GrowSmarter

Transforming cities for a smart, sustainable Europe

FROM DREAM TO REALITY

RECOMMENDATIONS FOR POLICYMAKERS AND PRACTITIONERS

www.grow-smarter.eu

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QUOTES FROM MAYORS IN STOCKHOLM, BARCELONA AND COLOGNE AND THE GROWSMARTER COORDINATOR

"The GrowSmarter project has helped Stockholm become a smarter city and has shown new ways to help reduce greenhouse gas emissions. It is my hope that these solutions are spread and taken up by more cities as the need for emissions reductions is urgent."

Katarina Luhr, Vice Mayor, City of Stockholm

"Most of the world's population is concentrated in cities, which are largely responsible for global emissions. We are part of the problem, but we also have to be the solution, by implementing the agendas for the fight against the climate emergency. That's why we need to share synergies. Under the GrowSmarter project, we in Barcelona, working together with Stockholm and Cologne, have shown that the fight against climate change depends on collaboration between citizens, companies, the academic world and public authorities. By working together we can make cities healthier, nicer and more sustainable."

Ada Colau Ballano, Mayor of Barcelona

"The GrowSmarter project is part of the SmartCity Cologne strategy. For Cologne, the GrowSmarter project was one of the first important and largely visible success stories within the SmartCity Cologne strategy. As the first German lighthouse city, we received national and international attention ."

Henriette Reker, Mayor of Cologne

"The GrowSmarter project has now successfully come to an end after enormous efforts by all 42 partners. The smart solutions, however, continue to reduce emissions of carbon and continue to be replicated in other cities thus accelerating the strive towards a fossil fuel free future."

Gustaf Landahl, Project Coordinator

INTRODUCTION
THE GROWSMARTER PROJECT

This report presents the conclusions and recommendations from GrowSmarter, a five-year project that demonstrated smart city solutions in energy, infrastructure and transport and provided other cities with valuable insights on how the solutions work in practice. The project included three Lighthouse cities, Stockholm, Cologne and Barcelona, as well as five Follower cities, Valletta, Suceava, Porto, Cork and Graz. GrowSmarter received funding from the European Commission's Smart Cities and Communities Horizon 2020 research and innovation programme.

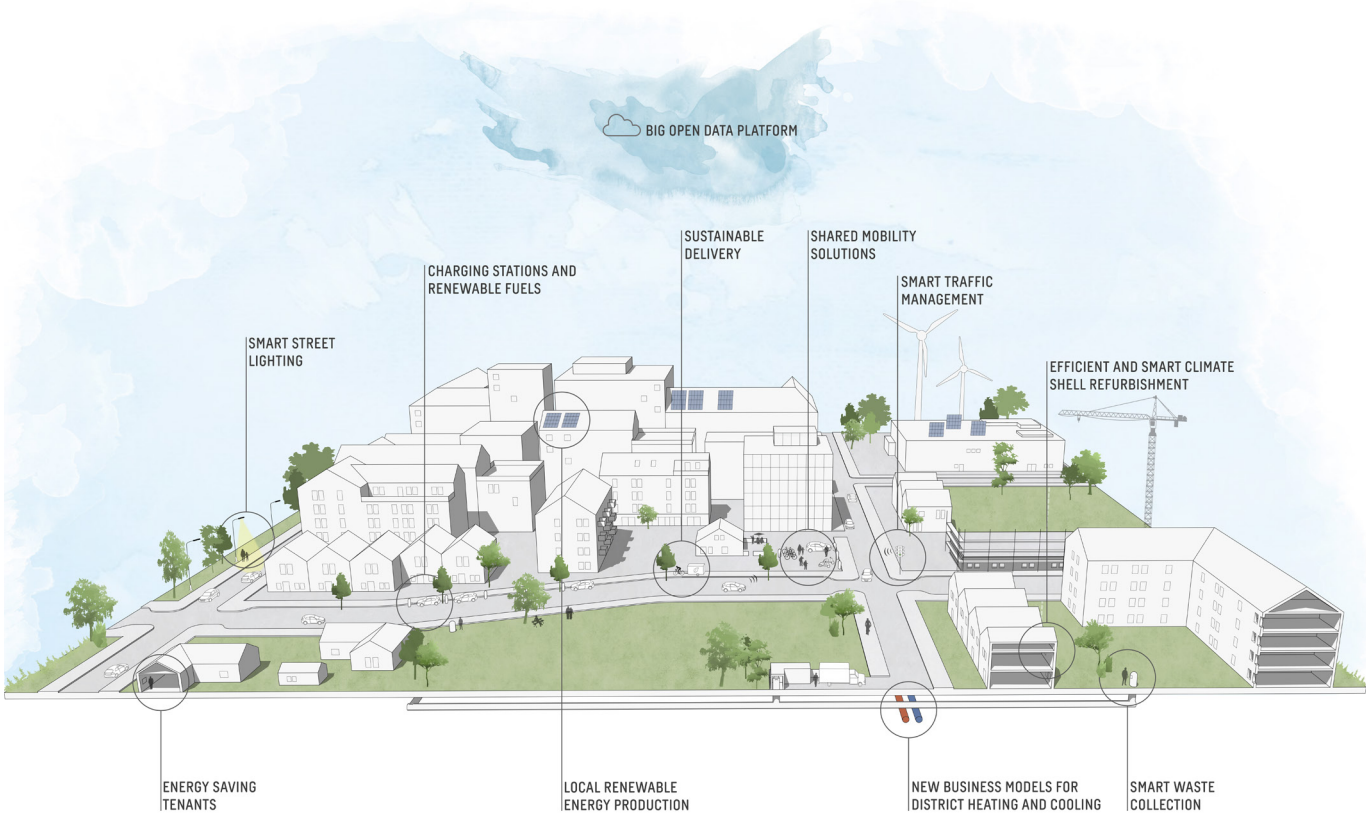
The scope of the project was to:

- demonstrate and validate economically and environmentally sustainable integrated smart solutions in the three Lighthouse cities;
- foster collaboration between cities, businesses and academia to transform the smart solutions into business models to be rolled out across Europe;
- improve the quality of life for European citizens, reduce environmental impact and create sustainable economic development.

GrowSmarter took a holistic approach to sustainable growth. The demonstrations in the Lighthouse cities were not the primary aim, but a means to contribute to solving city challenges and create validated business cases to initiate a market roll out of the smart solutions to Follower cities and the rest of the European market, thus helping Europe Grow Smarter.

The twelve solutions were designed to meet the three pillars of sustainability: economic, social and environmental concerns. GrowSmarter evaluated these solutions against targets related to climate change, energy usage, transport emissions and jobs: reduced energy by 60 percent, reduced greenhouse gas emissions from energy use, increased use of renewable energy by at least 60 percent, reduced emissions from transports by 60 percent and creation of 1500 new jobs.

The figure on the following page shows the solutions that were demonstrated by GrowSmarter. Where possible, these solutions have been implemented near each other to serve as demonstration areas for citizens, professionals and other cities.



The integration of the smart solutions demonstrated by GrowSmarter.

DRIVING FACTORS

In a rapidly urbanising world, cities need to become smarter, respond to citizen needs and reduce their environmental footprint. Currently, Europe's existing building stock plays a major role in energy consumption (40 percent of EU final energy demand). Modern buildings are energy efficient, but one third of Europe's housing stock was built between 1950 and 1970, when the technologies and materials used today had not yet been developed. By refurbishing these older buildings using new construction techniques, the amount of energy they use can be reduced by up to 76 percent. Energy retrofitting actions - complemented by information technologies and smart management - bring both tangible and intangible benefits: saving energy, money and emissions; increasing property value; creating jobs in the building sector; and improving living conditions and quality of life.

In addition, significant and yet insufficiently tapped value is offered by integrating both active and passive infrastructure networks within and across cities – be they energy, transport, communications or others. Many such infrastructures are ageing; budgets to replace them are stretched and they are procured and managed in silos. The potential for cities and their customers through new joined-up approaches, exploiting modern technologies is substantial.

Finally, improved mobility for citizens and businesses can make cities more attractive and competitive. Meeting Europe's 20/20 goals, tackling congestion, and improving air quality, accessibility and sustainability in most cities will require substantial changes in the transport system and operations, and in the mobility behaviour of people and businesses. Public and other transport services, timetables and ticketing, and interchanges are not always well connected. Innovation, a re-think of public-private sector cooperation and citizen engagement in new mobility systems and services are essential.

CONTRIBUTIONS TO AGENDA 2030

In 2015, world leaders agreed to 17 goals for a better world by 2030. Through these goals, countries have committed themselves to ending poverty, fighting inequality and stopping climate change. GrowSmarter's work contributes to the following global goals and targets for sustainable development.

- Double the improvement in energy efficiency
- Increase global percentage of renewable energy
- Promote access to research, technology and investments in clean energy

- Develop sustainable, resilient and inclusive infrastructures
- Enhance research and upgrade industrial technologies
- Promote inclusive and sustainable industrialization
- Upgrade all industry and infrastructure for sustainability
- Universal access to information and communications technology

- Inclusive and sustainable housing
- Provide access to safe and inclusive green and public spaces
- Implement policies for inclusion, resource efficiency and disaster risk reduction
- Affordable and sustainable transport systems
- Reduce the environmental impact of cities

LOW ENERGY DISTRICTS

INTRODUCTION

The main objectives of the low energy district solutions were to reduce energy use, environmental impact and carbon footprint of the energy systems connected to the built environment. The starting point of the actions was on the building itself and on cleverly combining and fine-tuning smart solutions.

In the EU, buildings are responsible for approximately 40 percent of energy consumption and 36 percent of CO_2 emissions. While it is important that new buildings are energy efficient, that alone is not enough to reach the Paris Agreement. As nearly 75 percent of the current building stock is energy inefficient, refurbishing existing buildings is necessary to reach climate commitments. The Energy Performance of Buildings Directive, revised in 2018, includes targets to accelerate the renovation of existing buildings, with the vision of a decarbonised building stock by 2050. GrowSmarter implemented measures that can help Europe reach these targets.

Reduced CO_2 emissions and energy savings. The energy retrofitting measures obtained great reductions in CO_2 emissions and energy savings. For example, in the refurbishments of one of the residential buildings in Stockholm, total energy use was reduced by up to 76 percent. As always, the specific conditions at each location will determine the ability to replicate the solutions, such as local regulation, climatic conditions, and cost of energy.

"In the EU, buildings are responsible for approximately 40 percent of energy consumption and 36 percent of CO_2 emissions. Energy retrofitting measures obtain great emission reduction and energy savings"

Social impacts were mainly positive. The measures resulted in positive social impacts, including decreased energy bills and improved indoor climate. Evaluations with tenants showed a positive view of the work done, with improved indoor climate and overall improvements on standard of living. In some measures, such as the residential buildings in Cologne, rents increased due to the energy refurbishments, while in other measures, rents increased based on other renovations besides the energy improvements. Also, some tenants were evacuated during the renovation.

Economic feasibility depended on size and climate. For residential buildings, two elements determined the financial sustainability of the measures: size and climate. The measures implemented in large buildings in cold climate countries (Stockholm and Cologne) were financially sustainable thanks to the reduction of energy bills. However, if one of the elements was missing, the financial sustainability was not achieved. In the case of Barcelona, the residential buildings analysed showed a reduction in energy bills. However, economic feasibility could only be achieved with public funds.

For tertiary buildings, financial results varied from building to building. Although most measures were found to be financially sustainable, some tertiary buildings were not financially sustainable because the incomes designed were lower than what the project needed. Economic sustainability was not achieved in some projects, where the reduction of CO_2 emissions seemed too small for the required investment.

Energy Management Systems, such as the Smart Home solution, guided the tenants to a more sustainable use of electricity and hot water consumption. Dimmers, plugs and sensors were coupled to a hub, and the data from those devices was shown on a tablet and/or mobile app. Other features provided information on the renewable energy potential available on the users' rooftops. Saving potential depended on the target group and user engagement. Another motivating factor was also if heating and hot water were included in the rent or not. Up to 15 percent of electricity saving was reached.

Waste heat recovery has great potential for replicability. A new business model to buy waste heat was demonstrated. In Stockholm, recovered waste heat from data centres and supermarkets was bought by a district heating company and fed into existing district heating networks. This helped meet local energy demands and reduced the need of peak production. The measures were economically and technically feasible. There is great potential for expansion.

Retrofitting of Ca l'Alier in Barcelona,

EFFICIENT & SMART CLIMATE SHELL REFURBISHMENT

Efficient and smart climate shell refurbishment demonstrated the impact of a combination of thermal refurbishment together with other energy efficient measures. The combination of these measures drastically reduced the net energy demand for all buildings.

More than 100,000 m² of residential floor and 20,000 m² of tertiary floor were retrofitted in total in the three Lighthouse cities. The measures included the following[2]:

- Low U-value windows
- Insulation of the buildings
- Pipe-in-pipe system to reduce hot water circulation losses
- Wastewater heat exchange system to preheat fresh water
- Water-saving tap fixtures
- Exhaust air heat pumps
- Air/water heat pumps
- Heat exchangers for district/geothermal heating
- Façade insulation
- Efficient lighting
- Efficient elevators
- Photovoltaics[3]
- Energy storage

Higher final energy savings were achieved in cities with colder climates. Climate is an important factor when considering energy saving measures. In Stockholm, an annual 64 percent reduction of the purchased final energy in the residential neighbourhood was achieved. In Cologne, the large retrofitting project implemented reduced the total final energy purchased by the neighbourhood by 37 percent on an annual basis. In the milder climate of Barcelona, an overall annual reduction of 30 percent of the purchased final energy was achieved in the retrofitting projects that included building thermal envelope upgrade.

Low U-value windows: Efficient but expensive. The U-value indicates the heat transmission. Lower U-values indicate better insulation. Old windows with U-values of about 2.0 were replaced with windows with a U-value of 0.7. The new windows reduced space heating demand and increased comfort and quality of living. The new windows also had a more efficient mounting procedure, even though the windows where heavy. In the Stockholm installations, frost occasionally formed on the windows since very little heat was emitted. Also, windows with U-values

[2] Key results are presented here. For more results, see *grow-smarter.eu.*
[3] See section *Local renewable energy production*.

as low as 0.7 were rather expensive. For replication without financial support, a conclusion is that a level of 0.9 is ambitious enough.

Window size and the need for solar gain need to be considered. In cold climates, the solar energy through light gain is beneficial. In warmer climates and when cooling is needed, the solar gain transmittance should be low.

New pipe systems can reduce hot water losses by 50 percent. The pipe-in-pipe system was installed to reduce energy losses from the hot water circulation system. Energy savings of over 50 percent were achieved. This measure was neither complicated nor very expensive and could be replicated in any city where water systems in buildings are accessible for installation.

Do not flush energy down the drain. Recovering heat from the sewage system to preheat hot tap water is a solution with great potential. Hot water use is a major part of a property's energy consumption, and all the hot water used in a building is flushed down the drain. A wastewater heat exchanger was installed in the drainage system to recover energy and preheat cold water before it was heated further. Savings were approximately 3.5 kWh/m^2.

"Do not flush energy down the drain. Recovering heat from the sewage system to preheat hot tap water is a solution with great potential. Hot water use is a major part of a property's energy consumption, and all the hot water used in a building is flushed down the drain."

The above measure is recommended to be combined with an energy classified water fixture. These reduced the energy use for domestic hot water by 9 percent.

In Stockholm, an Internet of Things (IoT) platform was used as a Building Energy Management System (BEMS). The platform improved building energy performance by helping the decision-making process related to the application of energy efficient measures in a residential building. The tool offers a proactive surveillance of the customers' installations with the regular analysis of building energy consumption data for its optimal use, and includes an adaptive heating control system.

New adaptive control for heating systems reduced energy use by 10 percent. Indoor temperature sensors were used to provide feedback to the heating, cooling and ventilation control system. The system adapted to the individual building's dynamics and responded to weather conditions. Hence, it provided heating and cooling more efficiently compared to traditional systems, decreasing overheating and undercooling in the buildings. The savings were around 10 percent. This may be installed in any city and to any building that allows automatic control of the building system. The benefits will be similar regardless of a cold or warm climate. (Depending on the existing infrastructure, the cost may be substantial for buildings without a sufficiently adapted energy system in place.)

Efficient air heat pumps reduced energy consumption. A new type of heat pump was used in Stockholm, recovering heat from the exhaust ventilation system for space heating and domestic hot water, which led to annual energy savings.

Årstakrönet in Stockholm.

To avoid noise from the heat pumps, potentially disturbing tenants, the heat pumps in Stockholm were installed on the roof. In Cologne the heat pumps were installed in front of the houses for space reasons. When selecting the heat pumps, care was taken to ensure that they were extremely quiet.

A noise protection report was also prepared to ensure that residents were not disturbed.

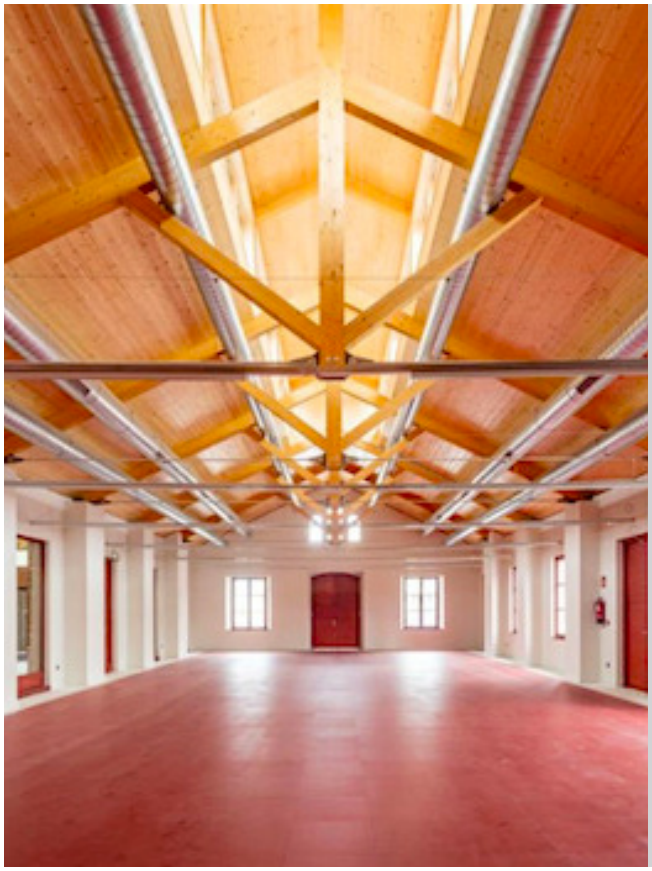
Increased comfort for residents. Surveys among tenants after the refurbishment presented good results for both summer and winter, in comparison to the results before the refurbishment. Tenants observed a more even and neutral indoor climate both in hot and cold outdoor temperatures. In Barcelona, one survey found that no one reported feeling hot in their homes in the summer, which is a remarkable result in a Mediterranean climate in buildings without air conditioning. This was a result of efficient refurbishment with isolation, among other things, improving indoor climate.

Clear communication and information to tenants was key. In case the refurbishment or part of it is financed by increased rent[4], or if evacuation of tenants is needed, good communication with the tenants is very important. Door to door campaigns and events were arranged to inform the tenants about the impact of the energy retrofitting in their apartments and how these measures help reduce their energy bills and increase their quality of living. Such events were held in Stockholm, Barcelona and Cologne together with the City administration. These were highly appreciated by the tenants according to surveys.

Combine structural refurbishment with energy retrofitting actions. The combination of structural and energy retrofitting works reduced the implementation costs (shared costs) and ensured that tenants were already prepared for the refurbishment of their building. This made it easier to gain approval for the energy retrofitting actions.

Quality levels and verification tests were necessary. In energy retrofitting works, contracts with installers should include minimum quality levels and penalties if those are not reached. A wrong installation can have a huge impact on the energy savings. For example, in one building, the thermal imaging analysis identified poorly installed windows, which had to be redone.

[4] In Stockholm, the energy efficiency measures did not influence the rent. However, the house owner did other renovations at the same time which did cause a rent increase. Rents were increased in Cologne due to energy refurbishments.



Interior view of the new R&D centre Ca l'Alier

SMART ENERGY USE IN HISTORIC BUILDINGS

Barcelona municipality transformed an abandoned textile factory to a research and design (R&D) centre for Smart Cities and the Internet of Things under a public-private partnership agreement. The R&D centre was designed under the nearly Zero Energy Building (nZEB) criteria. With these energy retrofitting actions, the municipality showed that it is feasible to recover abandoned industrial heritage buildings to be used as public facilities in order to preserve the city identity while implementing new technologies for smart energy use. The municipal urban planning department plays a key role in promoting these kinds of measures by implementing strategies for reconciling energy efficiency/renewable energy with heritage conservation concerns.

ENERGY SAVING TENANTS

Tenants themselves can contribute to being energy efficient and sustainable. Different types of home energy management systems (HEMS) for residential end users were demonstrated in order to help tenants optimize their behaviour to achieve maximum energy efficiency and reduce their energy bill.

Aim: raise tenants' awareness of their lifestyle. The deployed HEMS have different functionalities but a common aim: raising citizens' awareness of their energy consumption and engagement in becoming more energy efficient. Additionally, some systems provide control and automation functionalities for appliances.

Electricity savings of 15 percent were achieved. In Barcelona, the project provided an electricity consumption visualization platform called "Virtual Energy Advisor" to 450 citizens. Household annual electrical consumption decreased by 15 percent on average among users.

User engagement is crucial. It is necessary to plan communication campaigns with the tenants well in advance to inform them of the advantages of HEMS and overcome their doubts to share their energy consumption data. A target group analysis is required in order to know at what technical level the information needs to be. Older tenants potentially have less knowledge about smart metering than younger people brought up with smartphones. In addition, language barriers as well as different views on data sharing need to be taken into account.

...but user acceptance cannot be guaranteed. Even with extensive user engagement, user acceptance cannot be guaranteed. As experienced in Cologne, where the project expected to install the system in more homes than proved to be possible. Several attempts (events in the area, direct letters, presentations and demonstrations) were made to present the potential benefits of the system. However, due to a potential lack of interest or fear of new technologies and their mind-set towards data collection and analysis, most residents decided not to participate.

Display of a home energy saving system.

High satisfaction among users. Users/tenants overall were quite satisfied with the systems. In Barcelona, for example, a survey found that residents in Canyelles rated the system 4 out of 5 stars for customer satisfaction. In addition, in Cologne, a survey found that all users found it easier to heat their homes using their SmartHome system and that all users were able to better estimate their power consumption with the Smart Plugs.

Tertiary buildings also benefited. Two energy surveillance platforms were aimed at tertiary building users and operation and maintenance staff. The aim was to monitor the overall energy performance of the retrofitted buildings in order to better understand the energy consumption pattern and thereafter improve it.

Tenants together with a facility manager can make a difference. The installation of a HEMS is not enough to guarantee energy savings, but on-going work involving people living in the building is required, together with the right maintenance and surveillance. It is financially and technically advantageous to have the same contractor be in charge of installation as well as on-going facility management.

Data confidentiality limitations. The General Data Protection Regulation (GDPR) requires additional security measures, software development and legal considerations for energy visualization platforms. Data protection, privacy and security aspects must be prioritized in the design phase of the infrastructures to make sure the participation agreements with tenants are set.

Economic sustainability not guaranteed. The system must be used and energy must be saved in order to guarantee economic sustainability. Financially, the costs often exceed the revenue at this stage due to high cost of the system and relatively few users.

RECOMMENDATIONS FOR USER ACCEPTANCE:

- Address tenants early in the process. Educate them and listen to their needs and concerns. Let them give input and inform them about the increased comfort, quality of life, etc.
- Select an open-minded and tech-savvy tenant structure or area to start. Use them as influencers and multipliers of the concept and benefits.
- Start building an app with minimal features early and start adding new functionalities based on user feedback.
- Use a target user group to evaluate features and development.
- Teams who sell products need to be skilled in selling and marketing.

LOCAL RENEWABLE ENERY PRODUCTION

Smart management of local renewable energy production was based on local energy demands and combined the on-site electricity generation through photovoltaics with storage capacity for surplus production.

Solar panels and storage systems provided greater efficiency. Solar panels for energy generation with electrical storage systems were installed in all three cities to partly cover the electricity needs of both residential and tertiary buildings. In Barcelona, these systems are controlled by an advanced Energy Management System (EMS), which optimizes the operation of the elements through the interaction with the grid in order to maximize battery usage and minimize the cost of the electricity bills. In Stockholm, the EnergyHUB optimizes the energy flow between solar panels, energy storage and the grid, including peak shaving strategies. In Cologne, the photovoltaic panels and batteries are controlled by software that manages photovoltaics, electrical storage, heat pumps and district heating consumption in the same neighbourhood. Many of the installations cover large percentages of the building requirements.

For example, the photovoltaic and storage installations cover 20 percent of the total electricity consumption of some of the tertiary buildings, such as Valldonzella in Barcelona and Slakthuset in Stockholm. The installation at one residential building in Barcelona covers 65 percent of the building's communal space electricity consumption.

"The combination of energy storage and peak shaving strategies by smart control provides flexibility services for dense urban grids, which can lead to postponing investments in the grid."

Smart control system for grid management. The combination of energy storage and peak shaving strategies by smart control provides flexibility services for dense urban grids, which can lead to postponing investments in the grid. Peak-shaving from building-based energy storage can be combined to lower the contracted maximum power demand of dwellings.

In Cologne, the project developed an intelligent energy management system at the neighbourhood level. This software aimed to optimise the electricity consumption and heat generation of the heat pumps in the neighbourhood, as well as the use of the battery storages in order to maximize the self-sufficiency of the neighbourhood. The management system controls both internal (PV, air/water heat pumps, battery storage) and external (district heating) energy producers in the neighbourhood.

A similar system was installed in Barcelona, where the management software gathered information on photovoltaics electricity generation and optimized the energy flows based on the real-time operation and the forecasts of building consumption, weather and grid electricity prices.

Neighbourhood energy management systems are a relevant tool to approach low energy districts, controlling the energy consumption either by reducing it or shifting it during the day to flatten the demand curve. The future trend towards the creation of local energy communities makes this system have a great potential for replication, even more in neighbourhoods where buildings have a single owner. Nevertheless, data transmission and connection of energy systems are technical issues to be solved.

Regulations determine scalability of renewable electricity generation. The self-financing and scalability of local renewable electricity generation in cities is strongly dependent on national and municipal regulation. The right to community ownership of energy generation units and favourable city urban planning regulations for photovoltaic installations in buildings are crucial.

Regulations regarding local generation and electricity self-consumption (and electricity markets in general) differ to a significant extent in European countries. In both Stockholm and Cologne, the installed photovoltaics are smaller than the technical limit due to regulatory restrictions. In Barcelona, a new law allows various consumers to own the same energy generation unit and to sell the surplus electricity to the grid with remuneration. This new situation reduces the payback period and makes the technology very suitable for a group of buildings with complementary load curves.

Solar panels have been the major source for energy generation in GrowSmarter.

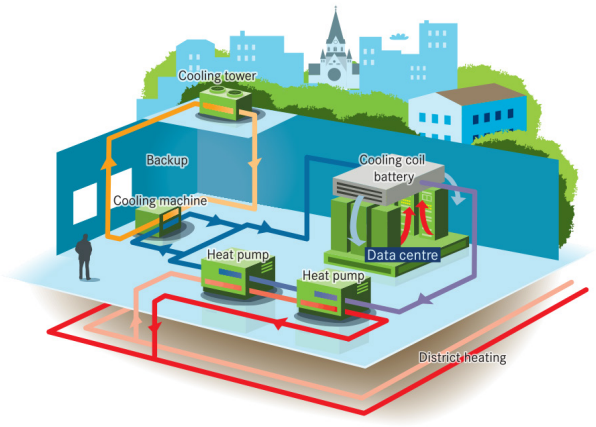
Regulations adapted to the current state of technology are required in order to fully deploy the creation of districts made up of ‘prosumers’ (buildings that both produce and consume energy) under advanced smart control strategies. In practice, it is not yet possible, and maybe not needed, to consider a single model throughout the European Union that allows the scalability of products and services associated with local energy generation.

NEW BUSINESS MODELS FOR DISTRICT HEATING & COOLING

New district heating and cooling technologies used waste heat from other facilities to lower the environmental impact of the existing building stock. These were economically beneficial solutions with great potential for replicability. There is currently no regulation in place that forces data centres and other waste heat producers to recover waste heat, and GrowSmarter encourages the EU to work on such a directive.

A new business model to buy waste heat was demonstrated. In Stockholm, recovered waste heat was fed into existing district heating networks to meet local energy demands and to reduce the need of peak production, which made the total production more sustainable. This was done by an innovative business model with plug and play heat pumps and contracts where the district heating provider bought waste heat from local energy sources such as data centres and supermarkets.

Waste heat from grocery stores made production more sustainable. Supermarkets with many freezers and coolers generate significant excess heat, which is often costly to get rid of. The heat reuse of the supermarket chosen for the GrowSmarter project had the potential of recovering 0.5 GWh of heat annually, a heat recovery that is sufficient to heat more than 40 standard apartments while reducing annual CO_2 emissions in Stockholm. Although it is technically feasible to install waste heat recovery from supermarkets, it may not be financially feasible.



Open district heating using waste heat from e.g. data centres.

Up to 1000 apartments heated from one data centre. The heat reuse of the data centre chosen for the GrowSmarter project has increased gradually to a level of approximately 540 kW heat, a heat recovery that is sufficient to heat more than 500 apartments while reducing annual CO_2 emissions in Stockholm. Once an additional server block is constructed, the system will be able to heat approximately 1,000 apartments.

Great potential for expansion. According to the results, GrowSmarter estimated that it would be possible to save 200 GWh of energy and heat 50,000 apartments in Stockholm if heat recovery systems were installed in data centres in locations where it would be economically feasible. In addition, GrowSmarter estimated that it would be economically feasible to install a heat recovery system at approximately 75 supermarkets within the district heating network. This would lead to a possible annual energy savings of 16 GWh, enough to heat 4,000 apartments.

"According to the results, GrowSmarter estimated that it would be possible to save 200 GWh of energy and heat 50,000 apartments in Stockholm if heat recovery systems were installed in data centres in locations where it would be economically feasible."

Feasibility depends on existing networks and building energy needs. To replicate at large-scale, a district heating system is required that can transfer the recovered heat to where it is needed. The business model is easy to establish and replicate, but the economic value of the recovered heat will differ between geographies depending on the alternative cost for heating. Small clustered district heating networks can also benefit from using heat recovery as a heat source.

The measure on waste heat recovery in Stockholm was economically and technically feasible. For the use of waste heat from the data centre, the pay-back time for the supplier will be within five years, and the economic values will be sustained over the total technical lifetime of approximately 15-25 years.

Waste heat recovery is an opportunity for the deployment of district heating and cooling (DHC) infrastructure in Mediterranean climates. Large waste heat sources in the urban environment were also used for the deployment of DHC infrastructure in Barcelona. In the project, a public tertiary building was connected to the local DHC network, whose heating and cooling is generated in a nearby plant based on thermal energy recovery (via the incineration of municipal solid waste from the city and use of sea water for cooling). In Mediterranean climates district heating and cooling technology is not widely spread, and thus it can be a costly option compared to other heating and cooling systems. Therefore, in moderate climates the economic feasibility of the connection of a building to a DHC network is strongly dependent on the proximity of the building to the existing network(s), the building energy needs, and the planned expansion of the network. A thorough economical pre-study should be done to justify the required investment for this solution. In the Barcelona case, local regulation in the district encourages the connection of large consumers to the existing network.

READ MORE

Read more about the measures implemented on our website http://www.grow-smarter.eu/home/ where you find all our reports and fact sheets.

INTEGRATED INFRASTRUCTURE

INTRODUCTION

Active and passive infrastructure networks offer significant value within and across cities – covering energy, transport, communications and other areas. Many such infrastructures are ageing but budgets to replace them are stretched, and they are often procured and managed in isolation from each other. Hence, there is substantial potential for cities and their customers through new joined-up approaches, exploiting modern technologies.

GrowSmarter applied a range of smart integrated infrastructure solutions, such as smart lighting as hubs for communication, smart waste collection turning waste into energy and big open data platforms. The topic of integrated infrastructure, in particular the work with data, contained many enabling measures. Costs for these measures may be high at first with a low number of users, but up-scaling can be easily achieved and may have a large impact later.

Insights in technical aspects. The solutions presented here provide insights about technical aspect, e.g. which provider to use, interfaces, prototypes, Wi-Fi capabilities, upcoming developments and legal aspects, e.g. data protection laws, traffic and parking restrictions, business tax exemptions, and installation certifications.

"The solutions implemented transformed traditional urban furniture to provide more services related to Internet of Things (IoT), wireless connectivity, and real-time digital information."

The activities carried out highlighted the opportunities of integrated infrastructures to develop new services for citizens and to understand short and long-term financial and technical implications to reach sustainability goals.

Solutions improved connectivity and safety and reduced energy demands. The solutions implemented transformed traditional urban furniture to provide more services related to Internet of Things (IoT), wireless connectivity, and real-time digital information. Cities must address the growing demand of mobile connectivity due to the large number of personal smart devices, IoT services and massive broadband mobile connections at anytime and anywhere. Quick access to information is a must, not only for citizens, but also for city managers to make informed decisions. Therefore, a wide network of sensors and actuators should be deployed around the city to monitor and control the city status.

Smart waste collection can help meet EU recycling targets and improve residents' quality-of-life. The European Commission adopted an ambitious Circular Economy Package, which includes a proposed target to recycle 65 percent of municipal waste by 2030. The smart waste collection system implemented within GrowSmarter increased the number of fractions recycled, and made it easier for residents to recycle, thus increasing the recycling rates. The system also reduced traffic related to waste collection by 90 percent and decreased CO_2 emissions by 71 percent. Less space was required for waste handling, which resulted in more common space and less congestion.

Open urban platforms are a necessary foundation for sustainable smart city solutions. The platforms serve as enabling measures to allow crossing data from different domains and thus facilitate the optimization of the processes implemented by other measures. The growing market requires both flexibility and standards. Horizontal platforms are more valuable than vertical platforms because of the benefits of aggregating and analysing data more easily.

Smart and safe use of urban data is fundamental for sustainable smart city solutions.

SMART STREET LIGHTING

The smart lighting, lampposts and traffic posts demonstrated several ways of increasing quality of life for citizens while saving energy. For example, smart traffic posts were used to provide Wi-Fi and charge electric vehicles. Smart lighting provided a safer environment and saved energy.

Three different smart street lighting technologies were covered:

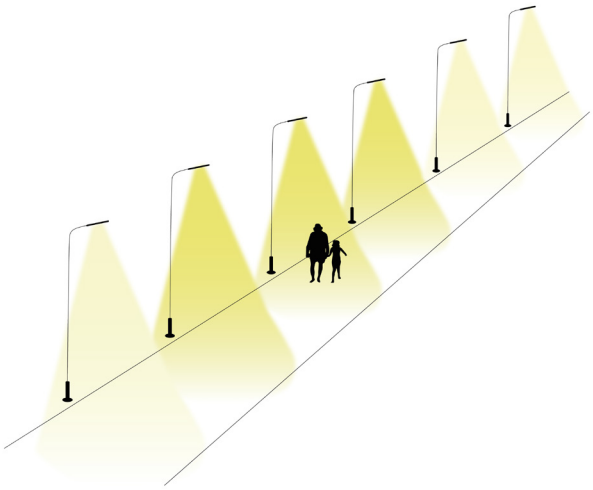
1. Sensor controlled LED lighting for pedestrian and bicycle paths with base lighting that increased when someone approached.
2. Pre-set lighting based on levels of traffic with self-controlled LED street lighting.
3. Remote controlled LED street lighting to provide sufficient lighting depending on the time of the day and the level of traffic.

Smart street lighting reduced energy consumption by 31 percent. All options tested led to energy savings: Sensor controlled LED lighting - up to 31 percent savings, self-controlled LED street lighting - up to 21 percent savings and remote controlled LED street lighting - up to 25 percent savings.

Easily scalable. All three types of smart street lighting are easily scalable, replicable and adaptable to the local situation, as long as the electrical connections and infrastructure can handle the technologies, or can be converted to do so.

Economic sustainability depends on electricity prices. Due to the very low electricity prices in Sweden the solutions were not economically feasible and have long pay-back times. The solutions would be economically feasible in countries with higher electricity prices.

Traditional lampposts were converted to telecommunication micro sites. The "Smart Tower" converted the traditional lamppost to new telecommunication micro sites that integrated wireless communication devices and sensors in Barcelona. The solution offered hyper-connected areas to resolve the growing demand of massive wireless and mobile connectivity in the city. A similar solution was implemented in Cologne, where electrical charging was combined with street lighting poles.



Sensor-controlled smart street lightning.

Smart lamp posts united different areas. Smart lamp posts encourage people to walk and bike in new places. By placing these posts strategically, neighbourhoods previously segregated were interlinked, and a new dynamic of people passing was achieved.

The Data Hub as optimising node. The hub collected and managed city data, allowing increased efficiency in infrastructure thanks to the integration and optimisation of several utilities, such as electric, water and heating smart meter infrastructures, and urban and environmental sensors.

Data Hub led to increased efficiency and reduced costs. When a fault occurs, the system sends a notice to the operator to solve the problem as soon as possible. This ensured optimal quality of supply and network at all times. It also implied that the number of operators' trips to and from the facilities was reduced, which had a direct impact on CO_2 emissions. In addition, the company reduced management costs, and the citizens received a better network with fewer outages.

The user should be centre of attention. User or tenant needs should be addressed early in the process. Educate them and listen to their needs and concerns. To test new solutions or pilot-projects, it may be best to select an open-minded and tech-savvy group of citizens and then use this group as spokespersons for the solution.

Organisational challenges with hubs were greater than predicted. It took time to work across departments, to get the commitment and resources from the management side, to find appropriate technical solutions that match regulations, and to finalise agreements. The city resources and competence are typically very limited at the beginning of a new endeavour.

"Smart lamp posts encourage people to walk and bike in new places. By placing these posts strategically, neighbourhoods previously segregated were interlinked, and a new dynamic of people passing was achieved."

Permitting processes can be slow and difficult. Departments usually only work as fast as the budget allows them to. This slows down the speed of transition. Often digital departments, not the lighting departments, are the ones that push for smart solutions. It is challenging to foresee all possible requirements and identify specifications prior to procurement.

SMART WASTE COLLECTION

By efficient sorting by tenants, waste handling became less complicated and more energy efficient. The optic sorting system took up little space and reduced heavy traffic in the neighbourhood by 90 percent.

GrowSmarter implemented a smart waste solution for residential areas that used different coloured bags for different sorts of waste and transported the bags underground to a collection station in the area. When the local waste container was filled, the waste was transported to a sorting facility where the bags were sorted optically by colour.

"As the system transported the waste underground, garbage trucks did not need to drive through streets to collect waste. This reduced CO_2 emissions from the trucks by 71 percent."

Data on usage helped analysis on behavioural change. The ability to quickly access data made it possible to make an analysis on patterns and behaviour based on recent data. Immediate access to data made user feedback possible.

Traffic in the area was reduced by 90 percent. As the system transported the waste underground, garbage trucks did not need to drive through streets to collect waste. This reduced CO_2 emissions from the trucks by 71 percent. In addition, less space was needed for waste handling, which meant more common space that could be used in other ways, including bike lockers, common indoor or outdoor spaces and commercial spaces.

Waste became valuable. The system showed an increase in recycling rates and resource efficiency. The residual waste was reduced by 66 percent, and the food waste was recovered to produce biogas to fuel buses, trucks and cars. Other waste streams were recovered as raw material for packaging and/or energy.

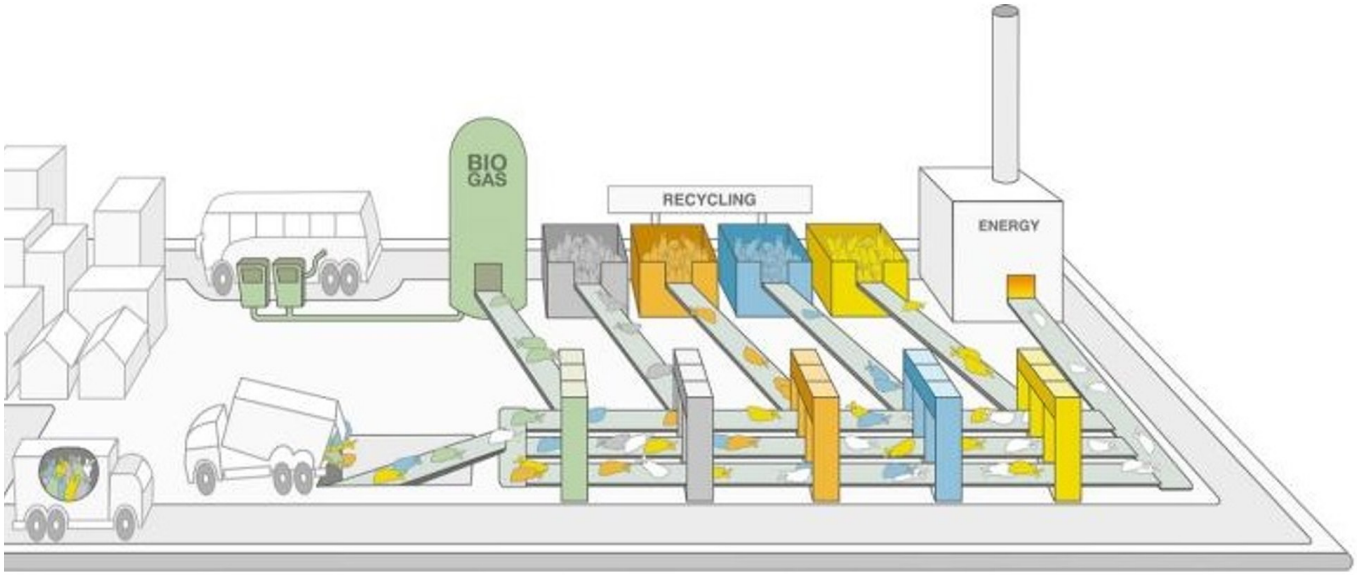
Smart waste collection with optic sorting.

Quality of life improved in multiple ways. Easy sorting for the tenants, as well as easy bag drop at only one place rather than having to walk a distance to a sorting station, was another positive change. Hence, the solution eased everyday life for the tenants. Tenants were content with this solution, according to a conducted survey. Prior to the installation of the system, there was no organic sorting in the area.

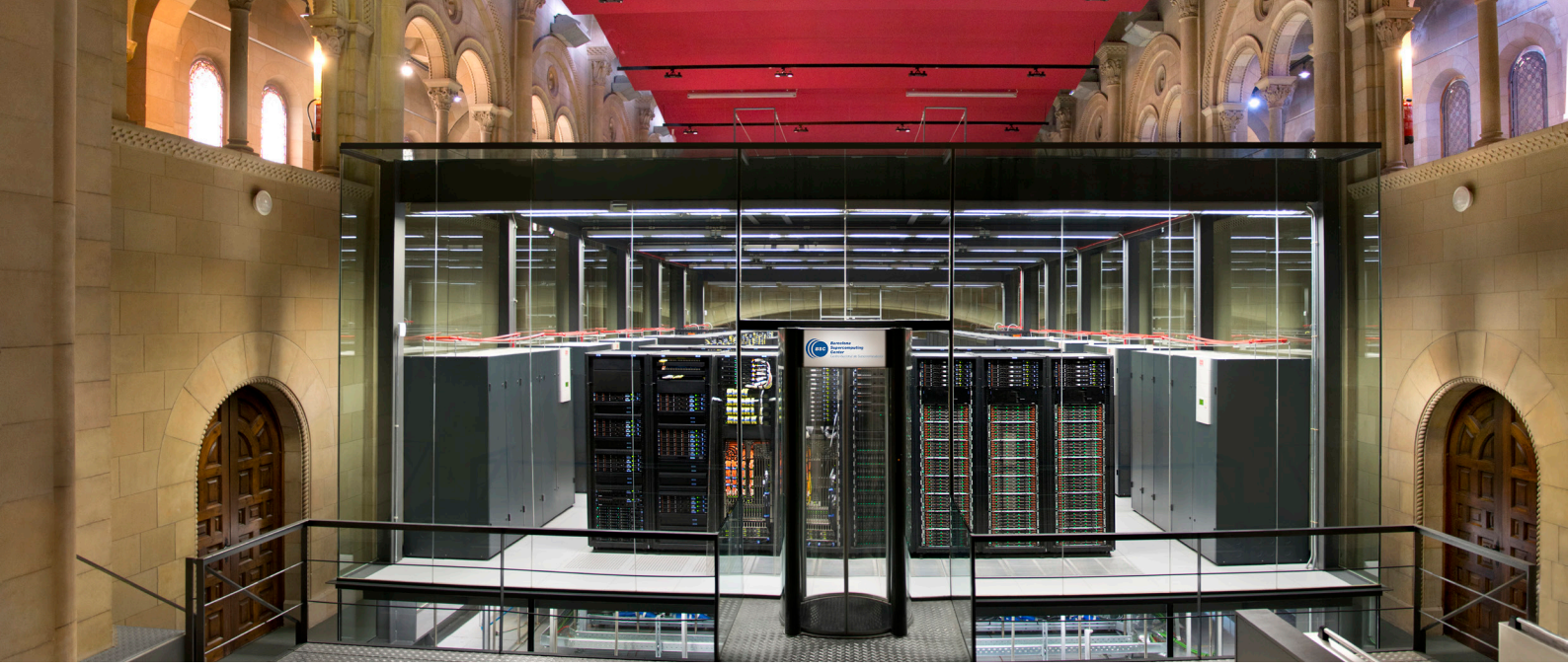
Tenant information campaigns helped with acceptance of a new system. It is often necessary to motivate tenants to change habits and utilize waste sorting systems. A success factor was clear and intense information campaigns in an early stage of the system introduction, shortly after system commissioning and/or shortly after tenants moved back in to the area following renovation work.

Data privacy must be considered. GDPR, and possibly other juridical restrictions, must be understood in order to build up a database on waste deposited in the system. For this project, this was solved by not including personal data in the registration, since a consent process was considered to have very little chance of success. If GDPR issues could be resolved, there is a possibility to get information on each tenant, which could be used for payment for waste handling.

Installation cost can be a challenge. The main challenge was installation costs and finding the location and space underground to fit the pipe work. While the installation itself was straightforward, the technology was rather sophisticated and required trained staff for commissioning and operations. Installation in historical or archaeological sites and old towns may be more challenging. Also, a solution for taking care of the waste from the collection station to the sorting facility needs to be organised.



Schematic of the optical sorting system, where coloured bags are separated for biogas production, recycling and incineration.



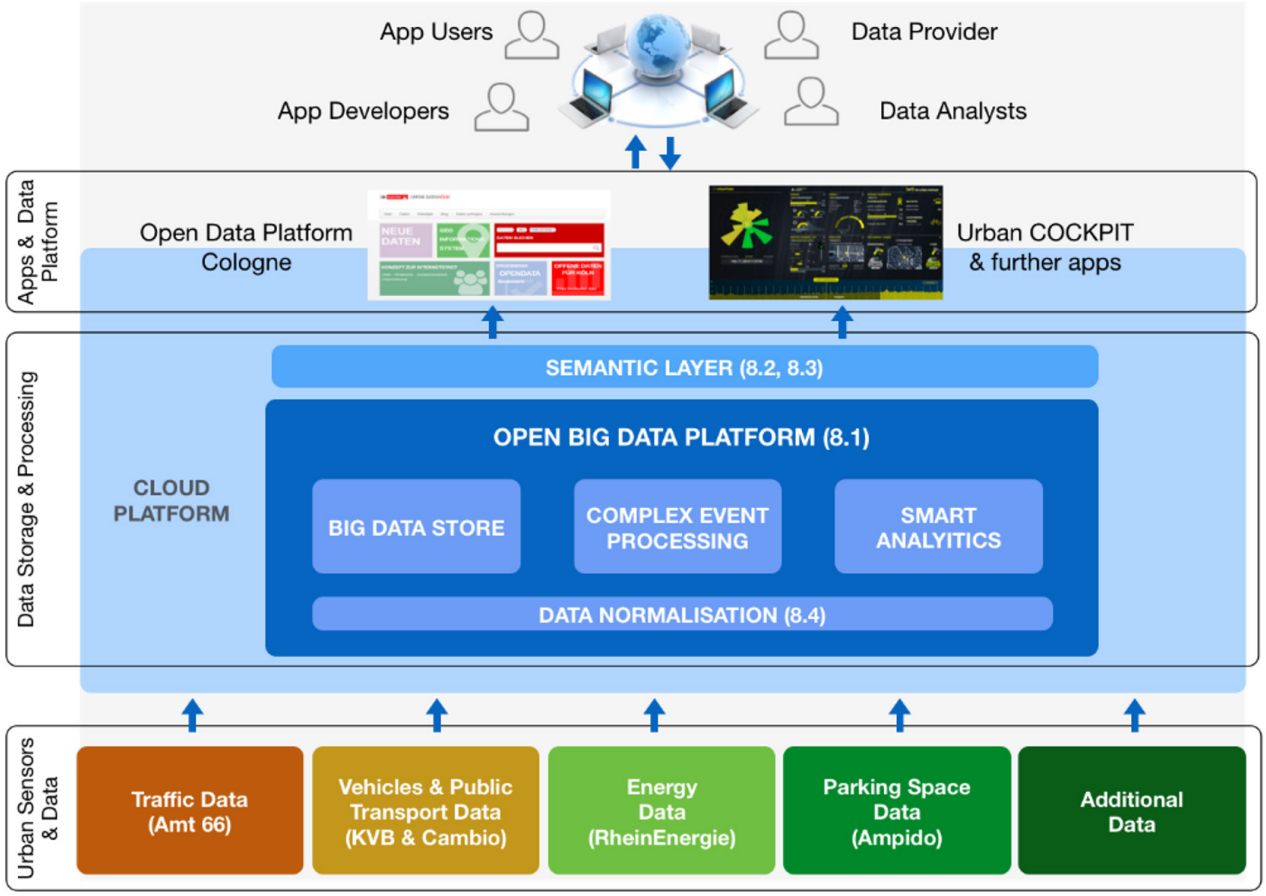
BIG OPEN DATA PLATFORM

Common shared city-owned data platforms provide support to planning and decision-making within the city administration. The platforms allow for the storage and analysis of real-time data from all departments, which fosters co-operation and co-creation.

Big data platforms serve as link between citizens and the city. The platform should form a base for dialogue with citizens and the business community via more transparent management. With a big open data platform, the status and the impact of various measures can be monitored in real time. Short and long-term scenarios can be simulated in more detail to improve the quality of decisions. A city can then manage environmental impacts more efficiently as well as be open for new policies and accelerate innovation of new services based on the open and available data.

Enabling measures facilitate other processes. The platforms served as enabling measures that allowed crossing data from different domains and thus facilitated the optimization of processes implemented by the other measures. The measures resulted in monetary savings due to the reduced time required to analyse and query data using a semantic integration tool.

"The platform should form a base for dialogue with citizens and the business community via more transparent management. With a big open data platform, the status and the impact of various measures can be monitored in real time."



Cologne's Big Open Data Platform UrbanPULSE with the Urban COCKPIT.

Easily replicable measures. Other cities can use the technology directly, only needing to re-implement the semantic access layer based on the way the data in their cities is accessed, and re-map their own data to the urban model facilitated by GrowSmarter tools. With open data platforms, data can be accessed in an integrated fashion, which facilitates app development and saves time. Additionally, apps developed for one city may be brought to another unchanged if the semantic urban model remains the same.

Interest and understanding is increasing. As these big open data platforms are implemented, interest from other parties and cities is rising, therefore fostering the development, improvement and distribution of the idea. The city of Barcelona for example is committed to developing CityOS, a city operating system that has as an important part of a city's semantic model. The urban model developed in GrowSmarter will be part of the more comprehensive city model. In Stockholm, the platform developed in GrowSmarter will likely be used for the entire city, and in Cologne a city-wide platform is in development as well.

PLATFORM AS A SERVICE: A NEW MARKETPLACE OF DATA SERVICES

In Barcelona, a platform was created to provide standardized access to normalized and integrated data through a GrowSmarter application programming interface (API). In addition, it offered a marketplace of data services that promotes co-creation of added value applications and urban services to manage and monitor the smart city, boosting new business models. The solution was devised as a Platform as a Service (PaaS), with a modular cost system to be flexible with different needs and requirements.

Competitiveness of industry partners must be considered. Industry partners fear losing competitiveness when providing data for free. It is necessary to identify a win-win situation, e.g. how can everyone use the open urban platform to support or even create new business plans and provide benefits. Possibilities exist to limit or contain the use of data, such as charging money for shared data, disclosing limited data or sharing data for a certain time frame or to certain participants.

"As these big open data platforms are implemented, interest from other parties and cities is rising, therefore fostering the development, improvement and distribution of the idea."

Contractual basics are needed. Municipalities and industry partners should define the use of data in contracts prior to project start. The use of individual data records must be specifically regulated by contracts in accordance with the applicable data protection regulations.

Growing market needs both flexibility and standards. The market for open urban platforms is growing quickly as more and more cities are conducting smart city projects. An open urban platform is a necessary building block for sustainable smart city solutions. Technical standards exist on the different smart city domains, but there are no common widespread standards yet. Together with a need for standards, flexibility is also key. By using a flexible and open horizontal platform, a wide range of sensors and data can be managed. The work needs to be agile, and the technical platform should support this, not be an obstacle.

Data collection must be driven by meeting the needs of the city. Focus on the needs to the city and how data collection and analysis could help meet those needs. Avoid collecting data first and then considering what can be done with it.

"Industry partners fear losing competitiveness when providing data for free. It is necessary to identify a win-win situation, e.g. how can everyone use the open urban platform to support or even create new business plans and provide benefits."

READ MORE

Read more about the measures implemented on our website http://www.grow-smarter.eu/home/ where you find all our reports and fact sheets.

SUSTAINABLE URBAN MOBILITY

INTRODUCTION

Urgent and transformative action is required to change how we transport ourselves and the goods we consume. GrowSmarter addressed complex urban mobility and transportation challenges through, among other things, sustainable delivery, alternative fuels and electric vehicles and sharing solutions for bikes and cars.

Significant reductions of emission and energy consumption were possible. This was mainly due to the use of alternative fuels and electricity, as well as use of bikes instead of cars. Shifts to renewable fuels and modal shifts were created within the project. Due to the small scale of the measures implemented, these reductions were not significant for the overall city emissions, but the benefits can be inarguably large in case of upscaling.

Cities should facilitate, citizens participate and companies implement. 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. Public and private sectors need to implement solutions for the identified needs in order to make a change.

Active mobility is always smart mobility. Active mobility (i.e. walking, cycling) is the smartest mobility solution in most contexts. It reduces congestion, improves health, and reduces 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.

Public space is a valuable commodity. The demand for physical space is a big challenge in the urban environment. For the implementation within GrowSmarter, public space was made available for free. In future expansions of such mobility 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. This could potentially lead to a more active engagement of stakeholders that will need to compete to acquire the locations where profitability is achievable.

SUSTAINABLE DELIVERY

Last mile delivery services using fossil free transport decreased emissions and simplified life for citizens. The construction consolidation centre demonstrated how to reduce the volume of heavy goods transportation in urban areas.

Bike delivery enabled all day delivery. In Barcelona, GrowSmarter launched a last mile delivery service in the old town. In this district, cars and trucks can only make deliveries in the morning, whereas cycle delivery is possible throughout the day. The solution also involved on-bike GPS for the biker and sensors to monitor the service and environmental conditions along the routes.

More efficient delivery. Cargo bikes have more flexible mobility in narrow and dense spaces than delivery vans (since vans are not allowed to trespass pedestrian areas), so cargo bikes travel shorter distances. Also, cargo bikes are not restricted to parking on authorized spots to load/unload. Thus, cargo bikes are more efficient than vans and light trucks.

Positive health aspects. Less fossil fuel driven traffic in the area improved the air quality, which had a positive impact on the health of residents. Also, less traffic created a better and safer environment for children to play in.

"Cargo bikes have more flexible mobility in narrow and dense spaces than delivery vans. Shorter distances and reduced emissions are a win for everyone."

Support from city administrations is needed. Last mile delivery is an emerging market that needs support from city administrations: designating a zone for deliveries with a dense population and high turnover of parcels, allowing actors to deliver within the zone and monitoring non-compliance, and identifying premises and agreeing a tenancy arrangement to enable implementation.

Delivery rooms enabled last mile delivery service for residents. In Stockholm, GrowSmarter transformed unused space in a residential building into a delivery room to enable last mile delivery service for goods bought online. Parcels were transported using e-cargo bikes to the delivery room. Delivery of a wide range of parcels was possible as the full space of a room could be used for storage. This service improved residents' accessibility to postal services whilst reducing delivery traffic as well as traffic to pick up points.

Socially sustainable urban planning. The delivery room provided a more inclusive solution for parcel delivery, as people with disabilities had easy access to their parcels. Instead of having to go to a store or other pick up point, delivery was done to the apartment building. It was also convenient for persons working long days or off hours who cannot always manage opening hours of pick up points.

"Delivery rooms enabled last mile delivery for residents, with fossil free delivery."

Innovative electronic key solution already replicated. Access to the delivery room is controlled by a smartphone app. The delivery service and the customer are given a temporary access key used for delivery and pickup. The application is extremely user friendly, as one only has to click the open-button on the phone while being close to the door in order to open it. This key solution is already replicated in construction consolidation centres.

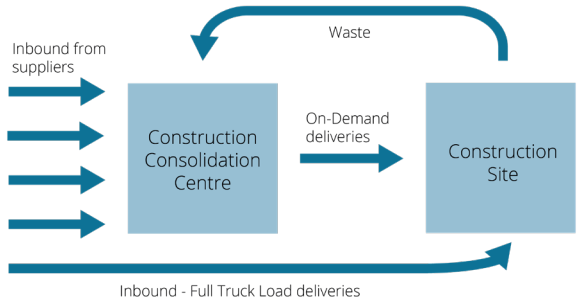
Identify physical space early in the project. Identify physical space for a delivery room early in a renovation or new construction project. Such space should be accessible for residents and couriers, yet also not compete with other functions (e.g. commercial spaces, cycle garages, laundry rooms, etc.). A variety of possibilities exist, e.g. installing refrigerators for food deliveries, and the relative advantages or disadvantages should be evaluated on a case-by-case basis to ensure a sound business model.

Replication has already happened. A wide range of cities and other stakeholders showed interest in replicating the delivery rooms, including PostNord, the postal service of Denmark and Sweden. As mentioned above, the project partners and app provider also developed related services using a similar approach, including unmanned "delivery containers" for use at construction sites.

Last mile delivery with cargo bikes saves time, space and reduces emissions.

Construction consolidation centre: A logistical set-up to reduce heavy goods transport. The construction consolidation centre was a logistical set-up to improve the conditions for construction projects, such as new developments or refurbishments. By planning the material flow and steering inbound deliveries to the centre, it was possible to increase the efficiency of the building process. The consolidation centre is located close to the site and allows material delivery twenty-four hours a day, allowing more efficient delivery and improved logistics for all part of the construction process.

Time, material and environmental savings. The use of the construction consolidation centre resulted in more efficient deliveries, reduced damage to material during deliveries and handling and reduced waste. This solution contributed to a major reduction in the environmental impact of a construction project. The use of fossil free fuel for last mile delivery was a major reason. The potential for reduced delivery time thanks to night time deliveries might increase the reduction further.



Workflow of the consolidation centre.

Regulatory authorities can create scale. Scale is an important factor for success. The scale of a construction project, along with its geographic location, influence the extent to which consolidation centres can deliver benefits in terms of reduced costs, emissions and better working conditions. 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 varies depending on the local context and pre-conditions, but it is hard to make it economically sustainable for just one site. To ensure maximum impact, regulatory authorities could introduce or extend zoning requirements to make consolidation of logistics services for construction and other traffic-intensive activities compulsory. This could reduce heavy traffic and incentivise use of fossil free fuels.

SPIN-OFF SOLUTIONS: CONTAINER-BASED CONSTRUCTION CONSOLIDATION CENTRES

The use of the construction consolidation centre in Stockholm has contributed to ongoing debates about smart logistics that have led to further development of new sets of services and partner collaboration. Replication and development of these measures is taking place, 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. Access to the container is controlled by a smartphone app. The delivery service and the construction company are given a temporary access key used for delivery and pickup. The application is extremely user friendly, as one only has to click the open-button on the phone while being close to the door in order to open it.

SHARED MOBILITY SOLUTIONS

Use of e-bikes, cargo bikes and electric cars made it possible to travel further, with greater comfort and with less cost and emissions than a fossil driven car. GrowSmarter implemented a range of shared mobility solutions that reduced CO_2 emissions and provided residents with sustainable mobility options.

Green parking index enabled alternative mobility services. The City of Stockholm uses a "green parking index" when planning new developments. This index enables property owners to reduce the number of parking spaces in new constructions in exchange for offering alternative mobility services, such as carpools, thereby reducing construction costs and facilitating a modal shift. GrowSmarter implemented this approach in large-scale renovation to assess its impacts and pave the way for wider adoption across the city. The car-sharing pool has been successful and used frequently by residents.

New market with few operators provides potential for expansion. 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 included maintenance and storage, along with the business model for concessions, membership, etc. However, there is potential to develop this service, as e-cargo bikes offer advantages over conventional cycles and other mobility services, such as kick bikes, as e-cargo bikes are suitable for family travels or transportation of large bulky items.

The electric car pool in Stockholm is highly appreciated by residents.

Bike and car pools improved social sustainability. Electric cargo bikes and electric cars offered a practical solution for families or individuals without the possibility to have a car. The bikes were cost effective, CO_2 neutral and beneficial to health through everyday physical exercise. Electric cars enabled CO_2 neutral transports when travelling by car was needed.

Public sector can create incentives for upscaling and replication. The combination of EU funding and green parking index enabled stakeholders to convene and demonstrate a new service for rental housing tenants. Incentives such as the Swedish Government's 25 percent subsidy for purchases of e-bikes and e-cargo bikes helped stimulate adoption by individuals, while 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, green parking indexes that oblige developers or property owners to provide such services or integration into bike-sharing systems or mobility stations offering "Mobility-as-a-Service" subscription packages.

A mobility station offered multiple transport alternatives at one location. In Cologne, this included 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 could pay for public transport as well as car-sharing using a mobility card. Cologne is now integrating mobility stations in the city mobility plan.

Car sharing reduced CO_2 by 73 percent. The station-based car sharing solution in Cologne saved about 73 percent CO_2, for example 117 tons of CO_2 in 2018. During the first year of implementation, an estimated 46 percent of the car-sharing users sold their private cars, based on survey data. Car sharing could hence replace many private vehicles. The charging stations in Barcelona have contributed to the reduction of 26.5t of CO_2 emissions in 2018.

Location, location, location. The location of mobility stations and car sharing stations was a key success factor. Car-sharing services required optimal locations to ensure financial viability of operations and significant shifts in citizen behaviour (with resultant environmental benefits). This was best achieved through long-term planning and cooperation. City administrations should 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. It is important to understand who owns the land and to ensure that locations are visible sites that match user needs or preferences. There may be restrictions on use of public land for private ventures. For example, German cities are only able to offer small spaces on public streets to private enterprises on three-year concessions, and German courts do not allow parking space-sharing services to operate on public land. Similar legislation applies in Sweden as well.

The cargo bike pool was introduced to residents at one of the information events hosted by GrowSmarter.

Resident involvement is key. Understanding the user group and its needs is important to ensure usage and estimate demand and the future profitability of solutions. Residents should be involved in strategic planning of mobility services, through public consultation procedures and continuous follow up during the start-up phase.

A dynamic market with potential for expansion. The dynamic nature of the market for mobility solutions means new private mobility operators are emerging. This adds to the complexity of developing business models for service providers, but at the same time offers potential to integrate additional services into or close by mobility stations (e.g. cargo bikes, scooters, delivery boxes). 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.

Combine even more and incentivise for greater usage. Parking of free-floating bikes and e-scooters could also be restricted to mobility stations in order to facilitate smooth integration of such services to the urban landscape. Incentives such as free parking for electric vehicles, or free electricity, may help stimulate markets but must form part of coherent long-term strategies for sustainable urban mobility.

RECIPE FOR IMPLEMENTING SHARING SOLUTIONS FOR E-BIKES AND ELECTRIC CARS

Before you start:

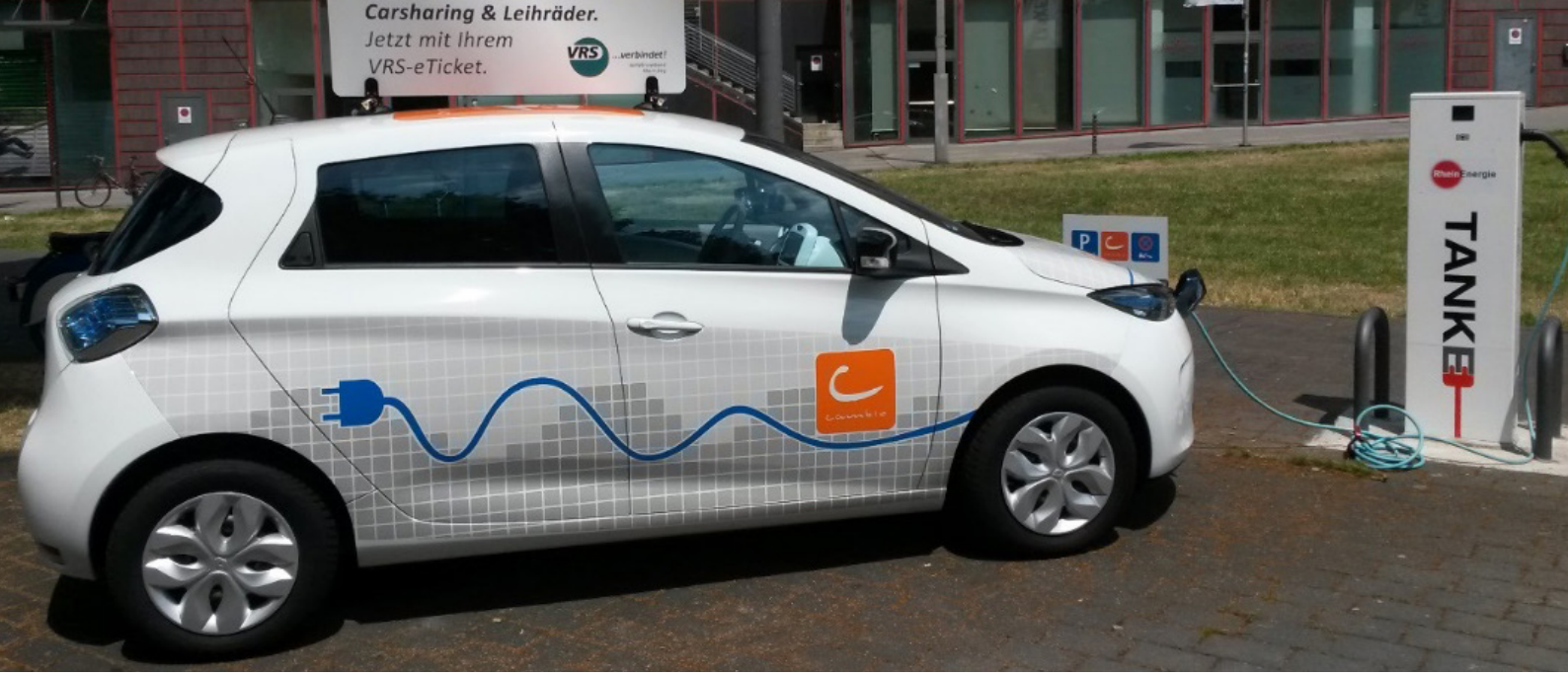
- Identify a long-term business model
- Identify your target group: general public, companies, others? Demographic characteristics of the area?
- Identify the goal of the car sharing: Sustainable mobility, revenue, socioeconomic improvements for residents, others?
- Identify where the vehicles should be charged. Charging boxes, ideal for indoor installation in garages, are cheaper than on-street charging points. Permits may be required

What you need:

- Parking space(s)
- Secure facilities for the bikes, to protect against theft and weather
- Electrical infrastructure - make sure it is user friendly. Contact the electricity network manager to check there is sufficient grid capacity for new charging infrastructure
- Parking signs with communication and instructions
- Electric vehicles with a booking system and data management. Take in offers on operation, maintenance and support equipment. Commission cable works and establish an electricity supply subscription

Launch:

- Communication is key. Make sure you have a solid communication plan targeting the relevant group before, during and after the launch
- A launch event can give an initial boost to the service. It gives an opportunity to instruct possible users and market the service



CHARGING STATIONS & RENEWABLE FUELS

A well-developed charging station system, with rapid as well as normal chargers, was a crucial piece of the puzzle towards reaching a fossil-free vehicle fleet. New fuel stations for renewable fuels for heavy vehicles increased incentives for use. These measures together enabled reduction of greenhouse gas emissions and pollutants.

Charging stations for electric cars. The project introduced five rapid charging points in Barcelona and one in Stockholm. A further eight normal charging points were installed in Stockholm, and ten charging stations with two charging points each were installed at six mobility stations in Cologne. The charging stations in Cologne are operated exclusively with green electricity. Multiple user groups including private vehicles, taxis, and car sharing services have used the charging facilities.

Installation of charging points on public land is complex. Installation of chargers on publicly-owned land was more complicated than installation on privately-owned land. Partners that own the land and electricity grid connection may be able to install charging infrastructure more rapidly. Having clear ideas and agreements about complex issues such as data management, maintenance, costs and revenues are important. When installing publicly-owned infrastructure, this means not only aligning actions with city strategies, but also finding new ways of accounting for measures which may not have obvious economic benefits but offer direct benefits on reduced CO_2, noise, etc.

Charging stations for electric cars need strategic placement to encourage use.

Charging infrastructure is currently financially unsustainable. The measures implemented in Cologne, Stockholm and Barcelona were found to be financially unsustainable. Pricing and payment methods should be further investigated. There are large benefits from economies of scale, particularly regarding decreasing marginal costs.

Expansion of refuelling network for renewable fuels used in heavy vehicles. Together with stakeholders, the City of Stockholm secured permits for new sites around the city to expand the refuelling network for heavy vehicles, with high-capacity pumps and larger bays. This increased the availability of renewable fuels such as ED95 (bioethanol), CBG (biomethane) and HVO (biodiesel) for use in heavy goods vehicles in Stockholm and the surrounding region.

Demand for renewable fuels exists on a fully commercial basis. Installation of new pumps on existing facilities located on privately owned land is relatively uncomplicated if on a commercial basis. Installation takes much longer if detailed plans have to be changed and if more than one public administration is involved.

Social acceptance for renewable fuel stations. The fact that the fuelling stations for heavy vehicles in general are on the outskirts of the city, in industrial areas, combined with the fact that it eases the increase of renewable fuel creates most likely a positive opinion among the public.

Car sharing in Cologne.

GROWSMARTER FINDINGS ON VEHICLE-TO-EVERYTHING (V2X) TECHNOLOGIES

The application of Vehicle-to-Building (V2B) technologies in Barcelona 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 electric vehicle supply equipment (EVSE) and plugs. This is likely due to concerns by 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

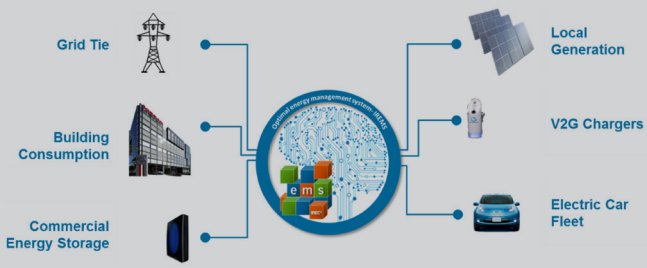
The legislative frameworks for electric grid operation do not address explicitly the issue of V2X applications. This is a challenge as requirements on stating how the electricity is produced exist. Furthermore, there is broad variation in V2G regulations across different regions (different building, 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 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 the V2X value proposition to end-users.

In addition, there currently is low 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, 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.



Schematic illustration of the potential applications of V2G charging in Barcelona.

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 from 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 total cost of ownership.

SMART TRAFFIC MANAGEMENT: PRIORITIZED TRAFFIC SIGNALS

Synchronisation of traffic signals to prioritise HVO-fuelled heavy vehicles also increased incentives for use of fossil free fuels.

Prioritize HVO-fuelled heavy vehicles by traffic lights. By synchronisation of traffic signals, HVO-fuelled heavy vehicles were prioritized. Environmental impact was reduced with reduced number of starts and stops for heavy vehicles. Safety was also improved by better traffic flow.

Complex integration of the system. The integration of the prioritized traffic light system into a dynamic traffic system was complex. Prioritising one mode of transport, or one type of fuel or technique, created incentives for small numbers of users, yet risked generating larger negative impacts for other road users not prioritized by the system. The indirect system impacts were thus hard to assess. Of course, by offering an incentive to adopt non-fossil fuels in vehicle fleets, the measure aimed to promote a transition to cleaner vehicles and fuels, which eventually would 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 were limited to the CO_2 saving generated by use of HVO in the fuel tank.

"By synchronisation of traffic signals, HVO-fuelled heavy vehicles were prioritized. Environmental impact was reduced with reduced the number of starts and stops for heavy vehicles. Safety was also improved by better traffic flow."

Pedestrians must not be deprioritised: The system with prioritized traffic lights works in cities with traffic control systems with long periods of prognosis security. Many traffic lights are programmed to change if pedestrians wish to cross the street. This will not be changed as pedestrians and bikers are prioritised. It is important when looking into new traffic management systems not to overlook the importance of walk and bike friendly traffic management.

"It is important when looking into new traffic management systems not to overlook the importance of walk and bike friendly traffic management."

Clear communication of benefits for behavioural and organisational changes. Establishing a system does not automatically lead to implementation, as organisational and behavioural changes require time and resources. It is important to have everyone on board, from all involved partners. A clear communication of how it works and benefits gained makes implementation easier. Better working conditions, increased efficiency and clear areas of responsibility are some of many improved aspects.

READ MORE

Read more about the measures implemented on our website http://www.grow-smarter.eu/home/ where you find all our reports and fact sheets.

RECOMMENDATIONS
TO THE EUROPEAN COMMISSION AND NATIONAL GOVERNMENTS

During five years of work with smart solutions in three Lighthouse cities, GrowSmarter has discovered success factors as well as gaps worth addressing. Recommendations below are based on the insights from the project but with a scope considering the broader context. These are hence recommendations to policy makers and practitioners who wish to contribute to the ongoing work of creating a smart and sustainable society.

- **Demonstration projects make sense.** From the experiences and the evaluation done within the frame of this project as well as other Lighthouse projects, it is evident that these kinds of solutions are fruitful. The possibility to test solutions, adapt them to fit local conditions, compare similar solutions in different contexts, and evaluate and elaborate on lessons learnt is crucial for the transition to a smart and sustainable urban society. Examples from this project are the mobility hubs in Cologne that are now part of the city's mobility strategy, the smart street lights in Stockholm that have been rolled out in several neighbourhoods and the delivery room in Stockholm that is currently being adapted to work in large scale with the national postal service. Demonstration projects can create new markets for smart solution providers as well as new cooperation between cities. Hence, it is important also to dedicate time and budget for demonstration, replication and upscaling, and there is a need for the EU to support this.

- **Ensure citizen involvement.** Include time and funding in Grant Agreements for engagement activities to build user acceptance and engage citizens as well as convince city departments. GrowSmarter experienced that when citizens where involved in preparation and implementation, the results improved. In order to foster acceptance of smart solutions, education for and engagement with the people who ultimately benefit is essential. Active and engaged citizens are key to true transformation of life in the city.

- **Ensure the inclusion of social sustainability in national strategies.** Quantify externalities in the development of national strategies to comply with the European Union's building retrofitting goals and strategies for fossil free urban transport. Include non-economical key performance indicators (KPIs), such as social benefits, in the development of national strategies for compliance with EU goals. District-scale energy renovation plans and urban transport strategies have several social benefits for citizens: less segregation, cleaner local environment, increased joint responsibility of the area, cultural preservation and attractive neighbourhoods for youth. Also, the quantification of health benefits and the associated cost savings for the public healthcare system should be considered.

- **Promote the development of information and communications technology (ICT) solutions.** Ensure good digital governance and enable public authorities to keep up with technology developments so that personal data is dealt with correctly and people feel that they are safe in using digital technologies and services. Focus on the needs rather than what's cool to do, meaning that development of solutions should be driven by needs for city development and request from citizens rather than inhouse based ideas.

- **Introduce a CO_2 tax.** A tax on emissions would be a clear and straightforward instrument to set out the direction needed for a sustainable future. It could further incentivise the public and private sectors to choose sustainable smart solutions rather than follow the well-trodden path.

LOW ENERGY DISTRICTS

- **Retrofitting is a proven measure for reduced emission.** In Sweden and all over Europe many property owners are facing the decision of either demolishing existing buildings to make room for new constructions or retrofit existing buildings. Facts showing the environmental and economic benefit of retrofitting must be highlighted. When retrofitting a building, like Skanska and Stockholmshem did in Stockholm, a lot of CO_2 emissions is avoided as the concrete frame is kept. Around 70 percent less emissions is produced when retrofitting compared to new constructions. This not only reduces emissions but also saves cost for the construction company and property owner. Despite this, new constructions tend to be prioritized by private as well as pubic actors, something that sometimes needs to be questioned.

- **Ensure energy retrofitting through funding and incentives.** The Commission as well as national governments must act as a source of funding to upscale energy retrofitting of buildings at a district level. Access to funding is crucial to the success of the energy package and calls on the European Commission to earmark structural funds after 2020 for clean energy for all Europeans. Subsidies from supra-municipal funds are often needed to upscale energy retrofitting, such as thermal envelope upgrades in the residential sector. Existing subsidies for the residential sector should be better computed based on real demands (instead of theoretical demands) and climate. However, even though funding is essential, energy retrofitting might not happen despite financial input. This might be due to businesses and public sector being unwilling to change or a lack of confidence in the economic benefit despite proven profitability. National governments must make sure that current requirements are adapted to the existing standards available in the market. It is also important to present positive examples on how retrofitting creates social, ecological and economically sustainable benefits, as done in GrowSmarter. By doing so, the bar can be set high enough for positive changes to happen.

"A tax on emission would be a clear and straightforward instrument to set out the direction needed for a sustainable future. It could further incentivise the public and private sector to choose sustainable smart solutions rather than follow the well-trodden path."

- **Regulations on small-scale electricity production must be reviewed and harmonized.** It is necessary to establish a European regulatory framework that empowers renewable self-consumers to generate, consume, store, and sell electricity without facing disproportionate burdens and fees. This should apply to both individual renewable self-consumers and jointly acting renewable self-consumers (i.e. various consumers that own the same energy generation unit and are able to sell the surplus electricity to the grid). Each country has its own legislation that establishes the regulations for small energy producers for whom this is not their main economic activity, such as housing or public buildings. For example, in Sweden if someone installs more than 255 kilowatt (kW) of photovoltaics on a property, it is necessary to pay tax as an energy company even if the energy is being used in the installer's own buildings.

Furthermore, the building owner cannot supply household customers with excess electricity without paying tax, and it is not allowed to transfer electricity between properties. This prevents housing companies and real estate owners from implementing large photovoltaic installations even when suitable. Regulatory changes to avoid these obstacles can be done, as seen in Spain.

- **Provide a legislation framework to foster local energy communities.** In order for building-integrated local energy generation to be self-financing, different models of local energy ownership are still to be tested. A regulation–free zone is a way to test smart local renewable energy generation. By letting innovations and business act without regulatory hindrances, the security needed for industrial partners to scale up distributed renewable electricity generation at community level is ensured and inefficient legislation pinpointed. This way, development and upscaling of smart solutions could co-develop with legislation development.

- **Promote demand-response services through national regulation.** Time of Use tariffs allow engaged and empowered users to gain substantial cost savings over fixed rate energy tariffs by shifting their consumption to advantageous times. A favourable regulation on demand-response and microgeneration services would increase the associated economic benefits from the use of energy monitoring and visualization platforms for the end users. This in turn would boost the scalability potential of smart monitoring services. It would also cut peaks, hence decreasing the need for power reserve on fossil fuel.

- **Adapt national laws to pave the way for the implementation of local energy retrofitting.** Swedish national legislation on energy use and energy efficiency in new buildings is firm and does not allow for local, more ambitious levels. This limits local initiatives and neighbourhood-level initiatives not only for new buildings but also for retrofitting. Adapting the regulation to facilitate local initiatives will help the upscaling of deep energy retrofitting in cities and increase the implementation of innovative measures in new buildings. Enable requirements in terms of building regulations that accept and expect green construction techniques and materials for new buildings as well as in retrofitting. Also ensure that all building codes accept and support local ambitions on energy efficiency, thus not restrain retrofitting or the development of near-zero buildings.

INTEGRATED INFRASTRUCTURES

- **Regulations on data sharing and General Data Protection Regulation (GDPR) must be harmonized and updated.** Due to the different regulations and the available IT infrastructure in each country, it is still not possible to consider a single model throughout the European Union that allows the scalability of products and services associated with the use of detailed electricity consumption data from smart meters, even though the current state of technology allows it. An example is Barcelona (along with other cities), where legislation needs to be changed in order for a third party to access consumption data from smart meters and district system operators. The introduction of the GDPR caused a lot of fear and even stopped projects. Legislation in general needs revisions to avoid being hindrances for electronic equipment.

- **Standardization of urban data platforms is key.** Continue the work on standardization for creating a reference architecture providing a mission and vendor agnostic approach for an enhanced interoperable, standards-based platform architecture and implementation. The interoperability of solutions is key.

SUSTAINABLE URBAN MOBILITY

- **Legislation must match reality.** Cities should be empowered with new regulatory means and resources to ensure Europe's transition to sustainable urban mobility. It must be ensured that electricity for charging comes from renewable sources, in accordance with Directive 2001/77/EC. Furthermore, it must be ensured that charging infrastructure encourages drivers to use electric vehicles.

- **Ensure transition to sustainable urban mobility.** Traditional city planning with car transport in focus must be part of the past. Support more creative use of public space where sustainable mobility is prioritised and a wide range of new mobility and transport services can emerge and flourish. National legislation could, for example, promote charging infrastructure on public land.

"Cities should be empowered with new regulatory means and resources to ensure Europe's transition to sustainable urban mobility. Traditional city planning with car transport in focus must be part of the past."

- **Supply of biofuel must be guaranteed.** Ensure through legislation the growth of sustainable biofuel supply from waste and derelict farmland in Europe in order to accelerate alternatives to fossil fuelled vehicles.

- **Collaboration across manufacturers is needed.** V2X technology performance and standards are under development. The Commission should oversee this development by bringing together manufacturers and other relevant sector stakeholders for developing the necessary regulations. Currently, there is a limited number of electric vehicle models that can support bi-directional power flow between vehicle and charging point (V2X technologies) as well as lack of V2X-ready charging. This is likely due to concerns by manufacturers over the impacts of V2X on battery aging, along with a lack of demand from vehicle users for V2X capability. It is hence necessary to manage potential concerns, such as data security, battery aging and range anxiety. It is evident from the project that EV users need education and engagement programs to understand the impact of their driving behaviour on battery performance as well as the opportunities to maximize their benefits via V2X activities such as addressing peak load issues. Warranty implications from battery manufacturers is an essential factor to address for EV users as it will directly affect their willingness to use the technology.

RECOMMENDATIONS
TO LOCAL GOVERNMENTS

- **Ensure citizen involvement for behavioural changes and increased quality of life.** The smart solutions described in this report increase citizens' quality of life. There must hence be defined users and end-users from the start. Engagement varies between different user groups. Communication and behavioural aspects need to be evaluated in order to adjust solutions to the user groups and their needs. It is crucial to determine user needs prior to service development. Just as important is the flexibility to manage responses after services launch. In order to do this, citizens and user groups must be involved from the very beginning. The value of the changes provided by the project must be understood and requested, or at least accepted, by the citizens at an early stage. Likewise,the long-term benefit must be visible and experienced by the citizens.

- **Include socioeconomic benefits in all parts of the solutions and business models.** 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 benefits are of particular importance in the context of smart and sustainable solutions and should be taken into account when evaluating the viability of measures and their benefits to society.

- **Political commitment drives implementation.** The municipal councils in each of the three Lighthouse Cities have clear commitments to reduce urban climate impacts and increase energy efficiency and sustainable urban mobility through proactive measures. Political decisions can affect the content of strategies and policies and send signals to markets; positive signals can enable and empower other stakeholders to initiate bold experiments and deliver transformative solutions. We urge each and every European city to commit to a date and establish a plan for when and how to become fossil free.

- **Experiment and be flexible!** Experimentation and flexibility facilitate continuous learning. Cities can facilitate experimentation in many ways, for example through formal mechanisms such as procurement – preferably challenge driven, and voluntary mechanisms such as city-wide Climate Pacts (in which signatories commit to reducing greenhouse gas emissions). By providing spaces for stakeholders to meet and identify shared interests and possible collaborations, stakeholders with different backgrounds and interests can come together and develop innovative new forms of services, as well as spin-off services outside of the project. 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.

LOW ENERGY DISTRICTS

- **Set ambitious goals for deep retrofitting.** Retrofitting in the city should be highly prioritised even if construction of new buildings also occurs. The existing building stock needs to be taken care of for a long-lasting, sustainable and inclusive city.

- **Adjust local urban planning regulations to facilitate photovoltaic installations.** Urban planning regulation should be an instrument to promote new PV installations, rather than limit them due to aesthetic concerns. New ordinances by municipalities that promote the use of rooftops for renewable energy generation have advanced the installation of photovoltaics.

"Retrofitting in the city should be highly prioritised even if development of new buildings also occur. The existing building stock needs to be taken care of for a long-lasting, sustainable and inclusive city."

INTEGRATED INFRASTRUCTURES

- **Flexibility in planning, implementation and prolongation.** Allow solutions to grow and adjust to the local context. The focus should be on the outcome and potential environmental impacts. For open urban data platforms, for example, avoid supplier lock-in by making sure the systems and solutions are flexible. Use clear and standardized interfaces between the different modules in the system to make it possible to switch out one part of the system without changing others. Another option to avoid supplier lock-in is by making sure in agreements that the data is owned by the city.

- **Prioritize open data platforms.** There can be challenges with obtaining necessary data and difficulties in establishing data collection routines for mobility patterns. Avoid this by using and enabling open data platforms. Equally important is to identify what data cannot be gathered due to legislation, and if possible, find other useful data types.

- **Reorganise and rethink city organisation to implement shared smart city systems.** Several different functions and departments can use the solutions and the data generated by a platform. The first investment of a smart platform is large and general and therefore difficult to make by an individual department even though the need is greater than any single department. There is a need for new responsibility areas within the city for these types of shared systems, as well as new competencies and new ways of working. Also, engagement of the city administration areas involved and training for public servants on new competencies on data use is needed. A wider use of these kinds of services is also beneficial for a payback analysis.

SUSTAINABLE URBAN MOBILITY

- **Mobility stations support fossil fuel free mobility.** Mobility stations and sharing options for bikes, e-cars and cargo bikes have proven to be great solutions from an environmental as well as socioeconomic perspective. The mobility stations in Cologne as well as the e-car sharing in Stockholm have decreased the number of privately-owned cars and emissions, resulting in better air quality and less congestion. The solutions are easy to adapt to local conditions.

"Mobility stations and sharing options for bikes, e-cars and cargo bikes have proven to be great solutions from an environmental as well as socioeconomic perspective."

RECOMMENDATIONS
TO PRIVATE COMPANIES

- **Work towards gaining social acceptance and adapt technologies based on interests and skills of potential users.** For example, engagement campaigns aimed at private owners of multi-ownership residential buildings are a key tool to succeed in the replication of energy retrofitting projects. Building end-users should be informed about the environmental benefits of energy efficiency solutions applied in buildings, and the importance of the users' behaviour. As another example, user engagement and acceptance are critical for the success of waste sorting systems.

LOW ENERGY DISTRICTS

- **Combine interventions with short and long payback periods.** Active solutions bring higher economic savings than passive actions and shorten the payback time. When combined, short payback investments (e.g. installation of efficient lighting systems or heating, ventilating and air conditioning (HVAC) equipment) can help compensate for long payback interventions (e.g. upgrade of façade thermal insulation), especially in mild climates with low heating energy demand.

"Residents should be informed about the environmental benefits of energy efficiency solutions applied in buildings, and the importance of the users' behaviour."

- **Use energy saving experts.** Collaboration with an energy savings expert is an opportunity to include energy efficiency measures that would otherwise be omitted. The energy expert can adapt the project and add energy efficient technologies in the structural refurbishment, as well as commit to guarantee a predefined energy savings target.

"Combine interventions with short and long payback periods."

- **Economies of scale should be considered in the economic assessment of a new business model based on energy retrofitting.** The positive impact of economies of scale should be assessed and might result from the combination of energy and structural refurbishment or large-scale refurbishment (e.g., clustering several buildings in the same city area).

- **Consider the increased value of buildings after retrofitting.** This brings much more favourable results in economic assessments rather than only quantifying energy savings thanks to the intervention. To overcome too long paybacks, externalities should be considered. Banks are progressively recognizing the proven lower probability of default in energy saving loans and the increased value of the assets after energy retrofitting.

- **Assess the decrease of the building's environmental impact.** The use of certificates to evaluate both the environmental and health impacts of buildings are a tool to increase the value of the property. The "green value" generated by the energy performance of buildings is progressively integrated in financial approaches, as a result of rising regulations and energy prices. The added value can help energy renovation of buildings become a sustainable business model.

"To overcome too long paybacks, externalities should be considered. Banks are progressively recognizing the proven lower probability of default in energy saving loans and the increased value of the assets after energy retrofitting."

- **For Home Energy Management Systems, focus on user acceptance and engagement.** Study the interests and skills of potential users and adapt the technology to effectively achieve a behavioural change. Consider targeting tech-savvy and environmentally-minded people in the first roll-out of Smart Home technologies.

INTEGRATED INFRASTRUCTURES

- **Smart waste management contributes towards a circular economy through improved sorting and reduced traffic.** The solution presented here reduced traffic by 90 percent meaning reduced cost and less emissions. There was an increase in the separation of food waste, which can be used for biogas production. Also, other fractions such as metal, plastic, glass and paper can be reused or recycled, hence contributing to a circular economy.

"Study the interests and skills of potential users and adapt the technology to effectively achieve a behavioural change. Consider targeting tech-savvy and environmentally-minded people in the first roll-out of Smart Home technologies. "

- **Understand standardization as a competitive advantage.** The industry often drives standardisation, so continue developing it together with other stakeholders. Make sure to offer flexible solutions to avoid the fear of lock-in.

RECOMMENDATIONS
FROM PROJECT MANAGEMENT

- **Target group participation is key.** Project management should maintain active and open dialogue with all target groups about their needs and ideas. Early and active involvement is likely to enhance the quality of projects. Target group 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. Involvement of users is important from a social sustainability and social inclusion perspective and can deliver positive indirect benefits.

- **Technology can 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 the measure could have higher potential benefit in other contexts. It is recommended to tailor the measure to the user groups at an early planning stage.

- **Evaluation of measures is essential but complex.** It has been challenging to identify common evaluation frameworks that reflect the effects of certain measures. KPIs and methodology need to be in place and clear within the first stage. Estimated impact should be considered (other than KPIs). A deeper understanding is needed of how impact assessment methodologies should be used in order to better adjust to the rapid transformation of urban mobility, for example. Also make sure to establish baselines before implementing projects. Measure and evaluate environmental factors and use the results to influence changing behaviour, such as reducing traffic. Use accurate data to target the issues and solve problems. Understand the cost effects.

- **Involve and engage stakeholders early, widely and continually.** 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. 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. Hence, ensure that all partners are committed to delivery both during and after projects.

- **Plan to deliver.** Since the field of smart cities is undergoing a big transition, new partners that were not traditionally part of the sectors 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.

- **Avoid regulatory barriers.** Implementation of solutions should be consistent and sequential, i.e. the underlying policy frameworks should precede and facilitate implementation. Identify regulatory barriers early on in order to solve them more effectively.

WHAT HAPPENS NEXT?

Most of the measures implemented in GrowSmarter have potential for immediate replication and upscaling. For partners as well as cities, some results are of extra interest to exploit and develop further, as described below. Additional details can be found in the concluding reports for each work package.

LOW ENERGY DISTRICTS

- In cities with existing district heating network infrastructure, **the feed-in of waste heat into District Heating networks** has shown a high potential for replicability. In Stockholm, the new business model of Open District Heating tested by Stockholm Exergi has shown promising results and will probably be up-scaled in the city.

- The old districts of Barcelona have developed plans for the protection of the architectural heritage of **industrial buildings**. In the specific case of the public-private facility Ca l'Alier, the low-energy building is expected to be used as a **showcase for good practices in energy retrofitting**. Some examples of replication are the on-going building retrofitting actions by the Municipality of the industrial buildings L'Escocesa and Can Batlló.

- In Stockholm, results from the **deep retrofitting of residential buildings** are already being exploited to copy parts or the whole concept to retrofit similar residential buildings. For replication in large renovation projects for public housing, targeting slightly lower energy savings is foreseen to shorten payback periods and make the projects more economically viable.

- In Cologne, an action program called KölnKlimaAktiv 2022 includes many measures that further develop outcomes of GrowSmarter on a city-wide scale. The city will develop mandatory **guidelines for climate protection for retrofitting** and new construction projects. An **electricity saving initiative** for households and tertiary buildings has been created. Information and advisory services for citizens are also planned for the installation of **photovoltaics on rooftops**.

Valla Torg in Stockholm is one of the sites for energy retrofitting.

- Naturgy will continue exploring opportunities to participate in **commercial building refurbishment projects** in order to implement energy retrofitting actions, using the **ESCo business model** through a private/private contract tested under GrowSmarter.

WHAT HAPPENS NEXT?

INTEGRATED INFRASTRUCTURES

- The experiences from the **smart lighting** measure was used in the planning and procurement of smart lighting in another location in Stockholm where 180 smart lights will be implemented starting in 2020.

The City of Stockholm and GrowSmarter won the Smart City Award 2019.

- The experiences from GrowSmarter regarding the implementation and operation of the **Internet of Things (IoT) platform** has been an important input for the planning and procurement of a city-wide IoT platform in Stockholm. The procurement is now in its final stages.

- The Cologne partner AGT has already started to exploit the **GrowSmarter Energy Insight Dashboards** in collaboration with the Gateway manufacturer Homee. Access to the GrowSmarter dashboard has been offered to all Homee Gateway users. This activity allows further testing and validation of the features developed in GrowSmarter.

- The solution of **smart waste handling** in Stockholm is being showcased to clients on the global market. Envac is planning further development of the concept to increase reliability, reduce energy consumption, improve the end user experience, and incorporate an incentive/feedback system to increase recycling.

- In Barcelona, GrowSmarter's **big open data platform** helped establish collaborations with other project partners that go beyond the GrowSmarter lifetime and scope. Additionally, the Municipal Institute of Informatics (the technical branch of the city hall) intends to include the Urban Model that was developed as part of their future CityOS semantic model for the city, the unique point of access to all city resources and services.

- In Cologne, city-wide negotiations are underway regarding the use and implementation of a **big data platform** with the entire municipal utility group based on GrowSmarter learnings.

WHAT HAPPENS NEXT?

SUSTAINABLE URBAN MOBILITY

- The **e-car-sharing pool** 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** 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** 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** and the Stockholm delivery room 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 to find a solution that can be implemented in all kinds of buildings and adapted to different types of e-commerce interfaces. A pilot is currently being set up to evaluate how this can be done.

- **Construction consolidation centres** are considered well-functioning by the partners, and exploitation of results is already happening. Based on lessons learnt from this project, the set-up will be modified and developed to fit different types of construction sites. A container-based solution is one example, using insights from both the consolidation centre solution and the delivery room solution.

- Expansion of **charging infrastructure** 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 is sharing knowledge on electric vehicles and charging infrastructure with cities and other stakeholders through a wide range of networks.

REFERENCES

LIST OF KEY GROWSMARTER PROJECT DOCUMENTS		
NAME OF DOCUMENT	**LINK**	**FINALISED**
Fact sheets on all the smart solutions implemented in the project.	http://www.grow-smarter.eu/solutions/	2016 - 2018
Technical and management reports on the project management procedures and the development of the project.	http://www.grow-smarter.eu/inform/reports/	Feb 2016, June 2017, Dec 2018, Dec 2019
Implementation reports on implementation of the measures in Low energy districts, Integrated infrastructure and Sustainable urban mobility.	http://www.grow-smarter.eu/inform/reports/	Feb. 2018
Draft concluding reports on the final results, lessons learnt and scalability of the measures in Low energy districts, Integrated infrastructure and Sustainable urban mobility.	http://www.grow-smarter.eu/inform/reports/	Feb. 2019
Final concluding reports on Low energy districts, Integrated infrastructure and Sustainable urban mobility.	http://www.grow-smarter.eu/inform/reports/	Oct 2019
Lighthouse cities market introduction Economic validation and assessments Smart city market introduction.	http://www.grow-smarter.eu/inform/reports/	Feb 2018 Jan 2019 Sep 2019
Reports on results of technical, economic and social validation.	http://www.grow-smarter.eu/inform/reports/	Dec 2018 Sept 2019
Data management plan.	http://www.grow-smarter.eu/inform/reports/	First version 2015
Project Result Brochure	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.

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*For more information about the **GrowSmarter** project, please visit:*

www.grow-smarter.eu

For the Lighthouse Cities, we also have basic project information in the local languages:

STOCKHOLM

COLOGNE

BARCELONA