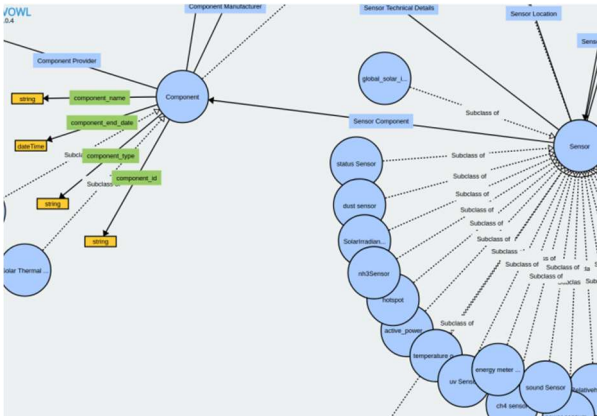
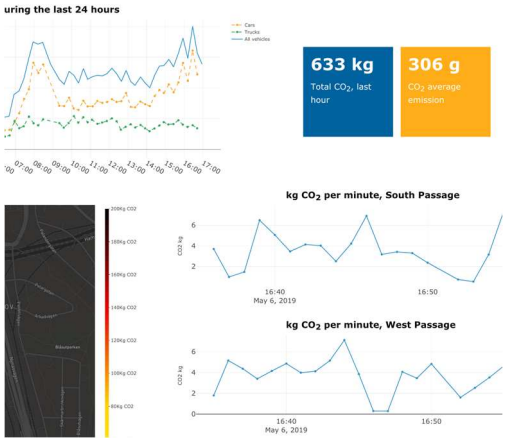
GrowSmarter

Transforming cities for a smart, sustainable Europe

IMPLEMENTING INTEGRATED INFRASTRUCTURES IN EUROPEAN CITIES - CONCLUSIONS FROM GROWSMARTER

D3.6 CONCLUDING REPORT WP3





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EXECUTIVE SUMMARY

This report describes the GrowSmarter conclusions of eleven measures within three solutions addressing the topic of Integrated Infrastructure in the GrowSmarter project implemented by its' three "Lighthouse Cities" of Barcelona, Cologne and Stockholm.

The report begins with a general introduction and overview of the measures, before proceeding with short descriptions for each measure. Lessons learned and general conclusions are described by topic illustrating potential barriers or opportunities to implementation, and contain recommendations for each topic. The general conclusions are summarized, and recommendations are given for different stakeholders on how to facilitate and accelerate roll-out of Smart Solutions.

The topic of integrated infrastructure, in particular the work with data, contains many enabling measures that have no directly visible influence on energy or CO2 savings or mobility impacts. Costs for these measures may be high at first with low numbers of users, but the up-scaling may be easily achieved and may have a large impact later on.

Each measure forms part of 12 "Smart Solutions" within the GrowSmarter project. In Chapter 4, recommendations to the European Commission, local governments and private companies are collated and discussed with reference to each Smart Solution. These findings inform the general conclusions of this report, which include the identification of challenges and opportunities related to:

- Administrative processes, laws and regulations (within countries, and in terms of variation between countries);
- Business models and issues related to gathering, use and ownership of data;
- User behaviour etc.

Key conclusions include a need to inform, communicate and plan early to allow time for intensive cooperation between stakeholders and actors. Topics are very complex and involve many law issues that can either prohibit or better lead to enabling the use of the data loads from integrated infrastructures cities are faced with. To achieve success, cities should be empowered with new regulatory powers and sufficient resources to ensure Europe's transition to sustainable integrated infrastructures.

The report thus provides readers with information on lessons learned per measure and per Smart Solution, along with thematic and general conclusions emerging from the GrowSmarter implementation and early evaluation phases. In doing so, the report provides key insights into the practical steps taken to implement measures and replicate good examples from GrowSmarter in other cities and contexts.

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INTRODUCTION

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

In this context, the cities of Barcelona, Cologne and Stockholm, together with a diverse group of public and private sector partners, formed the GrowSmarter project. GrowSmarter seeks 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.

This report presents experiences from the implementation and first evaluation of smart city solutions addressing the field of Integrated Infrastructures in GrowSmarter. The other two main topics Energy, and Sustainable Urban Mobility are covered in separate concluding reports. This report is based on analysis of interviews with measure leaders and other project participants, along with project reports and other relevant source material. In total, experiences from 11 measures are described to inform key conclusions and recommendations to policy-makers. These measures are clustered into four topics:

- Smart Lighting, Lampposts and Traffic Posts as Hubs for Communication (Smart Solution 5)
- *New Business Models for District Heating and cooling (Smart Solution 6, covered in WP2)*
- Smart Waste Collection, Turning Waste into Energy (Smart Solution 7)
- Big Open Data Platform (Smart Solution 8)

Many of these measures are enabling measures and therefore the amount of end-users who are reached is limited. The first costs are typically high and the amount of users low, but up-scaling can be easily implemented with potentially high impacts at a later time.

For more information regarding the details of each measure, the technical and financial evaluation and business models, please refer to the separate publically available ***fact sheets***, the ***implementation and evaluation reports*** and ***lighthouses cities market introduction*** documents as well as the ***periodic technical reports***.

Table 1: Short description of the content and aims of WP3 solutions and measures

Solution	Mea-sure #	City	What is it?	Aim
SS5 Smart lighting, lampposts and traffic posts as hubs for communi-cation	**M. 5.1**	STO	Smart Street Lighting	The intention is to use the most successful technology for dimming lighting in the city´s lighting program.
	M. 5.2	STO	Traffic analysis	Real-time data from pedestrian, bicycle and vehicle traffic is collected by sensors to give an understanding of how people travel to events taking place in the area.
		BCN	Smart lampposts	The "SmartTower" solution converts the traditional lamppost in new multifunctional towers or telecommunication micro-sites, offering space for communication devices and sensors.
		COL	Combined electric charging and street lighting poles	By combining electrical charging to existing street lighting poles, the aim is to enable a shared sensing infrastructure in the public realm.
	M.5.3	BCN	Smart Meter information analysis and actuators	The "Data Hub" serves as a data node collecting and managing city data. This allows for increased efficiency in infrastructures thanks to the integration and optimisation of several utilities, such as electric, water and heating smart meter infrastructures, and urban and environmental sensors.
		COL	Smart Plugs	The SmartPlugs, together with the SmartHome application give the tenants the ability to track current energy consumption of connected devices. People are informed about their own behavior and learn to adjust it. The intention is to reduce energy consumption.
SS6	This solution is covered in the WP2 report.			

SS7 Smart waste collection, turning waste into energy	**M. 7.1, 7.2, 7.3**	STO	Smart waste collection, turning waste to electricity, heat and biogas for vehicles	By collecting differently colored bags from residential areas with an Automated Waste Collection System (AWCS), transporting the waste bags underground and sorting them in a collection station, the aim is to improve the quality of life, increasing recycling rates and resource efficiency.
8 Big open data platform	**M. 8.1**	STO, BCN, COL	Big consolidated open data platform	The aim is to create a common shared data platform with the potential of real-time data where data from e.g. all city departments can be stored and analysed. This platform is linked to the GrowSmarter goals and is used as a planning and decision making tool for management, evaluation and policies, enabling smart city services. The platform should also foster co-operation and co-creation as well as reusability and portability.
	M.8.2	BCN, COL	Urban Models	The solution aims at developing a semantic model that reflects and connects three domains of interest: mobility, energy, and integrated infrastructures. This model is a basis for data integration, exploration, and query.
	M.8.3	BCN, COL	Semi-automatic instance mapping	The aim is to semi automate the data mapping process to the urban semantic model for data monitored in the city.
	M.8.4	BCN	Integration of sensor and heterogeneous data in standard data format	The “Integrated Data Platform” is a horizontally organized platform with the goal to manage and share data from the implemented measures. This platform works like a middleware component that collects and standardizes different types of data with the aim to be offered in a common marketplace where the Business Applications can make use of the GrowSmarter Integrated Data.
	M.8.5	BCN	Sustainable connected lighting to enhance safety and mobility	This measure is linked to the Smart Towers in Barcelona (M5.2), providing a smart solution to efficiently link the lighting management systems with other city services and infrastructures.

1 FIVE YEARS OF WORK: ACTIONS AND ACHIEVEMENTS

This concluding report covers the topic of integrated infrastructures, ranging from smart lighting, lampposts and traffic posts as hubs for communication and electric charging, to smart meter information analysis and actuators, smart waste collection as well as big consolidated open data platforms, including the integration of sensor data and heterogeneous data. An integrated approach is key to the roll out of these smart solutions.

This Chapter describes the measures, presenting information about implementation, technical feasibility and replication potential, along with key lessons learnt.

As the work-package titled integrated infrastructures is driven by many measures that are of an enabling nature, the focus is most predominantly on providing data that could lead to informed and therefore improved decision making. This can't easily be measured and often only indirectly impacts KPIs such as energy, mobility and CO2 emissions.

Please also refer to reports D3.2- Implementation Report and D4.3- Draft Concluding Report for more in detail views regarding each measure's implementation and evaluation information.

1.1 Smart Solution 5: Smart Lighting, Lampposts and Traffic Posts as Hubs for Communication

This solution covers the following three measures

M5.1. Smart street lighting
Stockholm

M5.2. Combined electric charging and street lighting poles & WiFi-to-grid connection
Stockholm, Barcelona, Cologne

M5.3. Smart Meter information analysis and actuators
Barcelona, Cologne

Measure 5.1 Smart Street Lighting

Stockholm

The intention in this measure was to use the most successful technology for dimming lighting in the city´s lighting program to save energy and reduce CO2 emissions while at the same time providing enough lighting to satisfy the feeling of security at all times.

What did GrowSmarter do?

The following three technologies have been tested:

- Sensor controlled LED lighting - up to 31% savings
- Self-controlled LED street lighting - up to 21% savings
- Remote controlled LED street lighting - up to 25% savings

Lessons learned

Reliability of the data is not always guaranteed. Standardization in various ways may help to speed up permitting or reduce material prices. It is further important to evaluate whether to choose a small or large pilot area (or mock-up) for manageable implementation. The feeling of safety is an important component, as it is difficult to establish a level of light that satisfies pedestrians. Maintenance of these systems will become more and more challenging as technologies evolve fast. This measure has the potential to offer many job opportunities.

Potential for up-scaling and replication

Street lighting is generic to all cities. The technical feasibility is very good since all European cities have similar amounts of hours requiring street lighting: Stockholm ~ 4 520 hours, Cologne ~4 480 hours and Barcelona ~4 460 of sun above the horizon. The technology could save similar amounts in any European city.

HOW DID THE MEASURE WORK?

Technical feasibility

The measure is technically feasible. Maintenance will become increasingly challenging as technology evolves fast. Standardization may help with the implementation.

Economic feasibility

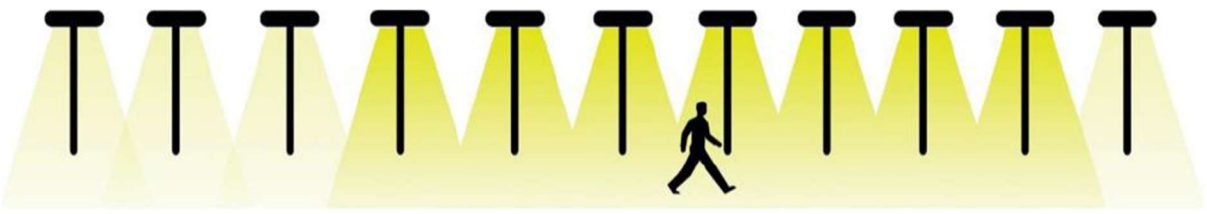
Due to the very low electricity prices in Sweden the solutions are not economically feasible and have long pay-back times. The solutions would be economically feasible in countries with higher electricity prices.

Replication potential

This measure is possible to be replicated in cities with similar infrastructure requirements & conversion potential within the lamp posts. Cork and Suceava have started looking into replication of this measure.

Key takeaway

There are several smart lighting technologies which can reduce vast amounts of energy for a city.



Measure 5.2 Combined electric charging and street lighting poles & WiFi-to-grid connection

Stockholm, Barcelona, Cologne

This measure is about the integration of lighting, environmental sensors and communication devices (BCN), the use of sensors to collect and analyze data about vehicle flow and emissions (STO) and electric charging (CGN) into a single respective lighting pole.

What did GrowSmarter do?

Real-time data collected by sensors in **Stockholm** give an understanding of how people travel to events taking place in the area, making possible the development of applications for lowering transport-based emissions. The **Barcelona** "SmartTower" solution converts the traditional lamppost in new telecommunication micro-sites that integrate wireless communication devices and sensors. In addition, Barcelona SmartTowers are connected to the Fiber Optic Backbone Network. Therefore, the solution offers hyper-connected areas to resolve the growing demand of massive wireless and mobile connectivity in the city. Networks can then connect the Smart Towers with the backbone network in the selected area. By combining electrical charging to street lighting poles in **Cologne**, the aim is to make walk-able urban areas ubiquitously connected, and to enable a shared sensing infrastructure in the open street spaces.

Lessons learned

When installing smart lighting systems, it is essential to make use of the implemented infrastructure (e.g. adding charging stations or connecting to Fiber Optic Networks or installing sensors that measure e.g. air pollution etc.) and to then provide the data on an open data platform to be able to analyze it and make good use of it, such as reducing CO2 by inspiring the use of more public transportation. Connectivity, positioning and electricity need to be (made) available. Use the opportunity to develop new services for citizens. Allow for resources within the city and external consults assisting in the process.

Potential for up-scaling and replication

This Measure may be applicable for any city and the possibility for up-scaling is very good.

HOW DID THE MEASURE WORK?

Technical feasibility
Different levels of implementation have their own technical feasibilities.

Economic feasibility
Financially and economically feasible because it enables better decision -making for city managers and new business models for Neutral Host Operators.

Replication potential
This measure is possible to be replicated in any city; suitable locations need to be found. Porto, Suceava and Cork are looking into replication of this measure

Key takeaway

Lampposts no longer provide light only, but turn into multi-functional smart "Humble Lamppost" city furnishings.

Measure 5.3 Smart Meter information analysis and actuators

Barcelona, Cologne

The **Barcelona** "Data Hub" serves as a data node collecting and managing city data. This allows for increased efficiency in infrastructures thanks to the integration and optimisation of several utilities, such as electric, water and heating, smart meter infrastructure, and urban and environmental sensors. The **Cologne** SmartPlugs, together with the SmartHome application give the tenants the ability to track current energy consumption of connected devices. People are informed about their own behaviour and learn to adjust it. The intention is to reduce energy consumption by encouraging behaviour change. Also refer to M3 in WP2.

What did GrowSmarter do?

The development of an app, showing the real-time status of the installed sensors with help of a camera in the 5 substations of the **Barcelona** project visualizes the status of the sensors inside the substation, therefore improving safety and the network. Overall, Barcelona management costs were reduced; the citizens receive a better network, less black-downs and potentially pay fewer taxes if a new plan is developed in the long-run to save expenses. In **Cologne**, smart plugs were developed in the context with the SmartHome system (M.3, WP2), because smart meters could legally not be used. The main technical challenge was the integration of the backend services into the 3rd party SmartHome kit without compromising the users' privacy.

Lessons learned

It is important to understand that a large number of sensors was needed in **Barcelona** to create a larger communications network and to see the operation on a larger scale with more impact. The main challenge and lesson learned in **Cologne** was getting tenants to participate, as the topic of smart meters and smart plugs is very much driven by certificates, standards and privacy issues. Whether it influences behaviour change and leads to savings remains to be seen.

Potential for up-scaling and replication

This Measure may be applicable for any city and the possibility for up-scaling is very good.

Key takeaway

Scale matters – understand legal framework, invest early and in engaging end-users

HOW DID THE MEASURE WORK?

Technical feasibility
Depends on legal situation in each country.

Economic feasibility
Financially and economically feasible because it enables better decision-making. It can be an enabling measure and/ or open up new business models.

Replication potential
This measure is replicable in any city, depending on the legal situation; distribution network is important. Cork is looking at replication.

1.2 Smart Solution 6: New Business Models for District Heating and Cooling

This topic is covered in work package 2, please refer to the

Low Energy Districts Concluding Report D2.6.

1.3 Smart Solution 7: Smart Waste Collection, Turning Waste into Energy

This solution covers the following three measures

M7.1. Optical sorting of waste
M7.2. Introduction of AWCS in an existing neighbourhood
M7.3. Waste collection statistics for individual households / businesses
Stockholm

Measures 7.1, 7.2, & 7.3 are discussed as a unit, since all measures closely relate and are seen as one measure.

Measure 7.1, 2, 3
M7.1. Optical sorting of waste
M7.2. Introduction of AWCS in an existing neighbourhood
M7.3. Waste collection statistics for individual households / businesses

Stockholm

In this measure differently coloured bags are collected from approx. 300 households in existing residential areas with a new Automated Waste Collection System (AWCS), transporting the waste bags underground to a container nearby. When the container is full, it is taken to a sorting plant where the waste is sorted in separate fractions. The aim is to improve the quality of life, increasing recycling rates and resource efficiency.

What did GrowSmarter do?

The newly designed inlet is able to weigh the waste and register fraction. The control system is brand new and the installation of a fibre network instead of copper allows the data traffic within the network to be larger and allows for multiple benefits, such as increased possibilities for system control and operational statistics. Waste sorting has increased to include food waste, and the sorting rates are better than before the installation of the AWCS. All these aspects allow for a better quality of service for the end user.

Lessons learned

Understanding juridical restrictions about who can collect and where does the waste go as well as the topic of tenant consent are essential (GDPR). The measure reduces traffic, which results in CO2 savings. Energy consumption for operating the installation is not meeting expectations. However, by simple means, the technology can be upgraded and substantially reduce energy consumption and then even further reduce CO2 emissions. Less space for waste handling means more common space. Incentives for and feedback from tenants improves the outcome; patience is needed to encourage tenants. Technology is sophisticated and requires trained staff for installation and commissioning.

Potential for up-scaling and replication

As the technical installation of the system is straight forward, the most important factor is securing the infrastructure for the waste sorting once it has been collected. GDPR, and possibly other juridical restrictions, must be understood in order to build up a database on waste deposited in the AWCS. Tenant information campaigns help with the acceptance.

HOW DID THE MEASURE WORK?

Technical feasibility

The system is technically feasible with sophisticated technology. Improvements, such as replacing minor technical components, could increase the end user experience and reduce energy use.

Economic feasibility

The system is economically and financially feasible, with an impact in job creation, not just during the deployment phase but also during the operation phase.

Replication potential

Scale advantage is high for areas with an existing sorting facility and recycling industry. Otherwise costs and benefits escalate proportionally to the area covered by the service. Porto and Suceava are looking into replication.

Key takeaway

Traffic reduced by 90%, CO2 emissions reduced by 71%, Rest waste reduced by 66% and congestion minimized.

1.4 Smart Solution 8: Big Open Data Platform

This solution covers the following five measures

M8.1. Big consolidated open data platform
Stockholm, Barcelona, Cologne

M8.2. Urban models
Barcelona, Cologne

M8.3. Semi-automatic instance mapping
Barcelona, Cologne

M8.4. Integration of sensor and heterogeneous data in standard data format
Barcelona

M8.5. Sustainable connected lighting to enhance safety and mobility
Barcelona

Measure 8.1 Big consolidated open data platform

Stockholm, Barcelona, Cologne

The aim is to create a common shared data platform with real-time data where urban data can be stored and analysed. By analysing real-time input, this platform connects to the GrowSmarter goals and is used as a planning and decision making tool for management, evaluation and policies, enabling smart city services. The platform fosters co-operation and co-creation within city governments and beyond.

What did GrowSmarter do?

In **Cologne**, GrowSmarter project data was gathered from thirteen data sources and placed on the Urban pulse platform. On top of the platform, two Urban Cockpits were implemented: one for internal project use with closed data and another one for external use with released data: https://cologne-internal.urbanpulse.de/ & https://cologne-up.urbanpulse.de/. In **Stockholm**, sensors measure vehicle, pedestrian and bicyclists flow using Wi-Fi sensors and multisensors in a selected area. The data is used to identify flow patterns and to consequently reduce CO2 emissions from transport by e.g. optimizing public transport service. **Barcelona** provides the overall data framework that offers access to data provided by GS Barcelona measures and could conceptually do this for the data in all GS cities.

Lessons learned

As this is an enabling service, costs can be high at first with low user acceptance. Understanding and dealing with data ownership as well as resulting contract work is key. The up-scaling is easily implemented and can have a high impact in the long run. Standardization work is important to create a reference model that offers unifying language, creating systemic comparability as well as interoperability of systems, licensing models and relevant norms. These systems should be driven by the city needs (practical) for information required for different services. The information may need to be structured in new ways, collected by new means, but all the same required to support some service defined as necessary.

Potential for up-scaling and replication

This measure needs acceptance and strong agreements as well as political decisions and guidance of all stakeholders and on all levels, defining goals, use case scenarios and the value of data. The measure needs to address private and public interests as well as trust and security. The use of a flexible horizontal and open platform approach and working with technical standards seems to yield best results.

HOW DID THE MEASURE WORK?

Technical feasibility

The system is technically feasible as it is based on standard products. Cloud computing makes projects easier to implement and also supports a "start small-grow big" approach.

Economic feasibility

Cloud computing costs should provide easily understandable price models. But: cost levels can be difficult to predict when scaling due to the use of different services that may have unique payment plans. Understand better decision making and potential time savings for gathering, analyzing and visualizing data effectively. So far, readiness and acceptance for paying and building the infrastructure is limited.

Replication potential

Technically, this is easily replicable, especially when working with standards. The issues are i.a. data ownership, reaching consent with all stakeholders and using flexible open data platforms. Porto and Graz have started looking into replication of this measure.

Key takeaway

Foster acceptance, understand and deal with data ownership, develop key use cases and use (open) data platforms that are flexible in terms of in- & output & ability to manage data over time.

Measures 8.2 & 8.3 Semi-automatic instance mapping

Barcelona, Cologne

The Barcelona solution aims at developing a semantic model that reflects and connects three domains of interest: mobility, energy, and integrated infrastructures, via an existing (IBM) top-level ontology (ISMP). The goal of the model is to facilitate heterogeneous data integration in a reusable, portable manner, and to offer a unique and rich point of access to this data. This requires mapping the data to the model – a process that is semi-automated via a collaborative tool. An exploration and query tool allows users and applications to query the data via the model, which makes changes in data (or data schemas) transparent. Depending on how data is actually stored, the Semantic Access Layer translates the semantic queries to concrete data accesses, and computes the combined result. Concretely, measure 8.2 accesses data via a REST API and a local TDB: Measure 8.3 is an enabling functionality for Measure 8.2.

What did GrowSmarter do?

The Urban Model contains a generic high-level city model, to which the verticals of energy, mobility, integrated infrastructures, and contamination monitoring, as well as relationships between concepts in the different domains have been added. The upper-level ontology supports the integration of data from the different vertical domains by providing the high-level semantic connections between these domains. More direct interconnections have been added that are not part of the upper ontology. A list of competence queries has been gathered, which reflects the different ways users may query the ontology. This is an enabling functionality for any measure and application that wants to use the semantic tool to easily cross data from different domains without having to know the underlying structure and port applications between cities without modifications.

Lessons learned

With this enabling functionality, it is essential to understand the benefits of the system when data from different heterogeneous is available, and to identify partners who can develop applications on top of the technology, stress the model and use data in complex manners.

Potential for up-scaling and replication

The urban model may be re-used by any other city as is, although a domain specialist should help extending it with those concepts that may not have been modeled for the origin city. Additionally, a city re-using this measure should re-implement the Semantic Access Layer to adapt it to its own city platform. A domain specialist needs to map the new city data to the model using Measure 8.3. Ensure enough data sources for input into the model.

HOW DID THE MEASURE WORK?

Technical feasibility

The urban model may be re-used by any other city when adapted to its own platform. New data needs to be mapped to the model.

Economic feasibility

A solution based on a semantic model makes sense when integrating data from many heterogeneous sources; otherwise the effort involved in this large scale approach may not be justified.

Replication potential

A new semantic access layer needs to be implemented and the model may need to be extended.

Key takeaway

A lot of data is needed to make the semantic approach scalable.

Measure 8.4 Integration of sensor and heterogeneous data in standard data format, Barcelona

This measure created a platform that provides standardized access to normalized and integrated data through a GrowSmarter application programming interface (API). In addition, it offers 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.

What did GrowSmarter do?

The horizontally organized platform manages and shares data from the implemented GrowSmarter measures. The platform is like a middleware component of the Big Open Data Platform that collects and standardizes different types of data with the aim to be offered in a common marketplace where the business applications like Business Intelligence algorithms, Monitoring Applications, City Dashboards, Semantic Layer, etc, can make use of the GrowSmarter Integrated Data. The solution allows to process and share large amounts of heterogeneous urban data in real-time to support decision making applications and therefore grants interoperability and a standard management.

Lessons learned

In GrowSmarter we learned that the challenge is meeting the demand and supply between user applications and integrated data. Sometimes there aren't applications for the integrated data due to a lacking clear use case or user demand, whereas other times there aren't enough data for a specific application due to measures providing not enough information and data as required to fulfil the demand application. The marketplace of integrated data services helps to boost the use of the integrated data and enables an easy way to develop new services and applications for the city and its citizens. Furthermore, the horizontal concept allows the platform to work across vertical services. Additionally, the modular concept allows the platform to provide new functionalities or to process new types of data sets, without disturbing the previous features.

Potential for up-scaling and replication

This solution of a horizontal platform based on standards and open source components is an enabling measure that is easily scalable and replicable to any other city because it is independent of specific data-sets and application domains.

HOW DID THE MEASURE WORK?

Technical feasibility

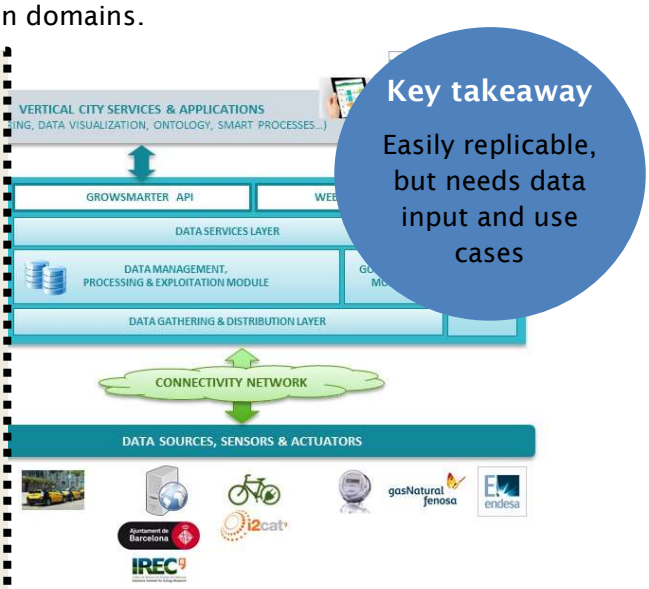
The horizontal concept of the platform allows to work across several vertical services. Its modular concept allows adapting its capabilities to any environment.

Economic feasibility

The solution has been devised as a Platform as a Service (PaaS), that proposes a modular cost system to be flexible with different needs and requirements.

Replication potential

This solution is easily scalable and replicable for any city.



Measure 8.5 Sustainable connected lighting to enhance safety and mobility

Barcelona

This measure is tied to the Smart Towers in Barcelona (M5.2), providing a smart solution to efficiently link the lighting management systems with other city services and infrastructures.

What did GrowSmarter do?

Typically, street lighting poles are managed by their own lighting management systems following a vertical/silo solution. A large city like Barcelona has different types of lighting systems and several subcontractors to provide urban lighting services. This makes it difficult for the urban planning department to have an integrated view and a common lighting management system for the whole city. As it was not possible to achieve an agreement with the Barcelona City Council to interact with the street lighting systems, the Smart Lighting API was focused on the two Solar HUB poles for lighting and wireless communications located on Cellnex' premises in measure 5.2. Then, a customized module developed by Retevison, makes remote real-time management compatible with the Sentilo platform. Sentilo is an open source sensor and actuator platform originally designed and developed by Cellnex, Opendtrends and the Barcelona City Council.

Lessons learned

The Smart Lighting API is a technological enabling measure that should be required by the own street lighting service management area of a municipality to be successful. This avoids mistrust when external actors, like TI providers, propose the deployment of horizontal solutions to get interoperable management of several systems, even when the solution is based on secured interfaces for systems interconnections. It is also recommended to implement city street lighting systems that allow remote management solutions through web services or APIs, in order to facilitate interoperability with other urban service management platforms.

Potential for up-scaling and replication

Involve all stakeholders early, an up-scaling should then be easily implemented.

HOW DID THE MEASURE WORK?

Technical feasibility

The Smart Lighting API offers interoperability to enable an integrated view of all lighting systems in the city.

Economic feasibility

The solution seems feasible because the Smart Lighting API offers lighting management as a Service, enabling better decision-making for city managers and the development of added value Smart Lighting Applications and Services.

Replication potential

Adaptations to each specific Lighting System should be developed to provide the Smart Lighting API.

Key takeaway

Link between lighting management and other city services improves smart city management.

2 LESSONS LEARNED

As stated at the beginning of this document, the work-package titled integrated infrastructures is driven by many measures that are of an enabling nature. Therefore the focus is most predominantly on providing data that could lead to informed and therefore improved decision making. This can't easily be measured and often only indirectly impacts KPIs such as energy, mobility and CO2 emissions.

The lessons learned and recommendations are addressing various stages and stakeholders of a process, such as smart user/ tenant involvement, smart governance, smart process and strategy, smart technology and design, and smart business.

2.1 Smart Solution 5: Smart lighting, lampposts and traffic posts as hubs for communication

Smart Governance on the way to implement smart solutions

A successful project is very much defined in successful leadership and networking between partners. Understanding who needs to be involved, motivating and supporting these persons during the project is very important as this falls often outside their official work tasks and their organisational role and responsibility. Use agile working methods.

Even though this may sound self-explanatory, make sure you have the resources and time needed for the planning, preparation and the user process, the implementation as well as the evaluation, especially when everything is new for the city organisation. Plan for enough city resources and competence and/ or involve an experienced consultant assisting in the process. If necessary, establish the understanding whether the environmental impact is more important than the commercial impact.

Use joint procurement and collaboration between municipalities and partners to scale up. Standardise processes to speed them up or to handle multiple requests at once. When dealing with physical infrastructure, make sure, it is clear who owns the infrastructure, who owns e.g. the sensors and who operates them. Retrofitting with sensors is usually not difficult, and cities need a strategy for knowing which locations need to be equipped with e.g. network coverage and environmental data.

Implement using a smart process & strategy

When developing solutions start with the need or problem and then define which sensor data and platforms are needed to provide answers and solutions. Start with something that is important for the city, even if it is on a very limited scale at first. Look for the right place (streets, potential public buildings etc); understand the challenges in that particular place as well as the stakeholders who need to be part of the process. Create the network needed and manage it. If the impact of the trial is positive, it can lead to big changes.

It is very important to agree on and know your goal to choose the most appropriate devices and communication system. While planning the project and the measures, it may be self-evident, but aim to receive comparable and reliable data.

Physical areas should be devoted for a particular measure. Infrastructure should be separated, when possible. For example, avoid mixing luminaires that are part or not part of the measure inside the same electrical cabinet to avoid confusion. Use a part of the measure to install "standard" components. It's a great benchmark and a great help in analyzing and validating collected data. Choose a correct asset to digitalize.

Implementing a global solution with a local version gives you room for improvement before growing. Have a strategy in place before implementing. E.g. Barcelona guidelines say that every new street should be prepared for smart lampposts (fibre optics, grid connections, etc.). It is important to understand that a solution can be used as a model to digitalize a company's entire network and at the same time advise the public administration on how to implement new assets of network.

Do not rush and buy sensors. Understand if there are limitations or restrictions to gather and analyse data. Look at your city and define places where sensors give most value for each given need. Make sure that these places have the connectivity and electricity needed. Integrate the authorization and authentication process in terms of technical and policy solution into the software development early on.

Show-case your idea by implementing smart technology & design

Design (aesthetics etc) and function (use, technical requirements) of a lamppost (or anything else) need to be combined into one excellent solution to show-case the idea.

Be sure to understand the grid capacities for the impacts of the systems. Are Fibre optics needed and in place? Different cities have various approaches, which may result in separate contracts for lighting power and sensor power ((BCN has two or more power inputs (Each service installed in the lamppost has its dedicated power supply: Wifi, sensors, lighting, traffic signals, etc.), Stockholm only has one)). Next necessary steps may be using 5G, 6G next generation networks and / or using block-chain. When implementing smart lighting, it is useful to use or test a combination of LEDs with solar lighting in countries with more hours of sun.

Decide where to install sensors and how many: for example in GrowSmarter Barcelona's measure regarding smart meter information analysis, some substations have more incidents per year than others and it is therefore interesting to have them monitored, but there are other facilities that have very few incidents and do not require anything more than a simple revision.

Select an open and extensible hardware solution, which allows direct access to the raw data when dealing with energy analytics. Take into account the scope of a LoRa Network in an urban environment, since buildings can interfere in communications.

Installing charging infrastructure to existing lamp posts in urban areas with little private and public space can be an option. Make sure to know who owns the lanterns and establish contractual relationships, if necessary. Is the lantern suitable for the integration of the charging stations, i.e. is there enough space for technology and wiring in the lanterns? Is signage in place to allow for electric vehicles having access to the charging stations? Can monetary charging be incorporated?

Smart solutions useful for developing new business models

Take into account the cost of the measure at first and in the long run. Understand if it is viable to scale up, e.g. to a large number of facilities / lamp posts etc. Costs may become a political decision.

Not all business models want to be shared publically. Test the solutions, improve not functional solutions and propose a new investment plan to scale up. When dealing with regionally or nationally regulated businesses, it is difficult to advise elsewhere and scale-up outside of the company.

Please also refer to the D3.3 implementation report, the D3.4 draft concluding report as well as the D5.4 technical and D6.4 financial evaluation reports for more technical detail in each measure.

2.2 Smart Solution 6: New Business Models for District Heating and Cooling

This topic is covered in work package 2, please refer to the

Low Energy Districts Concluding Report D2.6.

2.3 Smart Solution 7: Smart waste collection, turning waste into energy

Have all your ducks in a row

Coordination and good planning with all involved actors at an early stage is essential.

Overall, as the technical installation of the system is straight forward, the most important factor is securing the infrastructure for the waste recycling once it has been collected. Furthermore, end user engagement is critical to make sure that they adopt the new behaviour for waste sorting and recycling.

Respect tenant privacy

GDPR, and possibly other juridical restrictions, must be understood in order to build up a database on waste deposited in the AWCS. For this measure in waste management, this is solved by not including personal data in the registration, since a consent process was considered to have very little chance of success.

Tenant information campaigns helps with the acceptance of a new system, e.g. for facilitating waste sorting. Typically you need to motivate and convince inhabitants to make them utilize the possibilities of the waste sorting system. And, when this requires a change of behavior, a typical success factor is clear and intense information campaigns in an early stage of the system introduction, e.g. short after system commissioning and/or short after tenants moving back in to the area.

Understand your focus: energy use reduction and system installation varies in new vs. old buildings

Installation in existing building areas is sometimes harder than in new neighbourhoods. Historical or archaeological sites and old towns may be even more challenging.

Energy consumption has not met expectations and is considered too high. This is related to choice of technology for the automatic operation of the inlet hatch. By simple means this can be upgraded to a more energy efficient technology, and the energy consumption for the installation in Valla Torg is estimated to be reduced from 13 000 kWh to 3 200 kWh per year. This is beneficial for both operational expenses, as well as CO2 emissions.

2.4 Smart Solution 8: Big open data platform for saving energy and improving the quality of life

Introduction

Big data and open urban data platforms have become buzz-words in our increasingly digitized world. While information and communication technologies play a special role within the smart city concept, people and their values should always remain at the centre of our efforts. Considerable added value can be achieved for people when collecting, storing and optimally linking different data sets on an urban data platform.

Urban data is a basis for public services and urban development. Although the intelligent use of data paves the way to overcoming social inequalities, increasing the efficiency of public services, and making public investments profitable, the urban data market is still in an exploration phase. There are no universal approaches that allow cities to fully understand the potential of urban data for sustainable and intelligent urban development. In addition, there is a lack of comprehensive databases and appropriate and efficient data-driven business models for operating smart cities.

As an example: the basic idea for the creation of an open urban data platform (OUP) in GrowSmarter Cologne was to provide sensor data in real-time and in the form of so-called push information from GrowSmarter measures in energy and mobility. Cologne as a believer in OpenData ethics providing open and closed Data

Data was also gathered from the administration. This data was intended to inform internal technical procedures and third parties cost-effectively. Based on this, current situations within the city can be evaluated and future situations simulated. Thus, effects on the environment can be more efficiently understood, which leads to the appropriate actions. The key to making this work is real-time data.

The market for open urban platforms (OUP) is quickly growing because more and more cities are conducting smart city projects. A combination of OUP and OpenData is a valuable or even necessary building block for sustainable smart city solutions.

Experience in the three Lighthouse Cities Barcelona, Stockholm and Cologne varied to some extent. This is due to current country-specific data protection regulations on top of the EU Data Protection Regulation that applies at EU level. Therefore, at first glance, the GrowSmarter platforms are very similar, but the handling of each country's data is very individual to each country.

The goal may be to create a legal framework for anonymization of data and other framework conditions for various data sets. This may increase acceptance and willingness to share data.

Smart Governance, Process & Strategy to pave the way

Strong alignment and agreement with project sponsors in the city is needed. There needs to be a common view of what shall be achieved. It is essential to define a goal and a set of use case scenarios or queries that would need to be answered. Also define the data (and the corresponding infrastructure) needed. Explain how the data will be managed, who owns what etc.

Again, it may seem self-evident, but it is essential to respect and deal with various management levels, necessary political decisions and their deadlines, tender procedures, conflicts with other existing solutions or contracts, if applicable. Build an understanding of the advantages (and disadvantages) early on, with examples, show win-win situations. Use top-down (specialists) & bottom-up (future users) approaches during the process. Allow enough time for the process in general and for the management of approvals from owners or agreements with owners, of the physical infrastructure in particular.

The City could own a solution or a platform. This needs its own team to operate it and can lead to a new organizational structure over time. On the other hand, the City could also just be part of an operating company, resulting in less control, but a City may not want to be the owner of a platform in order to e.g. avoid resources.

Preconditions for a successful replication in other cities are among other things the acceptance of the technology and the release of (real-time) data, the possibility of technical implementation, understanding financing options and the clarification of legal requirements.

Smart Data Sources & Legalities are key

Make sure that all legal requirements and political decisions are in place. As there currently is no assigned value to urban data, it is essential to define the value of the data needed to accomplish your goals.

Data sources are key - they need to be evaluated carefully, including data privacy. Clarify early who the owners of the required data are and understand acceptance. Especially in larger structures there can be a large number of contacts with different acceptance and different company principles. To achieve good results, this requires good time management, contractual regulations for the use of the data and agreements with all parties.

Cities provide raw data and cities own data. This should be clear during the procurement process. Start early with external data source suppliers to ensure the availability of the data. Contracts that a city concludes should contain a clause for further use of the data arising in the context of the contract to avoid misunderstandings. Addressing private vs. public interests, trust and security are major concerns.

A flexible and open horizontal platform approach can manage a wide range of real-time data

Use a flexible and open platform approach that can manage a wide range of sensors and data including analytics and presentation of the data as well as provide exploration, query, analyses and presentation capabilities. The work needs to be agile and the technical platform should support this, not be an obstacle.

It is important that not only the evaluation data may be used, but that the individual measures can be linked in almost real-time, as far as this is legally and technically possible. The user group can be defined individually (e.g. only customers).

Technical standards exist on the different smart city domains, e.g. in mobility the OCIT-C protocol standard supported by modern traffic computers or GTFS as quasi standard for public transport data. German standards exist for smart humble lampposts and OUPs. They will be leveraged on an international level during the next 2-3 years. Spanish standards exist for Smart Cities and members of the team have participated in defining the UNE178104: 2015 standard (AENOR).

Smart Mapping and Ontologies

Every new data type / source needs to be mapped to the semantic model via the mapping tool; cities will need to generate their data schema (in triple - RDF - format) to pass it as input to the mapping tool.

If a city wants to use the GrowSmarter Barcelona mapping tool (8.3) to receive recommended data to model mappings, a domain specialist will need to be the responsible person for choosing between (multiple) recommendations. The mapping is based on the Urban Model and the city-specific schema. The city needs to generate this schema in triple format to pass it as input to the mapping tool.

Caveat: the mapping tool may find little or no useful mappings if the schema and ontology have little in common, and use a different vocabulary to label and annotate concepts. In this case, a domain specialist needs to make sure to "fix" the description of the city entities to use (some) overlapping vocabulary.

In some cases a city may also want to extend or customize the city ontology Barcelona developed with other domains or aspects typical of their environment. For this they will need both a domain specialist and an IT person that can extend the ontology. The domain specialists will help define the concepts and relationships that need to be added to the model and the ways the model will be queried.

Defining a semantic model is time consuming to start with, but it makes data integration scalable in the long run. There should be enough data to make the semantic approach worthwhile.

To successfully implement and use the Barcelona urban model approach the city needs: data from as many vertical domains as possible, domain specialists that can drive modelling, and users (e.g. application developers) willing to stress the model and use data in complex manners.

Recommendations and lessons learned for an integrated semantic solution of the urban mode are the following: it can more readily integrate new data without changing the data schema and without affecting applications on top of the data. A model is easier to understand because it is richer and domain oriented, instead of application oriented. It is essential to allow simple web access to data via URIs and to link with other standard concepts from other models. Also, import open linked data repositories.

3 POLICY AND PLANNING RECOMMENDATIONS

GrowSmarter's goal is to create a "blueprint" for sustainable city development. In concrete terms, the cities are to be supported in achieving the EU' climate goals. In one of this work package's measures, an urban data platform role is to connect the individual implemented measures and make the resulting data storage and optimization potential identifiable and realizable. The implementation of the political objective "Compliance with the EU's climate targets" is thus the basis for the establishment of these measures.

3.1 Recommendations to the European Commission

The user or tenant should be at the centre of our attention.

Users or tenants need to be addressed early in the process. Educate them and listen to their needs and concerns. Let them have active input and inform them about the increased comfort, quality of life etc.

To test new solutions or pilot-projects, it may be best to select an open-minded and technique affine tenant structure or area. Use these people as influencers and multipliers of the concept and its benefits to bring new solutions to areas with less interest. At the same time, it is essential to also bring innovation to the under-privileged. When building an app, start with minimal features early on and start adding new functionalities based also on user feedback as you move along. This makes it easier to adopt new tools. Use a target user group to evaluate your features and development. When selling products, ensure teams are skilled in selling and marketing.

Standardization of Urban Data Platforms is key

Continue working on standardization for building 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. This also depends on industries and procurements and is also true on the local level.

Urban Data Platforms are a very topical or up-to-date issue. Many German as well as EU follower cities are currently working on the introduction of an urban data platform. In 2016, a group of enterprises, cities (including Cologne), and the Fraunhofer group FOKUS met to underpin the importance of the EIP SCC lead initiative. They created a DIN SPEC consortium to extend the technical view of the reference architecture a group of European cities had discussed. The topics were data governance, data provisioning, and how to create an integrated digital urban infrastructure. The intent of the Reference Architecture and its design principles is to provide aspiring cities and communities a truly mission and vendor agnostic approach that results in an enhanced interoperable, standards-based architecture and implementation. This is specific to a mission of their specific city context. In addition, this Reference Architecture can be used with existing reference architectures to plan for improving interoperability, maturity and functioning of an expanding technology solution for smart city initiatives. This mission and vendor agnostic approach is meant to provide key elements. Concepts need to be addressed to make these resulting solution architectures interoperable.

GDPR revision

The introduction of the GDPR caused a lot of fear and even stopped projects only to make them restart in the middle of the process.

Legislation in general needs revisions to avoid being hindrances for e.g. electronic equipment. It is essential to keep up with the technical development, such as was the case with smart meters in Germany.

Allowing space for experimenting

As all countries have their own legislation, it is essential to allow for experimental room in pilot projects such as the H2020 projects, providing feasible alternatives to local laws.

There is no blueprint for successful integrated infrastructures, neither for cities, nor for companies or for society. In GrowSmarter, however, we dared something new and created new space for innovation. How can digital technologies be used to make work and life easier and at the same time provide added benefit to all? How can digitisation help? There are no general or conclusive answers to these and other questions posed by the digital transformation. What we have are possibilities and ideas that need to be tested, in sheltered spaces for joint experimentation, failure and rejection, learning and improvement. With these learning and experimentation spaces, companies and administrations can feel their way into the working world of the future.

Ensure internet access to all

As the internet is becoming an essential part of everyone's daily life, it is important to keep or provide cheap and accessible internet access free of charge to avoid digital divide.

E.g.: Many of the SmartHome solutions require internet access to work.

Monitoring

The EU can financially support cost effective measures in furthering research on information and communication technology (ICT) and smart city solutions that may not be feasible to set up at first, but are efficient in the long run.

By providing financial help, the EU can support the gathering of exact information about how much of a city's traffic is fossil fuel free or of continuous traffic metering regarding fossil-fuel freeness. By monitoring (e.g. introducing sensors), a city can obtain exact information about the amount of fossil-fuel free vehicles. As the metering is on-going a city can see if things are going in the right direction and inform vehicle owners about their contributions or the need to change their behaviour.

Citizen involvement & Dissemination

Include time and funding in Grant Agreements for educational events building user acceptance and active citizens as well as convinced city departments.

In order to foster acceptance of smart solutions, education for and dissemination to the people who ultimately gain quality of life is essential. Active citizens are key to true transformation of life in the city.

The Grant Agreements should include many more measures and funding for events, presentations etc. that promote creating acceptance within the citizens and end-users affected by the improvements. It could be helpful to include scientific monitoring when evaluating measures that directly affect the citizens (e.g. SmartHome). The EU should further support and contribute to the project's publicity, promotion and marketing to strengthen the local commitments.

3.2 Recommendations to Local Governments & Regions

Smart Governance - Structure, Process & Strategy

Put people first

Understand make sure that people come first, not technology.

Clearly define goals and expected outcomes, roles, indicators, preconditions and co-operation needs, build interdisciplinary teams and use agile processes.

Clearly define enabling measures and the partners' mandatory co-operation, if needed. The role of the city administration is typically the owner and enabler. In certain projects, the city can also be the responsible partner of an implementation.

Build up framework conditions for the city organization. Interdisciplinary teams are necessary to advance this topic of enabling measures and integrated infrastructures. Equip analytics professionals within the city with information that can be used to take proactive actions.

Define and/or disseminate a/your SmartCity Strategy to increase awareness and enable working over department boarders and/or organizational boarders.

What is the strategy's purpose? How do the citizens benefit from it? Measure what the city needs for decision making. Various strategies already exist. How do these complement the SmartCity strategy? Also define the impact on governance structure. Define who owns the infrastructure and/ or the data.

There can be a large impact on the governance structure. Several different functions and departments can use e.g. sensors and an IOT platform in the city. Each separate sensors-analysis-report could be procured independently. Locations where to put up sensors, the connection they require and sensor data handling process and ownership can be standardized. E.g. when using sensors analysing traffic flows, it could be wise to add environmental sensors (e.g. air pollution, weather) in the same location. Additionally, digital displays can inform people passing by.

The first investment of such a system is large and general and therefore difficult to make by an individual department. Why should one department pay for the initial cost and responsibility of its functions, if other departments can add for just a small fee the sensors they need and collect the data?

It is therefore important to reorganise and rethink this kind of enabling smart city system. They do not fit well in the existing governance structures as the need is always greater than any single department. The need for new responsibility areas within the city for these types

of shared systems as well as new competencies and new ways of working exist and become more important. A wider use of these kinds of services is also beneficial for a payback analysis.

Stockholm feels it is important that the city makes the initial investment and owns the sensors and the data. The vehicle sensor data can be combined with digital displays to direct personalized information to drivers. If the scope is large, then these displays are interesting for commercial reasons. By developing personalized commercials to drivers, this revenue would self-finance the costs for the city to set up and operate the sensors.

A cross-functional implementation requires a lot of discussions and dialogue with different functions and organisations. It also required dialogue with law and communications inside the city. It is of great importance for a city to define a SmartCity strategy. This strategy greatly helps to get the commitment and resources needed to include the different functions in the city for the project. It is also very important to have a manager who can work over department borders and with tasks that have never been done before. Every single document (procurement, agreement, communication plan etc.) have to be produced from the very beginning as these typically do not yet exist.

Preconditions needed & the need for use cases and user stories

1. With many of these measures, it is essential to have a city taskforce that covers the full implementation process with clear responsibility areas and roles. This taskforce must have the mandate to take decisions and have the budget to make the work needed. Equip analytics professionals within the city with information that can be used to take proactive actions. Integrate and train civic workers to understand the benefits to be able to use the new measures.

2. It is most helpful to define a clear use case for e.g. the sensors and data collected to show the vast potential using the data. At the same time there must be a sequence of use cases which can be performed after the first one is implemented. Use key performance indicators (KPIs) and think whole circle.

3. It is further essential to have defined users and end-users for sensors and data.

4. The city must dare to act and also to fail, but, if so, best to fail fast and at a small-scale. The city must work in agile processes and do this in close co-operation with sensor providers and platform developers.

Business Models & Finance

Understand or define the relationship between businesses and public administration and citizens (Public Private Partnership - PPP)

The relationship between the business and the public administration looks a little different depending on each country. In Sweden for example, normally the city has full responsibility of the waste transportation and treatment, but there are also private responsibilities such as the company FTI in Sweden which is responsible for collection and treatment of packaging and paper (from newspapers and magazines). Those stakeholders are key.

Encourage local governments in acquiring funding sources

Certain external funding sources or financing mechanisms are available, yet unknown. It is for example possible to receive external funding for innovation projects, such as the smart lighting technology. Key benefit is energy savings, which is both good financially and good for the environment.

Ethics

Understand ethical issues and risks in regards to gathering data, needing consent, anonymization and ownership of data, etc. (GDPR)

Beware of ethical issues or reputational risks when sensors or cameras are connected to a system. Laws need to be followed, data needs to be made anonymous and only the data needed should be transferred to the IOT/Big Data Platform. Certain ways of collecting data requires consent (approval) from the users. Citizens need to be informed about the fact that data is collected and which data (signage can help). Creating FAQ about solutions can be very helpful as well, increasing larger public acceptance.

Technology

Maintain safety at all times

When implementing smart lighting, make sure to maintain safety at all times, especially when dimming is used, which can cause users to feel unsafe. Pedestrian crossings can cause concern for traffic safety. As easy as it sounds, certain measures need a connected system with 24/7 power supply to achieve successful replication. Electricity, a structure to install to and connectivity should be available in most cities.

Regarding the smart lighting technology, an internal lighting engineer and an IT-coordinator as well as an external technical support and contractor, electrical fitter are needed.

Establish baselines before implementing projects. Measure and evaluate environmental factors and use the results to influence changing behaviour, e.g. reducing traffic. Use accurate data to accurately target the issues and solve problems. Understand the cost effects.

With certain sensors installed it is possible to very accurately evaluate the extent of CO2 emissions from e.g. traffic in a zone. This data can then be used to define the measures to reduce 60% CO2 emissions from traffic. Further it is possible to understand which specific events cause the highest CO2 emissions and therefore guide visitors to use other means than personal cars. As the measurements are on-going and in real-time, it is possible to see trends and also accurately define how efficient different measures to reduce traffic emissions really are.

Sensors can analyse the congestion and travel time between sensors. With outdoors displays and real-time or predictive traffic information it is possible to change behaviour to reduce traffic during peak travel times. Especially during events with a lot of personal traffic, it is possible to indicate to visitors for instance when purchasing tickets is more convenient and that travel with other modalities is faster and safer, increasing the travellers' satisfaction level.

Regulation

Use regulatory issues to the advantage of improving the quality of life.

The GDPR legislation is the same across Europe. Therefore the solutions developed and implemented in GrowSmarter can be used in any of the EU countries.

Several standards have emerged over the last few years. Some are open, while others are proprietary. The proprietary solutions are quite mature today. The open standards are capable, but there are many new ones emerging and covering different layers in the smart city ecosystem. This makes it hard to find the right one and there are very few use-cases which fully incorporates open standards throughout.

Avoid vendor lock-in by using open standards, flexible systems or making agreements.

Make sure the systems are flexible in terms of clear and standardized interfaces between the different modules in the system. It should be possible to switch out one part of the system without changing other. Another option to avoid supplier lock-in is by making sure in the agreement that the data is owned by the city.

Understanding ownership of infrastructure makes it easier to implement certain measures. In the Cologne case for example, the lanterns belong to the RheinEnergie, even though they are in public space. This meant that the RE could virtually choose the suitable lanterns themselves. The technicians are already familiar with the existing infrastructure and are therefore able to install the charging columns relatively easily.

Making sure regulatory issues are in place, e.g. whether existing infrastructure is suitable for the integration of charging stations. Also suitable signs in the city can ensure that the charging station is kept free for electric vehicles.

Increasing quality of life using intelligent waste management

Use Smart waste systems to increase citizens‘ quality of life

Smart waste collection can reduce traffic during peak-times, as there is no collection above ground and less servicing of sub-stations needed. This also means reduced noise, less CO2 and increased air quality. Energy consumption can be substantially reduced by simple means, eg. replacing minor technical components, which even further will reduce CO2 emissions and operational expenses. At the same time, congestion is reduced in the local area by replacing waste rooms/houses with smart waste inlets. All these aspects increase citizens’ quality of life.

The smart waste measure creates new jobs and minimizes heavy and dangerous jobs at the same time. Cities need infrastructure for waste sorting and/ or the will and power to develop such infrastructure as well as solid financing. The measure can be financed by city investments, private developers or user payments (pay as you throw)

Recycling rates, and awareness for inhabitants, can be increased by introducing The GrowSmarter waste management system. In order to minimize waste generation and maximize reuse and recycling we need systems that can encourage better behaviour. These systems should also be easy to use as well as cost and energy efficient. The GrowSmarter waste management system combines all these factors.

To increase recycling and waste awareness, measurability is key. The weighing of waste is operating with minimal disturbances in the GrowSmarter waste management system, thus facilitating the needs for city management and planners. The fact that the GrowSmarter waste management system combines public (rest and food waste) with private (packaging) responsibility further increases the possibilities.

Open Data, when provided to the community, encourages new services and innovations, ultimately improving the quality of life.

3.3 Recommendations to Private Companies

Clearly define goals and expected outcomes.

Clearly define the co-operation, if needed. The role of the private companies is typically to be a responsible partner of an implementation. Understand that there will be many framework conditions for the project and interdisciplinary teams. Take proactive action.

Understand or define the relationship between businesses and public administration and citizens (PPP).

The relationship between the business and the public administration looks a little different depending on each country. Understanding ownership of infrastructure makes it easier to implement certain measures, please also refer to the comments regarding the Cologne charging infrastructure or the waste management arrangements in Stockholm above. Understand that it is mandatory to have legal documentation in place.

Cities continuously need to provide better solutions. Understand that enabling technologies provide sensors or data for many users to develop new concepts.

Many of the measures in this work-package are enabling technologies. Cities will not build a business model on this to make money. The idea is to provide sensor data and a platform, in order for many users to use the data, both within the city as well as by external organisations and companies. The idea is also that it will be easy and cost-effective to install new sensors and gather the data into the same platform with the same connections. This will also greatly shorten the time to set up sensors and start getting data to analyse or use for steering city infrastructure.

Complicated administrative procedures may prohibit replication.

Regulated companies have complicated administrative procedures, which may make it difficult to replicate, please also refer M5.3 in Barcelona.

Replication of a platform may be technically easy, solutions may differ

The big open data platform measure's business model functions by delivering an Internet of Things (IoT) cloud platform capable to gather data from sensors and other data sources, store data, analyse data, present and distribute data to different stakeholders. Services can be delivered to assist in creating specific solutions or complete projects. As each city has its specific requirements and demands, the replication from a platform perspective is easy while the solutions might differ.

Standardization

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

4 CONCLUSIONS

4.1 Smart Solution 5: Smart lighting, lampposts and traffic posts as hubs for communication

The measures in smart solution 5 were all quite different, which makes it difficult to make general conclusions, but all of what is described below applies.

Where implemented, the measures all worked out, made sense and are fairly easy to be replicated. It should be noted though, that complicated systems add more complexity and may ask too much for people implementing the measure. It is therefore important to involve and prepare at an early stage as well as keeping complexity to a minimum.

When installing smart lighting systems and the demand for other services exists, it may be good to make use of the implemented infrastructure and add charging stations or sensors that measure e.g. air pollution, and then provide the data on an open data platform, etc. Use the opportunity to develop new services for citizens. For air quality monitoring required by the EU these sensors are typically not sufficient. In general, it is necessary to check if other uses can be included, at the same time creating new business models by letting other services be included in the poles. Best, if these services pay for that possibility.

It is important to evaluate whether to choose small pilot areas/ mock-ups for manageable implementation, or whether to choose a larger number of sensors and create a larger communications network to see the operation on a larger scale. The organizational challenges can be greater than predicted, as everything takes time when working across department boarders or even municipalities and implementing pilot project measures for the first time. Standardization in various ways may help to speed up permitting or reduce material prices.

The implementation of a SmartHome system for analysing the energy behaviour of tenants in Germany is as much a technical as a societal challenge. The tenants' rejection against having an installation in their home is manifold and cannot be solved by a one-fits-all address and technical solution. Information, education and negotiation should start early.

4.2 Smart Solution 6: New Business Models for District Heating and Cooling

This topic is covered in work package 2, please refer to the

Low Energy Districts Concluding Report D2.6.

4.3 Smart Solution 7: Smart waste collection, turning waste into energy

Reduced traffic means reduced CO2 and smart waste handling increases recycling rates, both resulting in a positive environmental impact. Less space for waste handling means more common space and less congestion. All this means an increase in the quality of life.

Incentives to and feedback from tenants are important to evaluate and improve the measures as well as foster acceptance. Energy consumption of the current installation can be substantially reduced by simple means, which will even further reduce CO2 emissions and operational expenses.

Overall, traffic was reduced by 90%, CO2 emissions were reduced by 71%, rest waste was reduced by 66% and congestion was minimized overall.

It is important to understand juridical restrictions about who can collect and where the waste goes go (city vs. private companies)? This means securing the infrastructure & investments for waste recycling.

Especially when planning in built environment, it is Important to do good planning in advance and coordinate with all involved actors and stakeholders. Fostering good relationships with facility managers, city developers etc. is key. Installation may be straight forward, yet technology may be quite sophisticated and requires trained staff for commissioning and operations.

4.4 Smart 8: Big open data platform for saving energy and improving the quality of life

Big Data is a topic that is increasingly interesting to many parties and across industries. The most important integrated infrastructure in the near future may be the long-term value of Horizontal platforms, the open urban platform, the implementation of devices/ sensors as well as connecting people and departments.

People, not sensors and systems, lack maturity for collecting urban performance data. Data Privacy issues must be managed with priority. The topic of data is very sensitive on industrial and public level. Therefore it may be necessary to take away the fears of disclosing data by making the use of data regulated by contract (public, closed, with or without costs etc.)

Horizontal platforms are more valuable than vertical platforms because of the benefits of aggregating and analysing data more easily. Implementing physical infrastructure in the city, for example devices, can take extensive time and cause obstacles. By using standardized open urban platforms, vendor lock-in can be avoided.

The term open data is defined as using open data specifications and interfaces and open platform architectures, free from discrimination. Open Data is data that may be used, disseminated and reused by anyone without restriction and Open Data can be reused if provided in a widely used machine-readable format. Open does not mean that any data and services have to be free of charge.

The Open Definition: *"Open means **anyone** can **freely access, use, modify, and share** for **any purpose** (subject, at most, to requirements that preserve provenance and openness)."*
https://opendefinition.org/

4.5 Overall Conclusions and exploitation of results for the topic of integrated infrastructures

Overall conclusions for this work package of integrated infrastructure include that some measures may be more useful for learning purposes than for scaling up. Some may be less about technology and more about developing new strategies. When working on a pilot project, be aware of time and resource constraints despite the overall commitment. Find committed people who embrace innovation.

In order to keep moving forward in the right direction with cities working on smart city solutions, we need to keep the positive spirit alive to strive for new and innovative achievements, show success and spur people on. Getting people on board is half the deal.

While certain measures are able to reduce electricity use and CO2 consumption (smart lighting, smart waste), others have a more indirect effect as they are enabling measures (big open data platforms) and are therefore difficult to portray with measurable key performance indicators. Understand framework conditions: human (e.g. resource constraints, commitment etc.), technical (e.g. which provider to use, interfaces, prototypes, WiFi capabilities, upcoming developments) and legal (e.g. data protection laws, traffic and parking restrictions, business tax exemptions, installation certifications). Make sure to plan informative meetings and workshops early on to learn about parties involved, acceptance & concerns, legal or data requirements, use-cases and challenges. Respect and value various needs for various areas & people (age, education etc.). Remember including the end user and understand who should gain from the benefits. Furthermore, use the opportunity of integrated infrastructures to develop new services for citizens. Some of the measures involve personal information. This means that data handled or stored needs to be anonymized in order to keep personal integrity. To further social acceptability, it is essential to inform either through posts on websites, in media or physical signs as well as through meetings and information events.

Understand and evaluate the size of your undertaking: if a small pilot area or a larger network/ scale are the best starting points to scale up later. Develop a city strategy or a blueprint for similar innovations, other areas or business models alongside the actions; include what has been learned along the way. Use a flexible, open and agile approach that can adapt to challenges, new findings and modifications.

As an example, the Barcelona development of an app, showing the real-time status of installed sensors with help of a camera in the 5 substations visualizes the status of the sensors inside the substation, therefore improving safety and the network. Overall, Barcelona management costs were reduced; the citizens receive a better network, less black-downs and potentially pay fewer taxes if a new plan is developed in the long-run to save expenses. It is important to understand that a large number of sensors was needed in Barcelona to create a larger communications network and to see the operation on a larger scale with more impact.

Using the smart waste collection measure as an example, it is highly dependent on the local or regional availability of a recycling industry. The scalability of this measure depends on a city having a recycling plant to send the separated garbage bags to. Therefore scale advantage is high for areas with an existing sorting facility and recycling industry.

Otherwise, costs and benefits escalate proportionally to the area covered by the service, reducing the scalability.

When undertaking large projects with a city-wide roll-out, start small and scale up slowly, include schools, universities, and people. Education is key.

Understand short and long term financial and technical implications to secure sustainability. Have a plan about who will take care of the equipment / data / etc. in the long run for sustainable development of each measure. Understand amortization and ROI. What may not seem feasible at the moment may be worth the investment in the long run to become a smart and connected city. Standardization processes are essential for the feasibility and sustainability of measures. This applies especially to the measures related to open urban data platforms.

Remember the fact that any new ideas or approaches keep developing along the way - use an iterative process!

Exploitation of results

As presented above, most of the measures implemented in GrowSmarter have potential for immediate replication and upscaling. Some solutions are already replicated in follower cities. This may include exploitation of procurement processes, etc. developed or learned as a result of the project.

- The experiences from the **smart lighting** measure was used in the planning and procurement of smart lighting in another location in Stockholm. Here, 180 smart lights will be implemented starting in 2020.
- The experiences and results from the **smart connected street environment** in Stockholm has been and will be exploited by the city in several different ways. First of all, the project highlighted the need for a smart connected strategy which was not existing. The mayors' office took this remark seriously and set out a budget for the development of this strategy. Also the work of planning and procuring a consolidated, shared IOT platform has started. The experiences from GrowSmarter regarding the implementation and operation of the IOT platform has been an important input for this process. The procurement is now in its final stages and in 2020 a city wide IOT-platform will be available in Stockholm.
- Work with **connecting traffic signals to optical fibre** started in GrowSmarter and the experiences is now going to be exploited with connecting 254 traffic signals in the upcoming years to the optical fibre network. Further there is a working group looking into how the connected traffic signals can be used for **collecting sensor data** in the street environment. A new sensor type called multi-sensors are currently tested in GrowSmarter. Using video image to analyse several different use cases is of great interest for Swedish cities, but there are legislative barriers. The site manager and IBM met a representative for the national organisation of Swedish cities and communities and agreed to share the technology and processes how to anonymise personalised information in a project which aims in defining guidelines for all Swedish cities in regard of using this type of sensors. This project will start in 2020.

- The Cologne partner AGT has already started to exploit the **GrowSmarter Energy Insight Dashboards** in collaboration with the Gateway manufacturer Homee. As part of this collaboration, potential access to the GrowSmarter dashboard has been offered to all Homee Gateway users. Homee GmbH has announced the availability of the GrowSmarter dashboard to its users via their community portal. This activity allows to further test and validate the features developed in GrowSmarter and assess its business potential. In addition we are exploiting the **GrowSmarter Dashboard setup as a testbed within the EU project IoTCrawler** extending the solution for general use in Smart Homes. In IoTCrawler AGT is investigating how artificial intelligence can be used to develop the next generation of search engines for the Internet of Things.
- The solution of **smart waste handling** in Stockholm is being show cased to clients on the global market. Envac is planning further development of the concept to increase reliability, reduce energy consumption, increase the end user experience, and to incorporate an incentive/feedback system to increase recycling. Envac has established a Cooperation with "Locallife" and discussions on launching their products as a complement in both Qatar and Singapore are in discussion.
- In Barcelona, GrowSmarters 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) intend 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, the topic of big open data platform has received much attention on a city-wide scale and is in the process of city-wide negotiations regarding the use and implementation of a big data platform with the entire municipal utility group based on the GrowSmarter learnings.

Start somewhere. Many questions arise from doing!

5 MEASURES AND CONTACT INFORMATION WITH INFORMATION REGARDING RULES & REGULATIONS

Solution	Measure	City	Partner(s)	Contact Person
SS5 Smart lighting, lampposts and traffic posts as hubs for communication	**M. 5.1** Smart Street Lighting	STO	City of Stockholm	Björn Lindelöf bjorn.lindelof@stockholm.se
	Rules & Regulations M5.1 No rules or legal issues known. Potential issue with supplying power for additional smart functions - same for many cities in Europe. Unclear whether this is regulated on an EU or national level			
	M. 5.2 Combined electric charging and street lighting poles	STO	City of Stockholm	Mika Hakosalo mika.hakosalo@stockholm.se
		BCN	Retevision	Carmen Vicente growsmarter@cellnextelecom.com
		COL	Rhein-Energie	Christian Remacly c.remacly@rheinenergie.com
	Rules & Regulations M5.2 Regulatory issue: Stockholm couldn't have charging in street lighting poles.			
	M.5.3 Smart Meter information analysis and actuators	BCN	Endesa	Carlos Rodriguez carlos.rodriguezn@enel.com
		COL	AGT	Martin Strohbach mstrohbach@agtinternational.com
	Rules & Regulations M5.3 Cologne: data privacy issues and the lack of "certified" meters until a change in law in December 2018 made it impossible to implement SmartMeters.			

SS6 New business models for district heating and cooling	This solution is covered in the WP2 Implementation Report			
SS7 Smart waste collection, turning waste into energy	**M. 7.1, 7.2, 7.3** Smart waste collection, turning waste to electricity, heat and biogas for vehicles	STO	Envac	Hans Anebreid hans.anebreid@envac.se
	Rules & Regulations M7 No rules or legal issues known. If data stored on an individual level, consent needed from the tenants. The reason for such data base would be individual feedback on eg. sorting ratio, or charging tenant per kg deposited rest waste etc. However, this is not necessary, it is sufficient to store data on a group level.			
8 Big open data platform	**M. 8.1** Big consolidated open data platform	STO	IBM	Stanley Ekberg stanley.ekberg@se.ibm.com
		BCN	BSC	Maria-Cristina Marinescu maria.marinescu@bsc.es
		COL	ui	Stephan Borgert Stephan.borgert@the-urban-institute.de
	M.8.2 Urban models	BCN	BSC	Maria-Cristina Marinescu maria.marinescu@bsc.es
		COL	ui	Stephan Borgert Stephan.borgert@the-urban-institute.de
	M.8.3 Semi-automatic instance mapping	BCN	BSC	Maria-Cristina Marinescu maria.marinescu@bsc.es

		COL	ui	Stephan Borgert Stephan.borgert@the-urban-institute.de
	M.8.4 Integration of sensor and heterogeneous data in standard data format	BCN	Retevision	Carmen Vicente growsmarter@cellnextelecom.com
	M.8.5 Sustainable Connected lighting to enhance safety and mobility	BCN	Retevision	Carmen Vicente growsmarter@cellnextelecom.com
	Rules & Regulations M8 **GDPR**, General Data Protection Regulation – EU rules Regarding Data Platforms, the EU Data Protection Regulation applies at EU level – therefore there is no difference between all GrowSmarter platforms. The goal may be to create a legal framework for anonymization of data and other framework conditions for various data sets. This may increase acceptance and willingness to share data.			

6 SOURCES / REFERENCES

List of key GrowSmarter project documents		
Name of document	**Link**	**Finalised**
Fact sheets	http://www.grow-smarter.eu/solutions/	2016-2018
Technical and management reports, D1.3, D1.4, D1.5, D1.6	http://www.grow-smarter.eu/inform/reports/	Feb 2016, June 2017, Dec 2018, Dec 2019
Implementation reports D2.2, 3.2, 4.2	http://www.grow-smarter.eu/inform/reports/	Feb. 2018
Draft concluding reports D2.4, 3.4, 4.4	http://www.grow-smarter.eu/inform/reports/	Feb. 2019
Lighthouse cities market introduction, D6.2 Economic validation and assessments, D6.3 Smart city market introduction, D6.4	http://www.grow-smarter.eu/inform/reports/	Feb 2018 Jan 2019 Sep 2019
Reports on results of technical, economic and social validation, D5.3, D5.4	http://www.grow-smarter.eu/inform/reports/	Dec 2018 Aug 2019
Data management plan, D1.2	http://www.grow-smarter.eu/inform/reports/	First version 2015
Recommendations for policy makers and practitioners, D1.7	http://www.grow-smarter.eu/inform/reports/	Nov 2019
Project brochure, D8.3 Project result Brochure, D8.10	http://www.grow-smarter.eu/inform/press-corner/	Update 2017, Nov 2019

GrowSmarter
Transforming cities for a smart, sustainable Europe

About GrowSmarter

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

GrowSmarter project partners

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