GrowSmarter
Transforming cities for a smart, sustainable Europe

IMPLEMENTING SUSTAINABLE URBAN MOBILITY IN EUROPEAN CITIES – CONCLUSIONS FROM GROWSMARTER

D4.6. CONCLUDING REPORT WP4

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Contact information for Site Managers

Barcelona: Gonzalo Cabezas Ruecas, gcabezasr@bcn.cat

Cologne: Julia Egenolf, Julia.Egenolf@stadt-koeln.de

Stockholm: Mika Hakosalo, mika.hakosalo@stockholm.se

Prepared by: Paul Fenton, City of Stockholm, GrowSmarter WP4 Leader and Maria Xylia, Sweco Energy AB. With thanks to all participants of GrowSmarter, past and present, who contributed to the implementation of WP4.

Email: paul.fenton@stockholm.se

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EXECUTIVE SUMMARY

This report presents conclusions following demonstration of 18 measures addressing Sustainable Urban Mobility in the GrowSmarter project and its three "Lighthouse Cities" of Barcelona, Cologne and Stockholm. Each measure forms part of five of the 12 "Smart Solutions" within the GrowSmarter project, which are briefly introduced in this report. General conclusions are described by topic with reference to practical examples from the project illustrating potential barriers or opportunities to implementation, and contain recommendations for each topic. These general conclusions are summarized, and recommendations are given for different stakeholders on how to facilitate and accelerate roll-out of Smart Solutions.

The urban mobility landscape is changing fast and a plethora of new actors are entering the market with innovative solutions – some of them are embraced by the public and become viable, while others fail. In such a fluid surrounding environment, avoiding lock-ins to certain technologies is key. Cities should have an orchestrating, but not restricting, role that promotes positive changes towards a sustainable system and "listens" to the citizens' needs and demands. Public consultations can be beneficial with regards to this aspect, but the process could be more streamlined to the particular issues faced each time.

The GrowSmarter project recommends more creative use of public space, through e.g. establishment of regulated spaces in which sustainable mobility is prioritised and a wide range of new mobility and transport services can emerge and flourish. Such spaces could address single topics – such as consolidated delivery services using sustainable last-mile providers – or address more comprehensive travel concepts including mobility stations and other offerings. To achieve this, cities should be empowered with new regulatory powers and resources to ensure Europe's transition to sustainable urban mobility.

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LIST OF ABBREVIATIONS

CBG	Compressed biomethane (biogas)
CNG	Compressed Natural Gas
CCS	Combined Charging System
CO_2	Carbon dioxide
ED95	Bioethanol
EU	European Union
HDV	Heavy-Duty Vehicle
HVO	Hydrogenated Vegetable Oil
ICLEI	ICLEI – Local Governments for Sustainability
ICT	Information and Communications Technology
KVB	Cologne's Public Transport Authority
MaaS	Mobility-as-a-Service
MFD	Macroscopic Fundamental Diagram
OEM	Original Equipment Manufacturer
PPP	Public-Private Partnership
SUMP	Sustainable Urban Mobility Plan
V2B	Vehicle-to-Building
V2G	Vehicle-to-Grid
V2X	Vehicle-to-Everything
WP	Work Package

1 INTRODUCTION

Across Europe, cities are embracing the pursuit of smart and sustainable development. Urgent and transformative action is required to reshape processes and practices influencing the design, construction and end-use of urban infrastructure.

In this context, the "Lighthouse Cities" of Barcelona, Cologne and Stockholm, together with a diverse group of public and private sector partners, formed the GrowSmarter project. The "Lighthouse Cities" are cutting-edge practitioners of sustainable urban development, whose measures shine a light on both the potential risks and benefits of different approaches.

GrowSmarter demonstrated '12 smart city solutions' in energy, infrastructure and transport, to provide other European cities with insights and stimulate uptake of processes, products, techniques and systems that can support the transition to a smart, sustainable Europe. GrowSmarter included 18 measures that aimed to resolve complex urban mobility and transportation challenges (see Table 1).[1] These measures were clustered into five topics:

- Smart building logistic and alternative-fuelled vehicles (Smart Solution 2)
- Sustainable delivery (Smart Solution 9)
- Smart traffic management (Smart Solution 10)
- Alternative fuel-driven vehicles for de-carbonising and better air quality (Smart Solution 11)
- Smart mobility solutions (Smart Solution 12)

This report is based on a wide range of project activities, including reports, evaluation data, interviews and workshops. Key results and conclusions from each of these measures are discussed in Chapter 2. In Chapter 3, the report also presents thematic and general cross-cutting lessons learnt. Chapter 4 presents recommendations for policy-makers and practitioners aiming to facilitate replication and upscaling good practice for sustainable urban mobility and transportation across Europe.

[1] Experiences from the planning and implementation of the measures were discussed in "Implementing Sustainable Urban Mobility in European Cities – experiences from GrowSmarter" (D4.3. Implementation Report WP4, February 2018). Emerging conclusions from the measures were presented in "Implementing Sustainable Urban Mobility in European Cities – first conclusions from GrowSmarter" (D4.4. Draft Concluding Report, February 2019).

Table 1: Short description of the content and aims of WP4 solutions and measures.

Solution	Mea-sure	City	What is it?	Aim	Page
Smart building logistics & alternative fuelled vehicles	2.1.	STO	Construction consolidation centre	Increase efficiency of logistic flows through consolidation of deliveries to construction sites. Use of alternative fuels in trucks.	9
Sustainable delivery	9.1.	STO	Neighbourhood parcel delivery room	Reduce traffic to and from post offices by enabling delivery of parcels to secure room by cargo bike.	10
	9.2 & 11.3.	BCN	Distribution of freight using e-cargobikes in inner city	Use of micro consolidation centres and e-cargobikes to enable sustainable inner-city last mile deliveries.	11
Smart Traffic Management	10.1.	BCN	Traffic management simulation tool	Test a new traffic management simulation tool to avoid or alleviate congestion in dense urban areas.	12
	10.3. & 11.5.	STO	Travel Demand management app	App to inform citizens and enable behavioural change by facilitating modal shift and/or use of alternative fuels or electric mobility.	13
	10.4.	STO	Traffic control system for passenger vehicles	Enable private vehicles to reduce starts and stops at red lights through use of vehicle-traffic light communication system.	14
	10.5.	STO	Traffic signal priority for HDVs using alternative fuels	Encourage use of alternative fuels in HDVs (Heavy-Duty Vehicles) and reduce number of starts/stops by offering signal priority to HDVs using alternative fuels at key intersections.	15
Alternative fuel driven vehicles for decarbonizing and better air quality	11.1. & 11.2.	BCN, COL STO	Charging infrastructure for e-vehicles	Improve infrastructure and increase the number of normal and fast charging points for e-vehicles in the Lighthouse Cities.	16-17
	11.4.	STO	Alternative fuel stations for HDVs	Increase number of alternative fuel stations for HDVs in Stockholm.	18
	11.6	BCN	Small distributed CNG grid	Installation of one small compressed natural gas (CNG) filling station giving service to CNG vehicles.	19
Smart mobility solutions	12.1.	STO	E-car-sharing pool	Promote shared use of electric cars and reduce number of parking spaces.	20
	12.2.	STO	E-cargobike pool	Promote shared use of e-cargobikes by residents.	21
	12.3.	COL	Mobility stations	Offer multiple travel alternatives at mobility stations offering multiple travel alternatives.	22
	12.4.	COL	Car-sharing	Expand range of car- and bike-sharing alternatives, both electric and fossil-fuelled, and integrate car-sharing with mobility stations (see above).	23
	12.6.	BCN	Smart taxi stand system	User sensors to improve queue systems at taxi stands and reduce search traffic.	24

2 FIVE YEARS OF WORK: ACTIONS AND ACHIEVEMENTS

2.1 Smart building logistic & alternative-fuelled vehicles (Smart Solution 2)

Integrated Multi-modal Transport for construction materials/logistics centre in Årsta (Measure 2.1)

Construction consolidation centres aim to increase the efficiency of logistic flows and reduce emissions from traffic. Inbound deliveries of different product types are grouped into single deliveries and distributed to the construction site at the right moment, thereby avoiding multiple deliveries by various suppliers. Waste can then be removed from the construction site using the same transport. This reduces congestion and risks (e.g. damage or loss of materials, loss of working time searching for lost materials) in and around construction sites whilst providing wider economic and environmental benefits.

What did GrowSmarter do? The distribution company Carrier established a consolidation centre in Stockholm and delivered materials to construction sites in Årsta, part of the Stockholm site. Results indicated that use of a consolidation centre reduces the number of deliveries, even though amount of vehicle-km is similar when compared to traditional approaches. More efficient travel flows and use of 100% HVO fuel further reduced CO_2 emissions. Results were compared with similar projects to demonstrate their validity.

Lessons learnt: The scale and location of a construction project influence the extent to which consolidation centres can reduce costs, environmental impacts and create other benefits (e.g. improved working conditions). In this case, and according to the information reported, the consolidation centre was not financially sustainable, possibly because of its small size. Consolidation centres offer clear benefits when implemented at larger, complex sites (e.g. multiple construction projects, many actors operating, diverse range of deliveries). The extent to which small-scale projects offer benefits depends on the local context and pre-conditions, which in GrowSmarter were not ideal. Deliveries occurred on a more ad-hoc basis than was planned, partly because the consolidation centre was relocated and key suppliers lay close to the construction site. A "tent solution" was introduced to improve consolidation at the site, and Carrier developed delivery containers (using technology from Measure 9.1.) as a new service enabling deliveries outside of working hours. Off-peak deliveries may offer a possible way to further increase efficiency of logistics flows to construction sites.

Potential for upscaling and replication: Construction consolidation centres have been implemented at larger scales in Stockholm and other cities; they can be replicated in most locations. For maximum impact, construction companies should include consolidation centres for large developments (approx. >1000 dwellings). Cities can use procurement and other tools to demand use of consolidation centres in e.g. new districts or large-scale renovation projects.

HOW DID THE MEASURE WORK?

Technical feasibility
The measure is technically feasible.

Economic feasibility
Scale is important. Several small projects or one large site/district may provide sufficient scale (e.g. multiple actors or public infrastructure projects).

Replication potential
Large – but it is important to take into account what type of construction project it is as the prerequisites can differ.

Municipalities could demand fossil-free transport at constructions sites and regulate allowed transport volumes (km transport/m² built) to promote consolidation centers.

2.2 Sustainable delivery (Smart Solution 9)

Integrated multi-mode transport for light goods (Measure 9.1)

Innovative logistics solutions can reduce traffic to and from post offices by enabling delivery of parcels to alternative locations, such as a secure parcel delivery room located on the bottom floor of a multi-storey apartment block. Delivery is done with fossil fuel-free transport.

What did GrowSmarter do? In Årsta, Stockholm, GrowSmarter gave residents of Stockholmhem's housing the possibility to order items for home delivery using a "c/o" address. Parcels arrive at a terminal and are transported to the delivery room using e-cargo bikes, instead of being transported to collection points. Couriers and residents access the delivery room using a smartphone app, which restricts access to those who have a parcel to collect. Delivery of wide range of parcels (e.g. furniture) is possible, as the full space of the room can be used for storage. This service improves residents' accessibility to postal services and reduces delivery and collection traffic.

Lessons learnt: In a survey of tenants, 88% indicated that they think the delivery room is a good idea, but very few tenants actually used the service (evaluation suggests around 35 parcels/working day are required for economic viability). However, as many of the tenants were older people who do not make orders online, higher levels of support and adoption may be observed in other areas. Another reason was that the "c/o" solution was not user-friendly, as online retailers and postal companies did not always accept that customers provided an alternative address. Formalising the delivery room as an official post collection point may resolve this issue, and clarify the cost issue – should tenants pay for the service as part of their rent, or should costs be integrated in delivery tariffs? This may also determine who should have access to the room (tenants or the general public). Other lessons included the importance of identifying suitable physical space for delivery rooms early in development projects; such space should be accessible for residents and couriers, but not compete with other functions (e.g. commercial spaces, cycle garages, laundry rooms etc.). The distance to key logistic terminals is another important aspect to take into account.

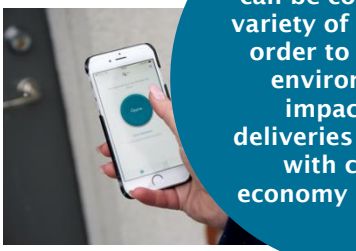
Potential for upscaling and replication: The potential for adaptation and further improvements to this measure is high. Additional functions can be added, such as delivery of refrigerated goods or other services residents' demand, such as sharing of cycles, machine tools or other items. A wide range of cities and other stakeholders have shown interest in replicating this measure, including PostNord, the postal service of Denmark and Sweden. The project partners and app provider have also developed related services using a similar approach, including unmanned "delivery containers" for use at construction sites (thereby providing a complement to measure 2.1).

HOW DID THE MEASURE WORK?

Technical feasibility
Technically simple but implementation feasibility is influenced by local structures for ordering and shipping goods online.

Economic feasibility
Economic feasibility depends on number of daily parcel deliveries. Tenants did not pay to use the room in this project.

Replication potential
High potential to replicate. Property owners and postal services have key role in selecting the locations and fostering collaboration.



The delivery rooms can be coupled to a variety of services in order to minimize environmental impact from deliveries and assist with circular economy initiatives.

Micro distribution of freight & Charging infrastructure for electric tricycles for micro distribution (Measures 9.2 and 11.3)

Use of micro consolidation centres and e-cargo bikes to enable sustainable inner-city last mile deliveries in dense urban environments.

What did GrowSmarter do? GrowSmarter facilitated the launch of a last-mile delivery service using e-cargo bikes from a micro-consolidation centre in the old town of Barcelona. The project secured temporary premises for the micro-consolidation centre, charging infrastructure for e-cargo bikes, and permits for operation in the old town. In this district, traffic restrictions apply to deliveries by cars and trucks in the morning, whereas cycle delivery is possible throughout the day. On-bike sensors were installed to assist with routing and to monitor the service and environmental conditions for research purposes along the routes. Over 207,000 journeys were made by the e-cargo bikes over a 26-month period, reducing CO2 emissions by approximately 96% compared to delivery by trucks, and also cutting noise and pollution. Moreover, delivery by e-cargo bikes resulted in an overall reduction in vehicle-km, as routes were more efficient and flexible.

Lessons learnt: Last mile delivery is an emerging market segment, and creative support from city administrations is needed to accelerate a transition to sustainable delivery systems. Such support could be given in terms of e.g. designating a zone for deliveries with a dense population and high turnover of parcels; mandating actors to deliver within the zone and monitoring non-compliance; and – in this case – identifying premises and agreeing a tenancy arrangement to enable implementation. Identifying a suitable location for the service, agreeing the terms of operation, and ensuring a suitable installation of the sensor units on the bikes were the main challenges and achievements. It is important to reach a trade-off between robustness, safety and functionality.

Potential for upscaling and replication: This measure can be adapted and replicated in most European cities. Municipal processes may need to speed up to keep pace with markets and clarify issues – such as the formal relationships between service providers, data ownership or the need for additional support mechanisms, e.g. restrictions on delivery times or use of delivery bays – in order to creatively change framework conditions in favour of sustainable parcel delivery. Delivery volumes play an important role, therefore contracts with logistics companies are necessary to upscale the solution. Regulation from the municipal side can be a strong driver; for example, last-mile deliveries in city centres could be required to be only by bike.

HOW DID THE MEASURE WORK?

Technical feasibility

No major problems occurred, but data collection was challenging from the technical perspective.

Economic feasibility

Emerging market segment, but the high initial investment costs can raise a barrier to further expansion. Large volume of deliveries needed for ensuring economic feasibility.

Replication potential

Possible to replicate in cities with similar infrastructure requirements. The policy and administrative barriers discussed above should be alleviated though.

This solution offers emission-free deliveries in parts of cities where most needed, such as historical centers and areas with high traffic. Deliveries with bikes offer higher flexibility in such areas.

2.3 Smart traffic management (Smart Solution 10)

Traffic management through Macroscopic Fundamental Diagram (Measure 10.1)

New approaches to traffic management simulation may help cities avoid or alleviate congestion in dense urban areas. Using a theoretical model for Macroscopic Fundamental Diagram (MFD) as a traffic management tool may inform strategies to avoid or reduce congestion. The theoretical approach can also be used to assess other policy areas, such as air quality.

What did GrowSmarter do? "Traffic management through MFD" was primarily a research initiative rather than an empirical demonstration. The implementation phase consisted of building the model to simulate a city district in the City of Barcelona. The City's Department of Mobility provided CENIT with data so that all traffic lights times were introduced to the model, along with the direction of the flow of each street and the number of lanes. Data collection at 22 points in the network enabled traffic light optimisation to enable improved traffic flows. Application of this model indicated how to alleviate congestion with resultant positive impacts in terms of e.g. reduced energy consumption and emissions. Estimated savings indicate 15-16% reduction in CO_2 and NOx emissions, along with significant reductions in traffic density and journey time.

Lessons learnt: Implementation of the measure has provided important input to traffic planners, indicating the potential for improvements in the studied district. Changes to traffic management systems in one district inevitably result in up- or downstream impacts observed elsewhere, and it is a significant to analyse the impact of increased queues on the periphery of the studied district. Large amounts of data are required for reliable analysis, and the system requires a homogenous traffic light network to function optimally. (Many cities have multiple networks operating in parallel, meaning some traffic lights can be operated from a central control, whereas others require manual adjustment by technicians on site). This makes the approach used more suitable in smaller conurbations of 10km^2 or less.

Potential for upscaling and replication: The tool could be used in other cities with congestion problems and homogenous systems. Emission reductions can be achieved and additional benefits include reduction of accidents as well as improved air quality. The County of Barcelona sees these results as promising and is planning to replicate use of the tool.

HOW DID THE MEASURE WORK?

Technical feasibility

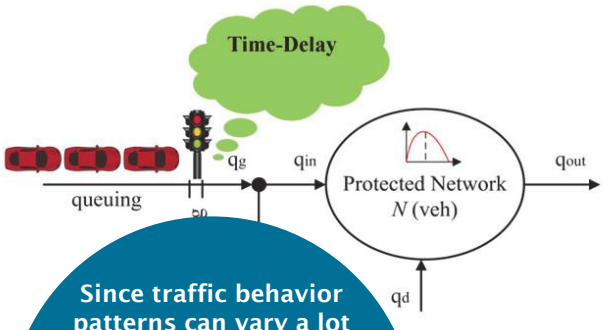
Obtaining and validating data may be challenging. Data was needed from multiple entities and in some cases, there was lack of willingness to share the data.

Economic feasibility

Difficult to verify the economic feasibility, since it is a theoretical measure.

Replication potential

Greater potential in smaller cities with homogenous traffic light networks and good data collection protocols.



Since traffic behavior patterns can vary a lot due to differences in street design and traffic flows, smaller areas with relatively common patterns for street traffic should be studied to obtain meaningful results.

Travel Demand management & Smart guiding to alternative fuel stations and fast charging (Measures 10.3 and 11.5)

Provision of information to citizens via smartphone applications may enable behavioural change by facilitating modal shift and/or use of alternative fuels or electric mobility.

What did GrowSmarter do? Two measures were combined to produce one smartphone app offering a travel management tool to help residents of Valla torg plan journeys and reduce their environmental impacts. A service informing drivers about the location of alternative fuel stations and electric vehicle charging points was integrated into the app, thereby promoting use of non-fossil fuel cars (for trips where car journeys are necessary). This combined service offered an integrated multi-modal portal promoting sustainable travel choices. GrowSmarter funded development, testing and demonstration of the app. This process took significantly longer than expected due to technical problems related to the GPS function in the app, which rapidly drained smartphone batteries. Once this was resolved and the visual identity of the app was finalised, the app was launched and 87 people users logged over 1100 trips during an 18 month period. Economic evaluation suggests that if 64 users shift from fossil-fuelled cars to sustainable modes, CO_2 savings approaching 138.5 tonnes per year could be realised (which would be considered economically sustainable).

Lessons learnt: It was difficult to attract users to the app, as many residents of Valla torg were elderly persons without smartphones; it is essential to have a clear idea of which market niche and target group(s) an app will serve. A clear and user-centric demonstration plan, involving particular actions to reach "challenging" target groups is strongly recommended. It is also easy to underestimate the technical complexity and costs of app development. Issues such as data ownership and management should be considered. Iteration processes are time-consuming and rival products emerge on a regular basis, meaning it may be necessary to rethink and redesign applications on a repeated basis.

Potential for upscaling and replication: Two Swedish municipalities have adopted the app as a tool to "nudge" citizens towards more informed travel choices. Solutions such as this can be replicated in other contexts, although their actual impact on user behaviour is unclear. Linking so-called enabling services to appropriate local or national incentive systems and sustainable transport modes may support nudging towards sustainable travel choices.

HOW DID THE MEASURE WORK?

Technical feasibility

The measure is technically feasible, but the real challenge is in attracting customers when the app is introduced to real users addressing their everyday mobility needs.

Economic feasibility

Software development is expensive. Partnerships with different mobility service providers could potentially secure revenue streams, but the measure was not financially sustainable in the demonstration due to lack of revenues.

Replication potential

Possible to replicate in other cities and contexts but adaptations to the needs of each local community may be needed.

Social acceptance of the measure plays and important role. Acceptance and usage rates may differ based on particular characteristics of each local community. Partnerships with mobility providers are of interest.

Traffic control system for passenger vehicles (Measure 10.4)

Emission reductions may be possible by enabling private vehicles to reduce starts and stops at red lights by creating a green light flow through use of traffic light communication systems.

What did GrowSmarter do? A specific route in Stockholm with eleven traffic lights was chosen to demonstrate a technique in which open traffic information data was used to find the optimum speed along the route to minimise queues and reduce emissions. The measure involved communication between the traffic control systems steering traffic lights and smart systems in vehicles which receive signals and indicate to drivers at what speed to drive to cross at a green light. The technical implementation comprised a number of key steps. First, data quality and the quality of forecast at each traffic light along the test route was checked. Such data is critical to ensure the information received by vehicles is accurate and reliable. Once data was tested, links between different servers were established to enable the vehicle included in the test to receive updates from the traffic control system.

Lessons learnt: Participating stakeholders acquired knowledge on how to implement the system, for example by identifying what kind of system conditions are most appropriate. The accuracy of traffic light forecasts and their predictability are the main prerequisites for successful demonstration. The implementation phase indicated that the proposed system would work better in cities in which traffic control systems are more predictable than Stockholm (where pedestrians have priority and can interrupt the flow of green lights).This was confirmed by the demonstration, reflecting the fact that many traffic lights in Stockholm are programmed to change if pedestrians wish to cross streets, and also the presence of fixed pre-programmed time intervals that determine the system responsivity.

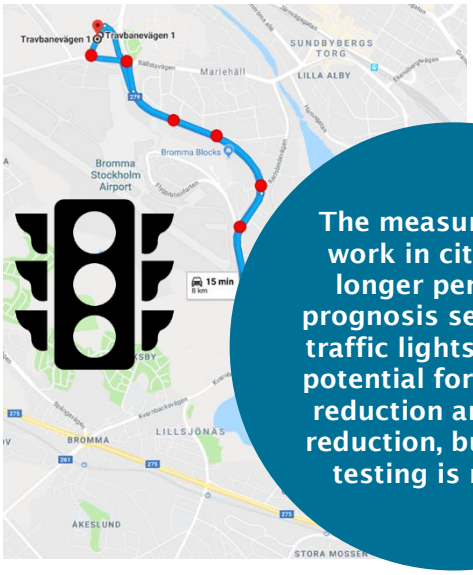
Potential for upscaling and replication: The decision to implement such systems is basically one for cities, and thus cities have important leverage over the ways in which such systems may be used. This means cities must acquire knowledge about systems and match them to physical and institutional contexts in order to get the desired results. The techniques demonstrated work, but the context has to be right to produce effective outcomes. Cities that are interested in implementing the measure should start by having dialogue with traffic light system provider to recognize if three core functionalities are in place: (i) good connection between signals along the route; (ii) the forecast system is able to correctly predict signals in more than 90% of cases; and (iii) good connection between signals and cars. Once these have been secured, a test drive on a selected stretch of road can be conducted. The technology can also be further tested in conjunction to autonomous vehicles' introduction. In general, introduction in a variety of city environments could be helpful in further testing the versatility of the system.

HOW DID THE MEASURE WORK?

Technical feasibility
Several challenges for completing the measure, the largest being predictability issues which in turn influenced the trust of drivers for the system.

Economic feasibility
The feasibility of the system will depend on the current traffic light system, however major investments are not feasible now.

Replication potential
Cities that want to invest in this technology must identify if a central control system exists that enables core functionalities listed above.



The measure would work in cities with longer periods of prognosis security for traffic lights. There is potential for emission reduction and traffic reduction, but further testing is needed.

Traffic signals synchronized to prioritize certain vehicles movement of goods (Measure 10.5)

By synchronising traffic signals to prioritise freight distribution using HVO-fuelled heavy vehicles, it may be possible to reduce the number of starts and stops for heavy vehicles and thereby reduce environmental impacts and improve safety at junctions.

What did GrowSmarter do? The Stockholm-based firm Carrier incorporated HVO-fuelled heavy vehicles into their fleet. A test route was proposed, but a pre-study indicated significant negative impacts for other road users. Alternative routes with fewer traffic lights were identified, making the potential positive impacts of the demonstration smaller, but also reducing the risk of major negative externalities. One of these routes was selected for the test, guidelines were defined, and technical systems were adapted to enable the demonstration. Specially-adapted mobile phones were programmed and installed into the test vehicles to enable data collection.

Lessons learnt: The process of route selection illustrates the complexity of integrating such a system into a dynamic traffic system. Prioritising one mode of transport, or one type of fuel or technique, will create incentives for small numbers of users, yet risk generating larger negative impacts for other road users not prioritized by the system. The indirect system impacts of such innovation are thus hard to value. Of course, by offering an incentive to adopt non-fossil fuels in vehicle fleets, the measure aims to promote a transition to cleaner vehicles and fuels which, if successful, would eventually remove the need for an incentive. However, at this scale and operating in isolation from other potentially complementary stimuli (e.g. congestion charge rebates or other benefits), the impacts of this action are limited to the CO_2 saving generated by use of HVO in the fuel tank.

Potential for upscaling and replication: De-carbonization of heavy goods transport implies a high importance, as well as potential, for the use of biofuels. Incentives such as signal priority and support for the development of infrastructure could mobilize actors to invest in such solutions. Integrating signal priority may be desirable on certain intersections or sites, such as ports, or form part of a systemic approach involving zoning, access restrictions or congestion charging. Replication is possible in most cities.

HOW DID THE MEASURE WORK?

Technical feasibility

The measure is technically feasible, but careful selection of the routes is needed to ensure maximum impact.

Economic feasibility

Potential benefits depend on the scale of application. Such measures can be particularly attractive for private businesses in the freight sector.

Replication potential

The measure could be replicated by private actors in the goods distribution sector. The scale of implementation influences the potential profitability.

It is important to thoroughly investigate routes and impacts on all kinds of road users. Implementation may proceed slowly due to capacity constraints on the actors involved.

2.4 Alternative fuel-driven vehicles for de-carbonising and better air quality (Smart Solution 11)

Developing charging infrastructure & E-mobility management system (Measures 11.1. and 11.2)

Installing charging infrastructure for electric vehicles contributes to increased use of electric vehicles, which offer environmental benefits compared to fossil-fuelled vehicles.

What did GrowSmarter do? The project introduced five rapid charging points in Barcelona and one in Stockholm. A further eight normal charging points were installed at Valla Torg in Stockholm (two of which serve Measure 12.1), and at six of ten mobility stations in Cologne (see Measures 12.3 and 12.4). A total of 10 charging stations (each with two charging points) using green electricity from renewables was installed in the project area in Cologne. In addition, an innovative form of Vehicle-to-Building charging was demonstrated in Barcelona. The charging facilities have been used by multiple user groups including private vehicles, taxis, and car-sharing services. At each site, results indicate the number of charging sessions has increased during the project, along with the share of electric vehicles in new vehicle sales. Provided the electricity supply is renewable (which it is at these sites), then use of electric vehicles offer significant CO_2 savings compared to fossil-fuelled vehicles.

Lessons learnt: Evaluation of charging behaviour shows that drivers with access to chargers at home or work use these for long charging periods. On-street charging is characterized by shorter periods, although often these exceed permitted time restrictions. Before a public charging station can operate, a lot of network planning and adaptation is required, which may take 4 to 6 months. Installation of chargers on publicly-owned land is more complicated than installation of privately-owned land; actors that own their own land and electricity grid connection may be able to install charging infrastructure more rapidly. For installations on public land, cities should address ownership issues and responsibilities regarding data management, maintenance, costs and revenues when issuing permits. This means aligning actions with city strategies, and finding new ways of accounting for measures which may not have obvious economic benefits, but offer direct benefits related to reduced CO_2, noise, etc.

Potential for upscaling and replication: European cities are rapidly upscaling and replicating charging solutions as the electric vehicle fleet grows. Incentives (e.g. free parking for electric vehicles) may stimulate markets but must form part of coherent long-term strategies.

HOW DID THE MEASURE WORK?

Technical feasibility

The measure is technically feasible.

Economic feasibility

Electricity sales do not always cover investment costs, although electric vehicle sales are increasing. New service providers and business models are emerging. Location choice is critical.

Replication potential

Possible to replicate in cities which aim better integration of e-mobility services. Local aspects should be taken into account, such as, for example the available electric grid capacity. A well-established charging infrastructure is a prerequisite for increased e-mobility.

Develop a charger location strategy which depends on whether public land or not is considered.

Developing charging infrastructure & E-mobility management system (Measures 11.1. and 11.2)

The V2X (Vehicle-to-Everything) system allows for bi-directional energy flow and interaction between the vehicle and the grid. In this way, the electric vehicle can be efficiently charged and discharged. With V2X chargers, customers may store energy in their electric vehicle and discharge it later (at peak hours) to for example reduce their energy costs.

What did GrowSmarter do? The measure was deployed at Nissan headquarters in Barcelona and focuses on the integration of V2B (Vehicle-to-Building) services (two V2X chargers) with on-site renewable energy generation (a Photovoltaic plant) and energy storage systems in the building. In order to control and optimize the operation of the V2X chargers and the storage, an Energy Management System and a SCADA (Supervisory Control And Data Acquistion) system that controls, monitors and processes data were developed.

Lessons learnt: Results indicate the potential to realise energy savings and CO_2 reductions, plus avoid use of fossil fuels, through use of the V2B approach. However, the challenging technical issues faced during the implementation of the measure indicate that the technology needs time to mature before large-scale replication of V2X is possible. Concerning regulations, V2X should be included in grid codes, as grid-related policy frameworks in many countries currently do not recognize EVs or EVSE as a distributed energy storage resource capable of injecting power into the network. It is not clear yet that business models using V2X technology are economically sustainable, but other factors, such as environmental responsibility and energy autonomy may also influence the V2X value proposition to end users. Regarding the public acceptance of the technology, it will be necessary to promote potential benefits and address possible concerns, such as data security or battery guarantees.

Potential for upscaling and replication: The concept of EVs in conjunction with the V2B chargers providing services to the building has been successfully demonstrated. Nevertheless, it is not clear that business models using V2X technology are currently economically sustainable. Concerning the replicability of the measure, further work should be done with the aim of reaching the full potential of V2X chargers.

HOW DID THE MEASURE WORK?

Technical feasibility

The measure is technically feasible. However, it has been challenging to implement due to the complexity of the solution and the lack of maturity of the V2X technology.

Economic feasibility

It was not possible to demonstrate that business models using V2X technology are economically sustainable. Novel business models have to be tested.

Replication potential

The measure could be replicated in other cities in public or private buildings with EV fleets. The way this measure is replicated will depend on the context of the city.

Key challenges include further understanding of V2X value proposition to consumers and development of customer-focused business models.

Refuelling facilities for alternative heavy duty vehicles fuel (Measure 11.4)

Heavy duty vehicles are significant sources of air pollution in urban areas but pollution and greenhouse gas emissions can be reduced through use of alternative fuels. To enable this, refuelling facilities offering alternative fuels need to be installed in and around major cities.

What did GrowSmarter do? This measure supported the expansion of Stockholm's refuelling network for alternative fuels used in heavy duty vehicles. Like buses, heavy duty vehicles required different facilities in fuel stations to cars and light vehicles, with high-capacity pumps and larger bays. The project funded staff costs, enabling the City of Stockholm to work strategically with stakeholders to identify appropriate sites and assist with necessary planning applications and secure permits. In total, seven alternative fuel stations were installed at 5 locations around the city. This increases the availability of renewable fuels such as ED95 (bioethanol), CBG (biomethane) and HVO (biodiesel) for use in heavy duty vehicles in Stockholm and its surrounding region. The number of alternatively-fuelled heavy duty vehicles (excluding 100% HVO-fuelled trucks) operating in Stockholm has risen from 356 in 2016 to 392 in 2018, with alternative fuels accounting for 28% of all vehicle sales in 2018.

Lessons learnt: This measure demonstrates that there is demand for use of alternative fuels in heavy goods vehicles on a fully commercial basis. Installation of new pumps on existing facilities located on privately-owned land is relatively uncomplicated, in the sense that installations are made on a commercial basis. However, installation takes much longer if development plans have to be changed. It is also important to reach agreements with partners about data collection, either voluntarily or as part of formal environmental inspection.

Potential for upscaling and replication: Dedicated infrastructure is required to enable distribution using heavy goods vehicles operating on alternative liquid and gaseous fuels. Cities need to work strategically in partnership with relevant stakeholders to ensure such infrastructure is established and support users in making a transition to alternatively-fuelled heavy goods vehicles. Part of establishing these partnerships is agreements on how data will be collected and handled, so that the city can monitor environmental impacts and identify ways to further accelerate the transition to alternative heavy-duty fuels. Another key issue concerns business models, as fuel station operators may have to diversify their business to cover investment costs for alternative fuel infrastructure. In the GrowSmarter demonstrations possible sales of fuel do not cover the investment costs.

HOW DID THE MEASURE WORK?

Technical feasibility

The measure is technically feasible and socially accepted among relevant stakeholder groups. The potential to increase use of alternative fuels in the sector is large.

Economic feasibility

Fuel station operators may need to diversify their businesses to cover investment costs. The public sector could, where possible, offer accelerate planning processes or offer subsidies on land/ property rights to accelerate roll-out.

Replication potential

Possible to replicate in various contexts and city environments.

Special agreements for data collection needed, as cities establish strategic partnerships for dedicated infrastructure for heavy-duty vehicles.

Small distributed compressed natural gas (CNG) grid (Measure 11.6)

Provision of refuelling infrastructure for alternative fuels such as CNG may help reduce greenhouse gas emissions in cities by reducing use of petrol or diesel in vehicles.

What did GrowSmarter do? One small compressed natural gas (CNG) filling station was installed to serve CNG vehicles in the city of Barcelona. The station was innovative and unique, based on a new concept aiming to optimize the station's integration into the urban landscape. This kind of technology for small CNG refuelling infrastructure had not previously been demonstrated for urban public use. A number of potential locations for the installation were proposed but none of them was approved by Barcelona City Council. An alternative approach was consequently adopted, where potential impacts of the measure were analysed using data from existing stations (three stations) that Naturgy operates within the city. The methodology for the evaluation of this Measure consists of the monitoring of two of the three CNG stations that Naturgy operates in Barcelona. It is necessary to locate the CNG station very close to a high-pressure gas pipeline in order to minimize the electrical consumption of the compressor unit at the same time that civil works costs are optimized. Since the processes described above have taken longer than expected, the demonstration period will exceed GrowSmarter's duration.

Lessons learnt: The approach is feasible and the use of CNG fuel offers a reduction of CO2 in comparison to petrol or diesel. Some of the main implementation challenges were related with the station design due to the limitations on available public space. The solution is to aim as much as possible for flexible and adaptive designs, while maintaining station CAPEX & OPEX at the same level as a conventional filling station.

Potential for upscaling and replication: There are plans to upscale the network of stations in the City of Barcelona and other cities could replicate this approach. The current network of filling stations and future deployment plan have been considered for defining the different location proposals. An alternative implementation pathway would be in collaboration with private stakeholders.

HOW DID THE MEASURE WORK?

Technical feasibility

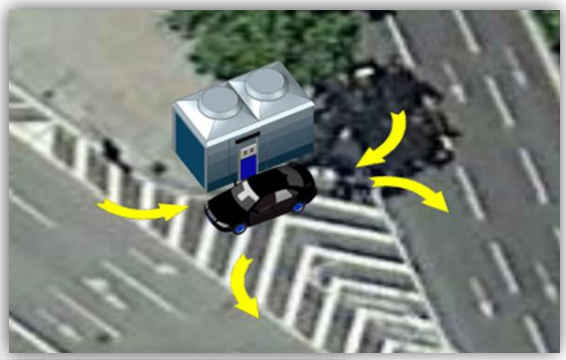
The measure is technically feasible, but implementation is challenging when it comes to localization of the infrastructure.

Economic feasibility

Not evaluated.

Replication potential

The measure can be replicated in parallel with expansion of urban gas distribution networks. Early dialogue between involved stakeholders is necessary in order to decide upon applicable locations. The possibility to collaborate with both public and private stakeholders should be early assessed.



Gas and electric mobility could be complementary in the urban landscape. Optimal use of public space can be promoted through such synergies.

2.5 Smart mobility solutions (Smart Solution 12)

Green parking index in combination with car-sharing pool with EV (Measure 12.1)

Electric car-sharing services are one of a range of smart mobility solutions that can encourage citizens to shift modes and travel more sustainably.

What did GrowSmarter do? A car-sharing pool with electric vehicles was launched at the Valla Torg site in Stockholm in February 2018. This car-sharing service is open to the public and residents of Stockholmshem's rental properties did not have to pay membership fees to use the service during the demonstration period. The car-sharing service also makes use of two charging points installed within Measure 11.1. By procuring this service, Stockholmshem is able to benefit from the City of Stockholm's "green parking index" regulation, which allows property companies to reduce to the number of parking spaces during construction of new housing if they introduce alternative mobility services for residents (the company is constructing new residential buildings alongside those renovated as part of GrowSmarter). The car-sharing pool has been successful, demonstrating continual growth during its 18 months of operations. Customers have driven a total distance of 43,809 km, avoiding 8,336 kg of CO_2 emissions compared to the same distance driven by a medium-sized petrol car.

Lessons learnt: The car-sharing pool is successful and frequently used by residents, especially at weekends and weekday evenings, offering residents in the district with access to sustainable vehicle transport and thereby discouraging private ownership of cars. As this approach is new for the rental housing company, not all arrangements were considered ideal (e.g. Stockholmshem paid the electricity costs of using the system both for their own residents and non-residents). There is potential to expand and replicate the service in other districts, but this may require adoption of a variety of business models and approaches.

Potential for upscaling and replication: This measure can be upscaled and replicated in many contexts. Housing companies, both public and private and for both owner-occupied and rental properties, can stimulate uptake of car-sharing services by dedicating parking spaces to car-sharing and facilitating new projects. If the willingness to pay is high for residents, parking spaces can be allocated to suppliers at market prices. A risk with this is that if the pool service is not used, the supplier will not be able to cover its fixed costs and therefore operate the service. For newly-constructed buildings, green parking index systems provide a better business case than for renovating existing buildings, where a subsidy might be needed. Additional costs can occur for securing the power supply for charging. It is recommended that cities raise the cost of private parking in order to support expansion of car-sharing services.

HOW DID THE MEASURE WORK?

Technical feasibility

The measure is technically feasible, however securing the necessary electric grid capacity can be a local challenge.

Economic feasibility

Difficult to evaluate the economic benefits at this stage since they are not captured by the partners involved.

Replication potential

Replication strongly dependent on willingness to pay for the service.

Carry out in-depth market analysis and align interests of different stakeholders. Explore willingness to pay for the service early.

Electrical and cargo bike pool (Measure 12.2)

E-bikes and e-cargo bikes have emerged as a practical alternative to vehicles for longer-distance commuting by cycle and for errands and logistics. Sharing such cycles may make them attractive to wider groups and enable larger numbers of people to reduce use of cars.

What did GrowSmarter do? The rental housing company Stockholmshem procured an e-cargo bike pool service from a contractor and installed the service alongside the electric vehicle car-sharing pool in Valla Torg, Stockholm. Implementation of this measure was complicated, as few companies existed that offered e-cargo bike pool services. Similar services operate in other locations in Sweden, but most are operated by members or volunteers, or linked to local businesses/public services. By launching this measure, Stockholmshem demonstrated a service that can add-value for tenants by increasing access to sustainable transport. Unfortunately, the e-cargo bike pool has had problems with repeated thefts disrupting services. During its first four months of operation, 33 trips were made.

Lessons learnt: One explanatory factor for low usage levels is demographic, as the service is based in a district with an elderly population. To better serve this group, one of the two-wheeler cargo bikes will be replaced with a three-wheeler, which may provide greater stability for some users. Thefts may be reduced by storing cycles indoors, rather than in an outdoor mesh cycle garage (which proved easier to burgle). The business model for private e-cargo bike pools is emerging and until now has mainly been the domain of not-for-profit service providers. Key issues to resolve when implementing e-cargo bike pools include the issues of maintenance and storage, along with the business model for concessions, membership, etc. In the demonstration, use of the service cost approximately €1.50 per hour. For future pools, Stockholmshem is considering purchasing e-cargo bikes and paying for a maintenance and booking system service.

Potential for upscaling and replication: Incentives such as the Swedish Government's 25% subsidy for purchases of e-bikes and e-cargo bikes can help stimulate adoption by individuals, but other tools could be considered to help stimulate e-cargo bike pools. These could include zone restrictions allowing e-cargo bikes where motorized traffic is not allowed (see Measure 9.2), green parking indexes that oblige developers or property owners to deliver such services (see Measure 12.1) or integration into bike-sharing systems or mobility stations (see Measure 12.3) offering "Mobility-as-a-Service" subscription packages.

HOW DID THE MEASURE WORK?

Technical feasibility

The technical implementation has not had any major complications other than the need to secure the bikes from theft. They are placed in a bike cage with electronic locks, but even this has not deterred thieves.

Economic feasibility

For the measure to be economically feasible either higher service prices or use rates are needed.

Replication potential

Good replication potential especially in new constructions, but the target group should also be considered, as well as anti-theft equipment.

Develop a clear idea of the service and user needs early in a development process.

Mobility station (Measure 12.3)

Mobility stations located across the city offer multiple transport alternatives at one location, including – but not limited to – public transport, car-sharing, bike-sharing and other services. By improving people's access to multiple travel alternatives, mobility stations offer a disincentive to own or use private vehicles.

What did GrowSmarter do? Nine mobility stations were implemented in Cologne, each with various formats and combinations of service including public transport, electric car-sharing, conventional car-sharing, dynamic pricing of parking spaces, timesharing of private and (during the project) public parking spaces, as well as conventional bike-sharing and e-bike-sharing. Customers can pay for public transport as well as car-sharing using a mobility card. The key steps taken to establish mobility stations include identification of possible locations (including analysis of customer needs), securing permits, preparing parking spaces and installing equipment, and preparing customer interfaces such as ticketing systems and signage. The mobility station signage developed by Cologne has become the standard used in the Federal State of North Rhine-Westphalia, and the City of Cologne has adopted a mobility station masterplan identifying 200 locations for new mobility stations to be improved or installed in the near future.

Lessons learnt: Mobility stations facilitate CO_2 reductions achieved through modal shift and appear to be economically sustainable for the partners involved. When planning mobility stations, it is particularly important to understand who owns the land on which mobility stations are located and to ensure that locations are visible sites that match user needs or preferences (i.e. easily accessible and not "out of the way"). There may be restrictions on use of public land for private ventures (leading to prohibitions, additional costs or fees, or need for exemptions). For example, German cities are only able to offer small spaces on public streets to private enterprises on three-year concessions, and until recently, German courts did not allow parking space-sharing services to operate on public land (similar barriers exists in Sweden). The dynamic market for mobility solutions means new services are emerging, adding to the complexity of developing business models but offering potential to integrate additional services into or close by mobility stations (e.g. cargo bikes, scooters, delivery boxes, more).

Potential for upscaling and replication: many cities are introducing mobility stations as part of their Sustainable Urban Mobility Plans, and in response to emerging trends such as the boom in "free-floating" shared services and "Mobility as a Service". Cologne is adding more mobility stations and the city's experiences highlight a range of tasks and challenges that other cities can learn from to replicate the concept. Parking of free-floating bikes and e-scooters could also be restricted to such mobility stations in order to facilitate smooth integration of such services to the urban landscape.

HOW DID THE MEASURE WORK?

Technical feasibility

Main challenge was to identify suitable locations.

Economic feasibility

A mobility station cannot be evaluated separately, but has large potential to increase use of public transport share and achieve positive externalities.

Replication potential

Good replication potential. Mobility stations should be complemented with more bike- and car-sharing.

Mobility stations provide valuable services for cities. Issues such as land ownership and relevant regulations that may limit or expand the services.

Electrical and conventional car- and bike- sharing (Measure 12.4)

Expanding the range of car- and bike-sharing alternatives can encourage modal shift and reduce emissions and use of private vehicles.

What did GrowSmarter do? Conventional and Electric car-sharing and e-bike sharing services were launched in Cologne and integrated into mobility stations (Measure 12.3) using charging infrastructure delivered by Measure 11.1. Eight car-sharing locations were established, six of which including e-charging. Three locations include e-bikes (at mobility stations in M12.3). Key steps included the identification of suitable locations for e-car-sharing as well as e-bike-sharing locations and the development and formalisation of agreements with the City administration and private stakeholders to ensure installation of the facilities. Cambio, the KVB and the City administration signed contracts to enable the use of parking spaces for e-car-sharing as well as e-bike-sharing services. Results indicated almost 2.3 million km driven by car-sharing customers using the eight stations, strong use of e-bikes and customer acceptance of the integrated e-ticketing system.

Lessons learnt: Identifying sites at which services could be located was time-consuming. In terms of operation, the optimal sites for mobility stations are not always ideal for car-sharing. Car-sharing services must be located in optimal locations to ensure financial viability of operations and significant shifts in citizen behaviour (with resultant environmental benefits). This is best achieved through long-term planning and cooperation. City administrations could explore ways to streamline e.g. permitting processes. Mobility stations can serve as "shop windows" for a range of services and can therefore be useful in marketing. These should be supported with integrated ticketing platforms to ensure fast transactions and enable public transport tickets to be "topped up" with other services.

Potential for upscaling and replication: Deciding which locations should be chosen for the car-sharing locations is key for the implementation of an otherwise technically feasible measure with high potential to replicate. Legislation that enables such services should be in place before implementing the measure.

HOW DID THE MEASURE WORK?

Technical feasibility

The measure is technically feasible without any major issues faced. Issues related to land allocation and legislation gaps are important to be considered.

Economic feasibility

Challenging to achieve, since the location of the stations was not optimal. Moreover, electric vehicles cost more, and acceptance issues may have led to reduced utilization rates.

Replication potential

Car- and bike sharing stations can be implemented everywhere. Particularly suitable are residential and mixed areas with a good local infrastructure and a good access to public transport as well as a good network of cycle paths.

Station-based car-sharing services can reduce levels of private car ownership and, as part of mobility stations, facilitate modal shift to sustainable alternatives

Smart taxi stand system (Measure 12.6)

Use of smart phone app matches taxi drivers and custumers, reducing the number of taxis cruising for customers and thereby reducing traffic and emissions.

What did GrowSmarter do? A new form of information system for taxi users and taxi drivers was introduced in Barcelona, making use of sensors at taxi stands to monitor the number of waiting taxis in real-time. The system is supported by a smartphone app that enables users to check availability of taxis at taxi stands located around Barcelona, thus enabling a reduction in the number of taxis cruising for customers. Implementation involved extensive discussions with the Regulatory Institute for Taxis. Taxi operators were informed about the measure and the temporary closure of taxi stands during installation of the sensors (one day per site). A driver survey indicated strong support of the measure, given its potential to reduce search traffic. Sensors were installed at taxi stands and publish real-time information about taxi availability via the application that taxi users and drivers can access.

Lessons learnt: Valuable experience was gained regarding the optimal placement of sensors for obtaining measurements, which types of taxi stands are appropriate for sensors, and the type of issues related to data communication between the sensors and the data management system. As with other measures, the process of obtaining permits for physical works took time. Similarly, the costs of network access and system use, and issues related with data costs (free for the City administration during the project phase) are long-term challenges for actions of this type. In the absence of regulations guiding taxis to use taxi stands, customers continue to prefer to hail on-street or be collected at, for example, their residence or office.

Potential for upscaling and replication: Sensor-based systems are likely to interest cities or sites with taxi stands, particularly those that enforce zones or restrictions on where customers may be collected, such as airports. Such systems can be linked to other requirements, e.g. use of non-fossil fuel vehicles, to accelerate the transition to sustainable transportation. Taxi companies increasingly use proprietary applications, which could be linked to sensor-based systems to provide real-time information on taxi location and availability. Similarly, sensor-based systems may contribute to development of mobility station or MaaS (Mobility as a Service) offerings or enable synergies with other kinds of mobility services.

HOW DID THE MEASURE WORK?

Technical feasibility

The measure is technically feasible, but it is challenging to monitor and evaluate its results. Establishing a baseline to compare to is difficult when testing just a few taxi stands.

Economic feasibility

Not evaluated.

Replication potential

Since the sensor maintenance costs as well as regulatory barriers have been an issue, the potential to replicate in other cities might be low.

Taxis cruising for customers might be prohibited in some cities. Long-term strategies should take into account the implications of technologies (e.g. maintenance, maturity, etc.) and their desirability.

3 LESSONS LEARNT

3.1 Thematic lessons

Alternative fuels and electric mobility

Concerns about climate change and the impacts of air pollution on public health demonstrate the urgency of reducing use of fossil fuels. Cities and stakeholders across Europe are mobilising to install charging infrastructure for electric vehicles, which consumers are adopting at an increasing rate (see Box 1 for charging infrastructure checklist). Moreover, alternative fuels are increasingly in demand, particularly for heavy vehicles.

The implementation of similar measures in the three "Lighthouse Cities" highlights recurring challenges affecting the introduction of infrastructure for alternative fuels and electric mobility. For example, public land is often more complicated to use than private land, and the planning and permitting processes that must be completed to initiate works are often convoluted and time-consuming. Improved coordination within municipal organisations may help speed up planning and permitting processes.

Simultaneous introduction of various logistics solutions (consolidation centres, delivery rooms) and alternative-fuelled/electric vehicles was common in the project and has been successful. It is worth replicating such an approach in the future, as the benefits are increased due to both effective logistics and low emission fuels' use. Prioritizing alternative vehicles' traffic flows can be a good incentive to promote a wider fuel switch in the future.

Related Smart Solutions: 2, 9, 10, 11, 12

Related measures: 2.1, 9.1, 9.2, 10.5, 11.1, 11.2, 11.3, 11.4, 11.6

Box 1: A checklist for charging infrastructure installation

Each of the "Lighthouse Cities" installed public charging infrastructure for electric vehicles. In the checklist below, we propose some simple steps for other municipalities seeking to install charging infrastructure, based on the lessons learnt from GrowSmarter:

1. Find out what equipment needed to charge an electric vehicle – in Stockholm, consumers are advised to charge using 230V and 16A, one-phase, mode 3, type 2 fixed chargers for normal charging at ordinary parking facilities. Three-phase chargers are suggested for daytime charging. Some vehicle models have different requirement, as does rapid charging.
2. Identify where the vehicle should be charged – different solutions are available, and preferable, for different user groups. Charging boxes, ideal for indoor installation in garages, are cheaper than on-street charging points. Permits may be required.
3. Consider who is likely to use the charging infrastructure and if payment solutions will be required, and to differentiate between conventional and fast charging options.
4. Contact the electricity network manager to check there is sufficient grid capacity for new charging infrastructure.
5. Take in offers including, if necessary, operation, maintenance and support equipment. Commission cable works and establish an electricity supply subscription.

Logistics and urban freight distribution

Logistics and urban freight distribution using fossil-fuelled vehicles account for an increasing share of transportation, with disproportionately high impacts on local air quality. Cities are urgently seeking ways to reduce such impacts by increasing transport efficiency (e.g. reduce

number of starts and stops, improve traffic flows, find synergies between transport services), and reducing use of fossil fuels (e.g. introduction of alternative fuels or sustainable logistic services such as cargobikes).

Construction consolidation centres have previously been demonstrated in large-scale construction projects for new districts in Stockholm. Due to their scale and unique characteristics, it is possible to realise a variety of economic and environmental benefits. Private construction companies and their suppliers have adapted to use consolidation centres in the knowledge that all companies operating in the district operate under the same terms and conditions. One lesson learnt from GrowSmarter is that locating the centre with good understanding of the demand for services in the surrounding area is pivotal in influencing the extent that the centre is eventually used and delivering economic and environmental benefits. The insights gained from the demonstration can help facilitate decision-making processes for the localization of similar sites in the future. The location of the consolidation centre should ideally be close to and, in the eyes of delivery companies, en route to the site.

Micro-distribution of freight with electric bikes gives excellent opportunities for emission-free goods' flows and reduced heavy traffic with minimal contribution to congestion. Such opportunities are of particular interest to apply in city centres and culturally or socially sensitive environments where it is particularly desirable to reduce presence of motor vehicles (e.g. historic areas or streets around schools). The role of local authorities as a facilitator that oversees and regulates the services is important in this context.

Delivery rooms is among the measures with large potential to replicate and upscale in GrowSmarter, because the measure was applied in a timely period where e-commerce and home deliveries are experiencing exponential growth in the city of Stockholm (similarly to many cities across Europe). The measure can been attractive to various relevant stakeholder groups; municipalities trying to reduce freight distribution -related congestion, private actors interested in delivering new services "at the door" of customers, as well as the users themselves which experience a more efficient way of receiving parcels, goods deliveries etc. However, in order to successfully expand the use of delivery rooms collaboration and support of key stakeholders, such as national post services, is required. Recommendations for planning smart urban logistics systems are provided in Box 2.

Related Smart Solutions: 2, 9, 10, 11

Related measures: 2.1, 9.1, 9.2, 10.5, 11.4

Box 2: Planning for smart urban logistics

- Procure what you want to achieve! If the target is to reduce emissions and traffic from logistics, policy measures should be introduced in order to restrict construction sites' traffic flows, for example, or promote the use of fossil-free fuels. Such targets would make the introduction of consolidation centres necessary. Another example would be to include delivery rooms in detailed plans for new residential areas.
- Location and financial scale in relation to key logistic terminals is important. Successful consolidation services require large volumes of transported goods, materials, etc. Identify a suitable scale (e.g. number of apartments) as early as possible.
- International postal services are linked to national ones; harmonized frameworks at the international level are needed.
- Plan in parallel to other planning processes. Ensure that information barriers are addressed: knowledge should be shared horizontally (among different stakeholder groups) and vertically (to sub-contractors).
- Digitalization is key for upscaling! Use such opportunities to modernize the sector.

Transport efficiency and smart traffic management systems

The experiences from implementing Smart Traffic management systems in GrowSmarter suggest that such systems can be used to make transport more efficient. This may reduce the environmental impacts of traffic in cities and provide value for drivers by for example reducing waiting times at junctions. However, the relative performance of traffic management systems depends on complex interactions which vary in different cities.

In the future, significant efforts must be made to plan, demonstrate and evaluate the functionality and viability of different traffic management solutions. However, there may be a tendency to discount the probability and costs of human factor influences – such as small decisions concerning e.g. the introduction of left turns or pedestrian crossings – when making assumptions about project planning for technical systems.

Similarly, the development of smartphone applications to facilitate behavioural change is technically possible, yet complex, subject to contextual variations, and success depends on the app fulfilling a need users may struggle to identify when asked. Experiences from other projects suggest that, with a plethora of apps available in a rapidly-changing market, it is challenging for new apps to provide clear added-value for users. Incentives (in the form of discounts, prizes or similar) may be required to stimulate adoption of apps, yet these may be hard to incorporate into a sustainable business model.

Related Smart Solutions: 2, 10

Related measures: 2.1, 10.1, 10.3, 10.4, 10.5, 11.5

Sustainable mobility and modal shift

Modal shift through reduction of journeys using motor vehicles and increased levels of walking, cycling, public transport and emerging low or zero emission services is key to achieving sustainable urban mobility. Emissions from fossil-fuel powered transportation can be significantly reduced through increased use of public transport and vehicle-sharing schemes, and increased use of alternative fuels and electricity in road transport can complement such efforts. Emission reduction through modal shift not only contributes to climate change mitigation, but also to reduced air pollution and improved urban environments.

Emergence of new actors and services may help diversification of mobility services aiming on inter-modal transport with higher environmental and social sustainability. Opportunities to integrate non-mobility services into conventional pricing models should be further explored, such as in the case of Cologne and Measure 12.4 where the Public Transport Administration's (KVB) mobility ticket was integrated with car-sharing services by Cambio. Rules concerning use of public land and administrative processes can hinder rapid transition (see Measure 12.3 for mobility stations in Cologne and Box 3). In some cases these measures might not be directly economically sustainable, but their contribution on modal shift leads to indirect benefits that should not be neglected.

Related Smart Solutions: 10, 11, 12

Related measures: 10.1, 10.3, 10.4, 10.5, 11.1, 11.2, 11.4, 11.5, 12.1, 12.2, 12.3, 12.4, 12.6

Box 3: A checklist for introducing mobility stations in cities

1. Think carefully about the specific target as well as the city context:
   - For example if you only want to reduce CO_2 emissions and have a hilly town, aim for bike-sharing with good bicycle infrastructure, and reduce road space for cars to prioritise e-buses.
   - If your town is flat but full of congestion, and your goal is to reduce traffic and the number and use of cars, take away parking spaces or make use of them very expensive. Then aim for good public transport infrastructure and a combined station-based bike- and car-sharing (possibly electric) in order to make people abolish their private cars and choose other modes of transport.
2. Involve all relevant departments of city council/municipal administration in dialogue for increased understanding and engagement to fulfilling the targets.
3. Try to identify visible spaces throughout your city where mobility stations would make sense: ask residents and use local knowledge!
4. Distinguish between the different modes of transport to offer. Be aware of the different effects, such as:
   - Effects on traffic from free-floating car-sharing vs station-based car-sharing
   - Accident risks related to speed of e-scooters or non-existent infrastructure for bike lanes
5. Consider different sizes of mobility stations:
   - Small: would be e.g. a car-sharing station with only one car type or a bike/scooter-sharing located directly in a neighbourhood.
   - Medium: could be a cargo-bike-sharing-station combined with car-sharing next to a tram or bus route or close to local shops.
   - Large: could be a big mobility hub next to a train station with a combination of taxi stands, car-sharing (offering cars from small size up to transporters, some of them EVs), bike-sharing, cargo bikes, public delivery rooms, trams, buses etc. In short, a new meeting point for the whole area. Don't forget that the bigger the size of the mobility station, the more time is needed for arrangements with partners.
6. Make the new mobility stations visible for your citizens, the presence of informative signs is crucial for successful implementation.
7. Adopt an integrated approach combining different modes of transport on one ticket or in one app. But don´t try to do everything all at once. You don´t need to have a full working mobility-as-a-service platform in place from the very first day. It is sufficient to begin with to combine tariffs of public transport, bike-sharing and car-sharing.
8. Be responsive to your citizens. Be on the spot at local events such as official street parties, have a good website and a phone hotline offered by the city council where somebody can answer to questions.
9. Invest in some marketing: send information to new dwellers, involve local companies and their fleets.
10. Last but not least: Don´t be afraid of the potential reaction of car drivers. Change takes time but emissions reductions must take place now!

ICT to support sustainable mobility and transportation

The emergence of new actors and services within the urban mobility landscape may complicate development and establishment of business models, but provides exciting opportunities for further diversification and integration of "non-mobility" services into conventional mobility solutions. Innovative ICT systems should be seen as an enabler for successful introduction of new mobility technologies and concepts. User friendly app interfaces can accelerate travel habit changes (as was the goal with Measure 10.3, for example). While the direct benefits of ICT system introduction can be hard to evaluate in the context of, for example emissions and energy savings, their potential to deliver significant indirect benefits or enhance the benefits of other measures should not be neglected. Additionally, the integration of mobility systems with other energy and infrastructure systems has a big potential within the smart city concept. Box 4 offers some examples on tools that can be used in order to facilitate adoption of smart mobility measures.

Related Smart Solutions: 9, 10, 11, 12

Related measures: 9.2, 10.1, 10.3, 10.4, 10.5, 11.3, 12.3, 12.4, 12.6

Box 4: A toolbox for smart mobility: how to accelerate transition to smart mobility solutions?

- Structural barriers can be addressed through e.g. fast-track planning and permitting processes. In GrowSmarter, the approval procedure for charging stations partially delayed the construction of the car sharing stations. However, and taking into account the tremendous development of this sector, the procedure has been greatly simplified and accelerated in the meantime.
- To optimize the visibility and acceptance of new infrastructure (such as mobility stations) locations) one way could be the improvement of existing or introduction of new signs (pedestrian signs, street signs, mobility station signs).
- Aspects related to the visual impact of the proposed solutions should be early discussed between the city administration and the industrial partners. Another point is the consideration of technical requirements e.g. the certification of safety and quality of the products which could lead to delays in implementation.
- Residents should be involved in strategic planning of mobility services, through for example but not limited to, public consultation procedures. In the case where this potential is deemed low, alternative locations or alternative business models should be evaluated in an iterative procedure.
- National/local incentives should be offered where possible to promote take-up. For example, the station-based car sharing solution could save about 70% CO_2 and should be an integral part of urban transport planning. In addition, this type of car sharing can replace many private vehicles. The first year of implementation, an estimated 46 % of Cambio customers abolished their private cars. With the presence of local and national incentives to do so, the potential that car-sharing has to offer in reducing car ownership would be significant. It is estimated that 1 shared car replaces 10 private cars (Cambio data).

3.2 General lessons

Political commitment drives implementation

Good mobility within the city is essential for all stakeholders and firm commitment from the public sector, especially at the municipal level, is important to drive implementation. The municipal councils in each of the three Lighthouse Cities have maintained clear commitments to reducing urban climate impacts through proactive measures to e.g. improve energy efficiency and increase levels of sustainable urban mobility. Political decisions can affect the content of strategies and policies and send signals to markets about the form of "mobility landscape" politicians expect to emerge; positive signals can enable and empower other stakeholders to initiate bold experiments and deliver transformative solutions.

Example: Plan for the unexpected: shifting political priorities can result in changes to the project priorities as well. In Barcelona (and in Follower City Graz), such shifting political priorities increased the City administration's emphasis on active mobility rather than motorised forms of mobility. As a result, one measure (a plan to promote car sharing) was removed from the project at an early stage. This change highlights both the possibility that political changes can have a material impact on project design, but also the need for flexibility in project design (i.e. to have a Plan B) and project administration (i.e. that both the project funder and Coordinator understand the new constraints/opportunities of the Implementing Partner).

Involve and engage stakeholders early, widely and continually

Beyond political commitment lies the next key challenge and prerequisite for successful implementation: *how can cities ensure that all partners are committed to the delivery of strategic objectives both during and after projects?* Extending producer responsibility to cover the life cycle functions for some kinds of products but may be more complex for mobility or transport services involving multiple stakeholders or services planned for and implemented at the district or city-level. Project-based approaches often secure commitment for the duration of the project, but in the worst cases may see services withdrawn as soon as the project cycle is over. Nevertheless, projects do offer an opportunity to learn from one another around shared goals.

Cities should maintain active and open dialogue with all stakeholders, especially citizens, about their needs and ideas. Early and active involvement of all kinds of stakeholders is likely to enhance the quality of projects. Citizen and stakeholder participation offers the potential to capture local knowledge, identify synergies or develop new ideas that otherwise may be unknown to local governments or businesses working in isolation. Similarly, collaborative approaches may enable cross-fertilisation of ideas between sectors, enabling urban planners to avoid approaching projects as "silos" and facilitating a more strategic approach to development. The demonstration of mobility and transport measures in GrowSmarter illustrate various examples that highlight the need for stakeholder involvement – and its potential to add value to demonstrations and accelerate upscaling. The citizens themselves are also a stakeholder group (and target group) with varied, but hopefully mostly positive view on less fossil dependent urban transport. Without citizen consent, new public policies are hard to implement. Involvement of citizens/users is important from a social sustainability and social inclusion perspective and can deliver positive indirect benefits.

Example: Careful planning and early dialogue can prevent both project delays and unexpected additional costs. For measure 12.6, extensive discussion with taxi associations and mobility providers in Barcelona were necessary in order to implement the smart taxi stand system. Other relevant examples relate to the lack of detailed market analysis prior to launch of some measures (e.g. measures 10.3 and 12.2.) which led to targeting incorrect target groups which in turn led to difficulties in the subsequent measure evaluations.

Plan to deliver

By illustrating successful examples and demonstrating the potential of a variety of measures, GrowSmarter has helped increase knowledge and awareness about the chronology of implementation, which may help with upscaling or replication, as well as management of similar projects in the future. It is recommended that the estimation of time plans and allocated budget for similar projects in the future allows space for identifying challenges and needs as well as strengthening partner collaboration prior to the actual measure implementation. Since the field of urban mobility is undergoing a big transition, new partners that were not traditionally part of this sector are involved. This leads to the formation of new constellations that naturally require some time to function effectively. The communication and common understanding of priorities is key for successful implementation and should be seen as an equally important part of the project as the execution part.

Example: Measure implementation should be consistent and sequential, i.e. the underlying policy frameworks should precede and facilitate implementation. This can be seen for example in the case of consolidation centres (measure 2.1) where the procurement processes should be updated with the hands-on experience of the operation of such centres to optimize the in- and outflows of goods, as well as encourage synergies between as many actors as possible. Such an example of synergistic integration would be, for example, the delivery of goods as the inflow and the collection of waste as the outflow. For Measure 12.3, which tested mobility stations in the city of Cologne, the city administration applied to the regional authorities for exemption from the law for operation/leasing of public spaces for the private

actor (Ampido) which was granted (albeit temporarily). It is recommended that cities contemplating similar measures identify such regulatory barriers early on in order to solve them more effectively. It is also recommended that initiatives are launched at national and EU level in order to explore the possibility of public space use with modern approaches. Adjusting regulations to the new mobility services emerging is necessary to avoid implementation on a one-by-one case which would result in higher administrative burdens.

Experiment and be flexible!

Experimentation and flexibility facilitate continuous learning. Cities can facilitate experimentation in many ways, through for example formal mechanisms such as procurement, or voluntary mechanisms such as city-wide Climate Pacts (in which signatories commit to reduce greenhouse gas emissions). By providing spaces for stakeholders to meet and identify shared interests and possible collaborations, GrowSmarter has demonstrated how, in a project form, stakeholders with different backgrounds and interests can come together and develop innovative new forms of service (e.g. delivery rooms) as well as spin-off services outside of the project (e.g. delivery containers). Cities should actively allocate resources to facilitate these kinds of initiatives and other forms of awareness-raising campaigns that can trigger transitions within and between sectors.

In these instances, planning can play an important role by instructing or guiding developers to use consolidation centres prior to the start of construction (thus enabling them to organise and plan their construction projects in advance of operation). An alternative is to leave "spaces" in plans – both within and outside of buildings – which can be used flexibly in the future (e.g. flexible-use community space for shared economy services, mobility hubs, etc). This requires the adoption of city or district-based approaches to planning, rather than a narrow focus on a specific site. In other words, planning should be more strategic and less deterministic, enabling behaviour, culture and markets to be shaped by the needs of residents, rather than the specifications of a building project.

Example: The use of construction consolidation centre (Measure 2.1) and launch of the delivery room (Measure 9.1) in Stockholm has contributed to ongoing debates about smart logistics that can potentially lead to further development of new sets of services and partner collaboration. There are signs of replication of these measures (as other construction companies, developers and housing associations adopt either or both ideas) and cross-fertilisation between these measures, with the development of a spin-off service in which container-based construction consolidation centres are operated using the smart lock system demonstrated in the delivery room. For Measure 9.2 the city of Barcelona showed flexibility and allowed moving the location from the San Marti living Lab area to historic centre of the city. This flexibility was offered under the condition that the operator is market neutral.

Know the market, know the users

To tailor a smart solution, one should ask the following questions: *"Who will use the service/product?*" and "*Who benefits and why?*". These questions can help adjusting effectively the GrowSmarter solutions to various local, societal, and behavioural contexts. Nevertheless, contemplating how the measures can be tailored to the citizen group that are the users is a recurrent lesson learnt from GrowSmarter. This essentially implies the need to adjust solutions (or parts of the solutions) to the citizen groups based on demographics, transport habits, and familiarity with new technologies (especially smart phones and use of smart phone apps). The latter does not mean that innovative transport solutions should only target the citizens most familiar with smart phones. On the contrary, familiarization with such technologies should be encouraged as it can have indirect positive social effects and potential to substantially improve life quality. However, in such cases, additional efforts in the planning stage should be dedicated in finding ways to educate the citizens more efficiently, as well as building trust to the new technologies prior to introducing the service.

Example: Using the right technology but in the wrong context/target group was observed to a certain extent for measure 12.6 (Smart taxi stand system). The technology did not work for Barcelona due to existing rules and praxis that made it easy to hail taxis on streets or book for collection at home, but would work in another context where the focus is on optimizing the service with regards to the taxi drivers and not the passengers (e.g. a city that only permits taxis to operate from designated stands).

Location, location, location

The essence of mobility is "being-on-the-move", and the way people and goods move within a city can change substantially depending on the particular characteristics of the city; understanding the concept of the local and location is very unique for each city. For companies, it is essential to know the local context and market in which it is intended to establish operations (see also previous section on market and users, as well as lessons learnt from Section 2, and Box 5 on the next page). This relates in part to the topics discussed in the previous sections – are you allowed to establish operations?; the rules and regulations influencing delivery of a service, the necessary physical space or permits needed to deliver a service, requirements that would favour or penalise your service.

The city's ability to influence the selection of location varies depending on whether the location contemplated is public, semi-private, or private. When it comes to public locations, the city should be able to set requirements and/or refer interested actors to specific locations that are reserved for pre-defined type of activities/installation. The identification of such location should be part of detailed city planning. It is important to see to the socioeconomic, non-segregation perspective when choosing locations; public features need to be available to all citizens.

The demand for physical space is a big challenge in the urban environment. In the case of charging infrastructure, a delimitation of spaces available and feasible to install chargers at should be made. In the case of Measure 11.1 in Stockholm this meant that the limited parking space available should be prepared and reserved for the installation of chargers. Public space is a valuable commodity. For the implementation within GrowSmarter this public space was made available for free. In future expansion of such services this space is going to cost and that means that the selection of locations becomes even more important in order to ensure economic feasibility. That could potentially lead to a more active engagement of stakeholders that would need to compete for acquiring the locations where profitability is possible to be achieved.

Example: The choice of location is of outmost importance in the case of, for example, placement of public charging infrastructure. In Measure 11.1 it was acknowledged that the identification of the charging locations needs to address the three following aspects: charging demand, physical space, and the technical feasibility. This approach can be generalized and applied to a variety of cases that have to deal with the choice of applicable location. Similar patterns can also be observed for measure 12.3 (see Box 5 for more examples).

Box 5: Identifying optimal locations – lessons from GrowSmarter measures

The selection of suitable locations is a key planning aspect that can ensure high user engagement and usability of a service, as well as potential profitability in the future and seamless integration to the existing infrastructure. The majority of GrowSmarter measures within this Work Package have come across the optimal location concept in various ways and expressions of it. The following examples from GrowSmarter measures show the various considerations that should be taken into account when discussing the location of a service:

Construction consolidation centre (Measure 2.1)

Assess the possibility to install additional services in already selected and used locations.

Micro distribution of freight (Measure 9.2)

In case where relocation is required, the city's role as orchestrating actor is important.

Travel demand management (Measure 10.3)

While a concept might not work on a specific location, it might be more suitable to others. Use the knowledge gathered from the first attempt into choosing the next location with a more informed decision-making procedure.

Traffic signal synchronization to prioritize certain goods vehicles (Measure 10.5)

Keep track of even not directly-related regulatory changes, as they might affect the optimal location selection.

Developing charging infrastructure (Measure 11.1)

Develop a location strategy which depends on whether public land or not is considered.

Alternative fuel stations for heavy-duty vehicles (Measure 11.4)

Installation takes more time if detailed plans need to be changed. Therefore, existing locations might be preferable since the infrastructure can be installed and integrated more easily.

E-bike cargo pool (Measure 12.2)

Understand the user group the service is aiming for before choosing the location.

Mobility stations (Measure 12.3)

Proximity to public transport stops, high sense of security, good accessibility are key in deciding the most suitable locations for mobility stations.

Car- and bike-sharing (Measure 12.4)

Car- and bike sharing services must be in optimal locations to ensure financial viability of operations and significant shifts in user behaviour. This is achieved best through long-time planning and cooperation.

4 POLICY AND PLANNING RECOMMENDATIONS

The introduction of innovative mobility concepts can be challenging to existing policy and planning frameworks and adjusting those requires considerable time. The growth of smart mobility services and ICT solutions in recent years overcomes the pace of change for legal frameworks and stakeholder constellations. By testing a broad variety of measures in GrowSmarter,a valuable glimpse on the gaps, barriers and potential opportunities was gained. These lessons should be used for planning more effective and user-friendly transport systems in the future. A relevant example of how testing a technology can provide useful policy recommendations can be found in Box 6 where the case of V2X technologies is presented.

Box 6: How GrowSmarter findings can help the expansion of Vehicle-to-Everything (V2X) technologies?

The application of Vehicle-to-Building (V2B) technologies in Barcelona (Measures 11.1 and 11.2) has revealed some of the barriers to further expansion of such services. These can be summarized as follows:

1. *Technology maturity*

Currently, there is a limited number of electric vehicle models that can support bi-directional power flow between vehicle and charging point (V2X technologies). There is also limited availability of V2X-ready EVSE (Electric Vehicle Supply Equipment) and plugs. This is likely due to concerns by OEMs (Original Equipment Manufacturers) over the impacts of V2X on battery aging, along with a lack of demand from vehicle users for V2X capability.

2. *Legislative gaps and lack of pricing signals*

The legislative frameworks for electric grid operation do not address explicitly the issue of V2X applications. This is a challenge in Germany as well, as requirements on stating how the electricity is produced exist. Furthermore, there is broad variation in V2G regulations across different regions (different building, electric and residential codes and standards, different permit processes). Grid-related policy frameworks in many countries do not recognize EVs or EVSE as a distributed energy storage resource capable of injecting power into the network. The grid interconnection and certification processes are therefore slow, expensive or often prohibited. In the example of Barcelona, acquiring the permits for a how a V2G charger was a first-time process, which was time-consuming.

3. *Business models and customer awareness*

It is not clear that business models using V2X technology are economically sustainable. Other factors, such as environmental responsibility and energy autonomy may also influence in the future the V2X value proposition to end-users. In addition, there currently is low levels of customer awareness of V2X technologies and their potential benefits. As a result, the value proposition to end-users is poorly understood.

Understanding these barriers first can lead to the design of future smart solutions. As a first step, it is recommended that the permitting procedures are standardized. Common decisions should be taken at EU level. Additionally, ToU (Time of Use) tariffs or capacity charges should be put under more detailed evaluation which would make scheduling V2X charging and discharging a potentially cost-effective application. It will also be necessary to promote the benefits of the technology to the broader public, as well as manage potential concerns, such as data security, battery aging and range anxiety. It is evident form the project that EV users need education and engagement programs to understand the impact of their driving behaviour in battery performance as well as the opportunities to maximize their benefits via V2X activities. Warranty implications of V2X activities is an essential factor to address for EV users as it will directly affect their TCO (Total Cost of Ownership).

Figure 5: Schematic illustration of the potential applications of V2G charging in Barcelona

Laws and regulations can represent both barriers and opportunities to implementation and demonstration of measures promoting sustainable urban mobility. It is thus important to consider the implications of both existing and proposed legislation and regulations when planning measures for sustainable urban mobility. It is never certain that new rules will be better rules, and proposals can move slowly through the congested corridors of power. Old

rules, even when ineffective or out-of-date, often exert substantial influence and are hard to change. Again, parking regulations provide a clear example, as these often impose patterns of development that counteract efforts to promote sustainable mobility. Box 7 discusses how policy incentives could further help promoting sustainable mobility solutions.

Box 7: Urban mobility zones and city "superblocks"

Stockholm's experiences with consolidation centres, both within and outside GrowSmarter, suggest there is a critical scale for consolidation projects; district-level coordination may provide a means through which small projects and entrepreneurs can make use of consolidation without cost penalties. Similarly, access restrictions are an important tool; Stockholm's successful and long-standing environmental zone and congestion charging scheme have had positive effects on both air quality and the numbers of vehicles entering the zone area. However, it may be possible to redefine aspects of the zone, or implement "zones within zones", to further reduce the number of journeys by vans and heavy goods vehicles in the inner city.

In Barcelona access restrictions were used to create pedestrian zones. The use of specific authorisations and exemptions enabled the establishment of the cargo-bike service serving the district; and the demonstration of a successful platform for cargo-bike delivery services led to other actors entering the market and expanding the range of cargo-bike delivery services in the city.

Local parking regulations need to be reassessed to improve planning for sustainable mobility; such work is politically-sensitive in each of the Lighthouse Cities and may require national or European-wide action to effectively overhaul inconsistencies and market errors. Parking spaces continue to be directly subsidised in many locations through for example free parking or provision of road infrastructure enabling drivers to access free parking spaces. Hidden subsidies also exist, such as inclusion of parking in development projects and the sharing of related parking debts in private housing associations between car users and non-car users. Moreover, there are unclear or limited regulations, such as consolidation centres or last-mile delivery services.

There is no doubt that policy incentives are needed to influence and accelerate the transition to smarter mobility systems. But policy incentives are not enough when the factors that influence the mobility patterns of the users of the system are not taken into account. In such cases, cities could potentially (re-)consider how infrastructure could be redesigned or access rules changed to create sustainable urban mobility zones, within which different kinds of consolidation services could operate. In Barcelona, one such approach is being demonstrated in the historic city centre to enable micro-consolidation and sustainable last mile deliveries by electric cargo-bikes; the city is also experimenting with another form of zoning with its "superblock" scheme. If applied at a large scale, this approach will result in significant public health benefits and environmental improvements (Mueller et al., 2019).[2]

The following section present the recommendations based on the lessons learnt from GrowSmarter. Key recommendations per stakeholder group are first discussed, followed by a detailed list of all recommendations divided in various themes.

4.1 Recommendations to local and regional authorities

Regulate public space use with focus on sustainable urban mobility

One of the key conclusions is that the choice of locations is particularly important when establishing smart mobility initiatives. The availability of public space in cities is often limited and should be regulated so that public spaces or platforms with a range of public or private service providers can be create. Such an approach gives the opportunity to involved actors to compete neutrally and increase the effectiveness of the solutions offered, both from the economical perspective, but from the mobility perspective as well. Regulations for the

[2] Mueller et al, 2019. Changing the urban design of cities for health: the Superblock model. Environment International. September 2019. doi.org/10.1016/j.envint.2019.105132

introduction of mobility stations can be very relevant in this context as they ensure smooth integration of new solution to existing transport systems, visibility and higher acceptance from citizens, as well as investments' cost-effectiveness in case where infrastructure is shared.

Designated delivery zones are recommended particularly for areas with dense population and high turnover of parcels/goods. Culturally and aesthetically sensitive environments are a great place to start, but delivery zones have benefits even in a variety of environments where longer driving distances and multiple deliveries in the same area are responsible for emissions that could be avoided, especially where there is lack on regulations on fossil-free fuels in transport. The local authorities can use pilot projects or exemptions to test approaches that encourage actors not only to deliver within such zones but also to do so with fossil-free fuels and then strictly monitor non-compliance.

Streamline administrative processes and give incentives

Administration when it comes to granting permits or adjusting regulations influencing new smart mobility technologies has been necessary for the majority of GrowSmarter measures. For example, the City of Cologne had to give exemptions to Cambio and Ampido from rules governing use of public space to operate their services; similar exemptions were required in Barcelona to set up the micro-distribution service. Demonstration projects like GrowSmarter give the opportunity to find out what is missing from an administrative and regulatory perspective and adjust frameworks accordingly. It is recommended that concrete suggestion for the necessary changes to these frameworks are given at the end of the demonstration period and their implementation should be swift. The main challenges in this regard are the engagement of actors across a range of municipal departments (increasing complexity and coordination needs) as well as the different levels at which legislation is developed (risks that national codes are not harmonized with local needs). For example, some permits and decisions in partner cities required the involvement and approval of many individuals; in some cases, this may have been legally necessary, but created long and inefficient processes that could, in a reformed system, be streamlined to deliver more rapid results.

Give incentives for new mobility solutions

Authorities should consider tax incentive programs for electric vehicles (or increased charges or penalties for fossil-fuelled vehicles) in order to curb barriers related to higher purchase costs related to conventional vehicles. Investing and promoting public transport, either by lowering the price or by increasing the quality of the service, could have spill-over effects with regards to fostering the use of car-sharing through well located mobility stations and for last-mile transport services. Additionally, partial funding of mobility stations which may not be financially viable but well connected with other means of transportation is also recommended.

4.2 Recommendations to private stakeholders

Explore opportunities for establishing first in new smart mobility markets

The role of smart mobility in developing the sustainable cities of the future is undisputable. Additionally, and since the transport sector is one of the main contributing sectors to carbon emissions globally, attention should be given to strategies aiming to offering low-environmental impact solutions for transport. Such solutions are becoming more and more sought by the public, as observed in the cases of mobility stations, car-sharing, e-vehicle charging and micro-distribution in GrowSmarter. Private actors have an opportunity to listen to public demand, understand which gaps can be fulfilled, and deliver appropriate solutions

first in the market. GrowSmarter's recommendation to private actors active in the mobility market is to carefully consider the potential of the broad range of tested solutions within the project and assess the costs and benefits of upscaling such solutions in the future (see previous sections and Chapter 7 Sources/References for further reading). This assessment should be based on the lessons learnt from the pilot demonstration but with an understanding of how potential impacts transform when solutions scale-up. With an understanding that smart and sustainable mobility is the future, the next step is to establish first in the market and build early the prerequisites to achieve the positive effects of economies of scale at later stage.

Work strategically in partnership with other stakeholders

The introduction of new infrastructure is costly and lack of information and collaboration within the sector can lead to unfortunate "lock-ins" to suboptimal solutions. A recommendation is that strategic partnerships are established early on, particularly when entering a new market segment or partnering with actors where little experience in collaboration exists. For example, mobility management service providers can collaborate for launching integrated apps, leading thus to higher user engagement and adoption of services. It is also recommended that partnership between new mobility service providers and larger market actors is pursued.

In Cologne, mobility stations represent the physical manifestation of such collaboration, as multiple service providers share the same space; moreover, this is complemented by a practical tool, mobility tickets, that allow users of public transport and car-sharing to shift between modes and adds value to the business model of both service providers. Another example for such partnerships is given in the case of delivery rooms, where national and international postal service organisations would be interested in collaborating with smaller sustainable delivery service providers. Mobility solutions (car-sharing, delivery rooms etc.) should be integrated from the start in plans for new housing developments, as it is more challenging to integrate if designs have been decided.

Analyse the market and organisational needs

In line with the above, the interests of different stakeholders should be aligned early in the development process. There is no uniform solution on the ideal technological options and location of services, so it is recommended that prior analysis is taken in order to adjust to the local context. Public-private partnerships (PPPs) are recommended in this context, as well as private actors contemplating taking responsibility for the whole package of mobility management services – essentially providing services and technologies, not just providing technologies, in line with the recent trends in the mobility sector. Finally, private actors should invest in educating their personnel in developing competencies related to the new mobility technologies, e.g. maintenance for electric vehicle charging infrastructure, where the lack of know-how among organizations is a hindering factor for further market expansion.

4.3 Recommendations to the EU

Lead the development of new technologies

Even though remarkable developments in new mobility technologies are observed in recent years, there is still a long way to go to achieve the level of maturity needed for establishing security in the market. The EU is a key actor in future development towards this direction and can provide policy support to solutions that have potential for large emissions- and energy

savings in the long term. Solutions that elaborate on existing concepts and have been adequately demonstrated before should not be prioritized. The capital needs should also be taken into account when considering financing proposed solutions. For example, the capital needed for testing new infrastructure is considerably higher than the development of an app, which leads to reluctancy of actors getting involved with demonstration. Therefore, in such cases EU support gives the opportunity to proceed and creates larger confidence in the solution.

Reform electric grid regulation and prepare for increased demand

Advance the preparations for large-scale electrification in the transport sector! This should not be confined to ambitious targets for decarbonisation through further electric vehicle deployment, as an inter-sectoral view on the impact of transport electrification on energy systems should be acquired. New storage technologies, for example, have the potential to effectively transform electric grids but lack of consensus on regulatory and technical aspects of the technologies' implementation is a major threat. The EU should coordinate dialogue across Member States, including a wide range of relevant stakeholder groups in order to first understand the technical limitations and potential of the technologies and then develop standards.

Within GrowSmarter these gaps have been observed for V2X technologies, batteries, and charging infrastructure. **Fel! Hittar inte referenskälla.** summarizes examples from GrowSmarter and lists all WP4 recommendations aiming to improve current sub-national, national and European legislation and regulations governing sustainable urban mobility in the three Lighthouse Cities.

Table 2: Aggregated recommendations based on lessons learnt from GrowSmarter WP4.

	Suggested course of action	GrowSmarter's recommendations	Actors
PLAN ***Land-use linkages to transport systems***	✓ thematically cross-cutting and multi-sectoral measures ✓ density optimization (e.g. zoning) ✓ proximity and co-location, functionality and inclusiveness	Use land ownership and relevant regulations to expand, not limit, the range of possible mobility service offerings. Be proactive and pay attention to mobility trends.	Local National
		Introduce and regulate public spaces or platforms in which a range of public or private service providers can compete neutrally.	Local
ENGAGE ***Urban institutions and governance framework***	✓ participatory mechanisms for socially inclusive decisions ✓ technology as enabler for systemic change	Carry out in-depth market analysis and attempt to align the interests of different stakeholders early in the development process. User perspective should be central.	Local
		Engage in early dialogue with stakeholders to ensure various approaches are discussed and considered prior to selection of the ideal technological options and location of services adjusted to the local context.	Local
		Have coherent long-term strategies considering the implications of new technologies (e.g. maintenance, maturity, etc.) as well as their perceived user desirability.	Local
GROW ***Transport Infrastructure investments and development for upscaling***	✓ long-term funding for strategic planning ✓ value capturing ✓ indirect benefits	As cities and other user groups are or will demand more fossil-free and low pollution services in the near future dare to lead the transition and establish first in the market.	Private Regional National
		Adopt more explicit statements of project goals for energy and climate in development agreements, either as pre-qualification criteria or binding contractual requirements.	Local Regional National
		Assess the impacts of upscaling tested solutions in the future, decisions should not be based just on the direct impact of a demonstration project.	Local Regional National EU Private
		Lead development of new methods and/or improvement of existing methods for assessing environmental, financial, and social impacts of smart urban mobility.	EU
		Promote dialogue for cross-OEM consensus on impact of V2X on battery degradation and development of standards or best practice to enable OEMs implement V2X without compromising battery warranties.	National EU Private

SHAPE ***Urban transport facilities and service operation***	✓ green transport-oriented development ✓ complete streets ✓ smart city districts	Designate a zone for deliveries with a dense population and high turnover of parcels; mandate actors to deliver within the zone and monitor non-compliance.	Local
		Develop higher level of public and political awareness and understanding of V2X technology and its applications.	Local Regional National EU
		Ensure consolidation services are available for logistics services and make use of opportunities – such as construction projects – to demonstrate them.	Local
		Invest on development of new equipment and methods for measuring traffic flows, fuel efficiency etc. based, for example, on big data analytics, advanced sensors, public surveys, and gamification techniques.	EU
		Work strategically in partnership with users/stakeholders for introducing dedicated infrastructure is needed for enabling distribution using heavy goods vehicles operating on alternative fuels.	Local Regional Private
		Partnerships with the different providers of mobility management services displayed in various apps can be beneficial in greater adoption of the services and should be pursued.	Local Regional National Private
ADJUST Legal and regulatory requirements	✓ environmental, financial, and social sustainability ✓ institutional and financial adjustments ✓ updated building codes and standards ✓ adjusted mandates and authority	Speed up municipal processes to keep pace with markets and clarify issues – such as the formal relationships between service providers, data ownership or the need for additional support mechanisms.	Local
		Evaluate the impact of the GDPR on relevant policy instruments for urban mobility.	National EU
		Reform grid codes to enable bidirectional flows between vehicle and grid and develop global standard for V2X technology to integrate to existing power, transport and communication systems (see example of CCS charging standard).	National EU Private
		Redesign energy tariffs to better reflect the real-time value of energy and capacity in the power system. This will enable buildings with smart flexible resources, such as V2X, to optimize charging and discharging.	National Private
		Explore ways to streamline processes, which currently depend on engagement of actors across a range of municipal departments to, for example, grant permits for parking spaces.	Local

5 CONCLUSIONS

In a dynamic mobility landscape, GrowSmarter grew smartly

As an EU-funded project aiming for significant reductions in CO_2 emissions and energy use, GrowSmarter purposefully challenged conventional planning processes and demands a more holistic approach to urban planning than has been the norm. GrowSmarter emphasised implementation of innovative solutions that are emerging and close-to-market and can potentially bring significant benefit to the environmental footprint of urban transport.

There has been a proliferation of new service providers in urban areas offering new forms of service or technology addressing e.g. personal mobility, vehicle propulsion, parcel delivery, and the data used in urban planning for transport management. Projects like GrowSmarter must be sensitive to such changes and be prepared to adjust the scope and content of measures to reflect market developments. Adaption to consumer needs prior to service development and reflexivity to manage responses after services launch. In this regard, the partners of GrowSmarter have had varying experiences which were documented in this report.

GrowSmarter tested a set of innovative measures but even within the context of such project the unpredictability of market breakthroughs is interesting to remark. The project adapted and introduced new concepts, such as the delivery room, yet outside of the project a wide range of new, unforeseen mobility services were launched in the Lighthouse cities.

This and other examples show that: (i) the changes in the landscape of smart mobility are sometimes too rapid to be captured within project timeframes; (ii) the solutions discussed In GrowSmarter have the potential to grow organically and become commercialized, i.e. the measures are close to society's needs for mobility services; and (iii) in connection to (i) and (ii) GrowSmarter has been a flexible project where solutions were taken to the next level, i.e. when the contemplated solution became commercial, GrowSmarter took the challenge to test a solution that built upon and advanced the already commercialized system.

Three Lighthouse Cities shone light on common themes

Urban mobility is a key part of city planning and has the potential to transform the everyday life of citizens and delivery of services within cities. In GrowSmarter, several innovative solutions were tested in the three Lighthouse Cities. Some of the key common themes observed from the implemented measures are:

- *Flexibility*: allowing the solution to grow and adjust to the local context. The focus should be on the outcome and its potential environmental impacts;

-*Engagement varies*: communication and behavioural aspects need to be evaluated in order to be optimally adjusted to the user groups and their needs;

-*Measuring impacts is unclear*: what makes a successful project? Evaluating the success of project varies and depends on the context, scale, and maturity of technologies as well as actor acceptance;

-*Timing is key*: both accounting for longer procedures but also try to optimize and improve the time needed for implementation through clearer legal frameworks;

- *Allow collaboration and new actor constellations to grow*: actors need to understand and trust each other first, so this should also be accounted as a part of the project at equal terms as the actual implementation.

- *Zoning/access as key theme cutting across solutions*: for last-mile deliveries (the demand for which is expected to rise rapidly as it was even observed within the related GrowSmarter measures) public-private dialogue is needed for selecting the operation areas and measures including zoning, time access, truck types, and incentive provision. Procurement can be an effective tool to change public sector logistics.

- *Prioritizing open data platforms*: delays in some projects have been observed due to challenges with obtaining necessary data and difficulties in establishing data collection routines for mobility patterns;

- *Understand which type of financial incentive works best*: for example, electric vehicles are subsidised in many countries at the moment. However, taxes are usually more effective than subsidies. In some other occasion, "nudging" and other behaviour-related incentives can be more effective than financial ones;

- *Business models*: one of the pillars of assessing business models is its payback time. The strict methodologies that are often used disregard significant socioeconomical benefits, such as health benefits and noise reductions, as well as the cost for emission savings (€/CO_2). Such secondary benefits are of particular importance in the context of urban mobility and should be taken into account when evaluating the viability of measures and their benefits to society.

Back to the future: mobility goes electric

Electricity is one of the key energy carriers for future urban mobility. While electricity has been traditionally used in tramway, trolley bus and railway systems in the past, an increase in electric vehicle ownership is expected in the future. The grid has been built to handle more stable loads and the stochastic use of electricity needed to satisfy charging needs, for example, can place significant challenges for maintaining the robustness of the grid. Even though the power demand that could be attributed to GrowSmarter measures is relatively small, problems already occurred in securing the grid capacity needed. GrowSmarter's experience is a call to more thorough investigations for ensuring the necessary grid capacity for decarbonization through electrification of Europe's transport sector. Furthermore, the electricity used for smart mobility applications should be "green", i.e. coming from renewable sources in order to ensure the necessary emissions reductions.

Drawing the right conclusions: context is all

A conclusion from the project can be that the technology can sometimes be right but the context wrong. A careful evaluation of the reasons why a measure is not working as expected should be of high priority, as there can be risk that a measure with an otherwise higher potential benefit can be neglected due to the context where it is applied. Mobility does not mean the same for everyone. It is recommended that tailoring the measure to the user groups targeted should be implemented at an early planning stage. The lessons learnt from GrowSmarter give the opportunity to cities contemplating introduction of sustainable urban mobility practices to be prepared for the unexpected and apply the experiences herewith in order to ensure faster and successful implementation.

The evaluation of mobility measures can be more challenging than other sectors due to the arbitrary nature of many trips, as well as the lack of harmonized indicators for new urban mobility technologies. It has been challenging to identify common evaluation frameworks that reflect the effects of the measures. A deeper understanding of how impact assessment methodologies should be updated in order to better adjust to the rapid transformation of urban mobility is therefore needed.

From the measures that have already been evaluated it can be observed that in most cases significant emission and energy consumption reductions are achieved, mainly due to the use of alternative fuels and electricity, as well as use of bikes instead of cars. Therefore, it can be said that both shifts to renewable fuels as well as modal shifts are observed within the project. It should be noted that due to the small scale of the measures implemented, these reductions are not significant for the overall city emissions, but the benefits can be inarguably large in case of successful upscaling. It can be argued that for the case of demonstration projects, an evaluation of absolute numbers is not the main objective, but rather evaluating the relative changes in connection to the potential for upscaling is the most interesting evaluation aspect.

Active mobility is always smart mobility

Active mobility (i.e. walking, cycling) is the smartest mobility solution in most contexts. It can reduce congestion, improve health, and reduce transport's environmental impacts. As a result, measures that increase active mobility should be prioritized. Additionally, it is necessary to avoid policy conflicts, i.e. measures that have the potential for rebound effects (increased energy consumption, increased car ownership etc.) that contradict the city's long-term mobility planning should be closely monitored and proactive measures to reduce negative impacts should be introduced.

Orchestrate, be creative, and do great things!

The urban mobility landscape is changing fast and a plethora of new actors are entering the market with innovative solutions – some of them are embraced by the public and become viable, while others fail. In such a fluid surrounding environment, avoiding lock-ins to certain technologies is key. Cities should have an orchestrating, but not restricting, role that promotes positive changes towards a sustainable system and "listens" to the citizens' needs and demands. Public consultations can be beneficial with regards to this aspect, but the process could be more streamlined to the particular issues faced each time.

In particular, we recommend more creative use of public space, through e.g. establishment of regulated spaces in which sustainable mobility is prioritised and a wide range of new mobility and transport services can emerge and flourish. Such spaces could address single topics – such as consolidated delivery services using sustainable last-mile providers – or address more comprehensive travel concepts including mobility stations and other offerings. To achieve this, cities should be empowered with new regulatory powers and resources to ensure Europe's transition to sustainable urban mobility.

Exploitation of results

As presented above, most of the measures implemented in GrowSmarter have potential for immediate replication and upscaling. Some solutions are already replicated in follower cities – for example, bike-sharing and e-car-sharing schemes have been introduced in Valletta, Malta. For partners as well as cities, some results are of extra interest to exploit and develop further, including:

- The **e-car-sharing pool** (measure 12.1) introduced in Stockholm will remain after the project and new pools will be set up in the neighbouring districts as new housing projects are underway. The business model will probably change somewhat in order to make e-car-sharing more profitable. Similarly, the **e-cargo bike pool** (measure 12.2) will probably be upscaled but using a different format, in which bikes and service will be taken care of by the housing company, and the booking system will be leased from an external service provider.

- Cologne has already incorporated the **mobility station** (measure 12.3/4) solution in the city's Sustainable Urban Mobility Plan with exploitation plans in all parts of the city. Parking of free-floating bikes and e-scooters could also be restricted to such mobility stations in order to facilitate smooth integration of such services to the urban landscape. Many other cities in Europe are working to implement mobility stations, and Cologne has been active in sharing its experiences with other cities through networks such as CIVITAS.

- Smart logistics solutions such as Barcelona's **micro-distribution service** (measure 9.2) and the Stockholm **delivery room** (measure 9.1) are ripe for upscaling. The results from the delivery room solution in Stockholm are already being exploited by the project partners together with the Swedish postal service in order to find a solution that can be implemented in all kind of buildings and adapted to different types of e-commerce interfaces. An adapted pilot is currently being set up to evaluate how this can be done. **Construction consolidation centres** (measure 2.1) are considered well-functioning by the partners and exploitation of results are already happening. Based on lessons learnt from this project the set-up will be modified and developed to fit different types of construction sites and different cities with different types of logistic challenges. A container-based solution is one example, using insights from both the consolidation centre solution and the delivery room solution.

- Expansion of **charging infrastructure** (measure 11.1/2) is a priority in all three lighthouse cities, as in most European cities. Stockholm is currently doing a city-wide screening of streets suitable for e-charging infrastructure, and sharing knowledge on electric vehicles and charging infrastructure with cities and other stakeholders through a wide range of networks. Concerning V2X solutions, they are considered to have potential to play a key role in the integration of the EV into the electrical grid and buildings' environment. The plan is to deploy new pilots at the European level in order to continue improving V2X solutions to fill the gaps between the actual state of technology and real market solutions. All of this taking into account the different regulatory conditions, stakeholders' interaction (electrical markets and agents), associated business models and user's engagement. Infrastructure enabling use of **alternative fuels in heavy-duty vehicles** (measure 11.4) can be installed in any city with a commitment to reducing the negative impacts of on-road freight transport. Smart traffic management systems can be exploited in cities or regions with appropriate technical systems, and in Barcelona, there is interest for a regional application of the analytical approach using **MFD** (measure 10.1) to reduced congestion.

6 MEASURES AND CONTACT INFORMATION

Table 3: Overview of the Smart Solutions, measures, cities and partners involved in WP4, along with the page number on which each measure is presented in this report. City names are abbreviated to BCN (Barcelona), COL (Cologne) and STO (Stockholm).

Solution	Measure	City	Partner(s)	Contact person(s)
SS2. Smart building logistics and alternative fuelled vehicles	2.1 Integrated Multi-modal Transport for construction materials/logistics centre in Årsta	STO	Skanska, Carrier	Rasmus Linge, rasmus.linge@cslogistics.se Ary Zanganeh, ary.zanganeh@skanska.se
SS9. Sustainable delivery	9.1 Integrated multi-mode transport for light goods	STO	Carrier, Stockholmshem	Olle Krönby olle.kronby@stockholmshem.se Rasmus Linge, rasmus.linge@cslogistics.se
	9.2 Micro distribution of freight	BCN	Cenit, I2CAT, Barcelona city council	Paco Gasparin, francesc.gasparin@upc.edu Sergi Saurí Marchan, sergi.sauri@upc.edu Marisa Catalan, marisa.catalan@i2cat.net
SS10. Smart Traffic management	10.1 Traffic management through MFD	BCN	Cenit	Paco Gasparin, francesc.gasparin@upc.edu Sergi Saurí Marchan, sergi.sauri@upc.edu
	10.3 Travel Demand management	STO	KTH	Markus Robért markus.robert@abe.kth.se
	10.4 Traffic control system for passenger vehicles	STO	Insero	Flemming Jensen FJEN@insero.com
	10.5 Traffic signals synchronized to prioritize certain vehicles movement of goods	STO	Carrier, City of Stockholm	Rasmus Linge, rasmus.linge@cslogistics.se
SS11. Alternative fuel driven vehicles for decarbonizing and better air quality	11.1 Developing charging infrastructure	BCN, COL & STO	City of Barcelona City of Cologne, RheinEnergie, Ampido	BCN: Gonzalo Cabezas Ruescas, gcabezasr@bcn.cat COL: Christian Remacly, c.remacly@rheinenergie.com STO: Eva Sunnerstedt, eva.sunnerstedt@stockholm.se

			City of Stockholm, Fortum	STO: David Holmbom, David.Holmbom@fortum.com
	11.2 E-mobility management system	BCN	City of Barcelona, IREC	BCN: Gonzalo Cabezas Ruescas, gcabezasr@bcn.cat
	11.3 Charging infrastructure for electric tricycles for micro distribution	BCN	Cenit, I2CAT	Paco Gasparin, francesc.gasparin@upc.edu Sergi Saurí Marchan, sergi.sauri@upc.edu Gonzalo Cabezas Ruescas, gcabezasr@bcn.cat
	11.4 Setting up refuelling facilities for alternative heavy duty fuels fuel	STO	City of Stockholm	Per-Erik Österlund, per.erik.osterlund@stockholm.se
	11.5 Smart guiding to alternative fuel stations and fast charging	STO	Fortum, KTH	Markus Robért markus.robert@abe.kth.se David Holmbom, David.Holmbom@fortum.com
	11.6 Small distributed CNG grid	BCN	Naturgy	Helena Maria Gilbert Cruz hmgibert@naturgy.com>
SS12. Smart mobility solutions	12.1 Green parking index in combination with car sharing pool with EV	STO	Stockholmshem, Fortum	Olle Krönby olle.kronby@stockholmshem.se
	12.2 Electrical and cargo bike pool	STO	Stockholmshem	Olle Krönby olle.kronby@stockholmshem.se
	12.3 Mobility station	COL	City of Cologne, Cambio, KVB	Holger Kahl, holger.kahl@hk-org.de
	12.4 Electrical and conventional car sharing	COL	Cambio (e-car-sharing), KVB (e-bike-sharing), Ampido	Holger Kahl, holger.kahl@hk-org.de
	12.6 Smart taxi stand system	BCN	Cenit, Cellnex, Urbisapp	Gonzalo Cabezas Ruescas, gcabezasr@bcn.cat Carmen Vicente, carmen.vicente@cellnextelecom.com

7 SOURCES/REFERENCES

List of key GrowSmarter project documents		
Name of document	**Link**	**Finalised**
Fact sheets	http://www.grow-smarter.eu/solutions/	2016-2018
Technical and management reports, D1.3, D1.4, D1.5, D1.6	http://www.grow-smarter.eu/inform/reports/	Feb 2016, June 2017, Dec 2018, Dec 2019
Implementation reports D2.3, 3.3, 4.3	http://www.grow-smarter.eu/inform/reports/	Feb. 2018
Draft concluding reports D2.4, 3.4, 4.4	http://www.grow-smarter.eu/inform/reports/	Feb. 2019
Lighthouse cities market introduction, D6.2 Economic validation and assessments, D6.3 Smart city market introduction, D6.4	http://www.grow-smarter.eu/inform/reports/	Feb 2018 Jan 2019 Oct 2019
Reports on results of technical, economic and social validation, D5.3, D5.4	http://www.grow-smarter.eu/inform/reports/	Dec 2018 Oct 2019
Data management plan, D1.2	http://www.grow-smarter.eu/inform/reports/	First version 2015
Recommendations for policy makers and practitioners, D1.7	http://www.grow-smarter.eu/inform/reports/	Nov 2019
Project brochure, D8.3 Project result Brochure, D8.10	http://www.grow-smarter.eu/inform/press-corner/	Update 2017, Nov 2019

About GrowSmarter

GrowSmarter (www.grow-smarter.eu) brings together cities and industry to integrate, demonstrate and stimulate the uptake of '12 smart city solutions' in energy, infrastructure and transport, to provide other European cities with insights and create a ready market to support the transition to a smart, sustainable Europe.

GrowSmarter project partners

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