehicles - thus expanding the potential pull and strengthening the business case.



Spill Over Effect on Heavy Duty Transport

Creating multi purpose infrastructure will also facilitate the transition of heavy duty transport which is a vital element in combating both emissions as well as air and noise pollution. It will also create the foundation for the roll out of e.g. taxies.



STRATEGIES

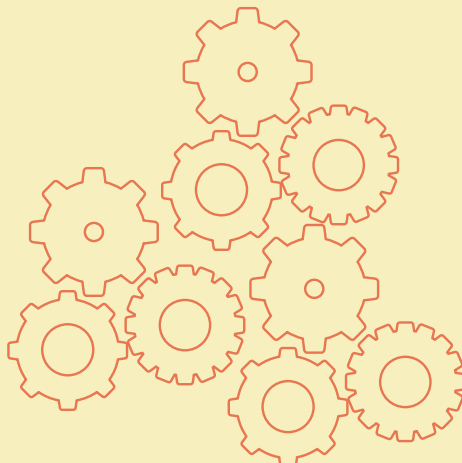
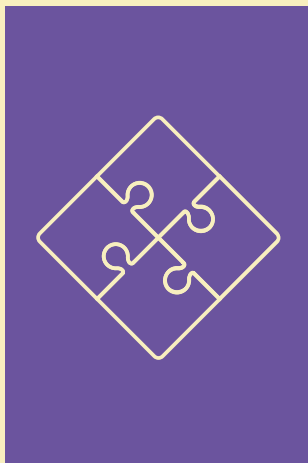
Comprehensive strategies

The roll out of hydrogen and fuel cell buses cannot stand alone

The experiences drawn from this analysis are that if the roll out of hydrogen and fuel cell buses are to be successful these initiatives cannot stand alone. While some of the nations involved in the Next Wave project either have hydrogen strategies or are conducting preliminary analyses for such strategies it is clear that comprehensive strategies for transitioning energy systems are imperative for the implementation of hydrogen and fuel cell buses.

Hydrogen enables sectoral integration and by the versatility of applications of hydrogen, large-scale production of hydrogen must be seen in a broader systemic context. This is not least in regards to transportation where all aspects of the sector must be included in order to create viable business cases for roll out and infrastructure.

Recommendations 02



INVESTMENTS

Investments in the hydrogen industry

The hydrogen and fuel cell value chain represents vast opportunities

Hydrogen and fuel cell technologies are key components in a successful transition of the transport sector. These technologies also represent vast business opportunities. This is especially the case in the Nordic Region where renewable energy production is already among the highest in the world. Green hydrogen produced on the basis of renewable energy by electrolysis presents the Nordic Region with a solution to not only the current fossil-based hydrogen consumption in e.g. industries, but also can also create new jobs, new industries and new export opportunities.

This requires strategic investments in renewable energy, research and development initiatives, infrastructure and in the new businesses in e.g. public/private partnerships. These investments will create the foundation for a strong hydrogen and fuel cell value chain in the countries that currently do not have a hydrogen industry, and it will strengthen the value chain in the countries where the industries exist.

Recommendations 03



SCALE & VOLUME

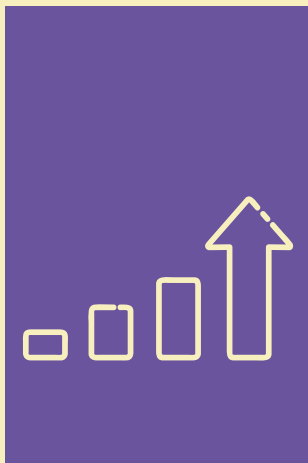
Scale & volume are imperative

Hydrogen production and fleet roll out must be scaled up

As is generally the case with commercialization and ensuring viability for business cases, scale is vital when it comes to hydrogen and fuel cell roll out. This is in terms of hydrogen production, consumer pull on infrastructure, and availability and price of vehicles. Large-scale production will decrease the price, and hydrogen has the potential to become lower in cost than fossil fuels.

Volume is therefore of the essence when it comes to roll out of vehicles. Whether it be buses, taxis or heavy-duty transport, volume of the fleets is essential for the guarantee of consumption that is necessary for infrastructure investments.

Recommendations 04



COLLABORATION

Nordic collaboration

There is massive potential for expanding Nordic collaboration in the field of hydrogen and fuel cells

The Nordic brand stands for quality and sustainability, and in this context collaboration on hydrogen and fuel cell implementation is a natural next step on our joint journey towards fossil independence. There are many areas in which the existing Nordic collaboration can be expanded in order to ensure further implementation of hydrogen and fuel cell technologies in general and regarding buses specifically. If the Nordic region joins forces in deciding to make hydrogen and fuel cell for transportation a priority, it can drastically change the market.

The analysis shows many areas where Nordic collaboration can facilitate implementation:

Recommendations 05



Joint representation of interest for instance through the Nordic Council of Ministers.

Joint procurement processes to increase volume

Joint public outreach and knowledge sharing

Joint research initiatives e.g. regarding total cost of ownership analyses

Joint investments