Work package T3
Activity 1

Deliverable 3.1 – List of bike supportive measures

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Responsible for Deliverable: **Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR)**

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Short Abstract

In the light of transport related issues regarding congestion, emissions, safety, barriers and space consumption supporting bicycle use may be a rewarding initiative. Bike supporting measures can be implemented on different contextual levels, i.e. European, national, state or county, local or municipal or even on industrial level. Deliverable 3.1.1 contains a catalogue of bike supporting measures only on municipal level (local level). The project plan provides strong collaboration with city authorities which are direct project partners in order to develop and implement bike supporting measures during the project phase.

Against this background, Municipalities/City Administrations can decide to (financially) support specific measures in order to facilitate bicycle and cargo cycle use. This very catalogue compiles a portfolio of measures which are designed to facilitate cargo cycles particularly. According to the specific local conditions, a municipality can select which measure is reasonable and should be implemented.

The FCCP project involves directly five city authorities, i.e. Aberdeen, De Hague, Groningen, Stuttgart, and Issy les Molineaux. In four cities test pilots with parcel logistics service providers testing fuel cell cargo pedelecs (FCCP) are realized, i.e. Munich, Cologne, Stuttgart and Luxemburg. The involved city authorities have committed to implement bike supportive measures throughout project duration. In the run of the FCCP project the measures will be discussed and selected during workshops to be conducted in each participating city.

All measures aim to increase the use of cargo cycles in order to substitute as many trips completed with conventional combustible-driven vehicles. As a positive side effect many measures also contribute to increased bicycle use in general.

The compiled measures comprise a broad variety: from infrastructural improvement to public campaigns. Measures specifically facilitating the use of fuel cell cargo cycles using hydrogen as the energy source are being developed together with the municipalities throughout the project. A literature review hasn't been productive, so the consortium decided to develop measures seeming reasonable and effectual together with the municipalities within the workshops (Chapter 2).

Stakeholders who may be interested in this document (besides the project partners) may be:

- **Politicians** and **decision makers** eager to increase bicycle use in commercial applications,
- **City authorities** keen to shift trips from conventional vehicles to sustainable cargo cycles,
- **Transport planners** who are interested in designing sustainable city infrastructures.

The catalogue also shows best practices in order to illustrate successful measures which are already implemented exhibiting positive effects like reduction of vehicle miles travelled with vans, reduction of noise or increase of road safety.

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1 Project brief

The Fuel Cell Cargo Pedelec project (FCCP) may represent a relevant element in the run for an emission free last mile delivery: the multidisciplinary consortium (1) develops a key element for hydrogen-driven micro vehicles, i.e. a small fuel cell converting hydrogen to power plus storage tank, (2) develops a logistics system for parcel logistics service providers facilitating cargo cycles equipped with this fuel cell system, and (3) collaborates with municipalities in order to pilot the technology plus logistics system and setting the framework. But, FCCP may not only be a powerful solution for last mile distribution logistics but also applicable for other commercial sectors and even private use (e.g. bringing children to child care, to school, or doing other activities and errands).

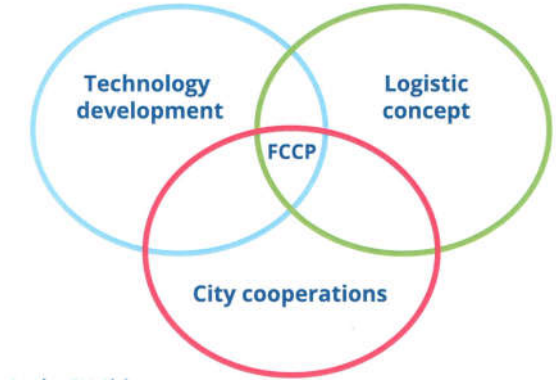

Figure 1 Scheme of the FCCP-Project

FCCP overcomes existing barriers which are exhibited by battery electric cargo pedelecs by using hydrogen as an energy source and a small fuel cell as a converter. Thus, high performance cargo pedelecs can be designed which are suitable for professional applications. Other improvements have to be made, too. Hubs, spokes, axis and the whole drive train have to be designed in a much more solid way which is also addressed by the project. Hence, a much broader roll out of cargo cycles in commercial applications can be realized in order to substitute conventional vehicles and achieve a sustainable last mile logistics distribution system.

In order to fully exploit the performance of the hydrogen cargo bike, a tailored logistics concept must be developed. Therefore, multiple aspects must be considered:

- The performance of the cargo cycle itself,
- The shipping volume (number of parcels, weight, volume etc.)
- The localization and installation of inner city hubs,
- The requirements of the last mile operator (logistics service provider),
- The requirements of online retailers,
- The requirements of the cities' authorities,
- The required infrastructure (e.g. hydrogen stations), and
- The existing infrastructure (e.g. bicycle infrastructure, delivery areas, pedestrian zones etc.).

In order to address the last two aspects of the list above, a dialogue with the city authorities is absolutely required. FCCP involves eight cities as project partners, i.e. Aberdeen (UK), the Hague (NL), Groningen (NL), Stuttgart (DE), Munich (DE), Cologne (DE), Luxemburg and Issy les Moulineaux (FR).

2 Introduction

Urban transport needs to change because it faces several challenges:

1. Reducing greenhouse gas emissions caused by the transport sector in the fight against global warming and climate change,
2. Reducing number of vehicles parked and driven within urban areas to avoid congestion, barriers and consumption of public (and expensive!!!) space,
3. Increase road safety in order to reduce fatalities and injured from traffic accidents,
4. Reducing vehicle miles travelled in order to fulfill 1., 2. and 3.,
5. Reducing harmful tailpipe emissions in the fight against pulmonary disease,
6. Finding alternative sustainable propulsion technologies using renewable energy and/or human power due to scarcity and increasing cost of crude oil and in order to address challenge 1 and 5.
7. Finding new and innovative concepts facilitating 1 to 6.

By addressing these challenges urban citizens may experience increased cities' livability because of decreased congestion, noise and air pollutions as well as increased road safety.

With regards to commercial transport, this need for change implicates the implementation of innovative technologies to replace combustion engines, new vehicle concepts, and also the introduction of new logistic concepts. Hence, changes in commodity flows within B2B and B2C sectors need to be considered. The globalized and dynamic retail sector implies particular challenges due to digitalization and online platforms being able to scale up in a never-seen-before velocity (e.g. Amazon, Alibaba, Zalando etc.). Online commerce grows double-digits year by year for over ten years now. As an example: in Germany more than 3.5 billion parcels were delivered in 2018. In order to increase attractiveness and at the same time to be able to deliver the tremendous amount of parcels, logistics companies have been offering new delivery options for their customers, like parcel lockers, deliveries directly into the boot of a passenger car or instant deliveries within 90 minutes à la Amazon Prime Now.

These impending changes in urban commercial transport require that cities provide a legal and infrastructural ecosystem enabling companies to innovate. To fulfill this responsibility, cities can use their competencies and influence in various areas:

- Legal competencies (for instance zoning planning or regulations)
- Infrastructural competencies (for instance street design)
- Financial competencies (such as initiating support programs)
- Coordination of relevant stakeholders (for instance coordinating property owners with logistic companies in the endeavor to build an urban consolidation center)

In the following, we propose a catalogue with measures that support the use of cargo bikes for logistic purposes in general (section 2) and hydrogen power cargo bikes in particular (section 3). This catalogue shall provide a comprehensive platform for discussions with the FCCP-involved city authorities. Which measure may be reasonable to be implemented will be discussed with the cities in the next step. Effective measures may vary between the cities due to the streets layout, population/business density, regulations/restrictions, topography, and even culture.

3 Urban planning measures

3.1 Micro depot – landlord model

Short description:	Municipality (or a holding company) operates a micro depot
Positive outcomes:	- Allows different logistic companies to use the same depot (space efficiency) - Allows municipalities to regulate the micro depot's use
Barriers:	- Requires space to be allocated for the construction of a depot - Requires financial and organizational resources - Opportunity costs have to be considered which occur if estate is not alternatively used

Micro depots are considered a prerequisite for cargo bike logistics. Also called 'urban consolidation centers (UCC)` or `logistics micro-hubs` these depots serve as a facility where cargo can be shifted from large transport units (containers) to cargo cycles or other light vehicles. Also, capacity for storage should be provided there. Different operational models have been considered. The logistics company can run the facility itself, which means every logistics company needs its own depot or network of depots within the city (non-shared). In regards to space efficiency the landlord model, where the municipality itself operates the micro depot(s), is an interesting concept. The municipality allocates public space for the installation of the micro depot and invests resources in the micro depot's operation. It has to be made sure that the allocated space fits the requirements of the logistic service provider. The advantage is that as the operator – the municipality – can regulate and respectively influence the use of the depot. For instance, fees can be adjusted with regards to ecological parameters, such as whether logistic companies use environment-friendly transportation modes for deliveries to and from the micro depot. Different companies can use a compartment of the depot for their logistics activities and share bathrooms, kitchens, delivery areas etc. (shared).

Example: KoMoDo[a] (Berlin, Germany)
In a pilot project, the city of Berlin has allocated free space on the grounds of a tram depot to the five major logistics companies in Berlin. Each company uses a container for storage of deliveries. All deliveries in a 3 km radius around the micro depot are executed by cargo bike. The project's evaluation showed that ca. 11t CO_2 were saved during the project phase, and that the residents approved the project because of noise and traffic reductions.

For further information:
https://www.komodo.berlin/

Figure 2 Cargo bikes used in the KoMoDo project in Berlin

Source: https://www.komodo.berlin/[1]

[a] Original German title: Kooperative Nutzung von Mikro-Depots durch die Kurier-, Express-, Paket-Branche für den nachhaltigen Einsatz von Lastenrädern in Berlin (*eng.: cooperative use of micro depots by Courier, Express and Parcel industry fort he sustainable application of cargo bikes in Berlin*)

3.2 Municipality gives public space to logistics service providers at subsidized conditions

Short description:	Cities allocate space to logistic companies for the construction of micro depots
Positive outcomes:	- Low level of organizational effort for cities - Private company can design its own ecosystem
Barriers:	- Requires public space - Less possibilities for regulation - Opportunity costs have to be considered which occur if estate is not alternatively used

An easy solution for cities enabling logistics companies using micro depots as urban consolidation centers is the allocation of public space to these companies. The logistics company organizes the operation of the depot itself. The advantage of this model is that it requires less organizational effort for the municipality apart from allocating public space. The disadvantage is that the city has less influence to regulate the usage and organization of the depot. Furthermore, deliveries by cargo bike via the use of micro depots are particularly effective in areas of high density. However, specifically in these areas public space is in higher demand, so it can be difficult to find adequately large areas available for such operations. Pilot projects are using swap bodies as storage. This solution would also mean that every company puts swap bodies in public space which cannot be tolerated in large amounts.

Example: Constance, Germany

In a cooperation with the city of Constance, DPD trialed a micro depot close to the city center. It consists of a container that securely stores parcels. Parcels get delivered in the morning and are delivered by cargo bike. The delivery by cargo bikes is advantageous because the city has many narrow streets that are harder to reach for conventional delivery trucks.

For further information:
http://www.dpd.com[2]

Figure 3 DPD is trialing a micro depot solution in the city of Constance, Germany

Source: http://www.dpd.com

3.3 Building construction restraints

Short description:	Implement areas for logistics operations (for instance micro hubs) in zoning regulations
Positive outcomes:	- Reserves space for logistics operations - Public Private Partnerships (PPP) are possible
Barriers:	- Competes with the need for residential, commercial or public service areas

In Europe's bustling cities, free available space is scarce and different stakeholders compete for its use. Therefore, it can be a hard task to find sufficient space for logistics purposes, as logistics usually generate smaller revenue than for instance residential or commercial use of grounds. In order to make space accessible for logistic operations, cities can implement areas designated for logistics in zoning regulations. This helps to guarantee the availability of suitable space enabling the application of sustainable last mile concepts. However, political leadership is needed for this process as the needs for residential, commercial or public service grounds is often quite high and leads to a strong competition among these different needs and interest groups. Nevertheless, this measure is effective at relatively low cost.

Example: Central bus terminal Munich

The building regulations restraint the land use to bus terminal on ground floor, retail on 1st floor, and office on 2nd to 4th floor.

For further information:
https://www.muenchen-zob.de/de[3]

Figure 4 DPD is trialing a micro depot solution in the city of Constance, Germany

Source: http://www.wikipedia.de

4 Pricing measures

4.1 Subsidizing commercially used cargo cycles

Short description:	Supporting interested cargo bike users by subsidizing the purchase of cargo bikes	
Positive outcomes:	-	Increases the likelihood of cargo bike purchases and therefore increases cargo bike use
Barriers:	-	deadweight effect: disadvantageous in case users would have bought a cargo bike also without subsidy (for market ramp-up ok; after successful market entry funding should be reduced).

In surveys among interested cargo bike users, the purchase cost is often stated as impediment to their acquisition. In order to support the diffusion of cargo bikes, authorities can introduce financial incentives to the purchase of cargo bikes. Programs vary in terms of subsidy amount, target groups (only commercial versus all interested users) and supported cargo bike models.

In Germany, many city and state governments have introduced subsidies for the purchase of commercially used cargo bikes. One important motivation for this measure is the high level of air pollution in many German cities.

Example: North Rhine-Westphalia, Germany
A lot of cities in North Rhine-Westphalia struggle with air pollution. The government therefore introduced a subsidy for cargo bikes as a measure to support emission free transportation. The subsidy is granted to private, commercial and public users with varying maximal amounts. Other cities also have introduced subsidy schemes like Graz and Berlin.

For further information:
https://www.elektromobilitaet.nrw/ [4]
https://www.graz.at/ [6]
https://www.berlin.de/ [8]

Figure 5 North Rhine-Westphalia supports the purchase of pedelec cargo bikes

Source: https://www.elektromobilitaet.nrw/

4.2 Public funding of scientific or commercial cargo bike projects

Short description:	Increase the visibility and diffusion of cargo bikes by supporting cargo bike pilot projects/facilitate access to cargo cycles without financial risk for SME
Positive outcomes:	- Supports the development of new applications of cargo bikes - Increases the visibility and diffusion of cargo bikes - Facilitates access for companies to test cargo cycles to see if it can be a use case
Barriers:	- Depending on the project, substantial financial and organizational effort is required

Electrically assisted cargo bikes are still an innovation in the transport sector. Many decision makers in companies do not know the capabilities of these bikes in regards of cost, usability, payload and transportable volume as well as acceptance amongst their staff. Therefore, it is important to support pilot projects that aim at testing new application areas for cargo bikes, providing cargo bikes for new target groups, or testing new delivery schemes such as micro hubs. Depending on the project's scope, this measure can increase the visibility of cargo bikes, attract public attention through media coverage or help to familiarize interested users with this technology.

Example: "I take the pressure off cities"[b], Germany

As many companies are interested in using cargo bikes but have little opportunity to try them, the German ministry for the environment started a research project that provided companies and organizations with the opportunity to test cargo bike at a cheap rate for several months. In addition to this testing opportunity, researchers analyze under which conditions the cargo bikes are used and what factors influence the adoption of cargo bikes.

For further information:
https://www.lastenradtest.de/[9]

Figure 6 Two models of cargo bikes tested in the pilot.

Source: https://cargobiketest.de

[b] Original German title: Ich entlaste Städte

4.3 Increase parking fees

Short description:	Increasing parking fees to reduce local traffic, free parking space for new (bike) infrastructure and strengthen the economic advantage of cargo bikes
Positive outcomes:	- Demonstrably reduces the demand for parking spaces which has multiple positive effects (less traffic, less emissions, more available public space) - Increases the economic advantage of cargo bikes over cars - Often, there is local support for this measure as residents benefit from reduced parking fees
Barriers:	- Enforcement of fees requires staff. However, some cities like Amsterdam successfully have digitalized parking fee enforcement - Traditionally, parking fees are subject to controversial public debates

Management of car parking becomes a strong focus for many European cities in order to reduce traffic and free space from car infrastructure. The introduction or increase of parking fees has strong advantages. They reduce demand for car parking, which has positive effects on traffic and the environment, but also helps commuters to find a parking space more easily. With regards to cargo bike traffic, parking fees can help to support cargo bikes by strengthening the financial advantage of cargo bikes over cars as cargo bikes are commonly exempted from parking fees.

Enforcement of parking fees can require substantial quantities of staff that sometimes is subject to verbal assaults. However, digitalized enforcement of parking fees as trialed for instance in Amsterdam and Paris make enforcement more cost effective and more convenient for staff.

Example: Amsterdam, Netherlands
The city of Amsterdam has successfully digitalized parking fee regulations. Before the reform, enforcement of parking regulations by parking officers tended to be rather slow and expensive, partly due to high sickness rates (most likely as a consequence to verbally aggressive drivers). Nowadays, a car equipped with scan technology registers the parked cars' license plates, controls whether fees are paid and initiates the post delivery of fines. This reform led to lower costs, better control rates and taken together, more efficient parking regulation.
For further information:
https://www.itsinternational.com/[10]

Figure 7 Parking spaces in Amsterdam

Source: https://commons.wikimedia.org/[11]

4.4 City toll for motorized vehicles

Short description:	Charge fees for motorized traffic when entering the city in order to reduce and modulate traffic demand, as well as to support (cargo) bike traffic
Positive outcomes:	- Increases the financial advantage of cargo bikes over cars - Modulates and reduces traffic
Barriers:	- Likely elicits strong public debates - Requires intensive planning and infrastructure investments

City tolls represent a potent measure to reduce or modulate motorized traffic. City toll schemes exist for zones (such as London's congestion charge) or important infrastructure bottlenecks such as bridges or tunnels (see best practice example Stockholm). By using dynamic pricing based on traffic demand, tolls can modulate the total traffic demand. Financial income generated by city tolls can then be used for other purposes such as road maintenance or the support of other sustainable mobility measures. City tolls are considered a potent measure for internalizing external costs of motorized traffic. More precisely, to date motorized traffic creates more costs and emissions than reflected in the usage costs. Therefore, charging additional costs such as city tolls help to integrate these external costs.

In comparison to access restrictions (see 3.2.5), city tolls offer the advantage to be a less radical measure, as vehicles are not banned completely from the city center but simply have to pay for entry.

Example: Stockholm, Sweden
The city of Stockholm implemented a congestion charge that was trialed for seven months in 2006. The main motivation was to modulate traffic demand such as that less congestion would occur during rush hour. Shortly after the inauguration, the city registered significantly decreased levels of traffic as compared to a similar day without charge. After the trial period, the city habitants voted in a referendum for keeping the congestion charge in place.

For further information:
https://www.roadtraffic-technology.com[12]

Figure 8 Automated toll station in Stockholm

Source: https://commons.wikimedia.org[13]

5 Regulatory measures

5.1 Restricted car access and/or conventional transport means

Short description:	Restricting car access by installing modal filters, implementing one-way streets or other measures to increase travel time advantages for cargo bikes
Positive outcomes:	- Leads to traffic calming - Increases travel time advantages for cargo bikes - Increases livability
Barriers:	- Restricting car access often leads to controversial public debate

Restriction of car access is an often applied measure in order to reduce traffic and make residential streets more suitable for bike traffic. A variety of measures is possible to restrict car access. Among the most popular are one-way streets and modal filters. The latter are barriers that block the street to cars while allowing passage for cyclists and pedestrians in all directions. Many cities in the Netherlands restrict car access in residential areas and thereby create an attractive network of bike friendly streets.

Restricting car access leads to longer travel times for motorized traffic, thereby increasing the advantage of bike traffic. In addition, traffic space can be reattributed for instance for the construction of micro hubs or create parking facilities for cargo bikes.

Example: Barcelona, Spain
The city of Barcelona started in 2008 to restrict car access by bundling nine blocks to a traffic calmed area. In these areas, also called 'superblocks' motorized through traffic is eliminated by installing modal filters. This measure frees public space and reduces traffic. Furthermore, travel times for motorized traffic increases, which results in a relative advantage for cargo bikes
For further information:
https://bicycledutch.wordpress.com[14]

Figure 9 Illustration of restricted car access Urban ecology agency Barcelona

Source: https://urbanland.uli.org[15]

5.2 Reduce access to city for motorized delivery vehicles

Short description:	Ban heavy trucks from driving into the city center.
Positive outcomes:	- Supports alternative modes of transport for inner city logistics - Reduces noise and air pollution in city centers - Reduces the risk of fatalities
Barriers:	- Likely creates opposition from economic stakeholders - Enforcement needs to be implemented

Implementation of driving bans for heavy trucks in the city centers is increasingly discussed as a measure to reduce the volume of heavy trucks in urban areas. Such bans can be established for certain times during the day/night or even permanently. They are expected to have multiple positive outcomes, but are also facing considerable disadvantages. With regards to the positive outcomes, a ban of heavy trucks reduces noise and air pollution, as well as reducing strain on the local infrastructure. As large trucks have larger emissions, the exclusion of these vehicles can be expected to have a considerable impact. A further positive outcome consists in reducing the risk of fatalities, as large trucks are significantly more often involved in fatal accidents with pedestrians or cyclists.

However, a ban of heavy vehicles requires the consultation of economic stakeholders, particularly if it is effective permanently and covers larger areas. In order to avoid strong opposition, the limitation to certain times is advisable. A further possibility to adjust access restrictions is to grant exemptions to some vehicles.

Example: Dublin, Ireland
In 2007 the city of Dublin introduced a strategy to reduce the volume of heavy-duty vehicles in the city center. To this end, a driving ban between 7 am and 7 pm for vehicles with five or more axles was established. In the following, a reduction of between 80 % and 94 % in heavy goods vehicles in the city center has proven the ban to be an effective strategy to alleviate traffic.

For further information:
http://www.dublincity.ie[16]

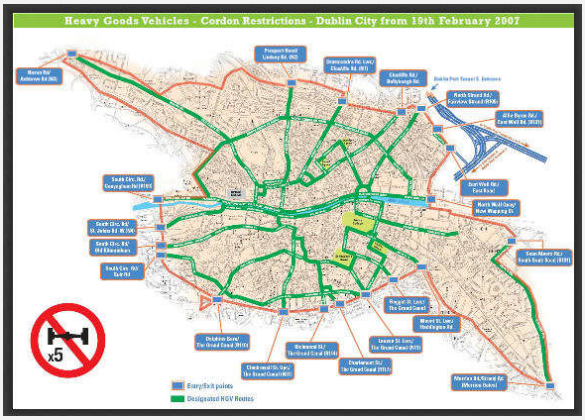

Figure 10 Map showing access restrictions for trucks in Dublin

Source: https://urbanaccessregulations.eu[17]

5.3 Circulation plan

Short description:	Divide city into quadrants and between them restrict access for motorized traffic
Positive outcomes:	- Makes trips by cargo bike more flexible and time efficient - Increases livability
Barriers:	- Requires strong political leadership

A potent measure to increase cargo bike traffic is the introduction of circulation plans. These plans divide large city areas into distinct districts. Motorized traffic is generally not allowed to pass from one district to the neighboring one. This measure has strong effects, notably the increase of pedestrian and cycling traffic, a decrease in motorized traffic and in emissions, which leads to augmented livability. The main reason why these plans support (cargo) bike traffic is that they significantly increase car travel times, which makes (cargo) bikes in most city trips the fastest and most flexibly transportation option.

Several cities including Ghent (see best practice), Leuven (both Belgium) and Utrecht (Netherlands) have adopted circulation plans. Often these plans are subject to strong public debates because they have a visible impact on the life of many residents. However, often its positive effect leads to strong acceptance.

Example: Ghent, Belgium
In 2017, the city of Ghent put its circulation plan into effect. It created a pedestrian zone in the center and restricted car access to six districts around it. Cargo bikes are permitted to pass between the districts, which led to a rise in bicycle traffic in general and to an increased advantage of cargo bikes over cars. Other positive outcomes include less car traffic and less pollution in Ghent's city area.

For further information:
https://www.logistics.dhl[18]

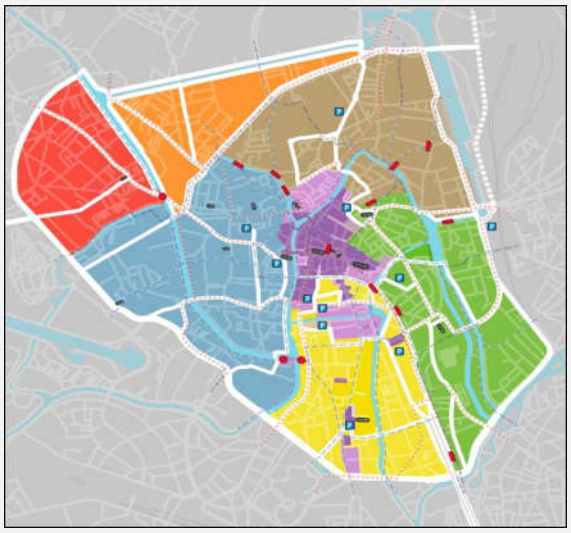

Figure 11 Map showing Ghent's accessibility for motorized traffic after the circulation plan's introduction

Source: https://astoria.be

5.4 Restricted delivery times for conventional delivery vehicles

Short description:	Restricting delivery times in urban areas in order to favor cargo bike deliveries
Positive outcomes:	- Creates an advantage in terms of flexibility for cargo bikes over cars - Calms traffic and facilitates the implementation of pedestrian zones
Barriers:	- Needs to be coordinated with economic stakeholders

Delivery restrictions for conventional vehicles are used in many cities. They are particularly useful in pedestrianized zones, where deliveries are expected to be performed outside primary shopping times in order to not create conflict with customers. Cargo bikes can benefit by being exempted from delivery times restrictions. As cargo bikes take considerably less space than conventional vehicles, such an exemption is often considered justifiable.

Example: Hamburg, Germany

The city of Hamburg trialed in 2019 a temporary pedestrian zone. One measure within this project was restricted delivery times for conventional vehicles, together with the provision of loading zones. The project evaluation showed that deliveries could easily be adjusted to the new time window, thereby concentrating deliveries to the off-peak time.

For further information:
https://www.altstadtfueralle.de[19]

Figure 12 Temporary pedestrian zone in Hamburg with restricted delivery times

Source: https://www.nahverkehrhamburg.de[20]

5.5 Maximum speed for motorized vehicles in neighborhood areas to 10 km/h

Short description:	Reduce speed for motorized vehicles to 10 km/h in order to make traveling by cargo bike more time advantageous
Positive outcomes:	- Gives cargo bikes a travel time advantage over cars - Leads to traffic calming with positive effects on livability
Barriers:	- Requires enforcement - Potentially leads to public debate

Reducing traffic speeds for motorized vehicles is an important component in making streets safer. Additionally, speed limits can help to support environmentally friendly means of transport such as cargo bikes. Speed limits imply that motorized vehicles are driven slower; thereby increasing the advantage of cargo bikes. Residential areas are particularly suitable for this measure, as it leads to traffic calming which is particularly relevant in dense urban areas with a lot of through traffic. To ensure the compliance with the speed limits, it is advisable to either ensure sufficient enforcement or preferably change the street design in order to make driving at 10 km/h intuitive.

Example: Bolzano (Italy)
Traffic regulations in Bolzano's medieval town impose strict measures that deter deliveries with motorized vehicles during specific times of the day. It however exempts the use of cargo bikes for deliveries. Defaulters have to pay fines which are automatically levied in line with automatic control systems that were set up in 2014. Further privileges are made available to cargo bike deliveries to encourage use other than motorized vehicles.

For further information:
http://www.cleanair-europe.org/ [21]

Figure 13 Typical cargo bike in Bolzano's medieval old town

Source: http://www.cleanair-europe.org/ [22]

6 Infrastructural measures

6.1 Building a network of high-quality bicycle infrastructure

Short description:	Providing a continuous network of cycle paths/ adjusting bicycle infrastructure to the needs of cargo cycles
Positive outcomes:	- good infrastructure is one of the most important requirements to increase cargo bike traffic - positive side effect: increases regular bike traffic, too, and thereby further reduces traffic related emissions
Barriers:	- requires strong political leadership because scarce traffic space has to be redistributed which likely creates opposition - requires intensive planning processes

High quality cargo bike infrastructure is an important requirement for increasing cargo bike traffic. In addition, high quality cargo bike infrastructure is based on several aspects. First, it is important to provide a network of bicycle paths. In many cities, bicycle infrastructure is provided only in certain parts of the city and cycle tracks often do not connect. Hence, it is important to provide cargo bikes full access to locations throughout the city by building a dense network of cycle tracks. These tracks need to be broad enough to allow overtaking, otherwise (particularly pedelec) cargo bikes risk to get slowed down by other bike users. Furthermore, cargo bikes require larger turning radiuses, particularly if they have three wheels. Cargo bikes are also sensitive to uneven surfaces, so it is important to ensure smooth surfaces.

Example: Copenhagen, Denmark
Copenhagen has started early to build a network of high-quality bicycle infrastructure. This included dedicated cycle tracks wide enough for up to three cyclists traveling alongside each other. This has proven to be a success: Bike commuters outnumber car commuters in Copenhagen. In addition to regular bike traffic, cargo bikes have become a frequently used form of transport in Copenhagen. They are often used by families for private purposes, but they are also used for commercial trips.

For further information:
https://www.eltis.org[23]

Figure 13 In Copenhagen, cargo bikes are a normal part of everyday traffic

Source: http://www.copenhagencyclechic.com[24]

6.2 Implement cargo bike parking facilities

Short description:	Build parking facilities dedicated to cargo bikes
Positive outcomes:	- Facilitates the use of cargo bikes - Facilities may also be used by regular bicycles
Barriers:	- Requires street space

Cargo bikes have specific requirements for parking. Depending on the model, they require more space and do not fit into some bike parking configurations. Cargo bikes can be parked on sidewalks if it is sufficiently broad, which makes the use and parking of cargo bikes quite flexible. However, for safe parking, particularly for longer periods of time (such as overnight), it is preferable to provide facilities such as racks that allow securing the cargo bike to a fixed object. Apart from the facility itself, it is also important to consider adequate signage. For instance, in Germany, the federal ministry for transport has recently introduced a specific sign that indicates dedicated cargo bike facilities.

Example: Potsdam, Germany

The city of Potsdam has created a code of practice for the installation of bike parking facilities. One part of this code shows guidelines for the installation of cargo bike facilities. This code is designed for companies that are involved in the construction of residential buildings. The aim of this code is the integration of safe and easy to use (cargo) bike parking facilities.

For further information:
https://www.mobil-potsdam.de[25]

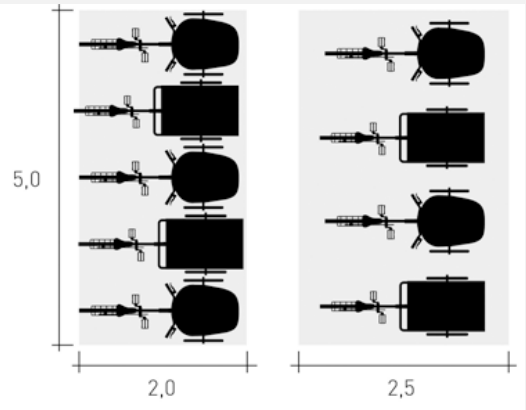

Figure 14 Illustration of space requirements for cargo bike parking spots

Source: https://www.mobil-potsdam.de [26]

6.3 Bicycle speed ways

Short description:	Build bicycle speed ways to connect different urban areas with high quality infrastructure
Positive outcomes:	- Provides a hierarchical network with fast tracks for longer distances - Improves cargo bike trips over longer distances by making them faster, safer and more comfortable - Improves conditions for regular bike traffic, too
Barriers:	- High infrastructure standard requires more intensive planning processes - As all major infrastructure changes, this measure likely creates opposition - Requires complementary dense network of bike paths for local distribution

To date, traveling long distances by cargo bike is uncomfortable in most cities. Bicycle infrastructure often declines in quality when moving further away from city centers. Additionally, travel time losses due to unfavorable traffic light signalizations add up on larger distances, thereby reducing the advantage of cargo bikes over cars.

In order to improve conditions for using cargo bikes on longer distances, bicycle speed ways connecting different parts of the city and its logistics areas with high quality bicycle infrastructure are a potent measure. They are commonly designed to accommodate higher traveling speeds in terms of broader width, larger curve radius and priority at intersections.

However, it needs to be noted that the higher quality standard of bicycle speed ways implies longer planning processes, higher costs and likely more opposition than simpler form of infrastructure. Despite the time and effort necessary for building them, cities across Europe value the strong advantages and therefore increasingly build networks of bicycle speed ways.

Example: Berlin, Germany

Berlin has committed itself to improving conditions for cycling significantly. One important measure is the construction of at least 100 km of bicycle speed ways in order to connect suburban areas with the city center. These bicycle speed ways will be at least 3 m wide (bidirectional: 4 m). Furthermore, these tracks are laid out for higher speeds by prioritizing them at intersection or reducing waiting times at signalized intersections.

For further information:
https://www.infravelo.de[27]

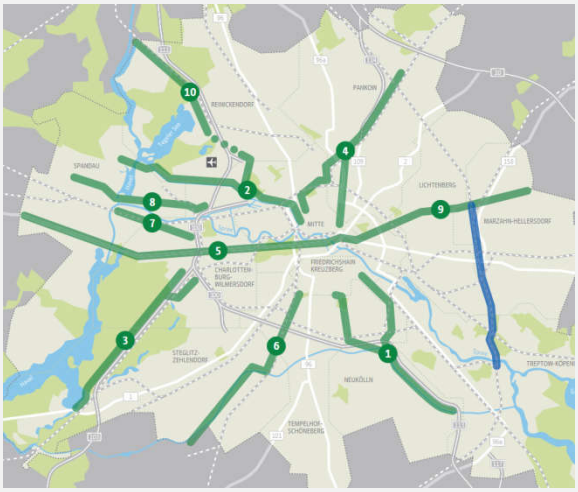

Figure 15 Berlin's bicycle speed ways

Source: https://www.berlin.de[28]

7 Measures to promote cargo bikes

7.1 Campaign for cargo bikes

Short description:	Improving cargo bikes' image and advertising the use of cargo bikes through campaigns
Positive outcomes:	- Positive impact on cargo bikes' image - Increases the public awareness for cargo bikes which potentially leads to increased use of cargo bikes
Barriers:	- Requires financial investments

Public campaigns in the traffic sector are frequent, particularly with regards to traffic safety. Yet, increasingly, cities advertise the use of environmental-friendly forms of transport. Such campaigns can include cargo bikes, too. These campaigns help to raise the awareness for environmental-friendly means of transportation. In addition, if successful, they can help to shift the image of cargo bikes towards representing a fun, environmental-friendly and desirable form of transport.

Example: Münster, Germany

The city of Münster has published a brochure aiming at promoting the commercial use of cargo bikes. The brochure was produced within the Münster Climate Protection Alliance. In the brochure, companies are advised on how various commercial needs can be met by cargo bikes and information on the purchase and maintenance of cargo bikes is provided.

For further information:
https://www.stadt-muenster.de[29]

Figure 16 Brochure to advertise the commercial use of cargo bikes (City of Münster, 2015)

Source: https://www.stadt-muenster.de[30]

7.2 Initiate cargo bike testing programs

Short description:	Providing cargo bikes for testing
Positive outcomes:	- Allows interested users to gather information about and experience with cargo bikes - Can support the decision to buy a cargo bike
Barriers:	- Requires organizational effort

In many municipalities, small initiatives are supported to provide cargo bikes for testing or for small everyday businesses. Such testing programs can help both private and commercial users to familiarize themselves with cargo bikes. Thereby, interested users can collect first hand experiences which help them with the decision whether to buy a cargo bike. Ideally, these initiatives offer a variety of cargo bikes, such as that the interested user can test various models in order to determine which configuration is suited best for the requirements. In addition to providing testing opportunities, this measure increases the public visibility of cargo bikes which can also help to increase cargo bike traffic.

Example: PedsBlitz (Hannover, Germany)
Starting in September 2015, the city of Hannover provided 52 pedelec cargo bikes that can be borrowed for testing. They are stationed at three different locations within the city. The 52 cargo bikes represent a variety of different models which aims at providing the possibility to test the suitability of different cargo bike configurations for the individual requirements.

For further information:
https://www.hannover.de[31]

Figure 17 One of the available cargo bikes within the PedsBlitz project (City of Hannover)

Source: https://www.hannover.de[32]

7.3 Use cargo bikes in municipal deliveries

Short description:	Supporting cargo bike traffic by operating all suitable municipal deliveries by cargo bikes
Positive outcomes:	- Creates a steady demand for cargo bike deliveries that support the rising market of cargo bike deliveries
Barriers:	- Possibly increased delivery costs - Not all deliveries may be suitable for cargo bike delivery

One further measure to promote cargo bike transport can be executed by means of executing all municipal deliveries by cargo bike. As municipalities commonly have a substantial amount of deliveries throughout all departments, such a shift to cargo bike transport creates a constant demand for cargo bike deliveries. Particularly in cities with to date little cargo bike traffic, such a measure can boost the cargo bike traffic market in an early stage. A potential barrier to this measure is that cargo bike deliveries might be more expensive than usual delivery methods. Additionally, most likely not all municipal shipments are suitable for cargo bike transportation. Nevertheless, the remaining extent of suitable deliveries is most likely high enough to represent a substantial boost to the cargo bike logistics market.

Example: The Bike's the Business (Brighton & Hove, England)
The Council of Brighton and Hove contracted 'The Bike's the Business' to handle the in-house postal and courier service by the council. This had a positive impact of reducing costs attributable to number of vehicles used and associated operational costs as well as improving speed of deliveries in addition to saving on emissions.

For further information:
http://www.cleanair-europe.org [33]

Figure 19 Council Supporting Cargo bike company in Municipal deliveries

Source: http://www.cleanair-europe.org [34]

7.4 Integrate cargo bikes in bike sharing schemes

Short description:	Integrating cargo bikes in public bike share schemes in order to provide a low threshold testing opportunity
Positive outcomes:	- Increases the number of cargo bike trips in the city - Offers a simple cargo bike testing opportunity - Increases the public visibility of cargo bikes
Barriers:	- Integration of cargo bikes into bike share schemes requires technological upgrades

Various bike sharing schemes only consider individual person movements for the last mile and do not really put emphasis on cargo bikes. As far as use is concerned, cargo bikes would normally either carry goods for the last mile destination or in some cases for transporting children from one location to another. Thus, the need to get to the doorstep of users is very critical in the case of cargo bikes as compared to shared bikes where individuals can conveniently walk to the final destination after getting off the bike. Cargo bikes are also expensive to the extent that not everyone can easily own one but for subsidies that are sometimes in place to encourage its use.

It is therefore critical to integrate cargo bike sharing into public bike sharing schemes so that they can be made readily available in a pool for as and when needed in order to reduce the potential of high financial burden on prospective users. This will in the end allow for people to test the usage of cargo bikes and encourage their use for everyday activities. However, if docking stations for these cargo bike sharing schemes do not terminate close to residential areas where goods or children would have to be conveyed to and from, the entire purpose would be defeated. This would arise where users would have to use the service to their homes and have to travel back to far reaching docking stations before returning back to where they started the journey making it very inconveniencing. Locating them close to the neighborhood will greatly increase patronage.[35]

Example: Hamburg, Germany
Hamburg has been operating a public bike share system since 2009 which is nowadays considered the most often used bike share in Germany. Starting in 2019, Hamburg now also offers pedelec cargo bikes. They are available at dedicated stations and need to be returned at the same location. As their usage is free, it offers interested members an easy opportunity to test cargo bikes.

For further information:
https://stadtrad.hamburg.de[36]

Figure 20 Hamburg (Germany) offers also cargo bikes in their public bike share scheme

Source: https://www.hamburg.de[37]

8 Specific measures in respect to hydrogen as an energy source

This section compiles a catalogue of municipal measures regarding the implementation of specific hydrogen infrastructure. Generally speaking, before consumption hydrogen needs to be produced and transported to the place of the application that may be a refueling station for mobile applications or stationary applications. Figure 21 shows a scheme of the four different hydrogen productions possibilities, i.e. by electrolysis through renewable energies, as a side product in the chemical industry (e.g. chlorine-alkali-electrolysis), gasification of bio masses, and natural gas reformation.

For hydrogen transport, either trucks or pipelines can be used. For applications, either mobile applications or stationary applications are possible.

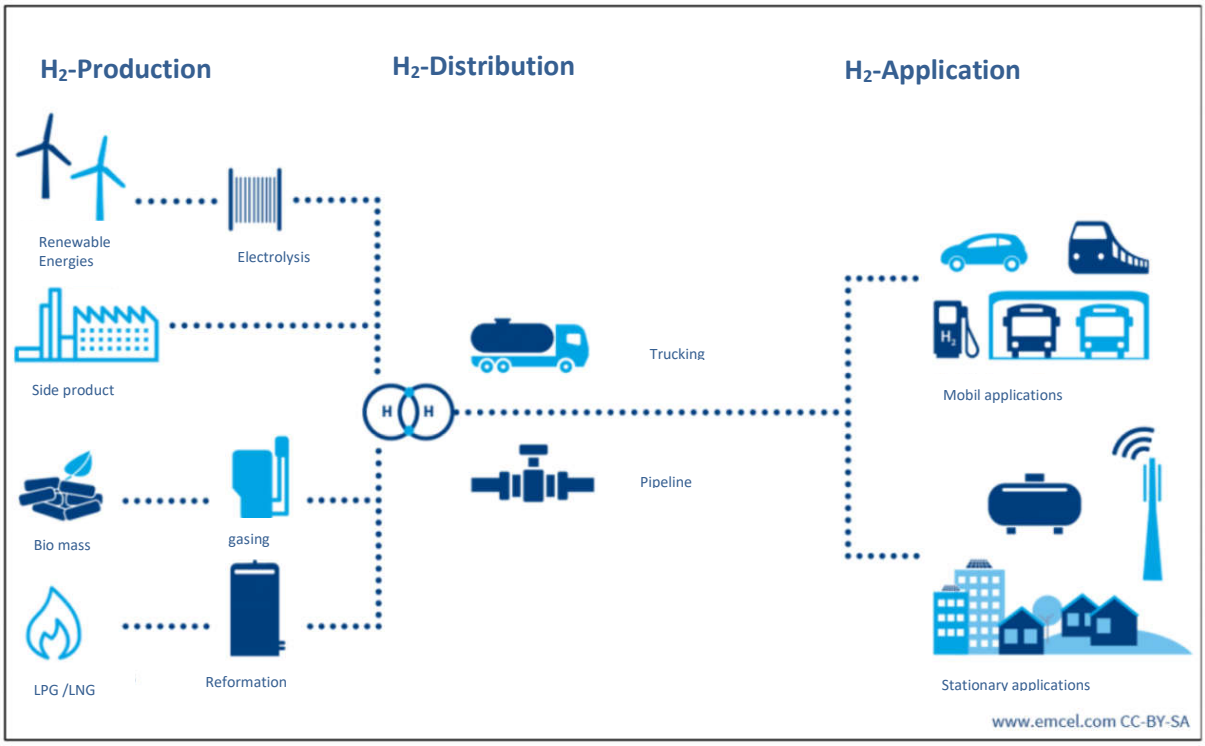

Figure 21: Production, transport and application of hydrogen

Source: According to https://www.emcel.com CC-BY-SA

8.1 Overarching EU Hydrogen Roadmap

In keeping with the Conference of Parties (COP21) Paris Agreement and in order to keep the global warming levels well below 2 degree Celsius above preindustrial levels, the EU has a vision to transition to a decarbonized energy system. Hydrogen production and use on a large scale is one of the main vehicles the EU plans to use in achieving the ambitions decarbonization objective. This is also a move to stay relevant in the hydrogen market, which is heavily competitive on the global front. Thus the EU has adopted several recommendations to give priority to attractive hydrogen applications while tackling key barriers to their implementation and build a masterplan[38].

Figure 22 is a graphical representation of the EU roadmap for creating a hydrogen powered system that relies heavily on clean hydrogen production to be produced using mainly wind and solar energy.

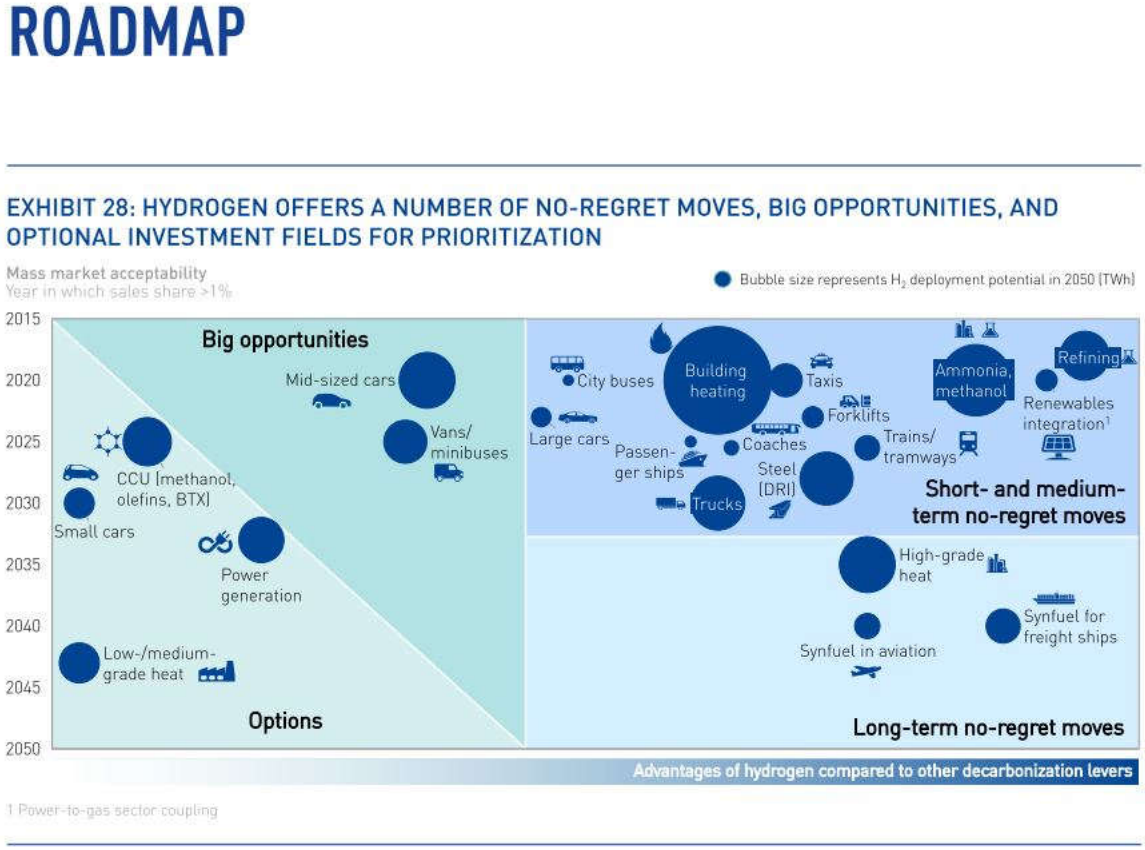

Figure 182: EU Hydrogen Roadmap

This roadmap has been the output of the public-private partnership called **the Fuel Cells and Hydrogen Joint Undertaking ("FCHJU")** which was established in 2008. Germany, as one of the key leaders in hydrogen and fuel cell technology in Europe, established the **National Organization for Hydrogen and Fuel Cell Technology ("NOW")**. This body has responsibility for the coordination and management of the *"National Innovation Programme for Hydrogen and Fuel Cell Technology (NIP)"* and the *"Electromobility Model Regions Programme of the Federal Ministry of Transport and Digital Infrastructure (BMVI)".*

According to a report by the European Commission on hydrogen strategy for the EU, investment in hydrogen will foster sustainable growth and jobs, which will be critical in the context of recovery from the COVID-19 crisis. The Commission's recovery plan highlights the need to unlock investment in key clean technologies and value chains. It stresses clean hydrogen as one of the essential areas to address in the context of the energy transition, and mentions a number of possible avenues to support it.[39]

8.1.1 Hydrogen Investment Agenda for the EU

The EU has a comprehensive investment agenda for the scaling up of hydrogen production and usage as evidenced in planned high investments in electrolysers and directly connecting them to 80-120 GW of solar and wind energy production capacity to provide needed electricity. There are also plans to retrofit half of existing plants with carbon capture and storage in addition to investments for hydrogen transport, distribution and storage, and refueling stations. An estimated total investment of between €180 to €470 billion is planned for up to 2050 in the EU.

To facilitate adapting of end-users to hydrogen consumption the EU has started the **European Clean Hydrogen Alliance** to play a critical role in the implementation of the **Industrial Strategy of the European Commission** for promoting investments to scale up production and demand for renewable and low carbon hydrogen. This will bring together various stakeholders namely industry, national, regional and local public authorities and the civil society in the entire value chain to promote and coordinate these investments. There are conscious efforts to engage the stakeholders in line with the investments and support the drive for innovative solutions, technology transfer, public-private partnerships and the testing of new solutions to be piloted.

8.1.2 Boosting Demand and Scale up Production for Hydrogen

The EU recognizes the need to boost demand for hydrogen usage while at the same time scaling up its production in appreciable volumes to meet the core markets of industrial applications and mobility. To this end it is captured under the Commission's new industrial strategy to substitute the use of carbon-intensive hydrogen in refineries, ammonia production among others. This is to be followed up with a basis for providing investments in and constructing zero-carbon steel making processes in the EU.

In the case of the transport sector, where hydrogen is seen as promising in the light of difficulty with electrification, it is proposed as a first phase to have captive uses for early adoption of hydrogen in the areas of local city buses, commercial vehicles or portions of the rail network where electrification is deemed challenging. There is, however, a caution for siting the deployment of hydrogen refueling stations (to be supplied by regional or local electrolysers) which should ideally be determined on detailed analysis of fleet demand and the respective requirements for both light- and heavy-duty vehicles.

The EU recognizes the appreciable transition to hydrogen as being long term requiring careful planning and taking due cognizance of the starting points and infrastructure that may vary across Member States. The commission plans to put in place EU-wide instruments, based on impact assessments, aimed at providing a supportive framework in regards to the transitional carbon emission reduction benefits of hydrogen. These instruments are to be in conformity to established standards defined in relation to existing **Emission Trading System (ETS)** benchmark for hydrogen production. Through the **Renewable Energy Directive** and the **Emission Trading System**, the EU has in place the supportive framework towards a cost-effective decarbonization through carbon pricing.

Beyond boosting demand and scale up of hydrogen production, the EU is also actively involved in promoting research and innovation in hydrogen technologies to complement efforts geared at speeding up the adoption of hydrogen powered systems. This is particularly useful in that when the technology matures and economies of scale improve the Total Cost of Ownership, it is most likely to decline (forecasted to be cheaper than BEV and ICE by 2026) and hence the likelihood of a rapid increase in adoption rates can be expected[40]. This is also fueled by the drive to ensure the EU does not lose out of the competitive hydrogen market.

8.2 Worldwide Perspective: Strategic Documents of Frontrunner Regions and Cities Supporting Hydrogen Infrastructure and the Use of Hydrogen Vehicles

A typical front runner city in championing hydrogen as an energy source is **Aberdeen**. According to a report by H2 Aberdeen, considerable investment has been made into hydrogen that takes away the

worry about the "chicken and egg" situation of which of the two should come first; either vehicles or refueling stations. The strategic document of the city contains a conscious effort to support vehicle deployments through available local policy mechanisms under support for private sector deployments. Here a long-term certainty is assured to the private sector by the creation of low E-zone exemption, use of bus lanes, free parking, tax incentives, among others. In a phase 3, the city of Aberdeen intends to extend its bus operation that runs on hydrogen as well as increase the production and distribution of hydrogen from about 400 kg/day Hydrogen Refueling Station (HRS) to 1000 kg/day HRS in line with planned implementation of about 10 bus projects. The concise strategy of the city with several objectives are captured under the broad categories of vehicle deployments, production and supply of hydrogen, hydrogen refueling infrastructure, non-transport applications, hydrogen supply chain, education and awareness and policy measures to ensure strategy and policy development at all levels of government are supportive of hydrogen technologies.[41]

Beyond Europe, other locations around the globe also have specific measures targeted at hydrogen as an energy source. **The United States** is on record as the first country to establish hydrogen and fuel cell technology in its energy strategy. This has been through several US government funded researches as far back as 1970 as necessitated due to the oil crisis. Between 1974 and 2000, focus was mainly on hydrogen production and distribution and hydrogen infrastructure through policies such as *"Hydrogen Research, Development And Demonstration Act"* in 1990 and *"Hydrogen Future Act"* of 1996. Beyond 2000 attention has been given to support for passenger and commercial vehicles in addition to the earlier focus areas. Prominent documents in line with this focus include *"National Hydrogen Energy Development Roadmap"* and *"Hydrogen Fuel Initiative and Hydrogen Posture Plan"*. In 2013, the Department of Energy of the USA launched the **H2USA**, a public-private partnership with FCEV OEMs, with a focus on the advancement of hydrogen infrastructure and providing an enabling environment for large scale adoption of FCEVs. Particularly the California Fuel Cell Partnership set up in 2019 has outlined targets for 1,000 hydrogen refueling stations and 1,000,000 FCEVs by 2030.

Currently one of the world's largest hydrogen markets for both production and consumption is the **Chinese market**, which has evolved since 1999 when the first Chinese fuel cell vehicle was developed. High-level strategic plans such as *"13th Five-Year Plan for Strategic Emerging Industry Development"*, *"Energy Technology Revolution and Innovative Action Technology (2016-2030)", "Energy Conservation and New Energy Vehicle Industry Development Plan (2012-2020)"* and *"Made in China 2025"* are evidence of strong government support to encourage and guide research and development of hydrogen and fuel cell technology in **China**. Beyond the research and development, there are also incentives in place to promote the use of FCEVs. Currently there are subsidies for FCEVs in place until 2025 even though those for BEVs are being reduced on a yearly basis. However, there are currently no subsidies for refueling stations at the national levels except at the local level for some cities like Foshan, and Zhongshan city where local subsidy policies are being set.

Coming out of the disaster of the Fukushima nuclear power plant accident, the government of **Japan** was forced to revise its earlier vision of achieving renewable energy through nuclear power. Instead the focus shifted to hydrogen with the government's firm resolve to make Japan a *"Hydrogen society"*. Consequently, the fourth *"Strategic Energy Plan"* was launched by Japan in 2014 detailing the use of hydrogen. Also, the *"Strategic Roadmap for Hydrogen and Fuel Cells"* was published defining an integrated approach to hydrogen production, storage, transportation and application. With the aim to commercialise hydrogen fuel cell power generation by 2030, the Japanese government published the *"basic strategy of hydrogen energy"* in 2017. In the automotive front Japan is accorded the first in

production of a commercialized car (TOYOTA Mirai) in 2014. This had been after several years of devoted research and development in fuel cell technology since 1990 by Toyota, Honda and Nissan. Presently, Japan tops the world as far as number of refueling stations are concerned with a total of 127.

Figure 23 is a tabular representation of the current and targeted fuel cell vehicles by type and the corresponding infrastructure according to the four main regions worldwide, where targeted policies are in place to promote usage.

		Passenger vehicles	Buses and coaches	Trucks**	Forklifts	Refueling stations
US	Current	7,271 [44]	35 active, 39 in development	prototype test	>30,000 [335]	~42 online [37]
	Target		5,300,000 FCEVs on US roads by 2030 [337]		300,000 by 2030 [337]	7,100 by 2030 [337]
China	Current	0	2,000+ [64 83 84 85]	1,500+ [94]	2	23 [89]
	Target	3,000 by 2020 [87] 1,000,000 by 2030 [336]	11,600 commercial vehicles by 2020 [87]			100 by 2020 500 by 2030
Europe	Current	~1000+ [42]	~76 [42 73 86]	~100 [88]	~300 [42]	~152 [71]
	Target	3,700,000 by 2030 [34]	45,000 fuel cell trucks and buses by 2030 [34]			~3,700 by 2030[34]
Japan	Current	3,219 [44]	18	N/A	160	127; 10 in progress
	Target	40,000 by 2020 200,000 by 2025 800,000 by 2030 [24]	100 by 2020 1,200 by 2030 [24]		500 by 2020 10,000 by 2030 [24]	160 by 2020 900 by 2030 [24]

Figure 193: Global Usage and Targets for Hydrogen

8.3 Catalogue of Single Measures to Set up a Hydrogen Eco System on Local Level

It is imperative for cities to adopt specific measures targeted at promoting and advancing the use of hydrogen as an energy source. This could find itself in applications of automotive industry or power generation and storage. In the sections that follow, a catalogue of specific measures are discussed as a guide for cities to select and adopt those that fit within local conditions and circumstances of respective cities.

In the next sections specific measures for setting up a comprehensive hydrogen strategy with its single measures are presented.

8.3.1 Development of a coherent hydrogen fuel station network for a city

Beyond the setup of hydrogen fueling station, the production of hydrogen, the transport and distribution of the hydrogen must be considered. Distribution could be through trucks or pipelines. The choice of setting up a hydrogen fueling station, either at the site of hydrogen production or remotely via a distribution channel, greatly impact the cost of operations and must be properly analyzed in order to make a decision. Clearly, it is important to optimize the economics of setting up a hydrogen fuel station and this can be achieved through securing of cheaper electricity and provision of services to balance the grid. This could lead to about 20 percent savings on production costs.

As far as distribution costs are concerned, it would be economically prudent to set up few larger capacity hydrogen fuel stations than several of small capacity. To optimize the layout of stations at low market penetration while ensuring maximum consumer utility and stimulation of future demand growth, the consumer convenience-based siting model could be adopted. Alternatively, the idealized city model which is based on hydrogen delivery distances could be adopted for use.

8.3.2 Facilitate / moderate a dialogue with stakeholders to install hydrogen stations

As a new system, the transition to hydrogen use as an energy source is heavily challenged with the development of hydrogen refueling infrastructure to satisfy a relatively low number of hydrogen vehicles. Viewed as a chicken-and-egg situation the challenge is considered in the high cost of production and delivery of hydrogen at a small scale to satisfy the limited demand on the one hand and provision of adequately distributed refueling stations for consumers to feel comfortable about owning a hydrogen vehicle on the other hand. Figure 24 shows a hydrogen station in Hamburg which costed about €2.9 Mio[42].

It is therefore of key significance to identify the stakeholders involved in the entire supply chain and engage them to chart a common pathway towards installation of hydrogen stations to be able to address the challenge of supplying hydrogen to small and growing markets and also benefit from the economies of scale in the process. Where some concessions must be given, the city authorities could use that to incentivize the private sector in the intended direction.[43]

Figure 204: Hydrogen fueling station in Hamburg, Germany (Source: Energytours)

8.3.3 Public relations/Information campaigns/knowledge transfer

Cities such as Aberdeen have set as a vison to become a leading region for a low carbon economy with hydrogen technology in Europe. Hydrogen is seen as an opportunity to support economic growth through inward investments, business development and job creation. A diversification of the energy

industry in the long term is deemed feasible through the creation of a local supply chain and a rise in demand for the transferable skills from the oil and gas sector. This is because some components of the hydrogen technologies are comparable to the oil and gas sector. Hydrogen technology is even more relevant in the context of energy storage constraints and grid capacity.

One form of hydrogen production is through electrolysis of water by running an electrical current through water in an electrolyser to split the water into hydrogen and oxygen. The use of electricity from renewable sources in this process leads to the production of hydrogen with very low carbon emissions. As an energy storage medium, hydrogen is compressed and stored until needed either to be converted back to electricity through fuel cells in vehicles or generators. Hydrogen could also be used directly in an internal combustion engine. This serves a storage medium for excess electricity production from renewable sources and make it available again when needed.

It is important to increase public awareness about this technology through effective public relations and information campaigns. Particularly awareness on the business opportunities presented by hydrogen for local companies especially those in the oil and gas industry should be carried out through stakeholder events. Working with research and development organizations is also important to identify the skills and training needs of the current and future hydrogen sector and develop educational materials where appropriate, particularly for early adopters.

8.3.4 Training sessions

Fuel Cell electric vehicles reduce the carbon emissions and air pollution levels in the atmosphere as they emit water vapour and are quieter to run. Supported with a good refueling infrastructure the use of hydrogen vehicles, particularly pedelecs can be very efficient in the last mile delivery process. It is therefore important to have targeted training sessions organized for different categorizations of delivery workers/businesses: self-employed delivery workers, SMEs in the delivery business and also large delivery/express companies.

Training sessions could be targeted at the following category of individuals:[44]

- Driver Training – This is to ensure that drivers are familiar with the controls of the vehicle and can safely ride them
- Hydrogen fueling staff training – individuals to be responsible for fueling the vehicles must be properly trained to assure high levels of safety and compliance to standardized procedures
- Maintenance training - Individuals responsible for maintaining the vehicles must be properly trained in the vehicle technology and corresponding safety protocols
- First responder training – individuals responsible for providing emergency treatment in the event of accidents are expected to be provided the needed training to handle such issues that may arise with the use of the vehicle

Properly planned and executed training will assure high levels of operations leading to maximum productivity.

Figure 215: Training session (Source: picktime)

8.3.5 Local Funding program for hydrogen infrastructure

At the local level, cities are encouraged to provide funding programmes aimed at incentivizing the use of hydrogen vehicles through the development of a local hydrogen supply chain. This is particularly relevant because of the perceived negative economies of scale regarding investment costs and the costs of operations for relatively small size of the early adopters. OEMs could also be supported to establish vehicle support centres at strategic local dealerships. Adequate funding provisions must also be made available for researching and improving on the technology to secure optimal economies of scale with the hydrogen industry.

Where skills shortages or high supply chain costs are seen as challenges against internal investments, it is required of cities to work hand in hand with the wider region to identify areas where investments could be more attractive or where earlier development of the supply chain is feasible. Additionally, it is prudent to engage early on with existing oil and gas industries to tap into and encourage relevant skills transfer and also with the siting of hydrogen infrastructure where their premises could be used instead of setting up at totally new locations.

9 Conclusions

The spectrum of bike supportive measures indicated in this document serves as a guide to cities in selecting appropriate solutions that will encourage the set up of an ecosystem for bike friendly cities. Specifically, the measures are directed to encourage the use of cargo bikes in commercial applications.

Cargo bikes bare advantages to conventional vehicles as long as they are legally considered a “bicycle”. That means the electric pedal assistant must not exceed assistance over 25 km/h and a nominal

continuous power of not more than 250 W. Complying with these legal aspects, cargo cycles can also use bicycle infrastructure for bypassing road congestion, can benefit from abbreviations through parks and other for vehicles restricted areas, or go through one-way-road in opposite direction (in the case for Germany, where it is allowed specifically).

Heavy duty cargo cycles challenge the legal restrictions of 250 W and also the required energy which is needed to transport heavy cargo several miles without the need for charging. Enlarging batteries for more energy storage means always more dead weight (proportionally). The striking advantage of a fuel-cell system using hydrogen as energy storage is, that with only little more weight for a larger tank, the storage capacity can be increased tremendously (disproportionately high).

Additionally, the use of clean (green) hydrogen plays a vital role in ensuring climate neutrality. That means, hydrogen must be produced by renewable energies. Otherwise the fuel-cell technology is not climate friendly, but at least it produces no harmful local emissions.

In the end cities are encouraged to embark on a participatory process of selecting amongst the various measures to come up with strategies for implementation. By conducting a citizen's jury, the final strategy developed can be holistically adopted by all stakeholders and implementation can be successfully carried out.

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