# Assessment report of clean fuel deployment experience in Scandria2Act corridor regions

## Interreg Baltic Sea Region Project #R032 “Sustainable and Multimodal Transport Actions in the Scandinavian-Adriatic Corridor”

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|---|---|
| Work Package | WP2 Clean Fuel Deployment |
| Activity | Increasing regional capacity to implement clean fuels in a corridor’s perspective, A2.2 |
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# Output Description (Application Form)

"The partnership has jointly agreed to publish a pamphlet instead of a longer report as the issue of transferability of the single case studies has been sufficiently reflected in the case-studies themselves and the partnership considered it of outmost importance to communicate the main findings of these case studies to a wide range of stakeholders providing information on where to obtain the case studies as a lengthy report wasn't regarded to be an successful mean of spreading the case-study results, especially to decision makers. Via send you both the pamphlet and the long versions of the three case studies via the messaging center. *The pamphlet has been much appreciated as a means of communicating the three case studies. However Skåne Association of Local Authorities has decided to, and is working on, completing the initial report, since there are some valuable material in it, which isn't used in the case studies nor in the pamphlet. The report should be valued more as a complementary report, which can be used by partner organizations in their continued work with the three cases, but mainly with the multifuel energy station.*"

Link to results, pamphlet and case study reports: https://www.scandria-corridor.eu/index.php/en/scandria-2act/clean-fuel-deployment

The activity will make use of the extensive experience in the respective regions and make them available for the development of clean fuels in the corridor. Partners agreed to develop new solutions by case investigations on Finance Models for Investments in Clean Fuel Infrastructure (Region Skåne), on Multifuel Refuelling Stations (Rise), and on electric mobility in city logistics (TH Wildau).

All cases will be summarised and evaluated by Skåne Association of Local Authorities for their transferability and identification of good practice. Results will be published in the "Assessment report of regional experience within the Scandria2Act" (O 2.2). The report will contain:

- A description of the single cases,
- Lessons learnt from the single cases (Success factors and challenges),
- An evaluation of the transferability to other corridor regions,
- Recommendations concerning the strategic action at decision making level

# Output Schedule

| Source | Deadline / Milestone | | | | | |
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| | 31.10.16 | 30.04.17 | 31.10.17 | 30.04.18 | 31.10.18 | 30.04.19 |
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| Expected | | | | | | X |

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# List of abbreviations

| | |
|---|---|
| GHG emissions | Greenhouse Gas emissions |
| DAFI | The Directive on the Deployment of Alternative Fuels Infrastructure |
| MES | Multifuel Energy Stations (two or more clean fuels) |
| BEV | Battery Electric Vehicle |
| CBG/CNG | Compressed Biogas/Natural gas |
| EV | Electric Vehicle |
| FCEV | Fuel Cell Electric Vehicle |
| LBG/LNG | Liquified Biogas/Natural gas |
| NGV | Natural Gas Vehicle |
| OEM | Original Equipment Manufacturer |
| PEV | Plug-in Electric Vehicle |
| PHEV | Plug-in Hybrid Electric Vehicle |
| The TEN-T Core Network | The Trans-European Transport Networks (TEN-T) is a project of the European Union to co-fund the establishment of a transport infrastructure connecting all EU Member States. |
| IPCC | Intergovernmental Panel on Climate Change |
| SPBI | Swedish Petroleum & Biofuel Institute |
| ISO | International Organization for Standardization |
| CEN | European Commitée for Standardization |
| CE marking | Consumer Electronics (EEA–European Economic Area |
| PPP | Public Private Partnership (financial models) |
| Ltd | Limited Company (UK) |
| AB | Aktiebolag (Swedish) |
| GREAT | GREAT - Great Regions with Alternative Fuels for Transport, an EU funded project. |
| KOL | Chronic Obstructive Pulmonary (lung) Disease |

| | |
|---|---|
| $CO_2$ | Carbon Dioxide |
| NOx | Nitric oxide/ Nitrogen dioxide |
| LH2 | Liquid hydrogen |
| SE | Sweden |
| NO | Norway |
| DK | Denmark |
| FI | Finland |
| DE | Germany |

# 1 Executive Summary

For the deployment of clean fuel infrastructure, mobility, and increase use of clean fuel vehicles are essential. Fostering and showing good examples and concrete cases are important to drive this development. Work package 2 – Clean Fuel Development within the Scanria®2Act project aims for that. The work aims to at fostering the corridor-wide deployment of clean fuels in an inclusive multi-fuel approach by optimizing utilization of clean fuels according to their specific advantages. Liquid Natural Gas/Liquid Biogas, Compressed Natural Gas/Compressed Biogas, Battery Electric Vehicles, Fuel Cell Electric Vehicles are in focus.

Three focus areas are at scope in this report ***Assessment Report of clean fuel deployment experience in Scandria®2Act corridor regions***. First, a study made by RISE of ***Multifuel Energy Station Concept***, second, a Region Skåne study made by Tricvector Traffic of ***PPP in clean fuel deployment*** (Cooperation between public and private partners in investment of clean fuel infrastructure), third, a study made by TH Wildau about ***E-Mobility in city logistics.*** All three technical support reports are presented and are stand-alone reports presenting in-depth analysis and details. Skåne Association of Local Authorities made a synthesis of these three and presented 31 October 2018 a pamphlet with the most important and top-level conclusions, findings and results in ***Green Mobility Solutions from the Scandria®-Corridor***, as the main delivery and can be seen in full text version in section 6.1 below. This report acts as a background report to the pamphlet in order to present more of the details analysed for the pamphlet.

In the report from Akershus and RISE ***Assessment of Clean Fuel Deployment and Market Access of Clean Fuels in the Northern Scandria®Corridor*** 10 key findings are listed according to section 6.

All three cases presented above of multifuel energy station, public-private cooperation and electrified mobility can in different ways help to speed up the development that is too slow in order to faster reach the EU-targets of $CO_2$-reductions. This can further be strengthened by tougher regulations and politics for $CO_2$-reductions in transports at all levels.

Further, the vehicle industry has started to work out new models that step by step is entering the market. The variety of models will increase over time making it easier to get hold of suitable vehicles for each purpose of use. OEMs usually need large markets for their R&D work and introducing new models at the market in order to get the economics and the profitability for the new models. At the same time both infrastructure and clean fuel base is needed supporting both supply-side and demand-side on these new virgin markets.

Local and regional decision makers can play an important role by working towards the solutions described in all three cases in this report. Mainly via the public-private cooperation and electrified mobility but can also play a part by supporting and/or financing multifuel energy stations. Setting local and regional targets for $CO_2$-emissions, better air quality and so on shows a way of supporting as well. The public sector play an important role by taking the lead and show the rest of the society that Clean Fuels work well in the municipality and it works well. The municipality has the possibility to start up the local Clean Fuel market by running their own vehicles refueling in the infrastructure the invested in themselves as the examples shows, and even reach almost break-even at an early stage. By cooperation among neighboring municipalities the market can be enlarged and spread to other municipalities and regions.

Transferability is in most cases good and can be spread to other municipalities, cities and regions along the Scandria®Corridor.

It is a challenge to balance both supply and demand during the build-up of clean fuel markets. A variety of clean fuels and a variety of vehicle models are developed side by side and a step-by-step introduction and phasing out of fossil fuels as the markets grow.

Looking forward; a lot is being done in at local and regional level setting up goals of different kind in order to achieve climate goals of $CO_2$ emissions, renewable energy, environmental zones in the cities and last but not least better air quality. The last one should not be neglected as the statistics say that there are more people dying in air pollution caused diseases than traffic itself.

Going forward means that more work needs to be done going forward to support the development of clean fuel vehicles, clean fuels, and clean fuel infrastructure.

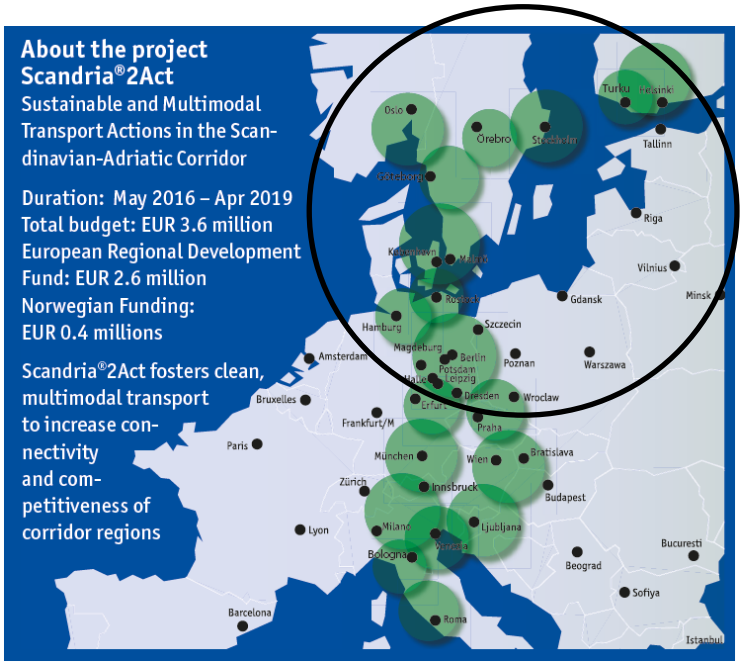
# 2 Introduction

The Scandinavian-Mediterranean transport corridor (Scandria®Corridor) is one of the 9 Core Net Corridors of the TEN-T Core Net, and the longest one of these. The northern stretch of the corridor includes the urban nodes Helsinki, Stockholm, Copenhagen and Berlin, thus connecting major urban centres and economic zones. As the corridor is a crucial axis for the European Economy[1] it has a specially appointed *European Coordinator*, currently the former President of the European Parliament Mr. Pat Cox.

In this report, the geographic scope of the Scandria®2Act project is referred to as "the Northern Scandria®Corridor" and includes:

- **Germany**: Hamburg, Schleswig-Holstein, Lower Saxony, Mecklenburg-Vorpommern, Brandenburg and Berlin.
- **Denmark**: the whole country.
- **Sweden**: The regions of Halland, Jönköping, Kronoberg, Skåne, Stockholm, Södermanland, Uppsala, Västmanland, Västra Götaland, Örebro and Östergötland.
- **Norway**: Oslo, Akershus, Østfold and parts of Hedmark, along the E-16.
- **Finland**: Uusimaa, Pirkanmaa, Southwest Finland, Tavastia Proper and Satakunta.

> The European Commission explains the TEN-T network as follows:
>
> "The ultimate objective of TEN-T is to close gaps, remove bottlenecks and eliminate technical barriers that exist between the transport networks of EU Member States, strengthening the social, economic and territorial cohesion of the Union and contributing to the creation of a single European transport area."




The most significant projects in the Northern Scandria®Corridor is the planned, but not decided, Fehmarnbelt Fixed Link Tunnel[2] and the Öresund Bridge, which connected Sweden and Denmark in year 2000.

Being a core transport corridor undoubted makes the Scan-Med corridor a large contributor to Europe's emissions of greenhouse gases. 94% of the transport in EU depends on oil for its energy need.[3] To continue developing a leading and competitive transport corridor, the European Union and the countries within the Scan-Med Corridor must have a strong commitment towards low-emission mobility.

[1] https://scandria-corridor.eu/index.php/en/corridor/scand-med (2018-03-06)

[2] https://femern.com/en

[3] COM (2016) 501 final, Communication from the commission, A European Strategy for Low-Emission Mobility

## 2.1 The importance of clean fuels in the European Union

European Commission President Jean-Claude Juncker outlined in the State of the European Union speech in September 2017:

*"I want Europe to be the leader when it comes to the fight against climate change. Last year, we set the global rules of the game with the Paris Agreement ratified here, in this very House. Set against the collapse of ambition in the United States, Europe must ensure we make our planet great again. It is the shared heritage of all of humanity."* [4]

In 2016 the European Commission adopted a "Low-emission mobility strategy" with the following prioritized areas:

- "Increasing **the efficiency of the transport system** by making the most of digital technologies, smart pricing and further encouraging the shift to lower emission transport modes
- Speeding up the deployment of **low-emission alternative energy for transport**, such as advanced biofuels, electricity, hydrogen and renewable synthetic fuels and removing obstacles to the electrification of transport
- Moving **towards zero-emission vehicles**. While further improvements to the internal combustion engine will be needed, Europe needs to accelerate the transition towards low- and zero-emission vehicles."[5]

The goal of the EU is at least 60% lower greenhouse gas emissions from transport by 2050 than in year 1990. Greenhouse gas emissions should be on a path to zero thereafter, but "emissions of air pollutants from transport that harm our health need to be drastically reduced without delay."[6]

The Directive on the Deployment of Alternative Fuels Infrastructure [DAFI] establishes a common framework of measures for the deployment of alternative fuels infrastructure in the European Union. The purpose is to minimise dependence on oil and to mitigate the environmental impact of transport.

The Directive sets out minimum requirements for the development of alternative fuels infrastructure, including charging points for electric vehicles and refuelling points for natural gas (CBG/CNG and LBG/LNG) and hydrogen, to be implemented by means of the Member States' national policy frameworks. These should also include common technical specifications for charging and refuelling points, and user information requirements. Each Member State shall adopt a national policy framework for the development of the market about alternative fuels in the transport sector and the deployment of relevant infrastructure.[7]

The European Commission concluded in November 2017 that the level of ambition in the DAFI-reports differ significantly and is in some ways inadequate for the high ambitions of the European Union towards a low and zero emission mobility. For example, nor the number of charging stations neither the number of planner LNG refueling stations for heavy duty vehicles in the National Programs are enough. November 6th, 2017 merely 8 of 25 National Programs met all requirements, Finland was one of them.

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[4] https://ec.europa.eu/transport/modes/road/news/2017-11-08-driving-clean-mobility_en (2018-05-04)

[5] https://ec.europa.eu/clima/policies/transport_en (2018-08-10)

[6] https://ec.europa.eu/clima/policies/transport_en (2018-08-10)

[7] Assessment of Clean Fuel Deployment and Market Access of Clean Fuels in the Norther Scandria Corridor, Gjerlöw J.C, Akershus County Council; Cornander C, RISE Research Institutes of Sweden (2017)

Only a few “set clear and sufficient targets and objectives and suggest support measures” for example, when it comes to set priorities and level of ambition for different clean fuels. Norway was not included since they are not a part of the European Union.[8]

The European Commission concludes however that the “deployment of infrastructure for alternative fuels [in the European Union] has recently gained momentum”[9]. Turning our focus towards the Northern Scandria®Corridor, despite the ramp-up for the deployment of infrastructure for clean fuels, the development is too slow to reach the desired national and EU/EEA targets for reduction of $CO_2$ emissions from transport.[10]

The demand for clean fuels increases, but not one single fuel will be responsible for cutting all of transport sector’s emissions. Instead, the European Commission predicts a combination of several clean fuels.

The importance of work going forward making the transport sector a zero-emission sector increases as the IPCC October 8th 2018 launched the report Global Warming of 1.5 °C with the message to speed up the work.[11] A number of climate change impacts are highlighted that can be avoided by limiting the global warming to 1.5 °C compared to 2.0 °C. This will require “rapid and far-reaching” transitions in land, energy, industry, transport, and cities.

The EU must now accelerate the deployment in two areas:

1. The TEN-T core and comprehensive network, which connects the EU-countries, such as the Northern Scandria®Corridor
2. The urban and sub-urban areas, where vehicles are being used for most of the time[12]

## 2.2 About the Scandria®2Act project

Scandria®2Act is a project that brings together regions located along the Baltic sea region stretch of the Scandinavian-Mediterranean Core Network Corridor (Northern Scandria®Corridor). The project aims to answer major regional development challenges associated with future transport development along the newly established Scandinavian-Mediterranean Core Network Corridor. It supports regional activities to foster the corridor deployment and to adopt regional development measures to the opportunities provided by the European transport policy approach.

Scandria®2Act covers partners from all Member States and Norway located along the Baltic sea region stretch of the Northern Scandria®Corridor. It represents relevant urban nodes as well as multimodal

[8] COM(2016) 652 final, Communication from the commission, Towards the broadest use of alternative fuels – an Action Plan on Alternative Fuels Infrastructure under Article 10(6) of Directive 2014/94/EU, including the assessment of national policy frameworks under Article 10(2) of Directive 2014/94/EU

[9] COM(2016) 652 final, Communication from the commission, Towards the broadest use of alternative fuels – an Action Plan on Alternative Fuels Infrastructure under Article 10(6) of Directive 2014/94/EU, including the assessment of national policy frameworks under Article 10(2) of Directive 2014/94/EU

[10] Assessment of Clean Fuel Deployment and Market Access of Clean Fuels in the Norther Scandria Corridor, Gjerlöw J.C, Akershus County Council; Cornander A, RISE Research Institutes of Sweden (2017)

[11] IPCC Global Warming of 1.5 °C https://www.ipcc.ch/sr15/

[12] COM (2016) 652 final, Communication from the commission, Towards the broadest use of alternative fuels – an Action Plan on Alternative Fuels Infrastructure under Article 10(6) of Directive 2014/94/EU, including the assessment of national policy frameworks under Article 10(2) of Directive 2014/94/EU

nodes along the corridor. The project coordinates efforts related to the deployment of the ScanMed Core Network Corridor as one of four Core Network Corridors connecting the Baltic sea region to the rest of the European Union.

The major objective of Scandria®2Act is to foster clean, multimodal transport through the corridor regions to increase connectivity and competitiveness of corridor regions while at the same time minimizing negative environmental impact induced by transport activities. To achieve this objective, the project partners have developed a joint approach that addresses:

- the deployment of clean fuels,
- the deployment of multimodal transport services and
- the establishment of a multilevel governance mechanism based on mutual dialogue between decision makers at regional, national and European level.

## 2.3 Aim of the study and target groups

Within the context of the Scandria®2Act project, this report has the aim be a stepping stone and a source of inspiration to empower regions along the corridor to deploy clean fuel solutions in a corridor perspective.

Based on the ten key bottlenecks and possibilities for increased deployment of clean fuels in the Northern Scandria®Corridor, we will present three cases and evaluate them for their possibility to empower the deployment of clean fuels in the Northern Scandria®Corridor either along the TEN-T core network or within urban and sub-urban areas:

1. Analyzing if it is possible to use one refueling station for many clean fuels in a **multifuel energy station**
2. Financing clean fuel infrastructure through **financial cooperation** between the public and the private sector
3. How to pursue a coordinated **city logistics solution using electric mobility**

This cases mainly addresses the following key bottlenecks and possibilities for increased deployment of clean fuels in the Northern Scandria®Corridor[13]:

- **Availability of Clean Fuel Infrastructure** is in general too limited to ensure clean transport throughout the Northern Scandria®Corridor. Lack of Clean Fuel Infrastructure in some countries may actually hinder the use of Clean Fuels for long-distance transport of goods and persons in the Northern Scandria®Corridor.

- **Regional and local decision makers will become more important as the main driver for shifting to alternative fuels in the near future.** The EU infringement and procedure against many Member States and Communities regarding air pollution (particle matters, NOx), increases the pressure to implement measures significantly reducing pollutants. There are several examples in the Northern Scandria®Corridor demonstrating how political decisions have fostered market development.

- The regional perspective is important in ensuring the development of Clean Fuel Infrastructure in such a way that it permits, and stimulates, transport with Clean Fuels. **Municipalities and**

[13] Assessment of Clean Fuel Deployment and Market Access of Clean Fuels in the Norther Scandria Corridor, Gjerlöw J.C, Akershus County Council; Cornander C, RISE Research Institutes of Sweden (2017)

**regions have the chance to be the main driver for clean vehicles while demonstrating their concern for air pollution control.** They can implement their own Clean Fuel Strategies and strengthen regional cooperation on the deployment of Clean Fuels In the best case, municipalities match each other in implementing measures and should be aware of (EU) financing instruments allowing the co-financing of strategic planning and investments. Collaboration between regions may give OEMs a larger market to address with a specific vehicle as well.

- **The cost of producing renewable fuels is generally much higher than that of fossil alternatives.** This may be because of low production volumes and the technology being immature. Furthermore, the infrastructure build-up and maintenance costs of CBG/CNG, LBG/LNG and hydrogen are above those of petrol stations. Also, no successful business case has been made thus far for the construction of charging stations. This is especially challenging in the market ramp-up phase when there is relatively low fuel demand.

- There are **several best practice examples of setting frameworks, using incentives and carrying out concrete measures** within the Northern Scandria®Corridor. Information about these should be more widely spread so that they can serve as inspiration for other regions.

Target groups are primarily experts and decision makers for clean fuel deployment in the national administration, regions and municipalities, but also clean fuel service and infrastructure providers.

## 2.4 Methodology and delimitations

This report is a background report for the pamphlet Green mobility Solutions from the Scandria®Corridor. A more communicative pamphlet was worked out summarizing the results of Clean Fuel Development making this report be a more complementary report standing next to the three report of case studies. The project management agreed to the following:

"The partnership has jointly agreed to publish a pamphlet instead of a longer report as the issue of transferability of the single case studies has been sufficiently reflected in the case-studies themselves and the partnership considered it of outmost importance to communicate the main findings of these case studies to a wide range of stakeholders providing information on where to obtain the case studies as a lengthy report wasn't regarded to be an successful mean of spreading the case-study results, especially to decision makers. Both the pamphlet and the long versions of the three case studies was sent to the messaging centre. *The pamphlet has been much appreciated as a means of communicating the three case studies. However, Skåne Association of Local Authorities has decided to, and is working on, completing the initial report, since there is some valuable material in it, which isn't used in the case studies nor in the pamphlet. The report should be valued more as a complementary report, which can be used by partner organizations in their continued work with the three cases, but mainly with the multifuel energy station.*"

## 2.5 Definitions

**Small municipality**[14]: The chapter on public-private partnerships and the possibility to finance new clean fuel infrastructure is targeted towards and evaluated based on its transferability to smaller

[14] German: Städte und Gemeinde (Kreise probably too large). Norway: primärkommun Finland: kommun Denmark: kommun Sweden: kommun

municipalities. In this report a small municipality has less than 100 000 inhabitants. Along the corridor the main part of the municipalities is small, making the definition cover the main part of the Northern Scandria®Corridor. The larger municipalities tend to have greater prerequisites in terms of market base, but also regarding competence and resources and therefore are more likely to build clean fuel infrastructure. The reason for this is explained in this quotation: “Although some smaller municipalities also have strategies and policies to decrease $CO_2$ emissions, there is often a lack of financial and personnel support to implement and follow up measures. Smaller municipalities tend to group together or work in cooperation with the regional level to implement measures. […] Whether the smaller municipalities are engaged in the question of clean fuel infrastructure on the policy level is often reliant on individuals (on the political or civil servant level) who are engaged and willing to drive the question forward. Ultimately in smaller municipalities, the question of resources is decisive in whether a policy is driven / taken forward.”[15]

**Clean fuel**: In this report, the terms Clean Fuels includes the following fuels:

- Electricity
- Hydrogen; compressed and liquified
- Natural gas; compressed and liquified
- Biomethane (upgraded biogas), compressed and liquified

Biogas is produced by the anaerobic digestion of organic matter such as dead animal and plant material, manure, sewage, organic waste, etc. Biogas contains methane (CH4), carbon dioxide ($CO_2$) and small amounts of other gases. After the removal of contaminants, biomethane is the same as natural gas, and can be used as a transport fuel in the form of Liquified Biomethane (LBG) or Compressed Biomethane (CBG)

[15] Interim report: Cooperation between public and private partners in investment of clean fuel infrastructure (2018) A Clark, A Börefeldt, S Fält (all Trivecor Traffic), O Mattisson (FEH, Lund University)

# 3 Co-locating infrastructure for clean fuels

## 3.1 Introduction

The demand for clean fuels increases. There is not one single fuel which will be responsible for cutting all the transport sector's emissions. Instead the European Commission predicts a combination of several clean fuels.[16] Looking closer at the DAFI-strategies for each country in the Northern Scandria®Corridor, this is also true. It is most likely that a range of different fuels and vehicles will develop over time as the markets grows making the Multifuel Energy Stations (MES) interesting. Differences between countries along the Scan-Med corridor have differences in vehicle park and usage of fuels. The mix in each country is a result of national policies and regulations, taxes and cultural differences over the ears. For example, varies the average size of the vehicles as well as the average age of the vehicle park making the vehicles bigger and older in the north/Scandinavia in a comparison to countries in the middle and south of Europe. In this way MES may play an important role along the Scan-Med corridor making it possible for longer transports along the corridor with a mix of alternative fuels and vehicles coming from different countries and regions. Note that multifuel energy stations are one supportive solution but not the only one.

This chapter focuses on the possibility to co-locate clean fuel refueling stations in the Northern Scandria®Corridor using a *multifuel energy stations concept*, instead of constructing one refueling station per each clean fuel. The idea of combining fuels[17] is partly to increase exposure and public awareness of clean fuels, but also by combining fuels at the same filling station it is likely that costs are reduce and efficiency increased.

### 3.1.1 Read the full report on multifuel energy stations

Peter Bremer and Erik Wiberg at RISE Research Institutes of Sweden RISE has written an in-depth analysis of co-locating refueling of clean fuels (Interim report: Multifuel energy stations for cars, buses and trucks (2018) E. Wiberg and P. Bremer).

The report, which is the main source of this chapter on multifuel energy stations, can be found at www.scandria-corridor.eu and contains details on co-locating fuels with a focus on safety risks concerning explosivity as well as positive synergies when combining clean fuels.

### 3.1.2 What do we mean with a multifuel energy station?

The term "multifuel energy station" (MES) has no clear consensus in the Northern Scandria®Corridor-countries Finland, Sweden, Norway, Denmark and Germany. In general, the term seems to be used for marketing rather than to form continuous reliable fueling networks.[18]

Terms which are found are, translated:

- *Energy station;*
- *Multifuel energy station;*
- *Alternative fuels refueling station;*
- *Multi energy filling station.*

[16] https://ec.europa.eu/clima/policies/transport/fuel_en (2018-08-10)

[17] Please note that there are other types of clean fuels, such as Ethanol, methanol and HVO which has not been included due to limitation in project scope. Also note that technological development can change the fuel division above, meaning for example that fast charging can be a viable option for trucks or liquified hydrogen for buses. The division above is based on the vehicles power requirement, fuel storage capacity on the vehicle, available infrastructure and cost of fuel.

[18] Interim report: Multifuel energy stations for cars, buses and trucks (2018) E. Wiberg and P. Bremer

The study, conducted by P. Bremer and E. Wiberg, studies three different types of multifuel energy stations:

- Cars
- Trucks
- Buses

Each station contains at least two of the following clean fuels: hydrogen; natural gas/biogas; liquified hydrogen and liquified natural/biogas and electricity. The latter not per se a type of fuel, but rather a form of energy, hence the word “energy” included in the term Multifuel energy station.

### 3.1.3 Which fuels do we include in the three station types?

Fuels included[19] in the study of each multifuel energy station are:

| | Hydrogen | Natural gas/biogas | Fast Charging of electricity | Liquified hydrogen |
|---|---|---|---|---|
| **Cars/light trucks** | X | X | X | |
| **Trucks** | | X | | X |
| **Buses** | X | X | X | |

### 3.1.4 Which problem will a multifuel energy station solve?

Multifuel energy stations has been studied due to the projected gap between supply and demand for clean fuel infrastructure in a corridor perspective for some of the clean fuels. It is important to try to balance supply and demand meaning both clean fuel infrastructure and clean fuel vehicles. Often the supply-side goes first and then it is filled demand side with a vehicle fleet running on clean fuels. One way to secure a balance is the public-private cooperation described in section 4 below. The public partner (often a municipality) can create an almost break-even solution by ordering and running their own public transports and waste disposal trucks by the clean fuels provided by the clean fuel infrastructure build. In this way the public partner shows the private sector that it all works fine and how to do it. A MES can support and help the supply-demand balance and show the public and private actors that it works. In some cases, where MES are build as a rebuilding of a conventional station, it is also showing the users of fossil fuels that it works fine.

Based on the idea that the Northern Scandria®Corridor should allow for all clean fuels to thrive this means that the local demand for one clean fuel could be much smaller than the local supply of clean fuel infrastructure. For example, the number of CBG/CNG vehicles in the Northern Scandria®Corridor part of Norway was less than one percent of the vehicle number in the Northern Scandria®Corridor part of Sweden. Yet, Norway would still have to offer CBG/CNG to the very few Norwegian cars as well as cross border traffic. The fuel industry play an important role to seek for the balance as the clean fuels are introduced along with conventional fossil fuels.

[19] **Cars/light trucks**: hydrogen (CH2), natural gas/biogas (CNG/CBG), fast charging; **Trucks[19]**: liquefied natural gas/biogas (LNG/LBG), liquified hydrogen (LH2); **Buses[19]**: hydrogen (CH2), natural gas/biogas (CNG/CBG), fast charging

The same goes for LBG/LNG which is a fuel used by heavy duty trucks, and currently there are few stations built. To allow for cross border traffic in the Northern Scandria®Corridor for these heavy-duty trucks every country must be able to supply LBG/LNG.

A profitable business case for a new clean fuel refuelling station with low local demand is obviously difficult to find. Especially if every clean fuel has its own station and 2/3: s of the profit comes from other things than selling the fuel.[20]

## 3.2 Status of multifuel energy stations

The following sub headlines shall guide decision makers in understanding possibilities and barriers of introducing multifuel energy stations in their municipality along the Northern Scandria®Corridor. Using the interim report "Multifuel energy stations for cars, buses and trucks" (2018) by E. Wiberg and P. Bremer the following chapter goes through the market demand and supply for clean fuels, economic implications, spatial planning, technical and safety aspects and policy.

### 3.2.1 Market demand and supply for clean fuels

As the number of clean fuel vehicles in the Northern Scandria®Corridor is increasing every year we can conclude that there is an increasing demand for clean fuels.

On the supply side, the European Commission concludes that the deployment of infrastructure for alternative fuels in the European Union has recently gained momentum.[21] Looking at the Northern Scandria®Corridor a vast increase of electricity charging stations shows.[22] The supply of hydrogen and biogas/natural gas filling stations is however not as evident due to the limited total number of and small increase in vehicle demand. Despite the ramp-up for the deployment of infrastructure for clean fuels, the European Commission also concludes that the level of ambition for clean fuel infrastructure described in the DAFI-reports (please see report introduction) differ significantly between countries and is in some ways inadequate for the high ambitions low and zero emission mobility of the European Union.[23]

Hence, the predicted future is that the supply of clean fuels will not meet demand. Turning our focus towards the Northern Scandria®Corridor, the development is too slow to reach the desired national and EU/EEA targets for reduction of $CO_2$ emissions from transport.[24] The EU must accelerate the deployment of clean fuels.

The idea of a multifuel energy station is a station where clean fuels can thrive side by side and be offered also in smaller amounts and not be spread out at different locations with their own business plan to be

[20] https://www.klimaoslo.no/2017/03/24/energistasjoner/ (2018-08-07)

[21] COM(2016) 652 final, Communication from the commission, Towards the broadest use of alternative fuels – an Action Plan on Alternative Fuels Infrastructure under Article 10(6) of Directive 2014/94/EU, including the assessment of national policy frameworks under Article 10(2) of Directive 2014/94/EU

[22] Assessment of Clean Fuel Deployment and Market Access of Clean Fuels in the Norther Scandria Corridor, Gjerlöw J.C, Akershus County Council; Cornander C, RISE Research Institutes of Sweden (2017)

[23] COM(2016) 652 final, Communication from the commission, Towards the broadest use of alternative fuels – an Action Plan on Alternative Fuels Infrastructure under Article 10(6) of Directive 2014/94/EU, including the assessment of national policy frameworks under Article 10(2) of Directive 2014/94/EU

[24] Assessment of Clean Fuel Deployment and Market Access of Clean Fuels in the Norther Scandria Corridor, Gjerlöw J.C, Akershus County Council; Cornander C, RISE Research Institutes of Sweden (2017)

met. In an interview with the online paper *KlimaOslo* the manager for Circle K Ökern (a refueling station which offers several different clean fuels) stated that 2/3 of the station's income is from other things than selling fuel.[25] Refueling stations has become service centers, affecting the business case (read more under 3.2.2 Economic Implications). This means that when the market demand for service stations at refuelling/energy stations with the most common fuels of the region has been met, the meeting of ends of the business case for the less requested fuels in a regional perspective, but high in a corridor perspective will be rather difficult.

For example; we see a much larger request for biogas in Sweden than in Norway and vice versa when it comes to hydrogen. The idea of a sustainable transport corridor would however require that clean fuels would be offered in all sections along the corridor, and the supply would depend on the demand of the traffic along the corridor, as well as the close-by residents.

There are currently not enough multifuel energy stations in the Northern Scandria®Corridor to be able to draw any conclusions from an operations point of view.

The table below is a list of planned Multifuel Energy Stations (September 2018).

| Name and place | Fuels offered | Status |
|---|---|---|
| Circle K Ökern in Norway | petrol, diesel, synthetic bio diesel, bio ethanol, fast charging (no gaseous fuel). The station used to offer hydrogen as well, but due to low market demand this is not offered anymore. | Operational |
| OK in Brabrand, Denmark | Hydrogen and fast charging | Operational?? |
| TOTAL in Germany (several stations) | hydrogen, charging, petrol diesel and some also integrates natural gas and Liquefied Petroleum Gas | Planned |
| Winter test arena for vehicles Arjeplog in Sweden | hydrogen, gaseous and liquid fuels | Planned??? |
| Uno-X Ås in Norway | hydrogen, fast charging and liquid fuels | Planned |
| Uno-X Skedsmo in Norway | hydrogen, fast charging and liquid fuels | Planned |
| Alnabru/Oslo in Norway | fast charging, compressed and liquified biomethane, hydrogen and biodiesel | Planned |

[25] https://www.klimaoslo.no/2017/03/24/energistasjoner/ (2018-08-07)

| | | |
|---|---|---|
| Finland: No stations are known to current date | Vaihtoehtoisten polttoaineiden tankkausasema, “Alternative fuels refueling station” | Proposed by Woikoski |

### 3.2.2 What can be said about economic implications?

As the report of RISE i covering only partial the economics of MES and there are uncertainties regarding the safety distances and therefore the amount of land use needed, it is quite limited possibilities analysing the economics of MES.

One of the main arguments for a MES concept is that the synergies between different clean fuels, and between conventional and clean fuels, are strengthened. This makes the introduction of clean fules easier, as the vehicle users see how it works with clean fuels at the station. As many types of vehicles and fuels are handled at the same station, the MES turns out as a show case making it easier to see and adapt for new users.

Further harmonization is needed as there are no consensus of the term MES in Finland, Norway, Denmark, Sweden and Germany at the moment. Further work needs to be done in order to establish a usable concept of MES. Then it can be standardized and spread around Europe. Without a ready concept fewer MES might being build. Safety distances for fuels in a MES vary a lot between countries and needs to be harmonized in order to get a clear picture of what areas of land use that are needed for safety at the stations. If larger safety distances are needed, this will make the cost for land use to increase, making it even harder to establish profitable stations. We pose a number of relevant questions that needs further investigation below that we find important:

- *Which combinations of clean fules exist that are most suitable in terms of safety distances and land use for an MES?*
- *What is the optimal combination of clean fuels in a MES?*
- *Synergies between the different fuels at a MES might be stressed further as a concept.*
- *Charging points for electrical vehicles are often placed where grid connections are strong and already exists or are at close range. What are the influences of this?*
- *In what ways are a MES different from a traditional station as of today with a mix of fuels?*
- *Are there other synergies with economic implications added in a MES (services etc.)?*
- *Fuel distribution might be more effective, and several fuels can even be converted on site. What are the economic implications of this?*
- *What are the possibilities and advantages of building fast charging and hydrogen production?*
- *What does the economics look like regarding* technical service of equipment that can be more cost effective as travelling time for personnel can be reduced when i.e. one technician can service both methane and hydrogen equipment?

### 3.2.3 Comments from the fuel industry in Sweden

This section covers the SPBI comments on MES and some issues in general based on interview.

According to interview with Ulf Svahn at Svenska Petroleum & Biodrivmedel Institutet (SPBI), the petroleum and biofuel industry organisation in Sweden, it takes very large investments to introduce clean fuels and MES in a large scale in Sweden. Introducing new alternative fuels takes a lot in terms of transports, logistics, infrastructure, stations and fuels, and the same time phasing out older conventional fuels. A critical mass of market base is needed in order to take the risk perform the investments. The industry has been striving for a long time for strong political signals and decisions regarding clean fuels in Sweden, and political signals are needed to lower the risk of the large investments. Sweden is a small country, meaning that the vehicle industry will not work out specific vehicles for the Swedish market.

The vehicle industry needs a larger global or European market, including political decisions, for clean fuels, in order to work out new vehicles in large scale. The vehicle industry needs large market shares to economically motivate the research and development of new type of vehicles. As both fuels, vehicles and infrastructure are needed to get the market for clean fuels going, it can be expressed as a type of Catch 22/hen-and-egg-problem in terms of supply and demand, meaning they need to go hand in hand.[26]

The industry in Sweden are not discussing the concept of MES - multifuel energy station at the moment according to Ulf Svahn at SPBI. SPBI further stresses that fact that there is a risk of closing down of a lot of small stations I rural areas due to poor profitability. The MES concept are most suited for rebuilding of larger stations near big cities and main highways, mainly for economic reasons. Large stations are often owned and run by bigger enterprises in different organizational forms. The run their business on large volumes of fuel sold and a lot of the profit originates from other services. Investments in infrastructure for new clean fuels are costly for each station, making it even more important with large volumes and/or higher profit margins. The smaller stations at the countryside should not be neglected making it too far to the nearest station. MES are not likely at the countryside given the circumstances today. It is most likely that MES will be build around city areas and along the highways since a large market base is needed in order to make it profitable and economically viable. The Scandria®-Corridor is therefore considered to be covered.

A differentiation of fuels is needed when going forward and at the same time strong and clear political signals durable over time is also needed to get this going. All fuels mentioned in this report are important along each other. SPBI also stresses the importance of lignin-based diesel and petrol that might be important as we go forward. The market for HVO can play an important role at the outset but in the long run it is not durable as the resource base is often a result of residue materials. Today Sweden demands 50 percent of the global production and 65 percent of the European production.

### 3.2.4 Spatial planning

Meeting the demand for clean fuels in a corridor perspective would require more refuelling stations to be constructed, also for those fuels with little demand. The advantage of a multifuel energy station would be that it gathers the needed space of several clean fuel refuelling stations and use less space in total. In theory. A few obstacles must be considered:

- For the first: when combing fuels safety measures must be taken. This means that you need a certain distance between fuels to avoid explosions, for example.
- Secondly: The Northern Scandria®Corridor-countries require different distance to nearby facilities and roads.

It is therefore, only using the information above, impossible to argue that the space required for three different clean fuel refuelling stations which can be implemented in the Northern Scandria®Corridor is larger or smaller than the space required for one multifuel energy station including the same fuels. The multifuel energy station would however only have on service centre, instead of one for each individual station given that this is the main source of income for refuelling stations.

The table below exemplifies the difference in safety distances for hydrogen in two Northern Scandria®Corridor-countries[27].

[26] Telephone interview 3 September 2018 with Ulf Svahn at SPBI

[27] According to ISO/TS 19880-1

| Safety distance | | Germany | Sweden |
|---|---|---|---|
| **INSTALLATION LAYOUT DISTANCES** *The installation lay-out distance is the minimum distance between the various units of the main equipment of the hydrogen installation required to prevent units causing damage to one another in case of incidents.* | Between Sub-Systems / Equipment of any kind | 1 m<br>Vessels without opening 0,5 m | 1 m |
| **PROTECTION DISTANCES** *The protection distance is the minimum distance required between the instal-lation/equipment to be protected of the possible source of an external hazard (e.g. a fire) to prevent damage*. | Presence of (liquid) combustibles above ground (like gasoline storage or tank truck) | 5 m | 50 m |
| | Private or public road (Collision by a vehicle, either present at the fuelling station or passing by a nearby road). | | 10 m |
| **CLEARANCE DISTANCES** *The clearance distance is the minimum distance between the potentially hazardous installation/equipment and the vulnerable targets within the fuelling station. Here, the hy-drogen installation is regarded to be the source, while the surrounding people /objects are considered to be the targets.* | Gasoline storage | 3 m | 25 m |
| | LPG storage | 8 m | 25 m |
| | CNG hazardous elements | | 12 m |
| | Bulk liquid oxygen storage | 5 m | 12 m |
| | Building inside the plant | | 12 m |
| | Building of combustible material | | 12 m |
| | Building openings/windows/access doors | | Same as for buildings in general |
| | Air intakes/ventilation | Out of hazardous area | Outside of hazardous area |
| **EXTERNAL RISK ZONE** *The external risk zone is the distance (or area) outside the fuelling station which has to be protected against hazards caused by the hydrogen installation. Here, the H2installation (i.e. dangerous units thereof) is clearly the hazard source, while people and constructions offsite are regarded to be the target(s).* | Public Road | | 10 m<br>(up to 50 km/h) |
| | Parking | | 6 m |
| | School/Hospital/ Place of public assembly/Other | | 100 m (exits from difficult to evacuate buildings) |

If a multifuel energy station is to allow for large safety distances, land use would be a problem in densely populated areas due to high land and real estate prices. It might even be easier to find several smaller areas to locate individual refuelling stations. On the other hand, the individual stations might then not even exist due to a low demand of a fuel. (Please read more under Economics 3.2.2)

As the current situation is one cannot construct a multifuel energy station for one country which could then be copied to another country, due to these requirements. Therefore, an important prerequisite for facilitating the deployment of infrastructure for multifuel energy stations is to develop internationally harmonized technical specifications for multifuel energy stations.

Different solutions can be considered:

- Apply reduced safety distances based on e.g. risk assessment or use fire resistant partitions/walls, if allowed by the applicable requirements
- Use equipment for the fuel with the most severe explosion related properties[28]

Both options must be balanced with the cost of the options.

According to SPBI it is most likely that the main part of the MES will be built as rebuilding projects of already existing stations owned by the larger companies in the industry due to economic reasons as mentioned above in section 3.2.3. This will be done by adding two alternative clean fuels at the station.

### 3.2.5 Technical and safety aspects[29]

To read the full overview on positive synergies as well as which incompatibilities must be overcome to ease barriers for the deployment of multifuel energy stations, please read chapter 7.2.5.1 in the Scandria2Act interim report “Multifuel energy stations for cars, buses and trucks”.

From the few market cases we can agree that it is possible to construct a multifuel energy station. P. Bremer and E. Wiberg also concludes that from a safety point of view it is possible to build a multifuel energy station including hydrogen (compressed and liquefied), electricity and biogas/natural gas (compressed and liquified).

Combining clean fuels gives several advantages. No major safety-related obstacles related to explosion risks have been identified in the study. This means that safety-wise, when it comes to the risk of explosions, there is nothing which prevent combining the clean fuels mentioned with each other or with conventional fuels in a multifuel energy station[30]. However, as written under 3.2.4 Spatial planning, the vast differences in safety distances in between countries does complicate the multifuel energy station concept.

When constructing a multifuel energy station there are certain things that should be kept in mind regarding safety when adding new fuels to a fuelling station, e.g. when it comes to explosion: fuels are categorized within equipment and temperature groups. One clean fuel’s explosion-protected equipment may not be suitable for another fuel.

To overcome some difficulties the multifuel energy station’s equipment should be designed to meet the requirements compatible with the most severe properties of possible fuels foreseen to be used. This needs of course to be balanced against the availability of such equipment and any increasing costs for a higher equipment classification.

If we look closer at the synergies in combining fuels the idea of combing fuels is partly to increase exposure and public awareness to make it obvious for vehicle users that there are alternatives to traditional fuels, but also that by combining fuels at the same filling station it is possible to reduce costs and increase efficiency.

[28] Interim report: Multifuel energy stations for cars, buses and trucks (2018) E. Wiberg and P. Bremer

[29] Interim report: Multifuel energy stations for cars, buses and trucks (2018) E. Wiberg and P. Bremer

[30] Best practice according to applicable international standards and specifications must of course be considered in a competent way. Interim report: Multifuel energy stations for cars, buses and trucks (2018) E. Wiberg and P. Bremer

### 3.2.6 How can policy be an enabler or disabler?

For each clean fuel included in the multifuel energy station there are international standards/specifications to be used. Some of the international standards/specifications are not fully harmonized as national standards in the Northern Scandria®Corridor-countries. Moreover, there is no common international standard for combining the fuels in a multifuel energy station.

EU directives applicable for safety related aspects of refuelling stations can roughly be divided into the following two categories:

- **Product directives,** to be considered for the design, production and trade of products, by manufacturers, importers and distributors
- **User directives,** with safety requirements for workers, to be considered for the installation and operation by employers and users

In addition, there are also other directives which are more or less related to safety such as the directive 2008/68/EC for inland transport of dangerous goods.

Following the Directive 2014/94/EU related to the deployment of alternative fuels infrastructure issued by the European Parliament and the Council of the European Union some of the international standards/specifications will form basis for coming European standards, which will be implemented as national standards/specifications in the ScanMed-countries.

However, there are differences between the countries related to installations (e.g. safety differences) and procedures for permit, notifications and inspections. National requirements for installation, use, maintenance, permit etc. of a refueling station may differ between countries and are additional to those of common European Standards (on which the national standards are based on).

“There are a number of common European generic standards which are implemented nationally in the actual countries including harmonized standards for the design and testing of explosion protected equipment, and for the installation, use, maintenance etc. of such equipment. The identified fuelling station standards for clean fuels refer to such European standards or corresponding international standards (on which the European standards are based on) to a high degree. This facilitates and paves the way for common requirements for multifuel energy stations, which facilitate the establishment of such stations in the actual countries (SE, NO, DK, FI and DE)”

For each fuel specific portion of a multifuel energy station, there are suitable international standards and specifications to be used. However, some of the international standards/specifications are not fully harmonized, as national standards/specification in the actual countries (SE, NO, DK, FI and DE). Some will form basis for coming European standards, which will be implemented as national standards/specification in the actual countries (SE, NO, DK, FI and DE). There are also some differences between the countries according to national provisions and code of practice, related to installations (e.g. safety distances for hydrogen stations) and procedures for permit, notifications and inspections.

However, member states of EU and EEA are not allowed to apply additional health and safety requirements for the design or additional verification of CE-marked equipment and assemblies complying with harmonized European standards. This is to allow free trade, without barriers, within the EU and EEA market. By the CE marking, the manufacturer certifies that the equipment fulfills the essential health and safety requirements.

Therefore, it is recommended to use CE-marked equipment and assemblies when designing a multifuel energy station. However, the national requirements additional to common European standard is a barrier

for the deployment of multifuel energy stations within the ScandMed-corridor. There are case studies[31] performed in 2012 of the establishment of hydrogen fueling stations in Norway which showed how such establishments can be facilitated be increasing operators' awareness and knowledge of the national differences and requirements.

Preferably, national guidelines should provide information and requirements supplementary to best practice according to national standards. These should be based upon common international standards. The complementary information should not duplicate or contradict requirements in the national standards but may cover requirements according to national provisions which are not covered by the standard. Such guidelines may also – in cooperation with the responsible national standardization organization – exemplify and clarify requirements in the standard.

Companies investing in multifuel energy stations, who cooperate and agree on certain standards/specifications to be fulfilled, can contribute to a harmonization in practice, be demanding such standards/specifications to be fulfilled in procurements.

From a corridor point of view, recommended is to develop a multifuel energy station standard, if possible due to differences on a national level, adopting it as a European standard and replace the current fuel specific standards for stations. The multifuel energy station standard would provide a common structure of requirements and methodology to be applied regardless of fuel type, facilitating the design and verification of a multifuel energy station. Available standard(s) make it easier to work out a concept of MES.

## 3.3 Findings and recommendations

These are the key findings for multifuel energy stations:

1. We have found that it is possible to build a multifuel energy station, and that combining fuels gives several advantages.
2. The definition of multifuel energy stations differs considerably, and there are very few such stations.
3. It is recommended that an international ISO standard is to be developed for multifuel energy stations for vehicles (MES) and adopt such a standard as a European standard.
4. Fuel distribution can be more effective, and several fuels can even be converted on site (i.e. hydrogen from electricity or methane)
5. Resources can be used more efficiently, e.g. electrical grid used for fast charging can be balanced by hydrogen production in an optimal way.
6. Customer services such as restaurants and restrooms can be shared which decreased costs.
7. Maintenance and inspection of equipment can be coordinated in a cost-effective way e.g. travelling time for personnel can be reduced when one technician can service both methane and hydrogen equipment.
8. Safety wise it is feasible to build the three refuelling stations proposed in the study if the correct safety measures are being taken.
9. It has been found that certain technical aspects for a multifuel energy station are well harmonized by international standards and European provisions (e.g. generic standards for explosion protected equipment), while other technical aspects are not.
10. There is a lack of a common harmonized specification of technical requirements for multifuel energy stations, which takes into account safety aspects related to the interaction of different

[31] Certification and approval procedures in Scandinavia for hydrogen fuelling stations and fuel cell electric cars, P. Bremer and T. Berg, SP (2012) *and* Safety in storage, handling and distribution of liquid hydrogen, EIGA DOC 06/02/E

fuels and energies provided by a multifuel energy stations, and which equates the requirements for different fuels where possible.

Different requirements in different countries complicate the development of multifuel energy station infrastructure. Current national differences are recommended to be minimized as far as possible by a common European standard for multifuel energy stations, with normative requirements for installations (e.g. quantified safety distances) and classification of hazardous areas (e.g. quantified extent of zones). Such a standard should include clean fuels such as CNG, LNG, CH2, LH2 and electrical charging of vehicles, and also conventional fuels as far as possible.

Regarding the technical aspects and financing, the following is recommended:

- Further development in small scale reforming units as well as methanation would be of interest.
- Combining the production of H2 by electrolysis with fast charging on multifuel stations and optimising the way an electrolyser is controlled when operated in conjunction with a fast charger.
- Funding options for MES should also be further investigated, compared to funding of separate fuelling infrastructures.

The synergies according to these recommendations, can drastically affect the business case for renewable fuel. Therefore, a multifuel approach should be considered to improve the business case and lower the costs for infrastructure.

An important prerequisite for facilitating the deployment of infrastructure for multifuel energy stations is to develop harmonized technical specifications for safety aspects of such stations, according to chapter **Fel! Hittar inte referenskälla.** in the technical support document.

To initiate the development of an international standard for multi energy stations for vehicles (MES), it is recommended to develop a first draft of such a specification based on the experiences and results of this project on best practice for MES. Such a draft should then be submitted to ISO, with a request to start the development of an international standard for MES. In case ISO would not start such a work, there is the option to do this in a similar way on European level, by approaching CEN.

The following activities are recommended to be included in such a project, to develop a first draft standard for MES:

- Develop a structure for such a standard which aligns as close as possible to the structures of the existing ISO standards/specifications for fuelling stations providing clean fuels such as CNG, LNG and CH2
- Compile the requirements according to these existing ISO standards/specifications into a draft standard for MES.
- Add requirements related to LH2 into the draft standard.
- Add requirements related to electrical charging of vehicles into the draft standard.
- Examine the existence of appropriate standards/specifications for fuelling stations providing conventional fuels (international, regional or national standard/specification for petrol filling stations) and requirements in such standards. Examine the possibilities to include

requirements and/or aspects for such stations/fuels, into the draft standard for MES. Proceed and finalize the first draft standard for MES, based on the results of these examinations.

# 4 PPP-financing solutions

## 4.1 Introduction (relevance for the S2A-corridor)

The report presents cooperation possibilities between the private and the public sector that lead to good solutions as well as lessons-learned from experiences in Sweden. The importance of the public involvement in the development of clean fuel infrastructure is especially highlighted. Clean fuel infrastructure includes distribution facilities, charging units and filling stations.

The study includes case study examples of clean fuel infrastructure investment projects covering the fuel types above from Sweden, with a focus on the Scania region, where available. Both passenger and freight transport are covered. The case studies are considered with respect to their transferability to other municipalities, with a focus on small municipalities: this means we highlight key points that need to be considered if another municipality is interested in establishing clean fuel infrastructure as described in the case presented in this report.

At the outset the mission was to seek for and apply the financing solutions in terms of PPP – Public-Private-Partnership Finance Models. As the cases was studied there were no PPP-solutions to be found in the relevant area. PPPs are usually on a large scale (several million euros capital investment) and a financial risk-sharing arrangement for large scale investments, and this was not to be fulfilled in the case studies. Focus therefore turned to public-private-cooperation for clean fuel investments. The cases available to study in this project reflects ways of cooperation and critical factors for success.

## 4.2 Read the full report

Anna Clark, Alexander Börefelt, Sebastian Fält at Trivector Traffic performed the work of the report in association with Ola Mattisson FEH, Lund University for the responsible partner Region Skåne and Skåne Association of Local Authorities in the project. Interim report: Technical Support Document – Cooperation between Public and Private Partners in Investment of Clean Fuel Infrastructure (2018)). The study analyses the conditions and critical factors for a fostering and deployment of clean fuel infrastructure based on public-private cooperation in smaller municipality.

The report, which is the main source of this chapter of public-private financing of clean fuel infrastructure, can be found at www.scandria-corridor.eu and contains details on public-private financing and cooperation based on case studies I small municipalities.

## 4.3 Which problem in the corridor will this solve?

The study and public-private cooperation for clean fuel infrastructure aims to support, deploy and foster the development in the municipalities along the Northern Scandria®Corridor. Findings of the study can be used for guiding this work in other regions, and hopefully strengthen and create new initiatives. By public-private cooperation risks are getting lower by risk sharing, mistakes avoided, and better conditions created for long run solutions. Hopefully the case studies and the findings can make neighbouring municipalities start to cooperate, combining resources, vehicles, infrastructure. This strengthens the deployment and fostering of clean fuel infrastructure by creating proper conditions for a long run build-up of these new markets.

### 4.3.1 PPP not valid

The findings from this study show that there are no public-private-partnership (PPP) financing models for clean fuel infrastructure in Sweden. By PPP financing models, we mean examples of public-private-partnerships which are built in order to finance projects whereby partners jointly own and take the risk (risk sharing) in the investment as well as running the infrastructure when established. The lack of PPP financing model examples is due to the fact that the infrastructure is on such a small scale compared to examples in the literature which usually refer to multi-million Euro investments which *require* funding from several partners. The cases studies found, and the limitations set to municipalities less than 100 000 inhabitants, makes the PPP not applicable. In the case of clean fuel infrastructure, the financial burden of establishing infrastructure can generally be carried by a single organization.

### 4.3.2 Organisational forms and cooperation

As markets for alternative fuel are not mature and completely established in a comparison to other markets such as those for example conventional fuels and vehicles and the infrastructure and logistic systems, special attention needs to be addressed to how to foster and deploy new virgin markets. One way of doing this is to base it on public-private cooperation in some form. Therefore, the organizational form is relevant in order to show the facts and arguments for how to organize public-private cooperation of clean fuel infrastructure. In the following sections we cover the organizational forms existing in Sweden.

In establishing clean fuel infrastructure, a new organization often needs to be created that owns and runs the infrastructure. The type of organizational form matters because it sets out the kind of cooperation that can be made among partners, and how it can be developed in the long term. In general, there are different legal forms to choose from, and which is most suited depends on the situation. Below are descriptions of different available legal forms in Sweden. The two most common forms, which also appear in the case studies, are described more fully, followed by a brief presentation of the use of contracts (instead of legal forms), and then a short description of other available legal forms which do not feature in the case studies.

#### 4.3.2.1 Other organisational forms

Other organisational forms relevant for Sweden consists of non-profit organisation, foundation and trading partnerships and limited partnerships are not the most suitable forms of organisation for economic activities and for infrastructural projects. Other existing forms of organisation are limited company, economic association and regulating contracts which are described below. In the cases studied the most common organisational form is limited company and economic association, and examples of regulating contracts can be seen in the cases.

#### 4.3.2.2 Limited company

The most common form for initiating joint activities is a limited company (in England denoted “Ltd”, in Sweden denoted “AB”). It is regulated by private law and constitutes a legal entity of its own. This kind of organization has a long history, and a framework has been developed over time giving today a clear distribution of roles and responsibilities in the business. It is regulated by The Companies Act stipulating that Owners' liability is limited only to the share capital invested in the company. Ownership is exercised by appointing the board, where the influence is distributed in relation to the ownership of voting shares. In return, the legislation stipulates rules to guarantee reasonable shareholder transparency in the company.

Studies of limited liability companies in relation to public bodies show that they work well and that there are advantages. The main advantages are:

- clarity in roles and mission: and
- possibility to create a separate economic entity specifying roles, rights and obligations for all stakeholders.

As a legal form, the limited liability works well to combine public and private interests. It is possible to mix financial resources from public and private bodies and still give each party influence in relation to share of ownership. Since the company accumulates capital over time, the economic value in the company (for the owners) might change over time.

Given that the economic value can change over time, it is important for the parties to agree at the outset regarding future changes; a consortium agreement specifies such terms, for example when additional partners enter, or existing partners leave. Thereby the parties eliminate the possibility that the mutual relationship of power changes as a result of the fact that any party sells its shares without the consent of the others. However, the form is heavy to administrate if there are a large number of owners (i.e. private persons).

#### 4.3.2.3 Economic association

An economic association is a legal entity and responsible for the activities in its own name. Economic associations are governed by special legislation supplemented by the association's statutes. The owners / members are solely responsible for the association's obligations in relation to the insured membership capital. The owners' mutual relationship and influence are governed by the statutes. In order to form an economic association, there is a need for at least three members. But on the other hand, the association cannot refuse someone to be a member as long as they share the interest of the association.

In addition, members are required to purchase, sell or otherwise use the association's services. The form appears to be possible to apply in public-private partnerships. It is especially well suited when there are a large number of stakeholders (members) since it has established procedures for individual members to enter and to leave the association.

It is possible for independent organizations to cooperate, for example within a project, by making agreements in contracts, and often this is also seen in network settings where several parties contribute in different ways in different parts of the network. But a contract/network solution provides a more complicated situation to divide financial risks. The organization that makes the investment will carry a higher financial risk, even though it is possible to agree upon sharing it. Looking at operational matters, contracts could be a good way to cooperate in terms of securing supply of input goods, or securing a customer base, from the facility invested in.

There are two elements that are primarily agreed in contracts:

1. Guaranteeing sales volumes
   For example, an agreement of buying a certain amount of fuel if a refueling station is built.
2. Sharing of tasks / competences / resources
   This can be quite wide-ranging and provides a way for the organization to take advantage of competences or resources which they do not have themselves, usually in a mutually beneficial way. For example, in using food waste (a resource) to produce biogas in exchange for reduced price biomethane.

## 4.4 Case presentation

The report describes 5 case studies of cooperation between public and private actors in the establishment of clean fuel infrastructure. Each case study includes:

- **A short description** of the clean fuel infrastructure which includes when it was set up, where it is located, what the driving forces were for the establishment, and other relevant details regarding how it is run.
- **A description of the cooperation between public and private actors** which describes the organizational form used for the infrastructure; the key relationships and contracts needed to set up the infrastructure as well as how the cooperation was established, and who owns and runs the infrastructure.
- **The market for the infrastructure** which describes the customers for the infrastructure.
- **Lessons learnt / transferability** to other municipalities. This section highlights the main lessons learnt *as highlighted by those interviewed*, and takes up several elements related to transferability of the experience to other municipalities focusing on:
    - Legal framework
    - Continuity of fuel policies, incentives, strategies
    - Possibility for smaller municipalities to do replicate
    - Constraints to transferability

The case studies were chosen to cover the different fuel types of relevance to this study. The aim was to take case studies from the Scania region which included examples of public-private cooperation, but the search was extended to other parts of Sweden (still located on or near the Northern Scandria®Corridor) when examples could not be found in the Scania region. These acts as good concrete examples.

The information for the case studies was collected primarily through interviews. Other material has also been reviewed to support the interview descriptions, including available reports from the websites from the projects described (e.g. GREAT and HIT-2-Corridor). The description is therefore a summary of this information, written within the context of this report.

The 5 case studies are:

1. Biogas Ystad-Österlen: biomethane refuelling stations (Scania region)
2. Hydrogen refuelling station in Gothenburg
3. CBG production facility in Linköping
4. Electric fast chargers within the GREAT project in Scania region
5. LBG refuelling station in Helsingborg (Scania region)

## 4.5 Transferability

All cases har more or less transferable to other municipalities and regions. There are specific local conditions of for example resource base for some of the clean fuels, close access to grid capacity connecting chargers, etc. that needs to be bear in mind when adapting the planning of the clean fuel infrastructure at different places along the Scandria®Corridor. Market base for the investment is crucial making it the business case viable. Existence of both public and private partners are available along the Corridor and near the city areas, creating conditions for cooperation and risk sharing.

All cases act as good examples of how to manage these clean fuel infrastructure investments. It is important to adjust each project to the local conditions in many aspects in order to make it work out and show up a viable business model over time. The most important aspect of transferability is the arrangements of-, and the cooperation itself between public and private partners when performing these types of high-risk investment on virgin markets. The public sector plays a crucial role by going in the forefront, reducing risks and by creating their own market by running public transports, waste disposal trucks etc. in their own municipality regime, showing that it works.

Regarding transferability and economics one can say that investments of this kind are high risk, both in terms of level of investment but also in terms of the market risk. The investments are often at a high level of risk and financing for both public and private by themselves and often an obstacle. The cooperation makes it possible for both public and private partners as the go together in cooperation in these investments. If public go in the forefront and bears a large share of the investment, the private partners can join at lower risk. The private partners would often not perform these high-risk investments by themselves. Risk sharing is a key to success in this case and are in general transferable everywhere.

Policies can also be transferable in a sense. Local policies are important by setting goals for renewables, better air quality, reducing CO2-emissions etc. municipalities play an important role setting the goals and framework, and this can be strengthened by collaborating with neighbouring municipalities. The framework itself is also transferable. Analogies can be made regarding regional- and national goals and frameworks as above.

## 4.6 Market risk and risk sharing

Public-private cooperation creates better conditions for development of clean fuel infrastructure itself, but also for the build-up of the virgin market of both fuel and vehicle users. This arrangement lowers risks by risk sharing based on baring different shares of the investment. This makes the economics of the market plan and business case more stable and profitable. The public sector play an important role by going in the forefront by for example baring a large share of the investment and at the same time adding demand by vehicles using the clean fuel in public transports etc in the municipality.

Important to note is that more or less all clean fuels in this study are immature markets. This means there are not yet developed and consists so far by quite few:

- infrastructural installations
- quite few infrastructural users
- quite few existing vehicles
- quite few users of the combination of fuel and vehicle
- quite limited varieties of types of/models of vehicles
- quite limited development of nearby access to fuels and resources (biogas)

Therefore, the market risks are quite high at the outset, but the can be decreased as the market grows, this in terms of both infrastructure, vehicles, fuel and market demand/users. Therefore, it is important to keep in mind to foster both the supply side and the demand side of this new market, on infrastructure, vehicles, fuels and users, in order to reduce risk on a new unmatured market for alternative fuels. Prices will be higher initially, but they will decrease as the market grows. As the risk level is high at he outset the interest rates of project funding will be higher, therefore it is crucial for the public side to take the lead in cooperation with private actors.

There exists also a political risk that can be limited if chosen technologies are supported in the regulations and policies. Lack of long-term political decisions creates the same type of problems in this case as in the energy sector in general. Long term policies therefore reduce risk.

Choice of alternative fuel also reflects risk in a technical way. As more than one technology are developed as we go along, there are a risk for choosing an alternative fuel the will not grow as much in terms of market and therefore will reflect higher prices and higher risk in a comparison to other more mature alternative fuels. It is important to follow this development when starting up a project like this when the market pre-study and business case is made at the outset. It is out of scope of this study to compare these risks of the alternative fuels.

Diversification of customer base is also an alternative way of lowering risk. Users of both small and large vehicles, doing transport work for different public purposes such as public transport, waste trucks, service and maintenance cars for municipality activities, patient transport etc. If this is combined with different private company's transport work services and private household vehicles, the diversification creates better conditions for a further deployment and enlargement of the market as more private actors increases the demand.

Public funding from EU or national or regional level (for the pre study and or the investment project) is a way of reducing the needed public and private funding, and therefore the risk exposure. Often there is a 50/50 funding of these projects.

Further, a public-private cooperation tends to make the participation of the private side make the project more market oriented as the private partners in general are more market oriented. This tends to make the market risk to become lower.

By sharing the risk in a public-private cooperation the lead role of the public side reduces the risk for the private partners. If the public side takes the biggest risk making the biggest investments, this makes the interest rate of private funding lower. This can be expressed as well as a lower discount rate (or WACC – Weighted Average Cost of Capital) or lower requirements of private project pay back (time).

## 4.7 Recommendations

→ **Use public financing from EU or national or regional level if it coincides with your own goals for the region / municipality**

There is often funding available, and it is important to use this in order to stimulate both supply and demand since often sustainable business models cannot be established from the beginning. Public financing is needed to kick-start establishment when the market is not in place.

→ **Lobby higher levels of government to support relevant incentives and legislation**

The national governmental level especially (or regional if they have legislative power in your country) have a role to play in creating the right framework conditions to support the vehicle market for clean fuels. Use your lobbying potential to support this in the right direction.

→ **Use the tools at your disposal to support both supply and demand**

It is not just through financing that the public sector can support the private sector in establishing clean fuel infrastructure. Understand what the private sector are interested in and go from there: if demand for the clean fuels needs to increase perhaps behavioral change measures are important or legislation or regulations, networking opportunities, etc. The public authority has a role to play in setting the right framework conditions.

→ **Choose the right fuels based on the profile of your municipality**

It is important to have customers for the fuel, so the right fuel type needs to be considered for the area e.g. large amounts of freight transit traffic can benefit from LNG refueling station, or a highly innovative authority that is developing fuel cell technology may want to support hydrogen refuelling etc. Consider what matches your needs and profile best.

→ **Be your own customer**

Use your own fleets and the transport for which you are responsible – or that you contract – as a way to create a market for the alternative fuel infrastructure. Engage companies and civil society to do so as well. The public sector can be the pioneers adapting new technology to show functionality and support the adoption by others.

→ **Join resources with other public bodies**

This can be done for example by grouping several neighboring municipalities together that jointly invest in infrastructure. Coordinating choice of alternative fuel/fuels among neighboring municipalities is one way to make the market larger and possibly grow faster.

**Think long-term and business minded**

→ **Do a market analysis before you start**

It is important that the conditions are right in order to set up the infrastructure, and this should be studied before the work is done. For the examples shown here, it has quite often been possible to get funding to study the pre-requisites before embarking on pilots and establishment of refuelling stations. This should look at whether the conditions are appropriate for a sustainable business model to be established in the long run. The market analysis also needs to be repeated regularly once the infrastructure is established.

→ **Cooperate with the private sector to create a market**

The cooperation with the private sector can take various forms. It is important to have a dialogue with private partners to understand their needs and build a cooperation model that takes this into account.

→ **Diversify your customer base from the outset**

Diversifying the customer base buying the fuel reduces risk for the clean fuel infrastructure. For example, if there is only one customer and they decide not to retrofit their fleet as agreed, this creates problems for creating a sustainable business model.

→ **Use (research) projects**

Publicly financed cooperation projects between private and public sector enable different organizations to work towards shared goals. It also gives the possibility to involve the vehicle industry if new vehicle technology needs to be developed within a pilot project and allows public and private partners to share their (differing) competences and experiences with each other.

This can act as a promotion channel for the vehicle industry and may reduce their risk of introducing new vehicles in pilot cases. However, even within a research project, the business model should be considered at the outset otherwise it is likely that the pilot cannot be scaled up.

→ **Bind partners who will buy the fuels**

Without binding partners, there is a risk that the market will not be established. Binding of partners can be done for example by getting them to buy shares/membership in the infrastructure/association or getting them to sign contracts. This can be another way to share the risk and can help to define clearly the roles and responsibilities as well as financial input from different actors.

→ **Look at and communicate the benefits in a wider perspective**

Even if the return on investment is not clear, consider how the infrastructure contributes to wider societal benefits. The benefits for air quality, fuel independence, $CO_2$ emission reduction and job creation are important for public authorities but are not quantified when the cost of infrastructure is considered. It is important to consider these wider benefits and internalize the cost of externalities. Communication on the benefits can help to get continued political (and financial) support.

→ **Consider using a publicly owned company for investments**

This reduces the risk for the public authority and focuses the investment towards being market-orientated. If the authority then changes policy, it should be possible to sell off investments more easily. Using a publicly owned company rather than a private company also allows more flexibility in terms of return on investment, and more investments directed by policy rather than (solely) profit.

→ **Be prepared for changes in the popularity of fuel types**

Be aware that changes in the use and popularity of different types of clean fuels can change suddenly due, for example, to changes in policy, market, technological improvements of other fuel types etc. This is not always within your control. But prepare by building a resilient business model by diversifying costumers and close cooperation with other actors in the value chain.

## 4.8 Storytelling

The cases show good examples of how to cooperate in clean infrastructure investment projects, to start up a virgin market, important factors to bear in mind to create a good start up. By showing and spreading these case studies it fosters the development of clean fuels for others to adapt. In some cases, there are lessons learnt and to avoid in order to get a better hit rate for success.

# 5 Taking the next step: electrifying city logistics

## 5.1 Introduction

23% of EU's greenhouse gas emissions comes from urban transport. Many European cities have set ambitious targets to limit such transport. Urban transport is also an important reason why air quality is beyond limits in many cities.[32]

- In Athens, Paris and Madrid a diesel-car ban will be introduced in year 2025.
- German Jurisdiction made it in February 2018 possible for German cities to ban diesel cars.
- Oslo has a day-to-day based system for ban of diesel cars based on the daily city air quality.
- Larger Swedish cities regulates heavy duty transport in urban areas through environmental zones.[33]

This chapter focuses on electrified city logistics; a solution where coordinated city logistics is done with electric vehicles. This is an advantageous solution with many environmental benefits.

### 5.1.1 Read the full report about E-mobility in city logistics

P. Michalk at Technical University Wildau has written a report "Interim Report: E-mobility in city logistics" (2018). The report provides an overview of what to expect if a municipality is interested in introducing electric freight vehicles in urban logistics operations for example. The full report can be found at www.scandria-corridor.eu. It contains deep analyses and a step-by-step-guide which is working as a guideline to the actual purchase of battery-electric vehicles and it shows some good examples from the city of Berlin as well as other parts of the Northern Scandria®Corridor. The step-by-step-guide can be adjusted and further developed for alternative fuel vehicles as well based on the same type of logic.

### 5.1.2 What is an electrified city logistics solution?

Urban mobility is a highly prioritized area in the EU and low-emission mobility is an essential component shifting towards low-carbon cities. The European Commission strongly encourages the exchange of best practice and new techniques for cleaner and better transport in the cities[34]

At the same time freight transport is an essential part of a well working and sustainable society. These transports could be equalized to the human body's bloodstream and without deliveries of goods and the collection of reusable materials and waste the society would stop working at a very fast pace.[35] Due to digitalization the e-commerce is increasing[36] and it is of great importance that this e-commerce doesn't contribute to more emissions when more goods are being delivered in urban environments.

A viable option to lower the number of vehicles in the city, while not restricting deliveries is coordinated city logistics. Every year large amounts of goods are being transported from suppliers to buyers. These vehicles do not only contribute to air pollution, and $CO_2$, who damages the climate or particles, such as NOx, which affect our lungs and health.

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[32] COM (2016) 501 final, Communication from the commission, A European Strategy for Low-Emission Mobility

[33] DENA report (2018)

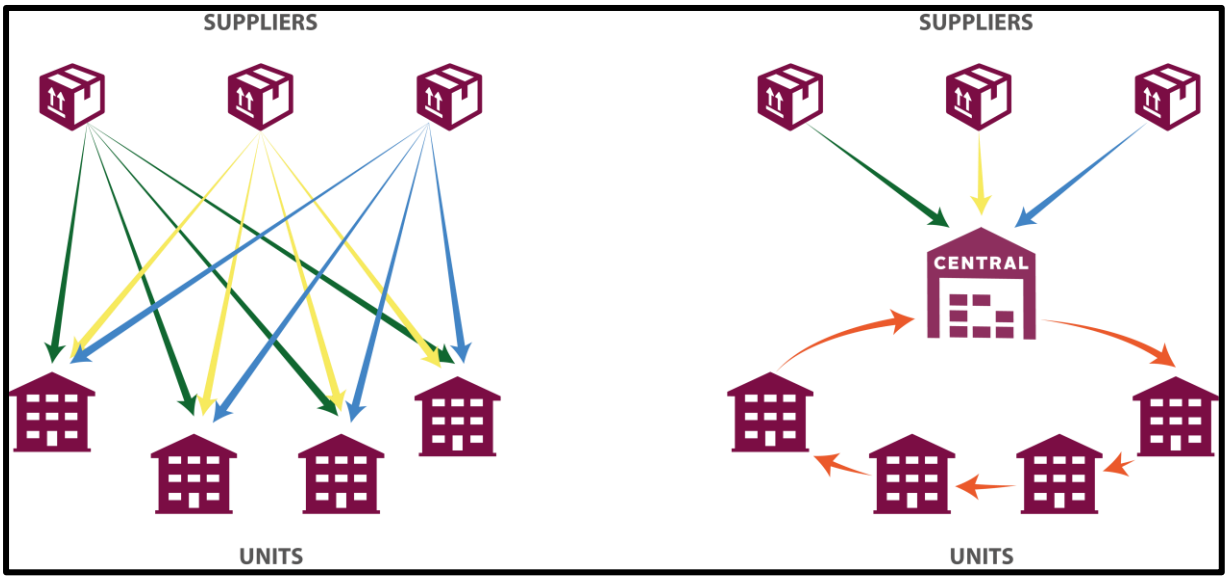
[34] COM (2016) 501 final, Communication from the commission, A European Strategy for Low-Emission Mobility

[35] Planera för urbana godstransporter (2017), Region Skåne

[36] http://ec.europa.eu/eurostat/statistics-explained/index.php/File:V1_E-sales_and_turnover_from_e-sales,_2008_to_2016,_EU28_(%25_enterprises,_%25_total_turnover).png#file (2018-03-28)

In Sweden there are many times more deaths caused by air pollution, that there are lethal accidents in traffic according to a study made by Swedish Environmental Institute 2014.[37] In the same study one analysis made regarding a hypothetical large-scale introduction of electric vehicles in the three big city areas in Sweden (Stockholm, Gothenburg and Malmö). Results indicated that the cost for introducing around 10% electric vehicles, 13-18 percent could be motivated only be the society related costs for air pollution related health effects in 2010. Traffic stands for the main part of these particles creating bad air quality besides wood-firing in Sweden. Toxic substances from traffic and particles from asphalt and rubber causes heart attacks, stroke, cancer, KOL, asthma, allergies and lower growth of lungs for children.[38] Hospitals, schools and city centres are some locations were the air pollution is especially sensitive or affected, deliveries are frequent and often, and/or humans especially vulnerable.

Coordinated city logistics is an advantageous solution which easily can be part of the solution in densely populated areas. Basically, it means that the suppliers deliver goods to a central unit and all goods can be delivered to the recipient at the same time. Many recipients are included in the route.




***Explaining coordinated city-logistics.*** **Source: Energikontor Sydost**

### 5.1.3 Which problems would electrified city logistics solve?

As 94% of the transport in EU depends on oil for its energy need, a coordinated city logistics solution might not be enough as a solution to be implemented in the Northern Scandria®Corridor, which after all is one of the most progressive parts of Europe in terms of deployment of clean fuel infrastructure and transport.

Coordinated city logistics could easily be deployed in both urban and sub-urban areas. A municipal or city organization is well suited for exploring the concept, and many city logistics examples from the Northern Scandria®Corridor can be found[39]. Coordinating the goods logistics for the deliveries to the

[37] https://www.ivl.se/download/18.343dc99d14e8bb0f58b5144/1443172332789/IVL+B2197_Exponering_2010.pdf

[38] https://www.svt.se/nyheter/inrikes/fororeningar-dodar-fler-an-trafiken

[39] http://www.kosava.se/ (In Swedish) 2018-03-14

municipal activities is already being done by a number of municipalities in Sweden. The positive effects are both environmental and economic.

Electric mobility is especially well suited to lower the local environmental noise and air quality impact made by urban transport as well as cutting GHG emissions.[40] Several European cities have already, successfully, applied different approaches in introducing electric mobility solutions into urban logistics-operations. Using an electric vehicle instead of other clean fuel vehicles is advantageous in areas without many different clean fuel solutions in place, as the electric grid infrastructure for electric vehicles is already in place.

Electric mobility in city logistics should especially be considered in urban and sub-urban areas which would like to minimize traffic from delivery services as well as lower the air-pollution both locally and globally. Electric mobility solutions are best fitted for densely populated areas due to driving range limitations. It is an easy, ready to use, solution and there are several real case examples which can be copied.

It could also boost the number of charging stations, however P. Michalk concludes that the city logistics vehicles would probably be charged during night time. This implicates that fast chargers wouldn't be necessary, merely slow or medium chargers.

Please note that the coordinated city logistics makes one important part to tackle the problem with GHG emissions and city air pollution by making the logistics more effective as the volume of goods increases. At the same time, the Electric mobility solutions also tackle the problem with GHG emissions and city air pollution as the electric, and other clean fuel vehicles, replaces conventional fossil vehicles for transports. Combining coordinated city logistics and electric mobility solutions creates a larger environmental impact.

## 5.2 Status of e-mobility in city logistics

The following sub headlines shall guide decision makers in understanding possibilities and barriers of introducing electric mobility in city logistics in cities along the Northern Scandria®Corridor. Using the interim report "E-mobility in city logistics" (2018) by Philip Michalk at TH Wildau the following chapter affects market, economy, spatial planning and infrastructure, technology, policy and environment.

### 5.2.1 Market: has the concept been tried before?

Combining electric mobility with a city logistic solution has already been tested and applied by several European cities. The interim report "E-mobility in city logistics" by P. Michalk, TH Wildau explains six different approaches in introducing electric-mobile solutions into urban logistics operations. The German Government made in 2009-2013 a large-scale effort and therefore four out of six cases are from the Berlin capital region.

Coordinating freight transport in urban areas is a complex area, but there are many examples of regions, municipalities and cities which can form great examples. In Sweden, year 2016, 30 municipalities in Sweden had coordinated their internal freight transport.[41] Berlin has many great examples of introducing electric mobility for such transports, some of them are listed below.[42]

[40] Interim Report: E-mobility in city logistics, Michalk P; TH Wildau, (2018)

[41] Planera för urbana godstransporter (2017), Region Skåne

[42] Interim Report: E-mobility in city logistics, Michalk P; TH Wildau, (2018)

**Selected e-mobility projects in the ScanMed-corridor:**

| | Description of case[43] | Country |
|---|---|---|
| 1 | **Last mile transportation of heavy goods,** mainly containers, with a mass up to 25 tons | Germany |
| 2 | Parcel services, short range, small size deliveries to retail shops **without fixed tours** | Germany |
| 3 | **Waste disposal** for private households using a 20-ton hybrid-waste disposal vehicle | Germany |
| 4 | Parcel services and delivery of goods to department stores during **nighttime** | Germany |
| 5 | Last mile transport for deliveries to retailers in inner city areas **using a small urban freight terminal** | Sweden |
| 6 | Delivery of goods **limited by colder weather** conditions | Finland |

All projects described went operational in a timeframe between 2011 and 2016. All cases listed above, were still operative as of January 2018.

The projects above were introduced for their low emissions ($CO_2$ as well as noise). Though the range of these vehicles is shorter, than that of comparable diesel vehicles all vehicles were pre-configured with batteries, that allowed for the requested range in the operational context they were used in. Due to the very high purchasing costs of the vehicles, only a small number of electric vehicles per fleet were purchased.

7,7 % of Sweden's retail consisted of E-commerce and shows a fast increase. Increased E-commerce is a good opportunity for the introduction of coordinated city logistics which would decrease number of transports in urban areas and thereby the emissions. More E-commerce leads to increased distribution but could take two different paths:

1. either increased individual deliveries or
2. less transport given that deliveries are gathered at local logistics center or equal where customers easily, without car, could collect their package.

However, another problem which must be dealt with is double transportation since many consumers would like to see their products in real life before deciding on the purchase (meaning returning the products creating a return transport).[44]

Electric vehicles are a ready to use in terms of technology. Development of electric passenger vehicles is much faster than for light duty vehicles and heavy-duty vehicles, and heavy-duty vehicles does require different technology than passenger vehicles and light duty vehicles, to avoid an enormous scale-up of the battery. There are challenges/limitations for heavier vehicles today in terms of the ratio between

[43] The full guide of the cases, as well as contact information can be found in "Interim Report: E-mobility in city logistics" (2018) by P. Michalk

[44] Strategi för den hållbara gods- och logistikregionen (2017), Region Skåne

weight/battery capacity/maximum transport load and distance. Vehicles of different sizes and brands can be bought.

The vehicle industry works to present new models of vehicles of BEV and PHEV to the market and the debate of the diesel cars has accelerated after the “diesel-scandal”. Some vehicle manufactures consider and or has already decided to stop selling diesel engines in Europe[45] or even stop developing combustion engines.[46] This will make the varieties of BEV- and PHEV-vehicles available for the market to increase, something which will overcome the bottleneck of limited number of vehicle models.

### 5.2.2 Are electric vehicles much more expensive?

An electric vehicle has a higher purchase price than conventional vehicles. The battery capacity is the most important cost driving factor. TH Wildau describes a cost comparison between diesel and electric vehicles in the case study, but the figures refer back to 2013 and the development- and build-up of the market goes fast for electrical vehicles.

These costs represent, costs carried by the vehicle operator. Due to the high purchasing costs, depreciation costs, are higher in 2013, than those of conventional vehicles. However, more efficient energy use and the lower costs of electricity (as compared to diesel-fuel) per transport kilometer in most European countries, as well as the simpler construction of electric motors, lead to lower energy- and maintenance-costs.[47] Note that the diesel vehicle market is a mature market with big volumes and low unit costs on a market with well-developed competition among retailers. The electric vehicle market is a quite new, unmatured market with lower volumes sold and lower competition in this comparison.

This comparison will change over time as the market for electric vehicles grows. The development of electrical vehicles goes fast, and the study above refers back to 2013. The trend since 2013 and onwards, for a total cost comparison is that the gap is closing as the market grows and prices go down. A total cost comparison, including depreciation, energy and maintenance, taxes included needs to be done and followed up as we go forward.

The differences between countries regarding taxes on diesel and both taxes, and subsidies for electric vehicles, and the differences of both taxes and electricity price makes the relative pricing different. Therefore, calculations need to be performed for each country and then compared in order to get the complete picture.

Another uncertainty regarding the comparing calculus above regards the handling of the batteries. This in terms of costs, but also in terms of life cycle analysis. Today studies show a very big spread in different carbon foot print results from batteries.[48]

The market for electric vehicles is new and under development, with uncertain prices for second hand vehicles and batteries. In recent years there has been an export of second-hand Clean Fuel Vehicles from Sweden to various countries, both within EU and outside EU. Often company leased vehicles around three years old ending their lease contracts. This makes the build-up of Clean Fuel Vehicles in a national perspective go slower, but must be seen in an EU perspective.[49] This might need new type of statistics and a follow up for all countries in order to speed up the number of Clean Fuels Vehicles in

[45] https://www.di.se/nyheter/da-ska-subaru-sluta-tillverka-dieselbilar/ (2018-08-08)

[46] https://www.di.se/bil/volvo-slutar-tillverka-bilar-med-forbranningsmotorer/ (2018-08-08)

[47] Interim Report: E-mobility in city logistics, Michalk P; TH Wildau, (2018)

[48] http://www.powercircle.org/batteriers_miljopaverkan.pdf

[49] Trafikanalys, Rapport 2017:06 Export av begagnade miljöbilar och fossilberoendet

use within nations and within EU. Another important factor is the scrap premium and its level of payment when scrapping old vehicles, creating market space for new vehicles that are more environmentally friendly. Higher levels of scrap premium create a greater incentive so shift out old non-environmentally friendly vehicles from the market a faster pace. For example, in Norway the scrap premium was increased from 3,000 NOK to 13,000 NOK (+333 %) when the replacement vehicle was an electric vehicle. The effect can be seen in the table below on page 44. [50]

Widespread investments in electric mobility for city logistics, by public organizations or as result of public procurement, would especially give electric light duty vehicles a greater market share, than the current one, which according to economies of scale, would lower the prices of the vehicles enabling purchase for more consumers.

### 5.2.3 Spatial planning and infrastructure

Space wise the charging infrastructure is as small as a parking space, which makes it possible to introduce charging in many urban areas. The electrical infrastructure already exists in most places in urban areas, i.e. it is well electrified, and an existing system is already in place.

Electric vehicles, used by parts of society, would not need any additional production of electricity or investments in distribution networks,[51] however charging stations must be built. Recommended for city logistics is a specialized charging station for normal, medium or fast charging or an industrial socket, which can handle high currents, is often needed. Industrial sockets can often be found at many commercial vehicle depots. In city environment with may close by charger might need an installation of steering equipment optimizing and distributing the load for each charging point if all charging points are occupied at the same time. This distributes the load evenly to all vehicles charging at the time.[52] This will probably be more common in city centers as the market grows and the number of charging point increase. This makes the need for re-building and strengthening the grid less needed as the instantaneous peak load will add up as many electric vehicles are charging at the same time in the same area.

Charging time of a medium sized electric vehicle[53] is at:[54]

- Normal charging: 6-8 hours
- Medium charging: 2-3 hours
- Fast charging: 0,5 hours

Most likely new charging stations or a stronger electric output would have to be built to handle the increased socket load. In some cases, the grid infrastructure needs to be strengthened and/or be combined with load distribution units. Urban/city areas are well equipped with the infrastructure for electric vehicles from the start which makes the investments for clean fuel infrastructure cost effective,

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[50] . https://www.tu.no/artikler/vrakpanten-mer-enn-firedoblet-for-den-som-kjoper-ny-el-varebil-resultatet-kom-momentant/442849

[51] Changing all of Sweden's passenger vehicles would increase Sweden's electricity need by 13 TWh or about 9 %. https://teknikensvarld.se/tar-elen-slut-nar-elbilarna-blir-manga-475142/ (2018-08-29)

[52] http://emobility.se/startsida/laddinfrastruktur/2-laststyrning/ (2018-08-28)

[53] Sort of vehicle and size of battery

[54] http://emobility.se/startsida/laddstationsguiden/forberedelser/1-2-snabbladdning-eller-normalladdning/ (2018-08-28)

however a commercialized electric city logistics solution would probably require designated charging stations at the finish/starting point of the vehicle.

Projects which have recharged vehicles during tours, have often concluded this to be impractical and recharging is recommended during non-operations-periods. This means that the battery capacity (how far the vehicle can go with one charging) which is the main driver of the electric vehicle cost, would have to be fitted for the whole distribution tour.[55]

The European Commission concludes that the current grids in general has a high enough capacity to handle a widespread usage of electricity within the transport sector. However, distribution can be an issue at peak load[56], and an analysis would have to be conducted how much the local urban grid can handle.[57] A scale up of e-mobility in the Northern Scandria®Corridor is possible, but considerations are needed for the strength of the local grid and how much charging of electrical vehicles that can be fitted. This situation varies a lot from grid to grid.

There are, in December 2016, totally 1 159 fast[58] chargers in the Northern Scandria®Corridor part of Germany, Denmark, Sweden, Norway and Finland and 6 249 normal chargers.[59] These numbers are constantly increasing following the Directive 2014/94/EU of the European Parliament and of the Council of 22 October on the deployment of alternative fuels infrastructure (DAFI).

### 5.2.4 Is the electric vehicle technology ready?

Electric vehicles are a ready-to-use technology. However, electric vehicles have been, and still are, under intense technological development. For example, the range of the vehicles have improved significantly over the past years and continues to improve with a greater variety of models of different size and purpose to fit a large market. For city logistics solutions light, medium and heavy trucks are good options, but heavy trucks are not fully accessible on the market. Although there are less manufacturers than to traditional fuels for light and medium trucks, the range of vehicles should satisfy many types of deliveries. Important for the improvement is a variety of flexible alternatives for battery capacity to fit the differences it needs for driving range and load of goods.

Comparing the countries in the Northern Scandria®Corridor with the rest of Europe, the countries are ahead both on battery electric vehicles (BEV) and plug-in hybrids (PHEV). Norway has a unique position, way ahead of both other European and Nordic countries regarding the market share of both PHEVs and BEVs. The numbers are significant compared to the rest of Europe.[60]

[55] Interim Report: E-mobility in city logistics, Michalk P; TH Wildau, (2018)

[56] COM (2016) 652 final, Communication from the commission, Towards the broadest use of alternative fuels – an Action Plan on Alternative Fuels Infrastructure under Article 10(6) of Directive 2014/94/EU, including the assessment of national policy frameworks under Article 10(2) of Directive 2014/94/EU

[57] Interim Report: E-mobility in city logistics, Michalk P; TH Wildau, (2018)

[58] The number for Germany and Denmark includes medium chargers.

[59] Assessment of Clean Fuel Deployment and Market Access of Clean Fuels in the Norther Scandria Corridor, Gjerlöw J.C, Akershus County Council; Cornander C, RISE Research Institutes of Sweden (2017)

[60] Assessment of Clean Fuel Deployment and Market Access of Clean Fuels in the Norther Scandria Corridor, Gjerlöw J.C, Akershus County Council; Cornander C, RISE Research Institutes of Sweden (2017)

The table below shows the increasing numbers of BEV in the Northern Scandria®Corridor.

| | Passenger vehicles | | Light Duty Vehicles | | Heavy Duty Vehicles | |
|---|---|---|---|---|---|---|
| | **2013** | **2015** | **2013** | **2015** | **2013** | **2015** |
| **Germany** BEV | 1,365 | 3,014 | 381 | 836 | 20 | 27 |
| **Denmark** BEV | 1,400 approx. | 7,450 approx. | 136 | 463 | | |
| **Sweden** BEV | 862 | 4,042 | 414 | 967 | | |
| **Norway** BEV | 8,102 | 27,383 | 272 | 1,006 | | |
| **Finland** BEV | 139 | 504 | 84 | 106 | | |

Range constrictions is less of a challenge in city logistics applications, compared to traditional driving, as the range which the vehicles transport goods tend to be short with many stops, and the battery capacity increases overtime in the vehicles. An alternative to recharging (Please see section 5.2.3 Spatial planning and infrastructure) might be to consider changeable stacks of batteries that can be changed and recharged while a new charged battery fitted in the vehicle for the next tour of goods. However, tests with battery-changing systems (i.e. the whole empty battery is being swapped for a recharged battery) have yet not been proven to be practical, as the very high costs of batteries lead to very high additional investment costs."[61]

Eco-driving is an important matter for conventional vehicles with combustion engines, both for fossil fuels and clean fuels to make the energy efficiency as high as possible and make the environmental impact as limited as possible. For electrical vehicles this is in most cases coinciding techniques but there exists a need for suitable eco-driving techniques for electrical vehicles in general. In the case of electric delivery trucks with a heavier load and weight this is even more important to save battery capacity and/or extending the driving distance. Training of this kind is therefore important.

Standardization, such as the interface between the charging station and the vehicle, is an issue occasionally discussed. However necessary standards are already in place. Suitable connectors/adapters exist to handle differences in plugs. One should also remember that the electric vehicles within a city logistics system would be local or regional, which makes it possible to match plug with charging station beforehand.

Recently a new type of electric road with possibilities to charge the electric vehicle while driving is now under construction in Lund. [62] This might open up for new type of solutions in the E-Mobility solutions in the city areas.

### 5.2.5 Policy

The European Commission states that "Local and regional authorities under the Covenant of Mayors for Climate and Energy should strive to include in their Sustainable Energy and Climate Plans measures

[61] Interim Report: E-mobility in city logistics, Michalk P; TH Wildau, (2018)

[62] https://www.lu.se/article/ny-elvag-utanfor-lund

aiming at cutting GHG emissions from transport and deliver on the collective estimated reduction of $CO_2$ emissions by 19% by 2020."[63]

EU policies aren't a hinder for the introduction of electric mobility in city logistics. One could argue that the policy is rather advantageous for the technology, if electric mobility is compared to other clean fuels. European governments or cities are announcing future restrictions on combustion engines[64], and car developers, for example Volvo, are following this trend[65]. The introduction of stricter green zones or environmental zones will make it more difficult for city center delivery vehicles which use fossil fuels, in some cases only allowing zero emission vehicles.

This being said, the electric vehicles' market is still new and policy measures such as subsidies and tax exceptions, are important.[66]

Two practical policy measures must be considered:

1. **Allowing drivers two drive electric vehicles with more than 3.5t gross mass with a normal class B license.**

   Background: electric vehicles often have a lower payload, due to high battery mass. At the same time drivers with class C licenses (trucks > 3.5t) are highly sought after. From the view point of logistics operators, this puts electric delivery vehicles in a disadvantageous position.

2. **Allowing electric delivery vehicles to make nighttime deliveries into certain densely populated urban areas at night.**

   Background: This might be prohibited in city centers. Though loading- and unloading noises might be an issue, they can be reduced by technical means (rubber buffers and rubber wheels on carts). A significant portion of loading and unloading activity, especially for department stores and shopping malls, also takes place within building-courts, thus minimizing the noise impact for the local population.

### 5.2.6 How does the concept impact the environment?

Delivery transport is often driven by many different freight companies, are driven on a specific route and are characterized by many stops where goods are delivered or collected. If one does consider all transports which delivers and collects goods, waste etcetera in a specific area one would rather fast realize how many transports are being done without any coordination in between. These transports can be more efficient, with the ambition to lower freight costs, number of vehicles, noise and emissions.[67] Using electric mobility would be a great bonus which would decrease the emissions to a minimum and reduce noise.

[63] COM (2016) 652 final, Communication from the commission, Towards the broadest use of alternative fuels – an Action Plan on Alternative Fuels Infrastructure under Article 10(6) of Directive 2014/94/EU, including the assessment of national policy frameworks under Article 10(2) of Directive 2014/94/EU

[64] https://ec.europa.eu/commission/commissioners/2014-2019/sefcovic/announcements/speech-30th-international-electric-vehicle-symposium-stuttgart_en

[65] https://www.di.se/bil/volvo-slutar-tillverka-bilar-med-forbranningsmotorer/ (2018-08-08)

[66] DENA

[67] Planera för urbana godstransporter (2017), Region Skåne

City logistics solutions implies a reduction of number of delivery vehicles and thereby safer environment, better air quality[68] and a reduction of used fuel due to higher energy efficiency of electric engines. Electric motors have a lower energy demand compared to conventional engines used by diesel and gasoline vehicles. The effect is especially found in urban environments, where vehicles must decelerate and accelerate often. This means that the tank/battery to wheel is more efficient. [69] No local emissions, which are hazardous to our lungs, would come from the tailpipe.

Moreover, electric vehicles have the benefit of reduced noise levels since electric vehicles don't have engines which emits noise. However, noise would still be emitted from tires/road sound and from loading and unloading. Although sound effect functions exist (fan-like sound) in most electric vehicles today making this a smaller problem. Quiet vehicles do have a negative side too though since pedestrians and cyclists are not able to hear a moving electric vehicle. Technical solution can minimize such issues.[70]

From a national perspective and if the concept is scaled up the source of the electricity which will charge the vehicles must be considered. $CO_2$ emissions will vary between countries depending on electricity source, for example wind power or coal power.[71] Increased usage of electric vehicles must be equal to increased investments in national green electricity production facilities.

Looking closer at the production of a battery of an electric vehicle includes metals, rare earth elements, which are extracted from outside the EU, mainly from China. The European Commission states "The risks associated with the concentration of production are in many cases compounded by low substitution and low recycling rates."[72] So, on the one hand, the dependence on oil from oil producing countries would decrease, but the dependence on rare earth metals would increase.

Electrifying light road transports might have the effect that logistics management will be even more important in order to optimize the routing and payloads. The combined work with both logistics management and electrifying vehicles work in a strong way in the direction of lowering GHG-emissions, higher energy efficiency and better air quality in the cities.

## 5.3 Bottlenecks and recommendations

**Bottlenecks and recommendations for customers/operators:**

- **GETTING STARTED**: Optimizing urban freight transport (city logistics) might be considered complex; however, guides can be found. The "Last Mile Logistics" project, supported by Interreg IVB, has for instance made an interactive map which can be used by city planners and TH Wildau has made a guide for decision makers and managers through a step-by-step instruction on the purchase of battery-electric vehicles for logistics applications.
- **PURCHASE PRICE**: An electric vehicle has a higher purchase price than conventional vehicles. As the electric vehicles' market still is new, policy measures such as subsidies and tax

[68] Local emissions would however come from tires.[68]

[69] For example: The project KV-E-Chain determined, that an electric 40t-truck needed about 0.3 kWh/ton-km, while a corresponding diesel-truck needed about 0.5 kWh/ton-km.

[70] Interim Report: E-mobility in city logistics, Michalk P; TH Wildau, (2018)

[71] The Smartset project showed, that $CO_2$ emissions for electric power production can vary widely from region to region, from Sweden with 0.017 kg/kWh up to 0.47 kg per kWh in Germany (with values up to 0.98kg/kWh in regions were brown-coal was used for power-production).

[72] http://ec.europa.eu/growth/sectors/raw-materials/specific-interest/critical/ (2018-03-28)

exceptions are important, which means customers and operators must do intense lobbying against national level. Prices are going down as the market is growing.

- **MODEL SELECTION**: There are challenges/limitations for heavier vehicles today, and there are limitations to the model selection for light and medium duty vehicles. Heavy duty transports is a bigger challenge with a different tonnage and load of goods. Vehicle R&D, electric highway etc. needs to be developed further.
- **MAINTENANCE**: As the market from BEV and PHEV vehicles are new growing markets, maintenance for vehicles and battery workshops are building up along the growing market. We assume that the existing maintenance market step by step transforms its competence and services as the market shifts from conventional fossil fuel vehicles to BEV and PHEV vehicles. Although at early stages there might be some learning to do and risks exists for a lower service quality. We assume that the market for maintenance, step by step, shifts spontaneously driven by market demand.

**Bottlenecks and recommendations for local decision makers:**

- **SCHEMES:** A financial burden or a ban put on operators of conventional vehicles, when entering – for example – an inner-city area have the potential to foster the use of electric vehicles.
- **EDUCATION:** Many electric vehicle operators have difficulties to find qualified repair-shops. This problem could be diminished by training and fostering training of maintenance personnel.
- **VITAL ACCIDENTS**: Quiet vehicles do have a negative side since pedestrians and cyclists are not able to hear a moving electric vehicle. Technical solution can minimize such issues.
- **INFRASTRUCTURE**: In some cases, the local grid infrastructure needs to be strengthened.
- **NIGHTTIME DELIVERIES:** Deliveries during nighttime might be prohibited. Though loading- and unloading noises might be an issue, they can be reduced by technical means (rubber buffers and rubber wheels on carts).

**Bottlenecks and recommendations for national level:**

- **PRICES:** Subsidies are still needed to make electric mobility in logistics viable. As high purchasing costs are the main barrier, subsidies should mainly reduce the purchasing costs for the operator.
- **GRID CAPACITY**: The European Commission concludes that the current grids in general has a high enough capacity to handle a widespread usage of electricity within the transport sector. However, distribution can be an issue at peak load, and an analysis would have to be conducted how much the local urban grid can handle.
- **ELECTRICITY GENERATION**: From a national perspective, the source of the electricity which will charge the vehicles must be considered.
- **REGULATING DRIVERS LICENSES:** Electric vehicles often have a lower payload, due to high battery mass. At the same time drivers with class C licenses (trucks > 3.5t) are highly sought after. This puts electric delivery vehicles in a disadvantageous position. National level should consider allowing drivers two drive electric vehicles with more than 3.5t gross mass with a normal class B license.
- **NEW DEPENDENCIES**: Rare earth elements are important metals for the vehicle batteries, and this is a growing concern within the EU and across the globe, since the main source for these are China.

**The successful e-mobility in city logistics solution**

The Scandria2Act interim report “E-mobility in city logistics” (2018) by Philip Michalk at TH Wildau guides decision makers and managers through step-by-step instruction on the purchase of battery-electric vehicles for logistics applications.

In general, four factors can be identified, that make an urban-logistics-centric electric-mobility solution successful:

| | |
|---|---|
| **Necessary Range:** | The use case needs to call for a range short enough to make the use of electric vehicles viable. |
| **Maintenance possibilities:** | Commercial vehicle users require quick maintenance service, to minimize down-times. Vehicle manufacturers should therefore have viable maintenance facilities close to the use-case area. |
| **Subsidies:** | Subsidies that lower purchasing costs for the user can have a large (perhaps the largest) influence on the decision of purchasing an electric vehicle, |
| **Temperatures:** | The climate must be, when transferring use cases to colder (or hotter) climates than mild central-European Climate. |

**Step-by-step process**

The step-by-step instruction shall help operators with the process of introducing electric vehicles into the vehicle fleet as well as guide through the purchasing of necessary infrastructure.

As electric vehicles come with certain constraints, the purchase process differs greatly from that of conventional vehicles. Electric vehicles are somewhat different than other vehicles in terms of considerations of finding a suitable vehicle matching the needs. Aspects such as battery capacity, driving range and purchase price differ somewhat. For example: The range of an electric vehicle depends greatly on its battery capacity. However, batteries are the most expensive component of any electric vehicle, with prices between 500 € and 1.000 € per kWh. A battery too small would lead to a vehicle that would not meet the operator's demands, a battery too large, would lead to much higher operating costs, than necessary.

**Step 1: Define your objective**.

To make you introduction process a success, you first should define your objective, in order to have clear indicator for your success.

**Step 2: Estimate the necessary range and annual milage**

The estimation of your necessary range and mileage differs from the type of vehicle-substitute you are planning.

**Step 3: Decide on Gross-Mass and Payload**

You can use the gross-mass of your current fleet as an indicator and choose a gross-mass as large as the one of the vehicles you wish to replace.

**Step 4: Estimate the necessary battery capacity**

Calculate the necessary battery capacity in order to reach the required range (estimated in Step 2). Formula provided.

**Step 5: Estimate your costs**

The purchasing price need to be established by procure price estimates from the vehicle-manufacturer or vehicle-vendor. Formula provided.

**Step 6: Estimate $CO_2$-savings**

The results are your current $CO_2$ emissions in kg, for the vehicles/tours you wish to substitute.

**Step 7: Choose the proper vehicle and conduct the vendor**

Catalogue provided.

**Step 8: Talk to your vendor about charging infrastructure and maintenance**

Using the inputs from step 1-7.

**Step 9: Choose a funding program**

List of funding programs provided.

# 6 Summary and conclusions

The summary and conclusions of this report is based on the most important, top level conclusions. The delivery of the ***Green Mobility Solutions from the Scandria®Corridor*** pamphlet delivered as the main delivery, and it can be found here: https://www.scandria-corridor.eu/index.php/en/scandria-2act/clean-fuel-deployment. This report is therefore is a background report to the pamphlet showing the background and facts. The pamphlet can be seen in text version in section 6.1 below. This was finished and delivered 31 October 2018.

The three technical supportive documents are pretty much rich in details and are pretty much stand-alone reports and can also be found at the link above.

DENA finished and published a Clean Fuel Deployment Strategy – ***Pathway to the future – Scandria®2Act Clean Fuel Deployment Strategy*** 18 December 2018. The connection from that strategy to this report and pamphlet are a bit limited due timing of work and limitations of inputs. Report and summary of the strategy can be found at the link above.

In the report from Akershus and RISE ***Assessment of Clean Fuel Deployment and Market Access of Clean Fuels in the Northern Scandria®Corridor*** 10 key findings are listed according to below. Each key finding is commented based on the results of the three interim reports summarized in this report.

1. National and corridor level: The deployment of Clean Fuels in the Scandria®Corridor is developing too slowly to reach the desired national and EU/EEA targets for reduction of $CO_2$ emissions from transport.
2. Stronger national incentives to foster infrastructure development and the use of Clean Fuels. Aims are different in different countries. Some of the Scandria®Corridor countries don't seem to use strong enough incentives to ensure the required development.
3. Availability of Clean Fuel infrastructure is in general too limited to ensure clean transport throughout the Northern Scandria®Corridor. Lack of Clean Fuel infrastructure in some countries may actually hinder the use of Clean Fuels for long-distance transport of goods and persons in the Northern Scandria®Corridor.

   ***Comment of 1. 2. and 3:*** *all three cases presented above of multifuel energy station, public-private cooperation and electrified mobility can in different ways help to speed up the development that is too slow in order to faster reach the EU-targets of CO2-reductions. This can further be strengthened by tougher regulations and politics for CO2-reductions in transports at all levels.*

4. There is a need for standardized payment systems for Clean Fuels across national borders.
5. A limited model selection of Clean Fuel vehicles and especially the limited consumer perception of these cars are obstacles to market development. BEVs with longer range are expected in 2017, but they will still be in the small and medium sized market. FCEVs are slowly entering the market and in limited numbers. A range of CGB/CNG cars are available in all segments, except luxury class, which will change at the end of 2017. Light and heavy CBG/CNG and LBG/LNG vehicles are also available for each weight category. In contrast, BEV trucks from 7.5 tons upwards are still not standard production vehicles. The same applies for FCEV heavy duty vehicles. At a market level, OEMs sales and marketing activities still focus on conventional combustion engines, mainly the segment of powerful larger vehicles such as the SUVs.

   ***Comment:*** *the vehicle industry has started to work out new models that step by step is entering the market. The variety of models will increase over time making it easier to get hold of suitable*

*vehicles for each purpose of use. OEMs usually need large markets for their R&D work and introducing new models at the market in order to get the economics and the profitability for the new models. At the same time both infrastructure and clean fuel base is needed.*

6. Regional level: Public transport plays an important role in increasing the use of Clean Fuels. Municipalities, counties and regions should demand that public transport is run on Clean Fuels. Regulatory measures may be used to foster this, where possible.
7. Regional and local decision makers will become more important as the main driver for shifting to alternative fuels in the near future. The EU infringement procedure against many Member States and Communities regarding air pollution (particles matters, NOx), increases the pressure to implement measures significantly reducing pollutants. There are several examples in the Northern Scandria®Corridor demonstrating how politicians have fostered market development.
8. The regional perspective is important in ensuring the development of Clean Fuel infrastructure in such a way that it permits and stimulates transport with Clean Fuels. Municipalities and regions have the chance to be the main driver for clean vehicles while demonstrating their concern for air pollution control. They can implement their own Clean Fuel strategies and strengthen regional cooperation on the deployment of Clean Fuels. In the best case, municipalities match each other in implementing measures and should be aware of (EU) financing instruments allowing the co-financing of strategic planning and investments. Collaboration between regions may give OEMs a larger market to address with a specific vehicle as well.
9. Fuel specific issues: The cost of producing renewable fuels is in general much higher than that of fossil alternatives. This may be because of low production volumes and the technology being immature. Furthermore, the infrastructure builds up and maintenance costs of CBG/CNG, LBG/LNG, and hydrogen are above those of petrol stations. Also, no successful business case has been made thus far for the construction of charging stations. This is especially challenging in the market ramp-up phase when there is relatively low fuel demand. Tax incentives or other supportive incentives as well as regulatory instruments are needed to make the clean alternatives more competitive.
10. There are several best practice examples of setting frameworks, using incentives and carrying out concrete measures within the Northern Scandria®Corridor. Information about these should be more widely spread so that they can serve as inspiration for other regions.

***Comment 6-10:*** *local and regional decision makers can play an important role by working towards the solutions described in all three cases in this report. Mainly via the public-private cooperation and electrified mobility but can also play a part by supporting and/or financing multifuel energy stations. Setting local and regional targets for $CO_2$-emission, better air quality and so on shows a way of supporting as well. The public sector play an important role by taking the lead and show the rest of the society that Clean Fuels work well in the municipality and it works well. The municipality has the possibility to start up the local Clean Fuel market by running their own vehicles refueling in the infrastructure the invested in themselves as the examples shows. By cooperation among neighboring municipalities the market can be enlarged and spread to other municipalities and regions.*

## 6.1 Green Mobility Solutions from the Scandria®Corridor

The Scandinavian-Mediterranean transport corridor is the longest one of Europe's nine TEN-T Core Network Corridors. The northern stretch of the corridor includes the urban nodes Helsinki, Oslo, Stockholm, Copenhagen and Berlin, thus connecting major urban centers and economic zones. Scandria®2Act is a project running year 2016-2019, which fosters clean, multimodal transport to increase connectivity and competitiveness of corridor regions. A permanent Alliance has been formed.

European Commission President Jean-Claude Juncker outlined in the State of the European Union speech in September 2017:

*"I want Europe to be the leader when it comes to the fight against climate change. Last year, we set the global rules of the game with the Paris Agreement ratified here, in this very House. Set against the collapse of ambition in the United States, Europe must ensure we make our planet great again. It is the shared heritage of all of humanity."*

In 2016 the European Commission adopted a "Low-emission mobility strategy" and also urged the EU-member states to write goals and plans for the introduction of more clean fuel infrastructure. The member states plans were however in some ways inadequate for the high ambitions of the EU.

The demand for clean fuels increases, but not one single fuel will be responsible for cutting all of transport sector's emissions. Instead, the European Commission predicts a combination of several clean fuels.

The importance of work going forward making the transport sector a zero-emission sector increases as the IPCC October 8th, 2018 launched the report Global Warming of 1.5 ºC with the message to speed up the work. A number of climate change impacts are highlighted that can be avoided by limiting the global warming to 1.5 ºC compared to 2.0 ºC. This will require "rapid and far-reaching" transitions in land, energy, industry, transport, and cities.

"The ultimate objective of TEN-T is to close gaps, remove bottlenecks and eliminate technical barriers that exist between the transport networks of EU Member States, strengthening the social, economic and territorial cohesion of the Union and contributing to the creation of a single European transport area." Source: EU COM

### 6.1.1 Multifuel Energy Station (MES)

#### 6.1.1.1 Challenges

The demand for clean fuels increases. There is not one single fuel which will be responsible for cutting all of transport sector's emissions. It is most likely that a range of different fuels and vehicles will develop over time as the clean fuel markets grow.

1. Availability of Clean Fuel Infrastructure is in general too limited to ensure clean transport throughout the Northern Scandria®Corridor
2. The cost of producing renewable fuels is in the initial phase much higher than that of fossil alternatives. This may be because of low production volumes and the technology being immature

#### 6.1.1.2 The solution

The idea of Multifuel Energy Station; co-locating clean fuels at one refueling station, is to ensure the supply of many clean fuels, even the ones with very low demand. Clean fuels have good synergies and could be of use for each other. It is likely that the synergies will lower the cost for the clean fuel provider,

compared to running several clean fuel stations separately. Strategically located Multifuel Energy Stations are likely to play an important role making it possible for traffic and transports to drive on clean fuels in-between countries and regions.

#### 6.1.1.3 Outlook

The term “Multifuel Energy Station” has no clear consensus in Finland, Sweden, Norway, Denmark and Germany. A few stations can be found in each country; conceptual or constructed. Synergies between fuels, which should be implemented to lower cost, are not in place and must be further investigated.

#### 6.1.1.4 Going forward

Station concepts are not transferable between countries, due to differences in rules for constructing and operating refueling stations. For example, safety distances to fuel storage areas can differ as much as 23 meters between countries. To transfer the concept of a multifuel energy station:

1. a new international standard for Multifuel Energy Stations must be developed
2. synergies between fuels should be deeply analyzed
3. funding for further research should be prioritized

#### 6.1.1.5 Strategic actions

Offering several clean fuels at the same station is most efficient. Strategic support needed:

1. support should be given to promote co-location
2. international standards for construction must be clarified
3. harmonized requirements for installation and classifications should be demanded by procurers

#### 6.1.1.6 Technical Support Document

The RISE – Research Institutes of Sweden has written an in-depth analysis of co-locating clean fuels: Multifuel energy stations for cars, buses and trucks (2018) E. Wiberg and P. Bremer. No actual cases studied; a list of cases shown. The report can be found at: www.scandria-corridor.eu/multifuel

### 6.1.2 Public-private financing of clean fuel infrastructure

#### 6.1.2.1 Challenges

Infrastructure investments are crucial to get clean fuel markets going. Initially, these are often virgin markets (immature markets). Therefore, the risk is high, and financing can be an obstacle both for the public and the private sector. However, investments in infrastructure is needed.

1. Regional and local decision makers will become more important as the main driver for shifting to alternative fuels
2. Municipalities and regions have the chance to be the main driver for clean vehicles while demonstrating their concern for air pollution control

#### 6.1.2.2 The solution

Public-private cooperation for infrastructure investments of clean fuels is a great option as it creates good conditions for market enlargement at the outset and creates a risk sharing that lowers the investment risk for both the public and the private partners.

Public partners can create a demand which is almost break-even for clean fuel infrastructure by being their own customer demanding clean fuel public transportations, waste disposal trucks, service fleet of vehicles etc. Collaboration with neighboring municipalities will strengthen the growth of the market.

#### 6.1.2.3 Outlook

Cooperation between the public and the private is nothing new. However, it can be difficult to understand which form of co-operation which the best choice is to minimize risks. There are several good examples on how to share risk and the financing between the public and the private (in Sweden); economic association, limited company, regulating contracts. EU-financing is often a welcome contribution.

#### 6.1.2.4 Going forward

Public-private cooperation and financing of clean fuel infrastructure can be copied and spread from one municipality to another. By adjusting the set up for local conditions, examples found in the technical support document are all transferable to other small municipalities. Local policy frameworks will continuously be needed to support deployment and transferability.

#### 6.1.2.5 Strategic actions

Public-private financing of clean fuel infrastructure can create conditions for enlargement of the market by introducing:

1. The model of public-private cooperation
2. The business model “be your own customer”
3. Collaboration between neighboring municipalities

#### 6.1.2.6 Technical Support Document

Region Skåne assigned Trivector Traffic to write an in-depth analysis of public-private cooperation and finance of clean fuel infrastructure in small municipalities. Five Swedish cases have been studied.

Report can be found here: www.scandria-corridor.eu/ppp

### 6.1.3 Electrified City Logistics

#### 6.1.3.1 Challenges

Urban traffic stands for a large share of transports and of greenhouse gas emissions. It is an important reason why air quality is beyond limits in many cities today. Many European cities have set ambitious targets to limit such transport. At the same time freight transport is an essential part of a well-functioning and sustainable society. These transports could be equalized to the human body’s bloodstream. Without deliveries of goods and the collection of reusable materials and waste the society would stop working at a very fast pace.

#### 6.1.3.2 The solution

A viable option to lower the number of vehicles in the city, while not restricting deliveries coordinated city logistics. Basically, it means that the suppliers deliver goods to a central unit and all goods can be delivered to the recipient at the same time. Many recipients are included in the route. However, a coordinated city logistics solution might not be enough. The solution would then be electrified city logistics, meaning using electric vehicles, which would lower the noise level and emissions even more.

#### 6.1.3.3 Outlook

Several European cities have already, successfully, applied different approaches in introducing electric mobility solutions into urban logistics-operations. Using an electric vehicle instead of other clean fuel vehicles is advantageous in areas without many different clean fuel solutions in place, as the electric grid infrastructure for electric vehicles already are in place.

#### 6.1.3.4 Going forward

Coordinated city logistics could easily be transferred and deployed in both urban and sub-urban areas. A municipal or city organization is well suited for exploring the concept. Limitations concerns heavy duty transports, driving range, and so far, a higher cost of vehicles. A high number of charging points at the same spot might need network investments to cope with high peak loads.

#### 6.1.3.5 Strategic actions

1. Promoting and spreading city logistic solutions
2. Promoting the use of the TH-Wildau step-by-step-guide for introduction
3. Supporting local legal framework and steering documents, goals etc.
4. Strengthening the existing grid

#### 6.1.3.6 Technical Support Document

Technical University of Applied Science Wildau has written an in-depth analysis of electrified city logistics, showing six good and operational cases from Berlin and Gothenburg.

Report can be found here: www.scandria-corridor.eu/e-mibility