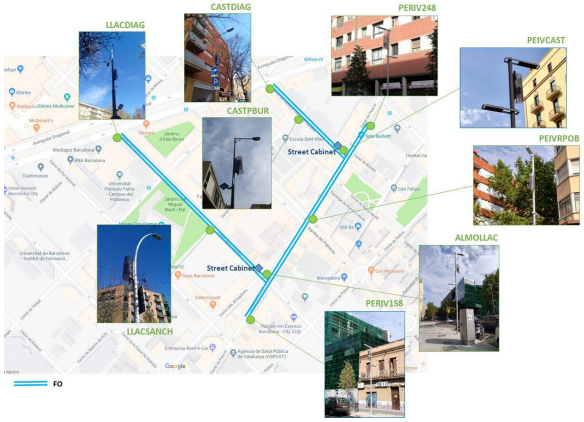
Ref. Ares(2018)1125692 - 28/02/2018

GrowSmarter
Transforming cities for a smart, sustainable Europe

IMPLEMENTING INTEGRATED INFRASTRUCTURE IN EUROPEAN CITIES - EXPERIENCES FROM GROWSMARTER

D3.3. IMPLEMENTATION REPORT WP3



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Date: February 28th, 2018

Version: **V.07**

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EXECUTIVE SUMMARY

This report describes the implementation of 11 measures addressing the topic of Integrated Infrastructure in the GrowSmarter project and 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 case studies describing the implementation of each measure; its main stakeholders and business model; key activities, achievements; and lessons learned.

Each measure forms part of 12 "Smart Solutions" within the GrowSmarter project. In Chapter 3, the lessons learnt per measure are collated and discussed with reference to each Smart Solution and several overlapping thematic challenges. 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

Key conclusions include a need to inform and plan early to allow 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 cities are faced with. To achieve success, cities should be empowered with new regulatory powers and 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 implementation phase of GrowSmarter. 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.

1 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 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 implementation 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.

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 ***evaluation reports*** and ***lighthouses cities market introduction*** documents as well as the ***periodic technical reports***.

2 INTEGRATED INFRASTRUCTURES IN GROWSMARTER

This chapter 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. The idea is to create business cases for each of the smart solutions in order to initiate market roll outs in the Follower cities, take up cities and the rest of Europe.

Content

Solution	Measure	City	Partner(s)	Contact Person
SS5 Smart lighting, lampposts and traffic posts as hubs for communication	M. 5.1 Smart Street Lighting	Stockholm	STO	Björn Lindelöf (bjorn.lindelof@ stockholm.se)
	M. 5.2 Combined electric charging and street lighting poles	Stockholm	STO	Mika Hakosalo (mika.hakosalo@ stockholm.se)
		Barcelona	Retevision	Carmen Vicente (growsmarter@ cellnextelecom.com)
		Cologne	Rhein-Energie	Christian Remacly (c.remacly@ rheinenergie.com)
	M.5.3 Smart Meter information analysis and actuators	Barcelona	Endesa	Carlos Rodriguez (carlos.rodriguezn@ enel.com)
		Cologne	AGT	Manuel Görtz (mgoertz@ agtinternational.com)
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	Stockholm	Envac	Hans Anebred (hans.anebreid@ envac.se)
8 Big open data platform	M. 8.1 Big consolidated open data platform	Stockholm	IBM	Tommy Auoja (tommy.auoja@ se.ibm.com)
		Barcelona	BSC	Maria-Cristina Marinescu (maria.marinescu@ bsc.es)
		Cologne	ui	Stephan Borgert (Stephan.borgert@the -urban-institute.de)
	M.8.2 Urban models	Barcelona	BSC	Maria-Cristina Marinescu (maria.marinescu@ bsc.es)
		Cologne	ui	Stephan Borgert (Stephan.borgert@the -urban-institute.de)
	M.8.3 Semi-automatic instance mapping	Barcelona	BSC	Maria-Cristina Marinescu (maria.marinescu@ bsc.es)
		Cologne	ui	Stephan Borgert (Stephan.borgert@the -urban-institute.de)
	M.8.4 Integration of sensor and heterogeneous data in standard data format	Barcelona	Retevision	Carmen Vicente (growsmarter@ cellnextelecom.com)
	M.8.5 Sustainable Connected lighting to enhance safety and mobility	Barcelona	Retevision	Carmen Vicente (growsmarter@ cellnextelecom.com)

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

This solution demonstrates remote, self-controlled and sensor-controlled LED lighting for pedestrians and cyclists and how these solutions increase traffic safety and perceived security. They demonstrate how smart traffic posts can be used to provide wifi and charge electric vehicles with additional built in functionality. The solution also includes smart meter information analysis to allow the tenants to track current energy consumption of connected devices. Furthermore systems will gather smart meter information at secondary substations that will be used to better assign priorities on the energy asset management.

Measure 5.1 - Smart Street Lighting, Stockholm

Measure 5.1 is testing and evaluating three different technologies. The intention and aim is to use the most successful technology (-ies) in the city´s lighting program, if it is successful. The technologies are:

- Sensor controlled LED lighting for pedestrian and bicycle paths to enable the lights to provide base lighting to satisfy the feeling of security at all times and increase the level of lighting when someone approaches. This technique has a potential to save 40-50 % energy.
- Self-controlled LED street lighting with pre-set lighting schemes based on levels of traffic has the potential to save about 20 % energy compared to regular LED lights.
- Remote controlled LED street lighting which can be controlled from a distance to provide sufficient lighting depending on the time of day and the level of traffic that comes with it. 30-50 % energy can be saved compared to regular LED lighting. 7-12 GWh can be saved yearly in the entire city using local grid energy supply.

Implementation

Implementation of this measure occurred during the summer of 2016 in Stockholm. The data collection period started in Jan. 2017 and is scheduled to run until December 2018. At the beginning of the data collection period, some problems occurred, but have been solved. At first, it was not evident, which data was supposed to be extracted, but this has been resolved. The implementation occurred early in the project and there were communication-related issues such as not receiving a signal or missing data stream. These electrical issues with signal problems were solved swiftly.
It was most important to decide on which technologies to use. In the end, four different technologic solutions were implemented. A standard communication protocol was developed in order to allow for the acceptance of different data on the same platform.

Stakeholders & Business Model

Stakeholders for this measure are the citizens, the City traffic department and contractors.
The city owns most of the solution. The connectivity system was rented or leased for the contract period. After the project ends, the system may need to be returned or bought. The current solution is very expensive because of a license fee for each node in the network. There should either be a limit to the extent of licensing fees or the City should buy its own protocol to avoid licensing fees. This business model is a Public-Private Partnership (PPP).

Activities and Achievements

During the implementation phase the following achievements had the best outcomes: the bike-part of the lighting, the really good collaboration with the partner setting up the system and the finding of a good contractor for the maintenance.

The challenge was tackling problems along the way: the team had not done anything like this before and were now able to understand how complicated the implementation was. They found out that it was essential to take pictures or write down the map addresses of the communication device to know the corresponding fixture. This is very useful for the management system. The team needed to add connections in the electrical cabinets. The connections were considered temporary at first. The team also learned about the importance of planning further ahead. Not all additional devices fit into the cabinets, so some space had to be added. Another obstacle was the communication with the power line, because interruptions caused by nearby construction work made the implementation difficult.
When using dimming, some energy gets lost, but this waste of energy is very small. During the summer months, full lighting is only used in very few hours during the day, which leads to larger energy savings than foreseen.

Smart Lamppost with LED and adaptive steering box on pole

Lessons Learned

It was interesting to see how hard it can be to work on what are new systems and different technology and that even the contractors didn't know how to handle at first. If the systems get too complicated, it may pose a problem because even more consultants need to be

involved who can keep the systems going. It is important for the planning to know about what is adding complexity. Things may sometimes be harder to implement than it looks or sounds in the planning phase.

Recommendations

- Go wireless!
- Establish a clear interface between the fixture and the connectivity
- Know the consequences for installation and maintenance
- Use the contractor to test a new system on a small scale and in an existing installation.
- Involve contractor in early stage.
- Use automatic positioning
- Look at a reference project to avoid additional development costs.

Next Steps

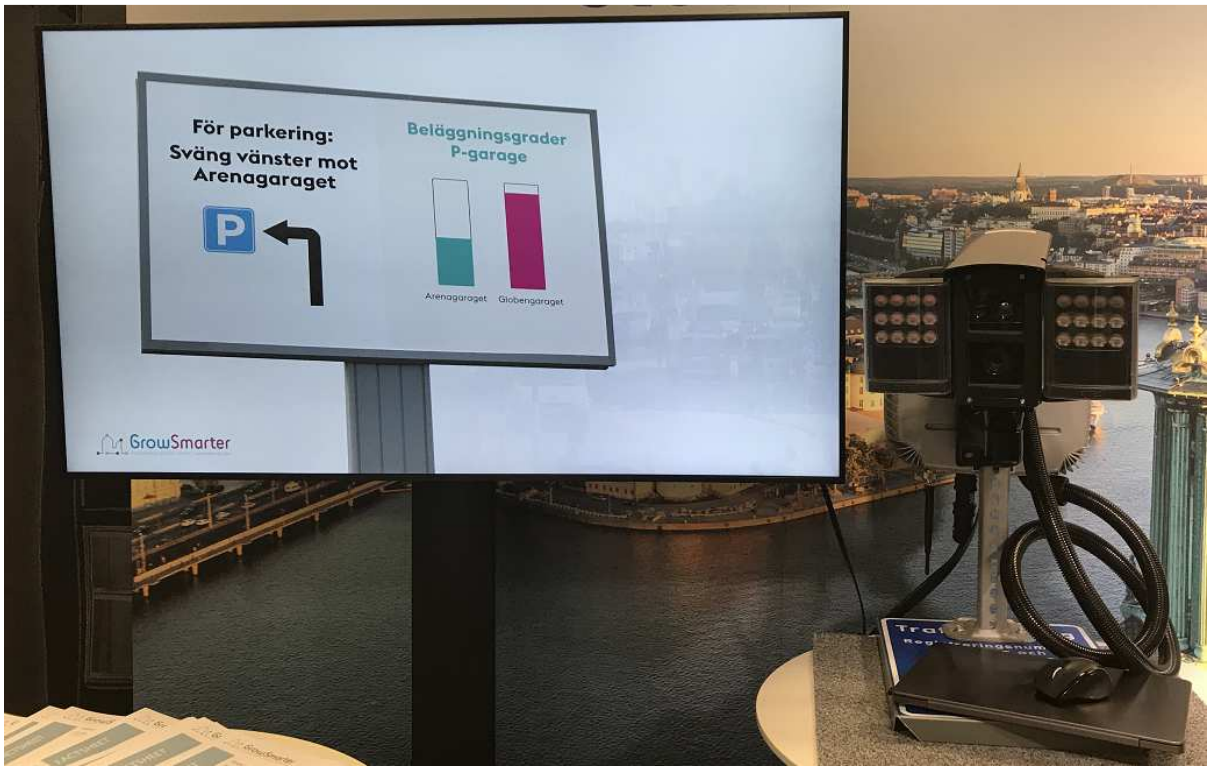
As the installation is in place, the collection of data & measuring as well as the evaluation are next steps. Visualizing the data will be the next challenge.

Measure 5.2 - Combined electric charging and street lighting poles, Stockholm

In Stockholm the smart connected city will use the extensive fiber optic network provided in the Slakthus area and administered by Stokab, a company owned by Stockholm City Council. Several Internet of Things applications and solutions are built on top of the network. The work with this measure was put to a halt while Stockholm City was defining the Strategy for the Smart Connected city.

Implementation

The actual implementation and installation of IOT equipment in the city environment started in September 2017 and continued until January 2018. Information from these sensors will in turn give indications for the need of other IOT equipment in the city environment. For instance the City of Stockholm might want to communicate to car drivers, pedestrians or bicyclists and therefore might use either apps or screens for this purpose. This communication part will be implemented after workshops for this measure are done. All equipment and technology needed in this measure is estimated to be implemented by May 2018.



The sensor for vehicle reading connected together with display to give vehicle specific information to drivers

The **implementation** has been done according to the following **key steps**:

1. Scan the market for IOT-equipment that can measure traffic and people flow in a defined zone.
2. Make field visits to analyse appropriate measurement points.
3. Check that the IOT equipment is able to be used both based on the current data protection laws and the coming GDPR.
4. Prepare all documents for procurement, and then conduct the procurement.
5. Define agreements that clearly state that the data is owned by the city and that the city has permission to make it open at a later date.
6. Sign agreements with providers.
7. The team analysed where electricity and optical fibre as well as city infrastructure are available to connect the devices.
8. The team worked on receiving permission from city and real estate owners to install the equipment.
9. The team developed a communication plan to communicate to both city authorities, politicians and the public about how the IOT equipment is analysing people's movements in the area and what this data is used for.

10. In case of absence of an appropriate structure to install IOT-equipment, the team has ordered a structure (frame tec.) where IOT-equipment can be installed.
11. The team installed the equipment,
12. The suppliers have met IBM to define what protocols to use to transfer the data into the big data platform (M8.1).
13. Make sure the equipment is working and safely producing data over the long run.

Stakeholders & Business Model

The City of Stockholm owns the solutions, but it is a joint city solution, not owned by just one department. It is very probable that this solution will later become part of the city's IOT and Big data platforms. These are not yet procured, but input regarding experiences is given to the city hall. This business model is a Public-Private Partnership (PPP).

Stokab carried its own costs. In the next year's City budget there are 50 Mkr (5 M€) for the implementations of an IOT and digital solutions related to the implementation of the smart connected city strategy. This allows the city hall to have a budget for this later on when the GrowSmarter project financing ends.

- Stokab - owned by Stockholm City Council, an independent actor that provides passive infrastructure in the form of optical fibres has the overall responsibility of making sure the fibre is available for the defined measurement points.
- St Erik Kommunikation – is a subsidiary of Stokab and is the party that installs the devices and makes sure they transfer the data into the fibre.
- Stockholm City Traffic department – responsible for procuring the equipment, has also defined where the measurement points should be. Responsible also for ordering the structure to connect devices. Responsible for the communication plan.
- Stockholm City Environmental and Health Administration – overall co-ordinating responsibility, support both the planning and implementation process.
- IBM – provides the IOT Watson platform where sensor data is transferred and where it can also be analysed and visualised.
- The IOT-technology providers – Facility Labs and Need Insight have been participating in the definition of measurement points and are responsible for making sure the sensors prove the results needed.

Achievements

It is important to understand that this is the very first time the City of Stockholm is implementing such a measure. Everything had to be done manually, which has taken more time than estimated. The most important component was the very strong commitment to this measure. Everyone is working hard to find solutions, to shorten timelines etc. The

group working on this measure both from the city and the private companies are highly skilled, and dedicated, which leads to a good end-result. Further challenges and how they were solved:

1. As this measure is so closely connected with Stockholm City's overall strategy of a smart connected city, everything the city does must also be looked at from a greater perspective. This is more than just an implementation in GrowSmarter. It is also the first larger implementation for Stockholm's strategy for a smart connected city. Support from the city hall was expected, but personal resources were only available for assistance until the end of 2017. This challenge was solved by putting more effort into the project organisation, extending the role and responsibilities of an external consultant.
2. Another challenge is the lack of resources and partly top management support. Even though there is a strategy and budget for implementing smart IOT solutions both in GrowSmarter and the City of Stockholm, it has in practice been very hard to get the key actors to find the time to work with their actions. It has been difficult for the key personnel to convince their management that they should put so much time on this as they have other tasks to perform. This challenge has been raised to the management, but it is a challenge that will need time to be solved. Our experiences will hopefully make future projects smoother and give more resources to key personnel to work with these tasks.
3. Schedule:
    a. The team originally started the process with another supplier for the sensors of pedestrian flow measurements. As the supplier could not produce an offer, the team needed to find another supplier. Therefore the procurement took longer than expected and was finalised after the vacation time.
    b. The team wants to have the communication plan available and all needed communication activities done when starting with the data collection and analysis. The traffic department has not been able to find a communicator from their organisation. This is still in process.
    c. Getting the permits from real-estate owners has taken more time than estimated. In some cases the organisation renting the premise has needed to give their permit to use the fibre cables and switches inside the building. All buildings are owned by the city, but the renting organisation might be external.
    d. Ordering the structure and having it installed has taken longer than expected.

Lessons learned

It has not necessarily been bad that the planning and implementation has taken longer than anticipated. During this time the City has developed its smart connected city strategy, there

is now general funding available in the city budget and the readiness of organisations has increased during this time. The Traffic Department has formed a smart city group where personnel from a wide area (street lights, traffic lights, parking, traffic analytics, IT etc.) are represented. Next year this group will have more person time to put in these efforts. Much of this would not have happened without this measure in GrowSmarter. The project spurred the city on and was used to actively challenge it. It has not been the technology but the organisational learning that has been the most important component in implementing this measure.

Recommendations

The recommendations based on the experiences in Stockholm are:

1. Make thorough investigations about the sensors and that the process of collecting data fulfil data protection legislations.
2. Analyse and involve in early stages the key personnel (the planners, persons responsible of implementation, users of the data, communication personnel) and their management.
3. Take in IOT experts and/or consultants to support the implementation process.
4. Start with a challenge or problem in a City to define how it can be solved with sensors and real-time data collection.
5. Choose a pilot area, where the challenge/problem is evident and make a plan where the sensors should be put to give the data and/or steer the city infrastructure.
6. Be aware that the implementation will take as long as you need to find and involve one by one different persons responsible of single tasks, and that these persons are located in many different organisations.
7. Make sure that you have a project leader/ manager who is able to work horizontally across organisations and who is able to take decisions along the process regarding questions that have never been asked before and who can also lead the operational implementation work.
8. Make sure that the agreement you make with the suppliers of sensors is flexible in terms of amount of sensors and the timeframe when the sensors are up and providing data, as well as being very clear about the responsibilities and ownership of data.

Next Steps

The next step is to get all sensors up and running and assure they all provide data into the IOT Watson platform. When the analysis in M8.1 starts, it will provide feed-back considering the position and right amount of sensors. If needed, the locations are changed or more sensors are added.

Measure 5.2 - Combined electric charging and street lighting poles, Barcelona

In the city of Barcelona, measure 5.2 is a smart solution that provides enhanced wireless access networks. The aim is to support the growing demand of mobile connectivity in the city for broadband mobile connections, IoT services, etc. The solution is based on transforming urban furniture like street lighting poles into new small urban telecom sites, which are called Smart Towers. The new multifunctional SmartTowers should be connected to backbone networks, in order to grant the provision of advanced communication access services.

Implementation

Implementation of this measure started in Feb 2016 and ended in Dec 2017. The initial agreement was for five Smart Towers, which were deployed during summer 2017 for the Municipality of Barcelona. The scope was then expanded with four additional Smart Towers, whose implementation ended in Dec 2017.

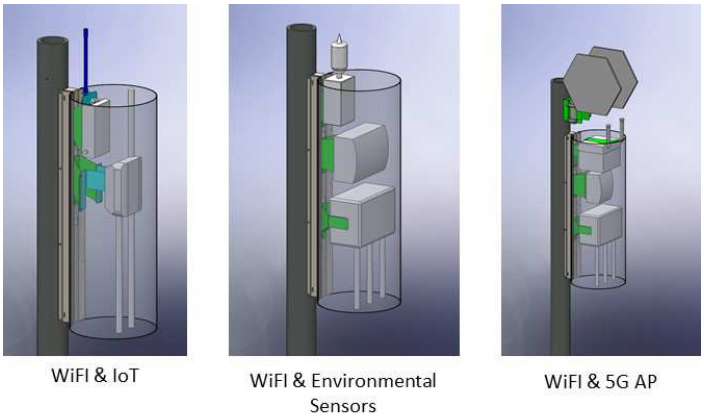
The Smart Tower solution isn't exclusive to improve wireless access networks in public spaces managed by the City council. There are other scenarios were this solution could be implemented like shopping centres, airports, transport stations, etc. We have therefore been working on several designs for Smart Towers in order to provide a proper option for the manager of the space where the measure is implemented (considering different features like aesthetic, functional, operative, etc).

Main activities carried out have been: meetings with stakeholders, space and location analysis, IoT and connectivity analysis, administrative procedures to obtain license to work in the streets, gathering of material and devices, and execution of the street works.

Key activities:

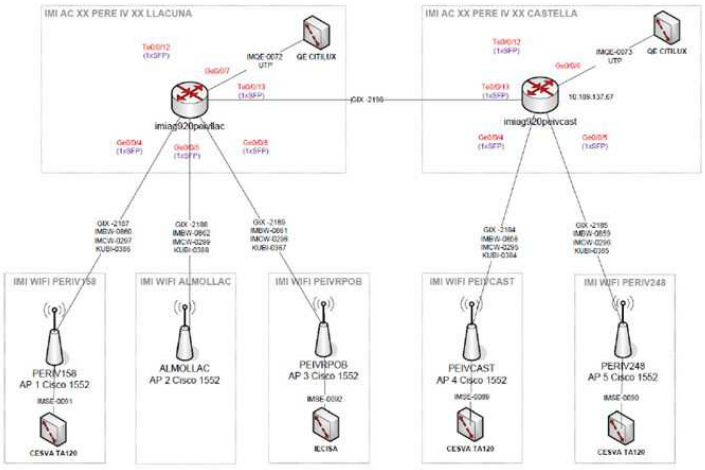
1. Meetings with stakeholders & collection of requirements (aesthetic, functional, operation and maintenance issues)
2. Pilot areas analysis (energy supply, connectivity to FO network, urban furniture availability, link budget analysis, WiFI coverage, IoT coverage, people affluence, etc)
3. Agreement with the landlord about the location and the Smart Tower design
4. Assessment of the Smart Tower design:
    - Physical and mechanical evaluation: devices layout into the Smart Tower, fixings, energy supply, connectivity aspects, etc.
    - Operative and functional evaluation: interference tests, data service configurations, etc.
5. Development of the technical project and fulfilment of all the administrative procedures to obtain licenses to execute the works

6. Gathering of material and equipment
7. Implementation of the Smart Towers:
    - Execution of civil works to supply energy and FO links to the SmartTower
    - Installation of sensors and communication devices
    - Logical set-up & commissioning



Layouts to allocate devices into the SmartTower (Barcelona City case) – Design

Layouts for new lighting pole designs, with and without solar panel - Design



Fiber-Optic interconnections diagram for licensing

SmartTowers - Barcelona city case - implementation

Stakeholders & Business Model

Main stakeholders are the space landlords (Municipality, managers of logistic areas, shopping centres, etc.), providers (installation materials, communication devices, sensor devices, etc.) and the subcontractors.

In the Barcelona City Council case, the municipality owns the Smart Towers, which are based on the "add-on" option over existing street lighting poles. The operation and maintenance during the GrowSmarter project is Cellnex's responsibility. After the GrowSmarter project is completed, there will be a contract between the municipality and the subcontractor that operates and maintains the communications network.

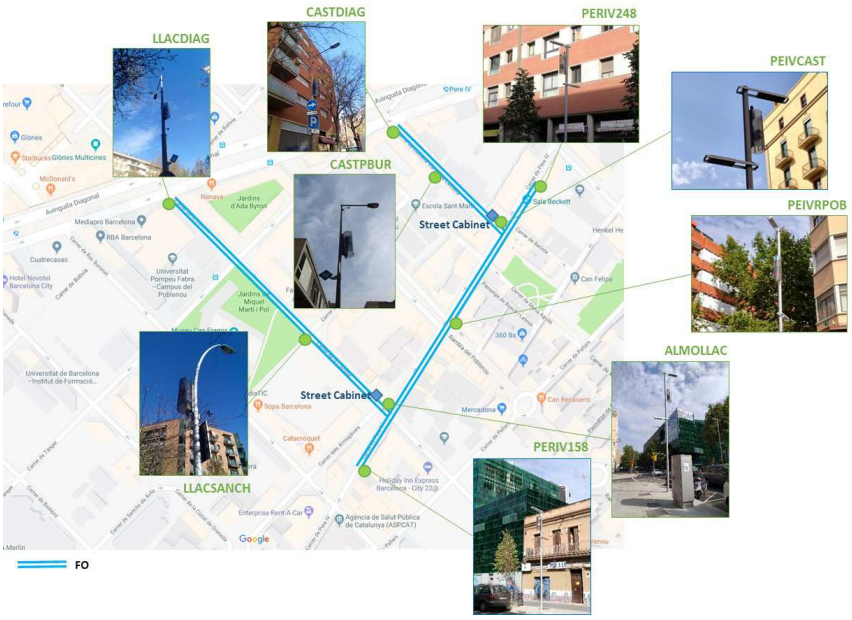
As it isn't an exclusive measure for public administrations, the business model is both B2B and PPP. The business model is based on a neutral operator who offers "connectivity as a service", where the communication infrastructure of the Smart Towers is used by other access communications operators like mobile, wifi, or IoT service providers. Thus, the solution is self-financing.

Achievements

It has been more difficult and time-intensive to achieve all administrative hurdles with paperwork and security licences than to develop and deploy the smart towers.

Slow delivery of sensor devices and communication equipment has also delayed the installation of Smart Towers, but now the Smart Towers have been built and are standing on the streets!

1) Barcelona City case: 9 Smart Towers, "add-on" solution over existing lighting poles, linked to the FO backbone network.



NAME	ACCESS POINT	SENSORS
PERIV248	WIFI – CISCO 1552	Sound – CESVA TA120
PEIVCAST	WIFI – CISCO 1552	Sound – CESVA TA120
PEIVRPOB	WIFI – CISCO 1552	People flow - IECISA
ALMOLLAC	WIFI – CISCO 1552 UBOX - URBIOTICA	
PERIV158	WIFI – CISCO 1552	Sound – CESVA TA120
CASTDIAG	WIFI – CISCO 1572	Wind & Air Pollution - CAPTOR
CASTBUR	WIFI – CISCO 1572	Wind & Air Pollution - CAPTOR
LLACDIAG	WIFI – CISCO 1572	Wind & Air Pollution - CAPTOR
LLACSANCH	WIFI – CISCO UBOX - URBIOTICA	Wind & Air Pollution - CAPTOR

2) Cellnex case: 2 Smart Towers, new lighting pole design, solar/grid connected with motion detection sensors.

Smart Towers - Cellnex case

Lessons learned

Barcelona is a big city with a complex city council. It has a lot of departments and areas involved in the Smart Towers implementation (city planning, mobility, street lighting, city services, ICT, etc.), and all of them need to be aligned with the requirements and deployment of Smart Towers. It has been hard to attain a solution that compiles and includes all the requirements for the involved municipality areas.

In the case of Barcelona City Council, Smart Towers have been deployed over existing lighting poles. However, lighting service has been isolated from Smart Towers' services (sensing, IoT and wireless access communications).

Recommendations

In the case of Municipalities, it is needed to know very well how the Municipality works, which areas or departments will be the "promoters" of the Smart Towers, which areas will be the "users", and which areas will operate and maintain the solution. It is needed to involve

all of them in early stages of the project, in order to gather all the requirements and deploy a solution that agrees with all of them.

It is also recommended to assess a mock-up of the Smart Tower solution before proceeding with the installation in order to check both mechanical and operative requirements.

When executing refurbishment works in streets, it is recommended to expand also the FO backbone network of the Municipality and provide street cabinets. Routers and edge communication devices can be stored here, in order to prepare the city for future connectivity services.

Next Steps

The next steps will be to connect the Smart Towers to the GrowSmarter data platform and to provide data for evaluation.

Measure 5.2 - Combined electric charging and street lighting poles, Cologne

Originally, Cologne did not cover this measure in the project. RheinEnergie is now able to add electric charging to existing street lighting poles. By combining electrical charging to existing street lighting poles, the aim is to make walk-able urban areas ubiquitously connected, and to enable a shared sensing infrastructure in the open street spaces.

Implementation

The implementation phase started after Cologne received funding from Stockholm with the 5th Amendment and ended in December 2017.

Key steps

1. After a market research the RE contacted several suppliers to get a better understanding of their products.
2. All technical requirements were discussed with the internal departments.
3. The team evaluated which lamp poles are most suited to add a charging station as the lamp pole needs to be positioned near the border between two parking spaces.
4. Before ordering, the team visited the production site of the chosen supplier to clarify all open questions regarding the installation.
5. The city of Cologne was informed which lamp poles are used to install the charging stations. The city can then install signs that allow parking for electrical vehicles only in front of the charging stations.
6. Installations of the charging stations by integrating them with the lamp poles' power grid.

Stakeholders & Business Model

The main stakeholders are the RheinEnergie (RE) and the City of Cologne. This measure provides charging infrastructure for the citizens and is a new business model for the RheinEnergie. It is a public-private partnership with B2C revenue streams.

RheinEnergie owns the solution. RheinEnergie does not need the permission from the public authority since it owns the lamp poles. The RE only needs to inform the public authority in order to install the signage. The measure is subsidised by the GrowSmarter project if the costs don't surpass the approved budget.

Achievements

The RE worked on achieving a very detailed overview about all possible stumbling blocks in advance to avoid them, please refer to the key steps described above.

Retrofitting existing lamp posts with electric charging stations - RheinEnergie

Lessons learned

The RE already had experience with installing charging stations. The installation on street poles is therefore just a new variation on this topic. While retrofitting existing lighting poles with charging stations, it is essential to find suitable positions of the poles near parking spaces. These parking spaces must be in public areas in order for the public to be able to use them. A sign will indicate that this parking spot is only available for electric cars.

The RheinEnergie had the great advantage of the lamp poles being in their possession. This allowed their technicians to easily integrate the charging stations into the lamp poles' power grid.

The lamp poles should not be too packed with other electronics to allow for enough space for the charging station cables. Charging stations on lamp posts could be an economical way of installing charging stations in Cologne's public areas without the hurdles of permitting through public authorities.

Recommendations

Check all the technical details and ask for an installation advice from the manufacturer.

Next Steps

At this point, the next step is the installation of the parking signs as well as the evaluation of the measure.

Measure 5.3 - Smart meter information analysis and actuators, Barcelona

In Barcelona, Endesa is deploying an innovative "Data Hub" or communication tool, named LoRa, allocated in a secondary substation. The aim of this new device is to serve as a data node collecting and managing city data. This will allow 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.

Endesa is sharing the data collected by the Data Hub named Multiservice Concentrator (MSC) with the City Platform facilitating the creation of some added value applications with the objectives of obtaining different efficiency related benefits as well as offering new smart grid services.

Implementation

The team began the implementation in March 2017 and hoped to finish before the end of 2017.

Testing the MSC (Multiservice Concentrator) with different smart meters and sensors came out with poor results. The team has designed digitalization of secondary substations.

Key steps:

- Decide communication technology after discard MSC as a Gateway.
- Decide what sensors are the more suitable to obtain the objectives.
- Decide delay of information to not saturate communications.
- Coordinate works to not disturb normal operation of network.
- Commissioning the system.

Stakeholders & Business Model

Stakeholders are

- Endesa ICT department. All communications in the company depend on them.
- Endesa Operations department. Users of system.
- Endesa Maintenance Department. Users of system.
- Enel Distribuzione. Designer of MSC.
- The citizens and therefore the city of Barcelona benefit because the goal is to improve the existing service.

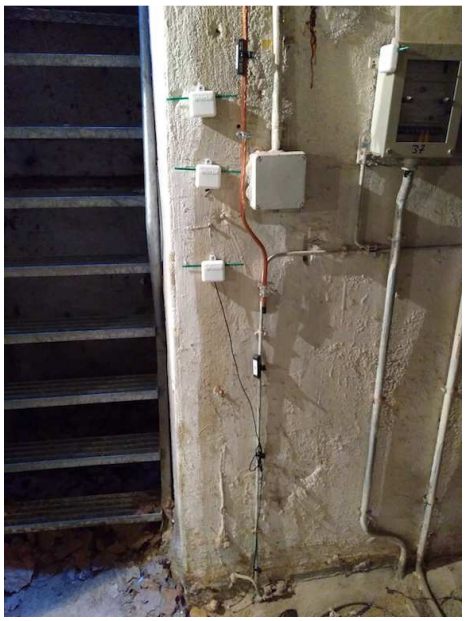
Endesa/ Enel own the solution and are working within their assets. The measure is self-financing. The business model can be PPP, B2C or B2B.

Achievements

The measure is behind schedule because the intention was to use MSC as Gateway. The team had to change it and use a new communication protocol, because it was not working as expected.

The main change was to replace MSC with the LoRa protocol in order to allow for communication between all devices.

Smoke sensors



Electrical tags

One of the challenges was to deal with the administrative problems within the very rigid and security-driven company.

The main challenge was to implement the measure without causing difficulties to the existing network. Endesa programmed the installation activities of the equipment in the most effective way possible to interrupt as little as possible in the lives of the citizens. The works were scheduled in advance and the supply cuts were as short as possible.

Lessons learned

It was important to understand that this solution can be used as a model to digitalize all the company's network and at the same time advise the public administration on how to implement new assets of network.

Recommendations

- Choose a correct asset to digitalize.
- Implement a global solution with a local version.
- It's very important to know your goal to choose correct devices and communication systems.
- Check the local regulations

It's very difficult to advise and help other cities with recommendations, because Electric Distribution is a regulated business and handled completely differently in different countries.

Next Steps

Test the solutions, improve not functional solutions and propose to our CEO a new investment plan to digitalize all networks (more than 135.000 secondary substations).

LoRa Node in a Secondary Substation - Environmental Sensors – LoRa nodes

Measure 5.3 - Smart meter information analysis and actuators, Cologne

The aim of this measure is to foster behaviour change and therefore reduce energy consumption.

In Germany, legislation has not yet passed the issue regarding certified smart meters. Their rollout was supposed to occur in 2015/2016 and is now delayed until the beginning of 2018, due to the needed IT adjustments. So far, the currently available Smart Meters do not fulfill the required German data safety conditions and cannot be installed. Therefore, AGT will install smart plugs in conjunction with the smart home system provided through the RheinEnergie AG's provider.

The combination of the SmartHome application and the SmartPlug device allows the tenants to track current energy consumption of connected devices. The application documentation clearly shows the devices' consumption for comparison and analytics.

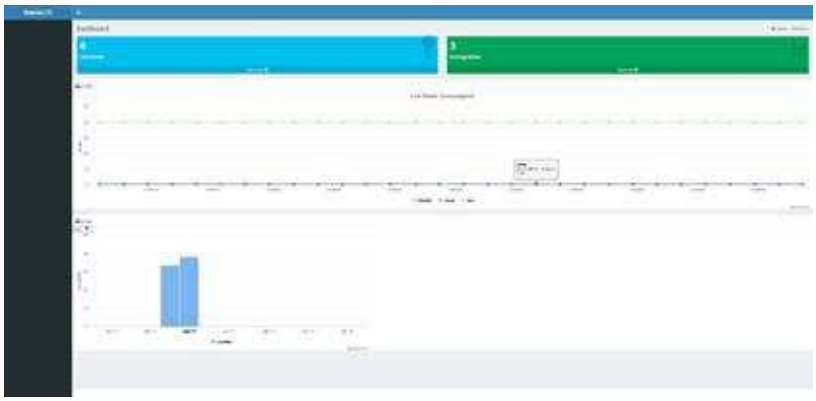
Implementation

The implementation started in January 2016 and will end in March 2018.

A Smart Home system with smart plugs will be deployed in a selection of homes. This collected data will be used to analyse the tenants' energy consumption patterns and give advice on smart energy use.

Key steps are:

- Re-design of the Gateway-Software
- Adaptation of the backend software to become operational with AGT's IoTA platform
- New development of the front-end software
- Development of new energy analytics based on historic energy data
- Design of a new smart energy system due to changes in the data delivery in Cologne



Energy consumption (live and aggregated)

Energy Classes based on Energy Usage

Smart Plug on Dishwasher

Stakeholders & Business Model

Stakeholders are

- Developers: Gathering of requirements for the data collection, data processing and storage. System design taking scalability and performance into account.
- Data scientists: Design of data analytic models for different energy analytic methods, defining requirements for data gathering, defining front-end capabilities.
- Project manager: defining data analytic functionalities and front-end capabilities.

The solution is owned by AGT. AGT provides the service to the tenants during the project run-time. In general AGT would license or provide the data analytic services to energy providers. During the run-time of the GrowSmarter project the measure will be partly financed by the European Union and the AGT funding. This measure can be implemented as an added service for utility companies' customers (B2B or B2C) or as a Public-Private Partnership with local authorities to complement their climate change mitigation strategies.

Achievements

The adaption of the existing data collection infrastructure to become part of AGT's IoTA platform worked better than expected, but the consolidation and transfer of all historic data into a cloud-based data infrastructure caused and still cause difficulties due to the size and fragmentation of the data sets.

Lessons learned/ Conclusions

It has been interesting to understand that it is difficult to manage very large data sets for the development of energy analytics.

The involvement of tenants is a large component because without them, it is impossible to implement this solution, as they need to sign and give permission to use the smart plugs. The team needed to take German legislation and regulation into account, please refer to the introductory explanation above.

A key success factor was the existing know-how from a previous project on energy data gathering and data analytics.

Recommendations

- Find tenants willing to be part of the trial early on
- Clarify the data delivery
- Talk to tenants about their demands

Another advice is to convince energy providers to use high frequency energy data to allow smart energy analytics that will help energy providers to better plan and utilize their energy delivery and tenants to save energy.

Next Steps

AGT is working on implementing the alternative solution using SmartHome & SmartPlug systems instead of SmartMeters.

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 implementation report**.

2.3 Smart Solution 7 - Smart Waste collection, turning waste into energy

This solution demonstrates a smart waste solution for residential areas using differently colored bags for different sorts of waste, transporting the bags long distance underground and sorting them automatically in the collection station, in the area.

This measure aims to improve the quality of life, increase recycling rates and resource efficiency. The food waste is intended to be recovered to produce biogas, which fuels 400 buses and trucks and 15,000 cars. Other waste streams are recovered as material and/or energy. The challenge to use conventional automated waste Collection Systems (AWCS) has been the installation costs, as well as finding space underground to fit the pipe work.

Measures 7.1 Optical Sorting of Waste, 7.2 Introduction of AWCS in an existing neighborhood, 7.3 Waste collection statistics for individual housholds/ 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.

Implementation

The implementation phase started in the first quarter of 2017 and is scheduled to end in the last quarter of 2018 (preliminary). This measure was dependent on construction works and the installation of electrical power, which are circumstances beyond Envac's control. There was also an issue with the approval of the container collection itself. Change of entrepreneurs within the City of Stockholm made communication difficult but was resolved. The original plan was to sort waste in the collection station. The final plan is to register waste fraction and user ID (groups of users) at the inlet point to be able to build statistic data on sorting rate. This has to do with coloured bags and maybe because of lack of space.

Key steps:

- Development of new waste inlet (before and during implementation)
- Development of new pipe system (plastic pipes and its joints) (before and during implementation)
    - Normally steel pipes are used, this was very different, and procurement for it is different: now subcontractor buys, delivers and installs, connections are different, this development went on during implementation, and problems were discovered here.
- Procurement of new inlet type and new pipe system
    - Became more expensive, use more serial production for next batch
- Delivery and installation of inlets, pipes and all equipment in collection station (mostly standard Envac solution in CS)
    - Building with fan, control systems, container, pipe networking
    - Most of components are standard, new: mainly about control system
- Commissioning
    - Connect with electricity
- Coordination work with adjacent contractors. (Civil works, el power installation, collection entrepreneurs etc.)

Stakeholders & Business Model

The Stakeholders are

- The real estate manager (Stockholmshem) is an important stakeholder because they own the facilities and coordinate the refurbishment of Valla Torg.

- Site contractors (mainly Skanska) are performing a huge part of the refurbishment including time planning etc., and are a key coordinator for Envac.
- Sub-contractors (inlets, piping, and collection station) are installing the equipment.
- 3 units within Envac (Head office for management *(managerial)*, Envac Iberia for inlet development *(Spanish, due to resources – had free resources, but head office lacked resources*, Envac Scandinavia for the actual delivery of the system) – *also did O&M*
- The City of Stockholm is a key stakeholder within GrowSmarter as well as a key stakeholder for waste collection (transportation of the container from site to treatment and back). This is something law prohibits Envac to do itself.

Envac has the immaterial property rights and is also doing the physical installation during the first two years. The measure is then transferred over to the real estate manager Stockholmshem; it is a Public-Private Partnership.

Envac vs Real Estate Manager, Stockholmshem (public housing): Agreement that Envac build, own, and operate the installation the first 2 years. Then the installation will be owned by Stockholmshem. This is good for both partners as it helps during the learning process.

The measure is partly EU and partly Envac financed. By the end of GrowSmarter project, it will be financed by Stockholmshem.

Achievements

The system has been implemented. Most of Envac part of the installation has run smoothly. No unusual hinders with the delivery itself.

Inlet where the tenants put their different coloured bags

The container where the vacuumed waste ends for transportation to a sorting facility

One of the challenges is the formal relationship between Envac and the Waste Authority (SVOA) is such that there is an agreement on transportation and treatment of the sorted waste (which is beyond municipal responsibility). The container will be transported an hour away from city: only because optical sorting can happen there. This will only occur during the project time. Normally this would be handled within the City.

There is no solution yet for where sorting will happen after the project, but the discussion is on-going. Stockholm is planning to invest into a sorting facility to be ready in 2021, so there is a gap during the years 2019 - 2021. This gap needs to be solved and is in the current political discussion.

Some of the Obstacles encountered:

- Fans require lots of power, 50-65 amps, was installed late in project because the team depended on the external grid-operator not involved in GrowSmarter to re-route electricity. This was not easily done, because the team could not pressure the grid-operator, but succeeded eventually.
- Scaffolding was in the way on the ground where pipes were supposed to go. Skanska, doing the refurbishment of the buildings, had to first move the material to another location.
- New components, new methods, but only few problems, nothing big.

The pipe through which the waste from the inlets are vacuumed into the container inside the terminal

For a video showing the system, please see the following link:

https://vimeo.com/237059293

Lessons Learned / Conclusions

- Issues within the development of the inlet, mainly the optical reader (bag colour reader). The reader was replaced with a more sophisticated component. Much technology and many components are inside the inlet.
- Some commissioning issues with the weighing solution. This was solved by adding resources to the commissioning. Inlet performs weighing on each bag, scale needs to be calibrated. One of developers in Spanish company had to fly up to calibrate.
- Law issues for the statistical data base (personal data not allowed without consent): No individual database will be created, we will settle for a group based data base. No consent from tenants asked for and no professional help from the owner was received. The partner also tried to work with Fortum, but they only have one building and therefore can only get consent from that one building.
- Practical issues with coordination with the construction works. There was scaffolding where the waste pipe trench was planned. No possibility to re-route the piping due to physical obstacles, hence a major delay of the installation of waste pipes.
- Dependency on sorting facility within the city. Envac can't do this stand-alon and needs to rely on the City. Envac suggested solution with moving container to facility outside the City.
- Technical challenges and new components within the product lead to challenges.
- Product development towards a dead line from the client. The relationship between the client and the GrowSmarter project was challenging but good. Most of the development is market driven.
- An information campaign was of extra importance due to special circumstances for the GrowSmarter project. The inlet was a new kind of inlet and therefore needed material for an info campaign. The tenants were not expected to know how to sort this new way with all bags in one inlet, since this is not typical in Stockholm.
- Some of the juridical restrictions in waste collection were: Who can collect? envac: inlet to container, city: container to sorting facility.
- The administration towards the GrowSmarter project is rather labour-intensive, and difficult to cope with for a small organization like Envac. A firm this size has limited resources and feels a little frustrated to get all the reports handed in before due date. This causes errors in reports.
- The long experience of market driven product development, and all other aspects of this kind of installations within Envac (around since 1960's) helped implement this measure and may be difficult for a new start-up company.

The terminal building which has the vacuum technology and storage of waste described above

Recommendations

- Stakeholder analysis. List top 5 stakeholders and make contact early.
  - *Regardless of company being new or having experience.*
- Secure infrastructure for optical sorting
  - *No existing infrastructure in Stockholm, had to rely on second City to function, required extra work.*
- Early planning of civil works and electrical infrastructure
  - *Lack of electrical power led to major delays.*
- The Envac installation itself has been more or less according to expectations, as far as can be analysed to date. The handling of the sorted waste, the waste stream, is however dependent on the infrastructure of waste collection within the city, which unfortunately has not been coherent with the GrowSmarter ambition.
  - *Sets limits when analysis is done, environmental aspect: container on truck*
  - *Initially ambition was to sort on site, then within city, then outside. Time plans didn't function well together.*

Next Steps

- Continue and finalize the installation
  - *One inlet in operation, 2 more in installation, 6 more to come.*
- Evaluate our new technology
  - *How does technology work and how well can we take care of the waste? Need to ensure intact plastic bags!*
- Develop the technology further
- Take the concept to the market

2.4 Smart Solution 8 - Big open data platform

Measure 8.1 - Big consolidated open data platform, Stockholm

The City of Stockholm had three main aims:

- To create a common shared city-owned data platform with real-time data where data from all departments can be stored and analysed for the long term.
- To connect the platform to the goals in GrowSmarter and use it as a planning and decision making tool for all planners and analysts.
- To use the platform for co-operation and co-creation, i.e. in internal workshops as well as including other cities.

The intention is to meet with different city departments to find suitable use cases for building an open consolidated data platform.

The use-cases chosen were "Sensing City Scale People Movements" and "Movement of Pedestrians/Bicyclists". In "Sensing City Scale people movement" IBM planned to analyse mobile phone data to show how people move in the city over time creating heat maps. This analysis was to be matched against other data such as public transport capacity, traffic measurements, weather etc. to see how well the different transportation modes and capacities are optimized in the city.

Implementation

The implementation phase started in April 2017 and is expected it to end in March 2018.

The main change is that the original plan to leverage mobile phone data had to be abolished due to the legal considerations and decision by the TelCo legal department.

Due to the delay in getting access to relevant sensor data sources that are required for the visualization and analysis providing the needed insights into the flow of citizens and vehicles the implementation has been delayed by approximately 6 months.

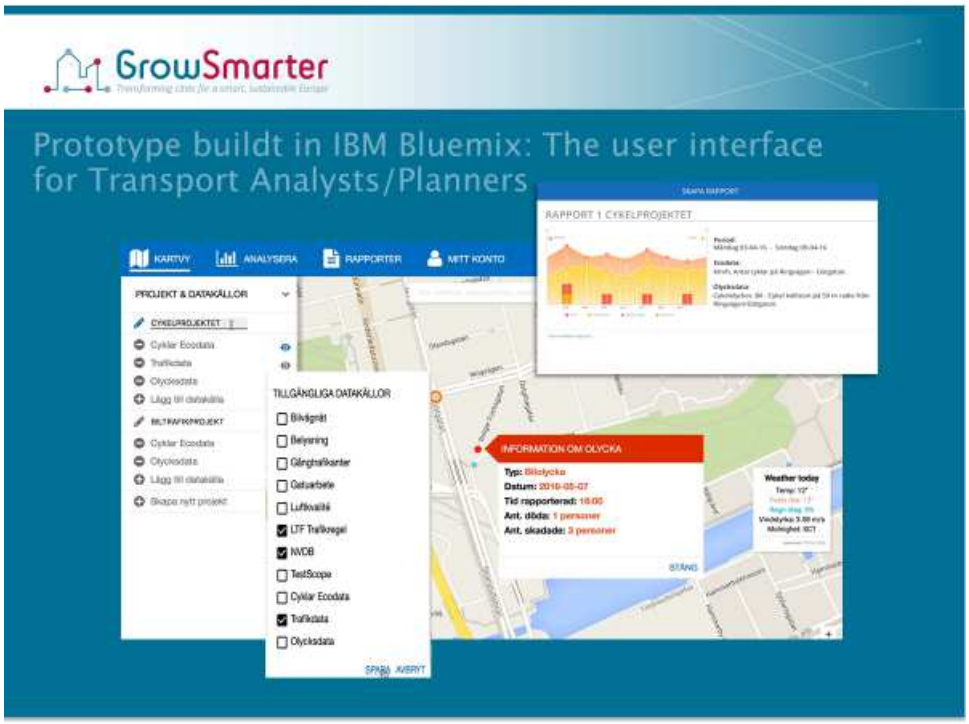
Key steps

- IBM Bluemix – Open, Big Data, IoT and Analytics Platform was made available in 2016 to the project.
- User Design Thinking workshops: City of Stockholm, Transport Administration (Transport Analysts/- Planners) was executed in 2016.
    - Design Thinking to understand challenges/needs/potential benefits/potential solutions
    - Defined data needs and potential new sources for real-time data (mobile data/sensor data)

- Development of the first prototype of a working user interface for Transport Analysts/Transport Planners in the IBM Bluemix open, big data, innovation cloud platform for these users was executed in 2H 2016.
- Data Sorurces study (existing/new potential data sources) executed together with Traffic Department, STOKAB, St Erik Kommunikation and Environmental Department of the City of Stockholm in 2H 2016 and 1H 2017.
    - Existing data sources identified available through the City of Stockholm, their relevance and access options working with Traffic Administration and Royal Institute of Technology (KTH).
    - New potential mobile phone position data sources – availability assessment working with TeliaSonera lead to conclusion by TeliaSonera Chief Legal Councel as not a leagally feasible data source even if anonymized using currently available technologies due to GDPR.
    - New potential sensor datasources – availability and relevance? Conclusion: identified relevant WiFi and Videosensor technology and potential vendors together with Traffic Administration and the Environmental Administration.
- City of Stockholm initiated and concluded a procurement process for new sensors which was finalized in the third quarter of 2017.

Stockholm GrowSmarter open innovation platform

Workshop findings



Workshop findings

Stakeholders & Business Model

Stakeholders are

- Developers: Gathering of requirements for the data collection, data processing and storage. System design taking scalability and performance into account.
- Data scientists: Design of data analytic models for different transport analytic methods, defining requirements for data gathering, defining front-end capabilities
- Project manager: defining data analytic functionalities and front-end capabilities

The solution is developed and implemented based on the use cases defined and their functional requirements using the IBM Bluemix Platform and IBM architects and developers. The platform is available from IBM as a cloud based platform with approximately 140 services where your specific use cases and requirements can be addressed. This measure can be used as a Public PaaS, a Private PaaS or installed on premise by the customer.

IBM has provided the platform and the project Management, the architects and developers based on the EU funding for this measure. The City of Stockholm has procured the new Sensor Data sources. The measure is financed by the EU budget.

Achievements

New WiFi and Video Sensors implementation in Slakthusområdet and data access and integration are currently planned. First real time data access and integration into the IBM Bluemix platform was expected and planned for by the end of 2017.

- The Open, consolidated Big Data IoT platform is available.
- The first user groups (Transport Analysts/Transport Planners) have been engaged and participated in Design Thinking workshops.
- There is a strong consensus of the value and potential in providing new insights for the defined use cases by advanced visualisation and analytics.
- A first prototype of a working environment (User interface) have been built.
- Relevant new sensor data sources are procured by the City of Stockholm and is being implemented during 2H 2017.
- The technical preparation for the acquisition and integration of the sensor data into the IBM Bluemix platform has been done.

The main obstacle is that the original plan to leverage mobile phone data had to be abolished due to the legal considerations and decision by the TelCo legal department.

The team had to redefine the use cases based on alternative and more geographically limited sensor data sources.

New sensors had to be procured by the City of Stockholm for test and assessment in this measure.

The City Area - Slakthusområdet

Lessons Learned / Conclusions

As this is a benefit for the city as a whole, it took a lot of time and many discussions to understand the benefits of a shared system. The idea of co-creation and co-operation is a paradigm shift and requires new skills, new internal organization and a new approach in many ways.

Recommendations

As this is a fairly new development and systems are not well defined, it is recommendable to start small, limited in scale and expand when it is known more about intentions as well as how many and which resources are needed. Find answers to questions such as "Who administers the system?". Take time to resolve questions and do not rush, as much risk is involved. Include the internal city departments first before adding other actors. Conduct tests before moving on.

Next Steps

- New WiFi and Video Sensors implementation in Slakthusområdet and data access and integration. First real time data access and integration into the IBM Bluemix platform expected and planned for in 4Q 2017.
- Based on the data quality the use cases will be revisited in new design thinking workshops and the analysis as well as the visualisation and combination of new and existing data sources will be further developed to try to provide even more valuable insights.

Measure 8.1 - Big consolidated open data platform & 8.2 - Urban models & 8.3 - Semi-automatic instance mapping, Barcelona

The Barcelona solution aims at developing a semantic model that reflects and connects three domains of interest: mobility, energy, and integrated infrastructures.

Users can browse and query the ontology. A semantic access layer will translate semantic application queries (i.e. queries over the semantic model rather than the actual data) to queries that access the city data platform.

One of our goals is to provide a solution in which application writers could deploy their services in different cities without modifying the code (if the new city adopts our city semantic model and develops their own semantic access layer). An important part of this translation involves a cooperative and semi-automatic mapping tool which will return recommendations for correspondences between the semantic concepts and the actual concepts in the city schema.

The goal is to provide a solution that is easier to evolve, maintain, and import to new cities with different data and use patterns. This should also be a solution that allows applications to work as-is over new data rather than having to undergo implementation changes - to the extent that data exists. Our approach is based on developing an urban semantic model, concretely an ontology (8.2). An important part in the process of adopting a semantic solution is how difficult it is to populate the model with actual data.

Measure 8.3 semi automates the data mapping process to our urban semantic model for data monitored in the city of Barcelona.

Measure 8.2 also provides data exploration and semantic access capabilities to the actual data integrated by the GrowSmarter Platform and accessible via a REST-type interface (REST API).

Implementation

The measure 8.1 is implemented during months 25 - 33, January – September 2017

8.2: M17 – M22: May - October 2016

8.3: M17 – M25: May 2016 - January 2017

The final report for the M8.1 implementation phase was due at the end of September 2017; it was finished in December 2017.

Measure 8.1 was initially centered on end-to-end applications. There will be at least one of them, but the focus is not mainly the applications. The semantic access layer (in 8.2) underwent changes to finally access city data via a REST API.

8.1:

- Designed the integrated architecture that enables semantic access of applications to data stored in the GrowSmarter data portal.

8.2:

- Implemented the energy and mobility ontology, with help from IREC and CENIT, and connect them via a high-level city ontology (developed by IBM)

- Designed and implemented the semantic access layer
- Connected with the GrowSmarter API (measure 8.4)
- Adapted an existing tool for exploration, query, and visualization of ontology

8.3:

- Implemented the collaborative web interface for mapping, which is built around LogMap (U. Oxford)
- Integrated the visualization tool (VOWL) for editing and addition of mappings

Stakeholders & Business Model

BSC owns the solutions. BSC is a research partners and therefore has no business. The measure is financed through GrowSmarter. The business model could be either a B2B or a PPP.

Measures 8.2 and 8.3 will be open source tools. The business model is to provide consultancy on customization of the platform, data integration and tool deployment online, together with O&M services (annual maintenance fee).

Achievements

Overall, the team had the full support of the partners from IREC and CENIT in the model specification phase.

API changes and unavailability of data have been the challenges. They still are, because there will be less data than originally thought, which makes the approach harder to test in real scenarios.

Lessons Learned / Conclusions

Without many sources of data and/or applications that will use it, it´s harder to make the case for a semantic technology solution, despite the many great advantages.

Success factors

- Cooperation of domain specialists (energy, mobility)
- Quantity (and quality) of integrated data
- The technology available for data access makes a difference in terms of how fast the queries run, e.g. REST aPI vs SPARQL point.

Recommendations

- Make sure you have domain specialists willing and with time to help you define the model and the ways this model will be queried.
- Make sure you will have enough data.

- Identify partners that can commit to developing applications on top of your technology.

Other cities can use the technology directly, although they need to re-implement the semantic access layer based on the way the data in their cities is accessed.

Secondly, a follower city will need to use the mapping tool (8.3) to populate the model with data by choosing from the recommended mappings. A domain specialist will need to be responsible for choosing between (multiple) recommendations. Depending on the city schema they have, the city may need to generate the equivalent schema in triple format to pass it as input to the mapping tool.

Thirdly, in some cases, a city may also want to extend or customize the city ontology BSC 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.

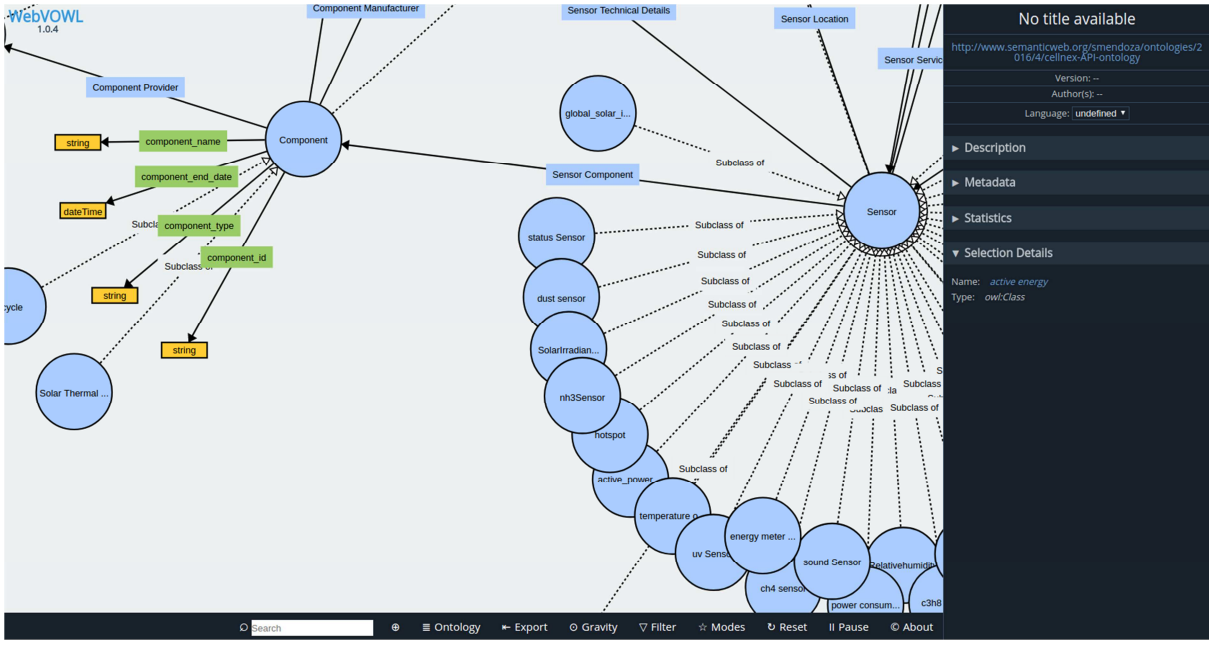
An important caveat: the mapping tool may find little or no useful mappings if the schema and ontology have little in common, and use a different vocabulary to label and annotate concepts. In this case, a domain specialist needs to make sure to "fix" the description of the city entities to use overlapping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

Next Steps

8.1: Delivery of the final document.

8.2: Test with real data; add annotations to ontology if necessary.

8.3: Test usefulness of mappings.



Screenshot for the VOWL integration that helps choosing the best mapping from the ones recommended by 8.3

Measure 8.1 - Big consolidated open data platform & 8.2 - Urban models & 8.3 - Semi-automatic instance mapping, Cologne

The ultimate aim in Cologne is to create a common shared data platform with real-time data where data from all departments can be stored and analysed. This platform should connect to the goals in GrowSmarter and be used as a planning and decision making tool for all planners and analysts within the city administration. Last, but not least, the platform should foster co-operation and co-creation.

By consolidating, aggregating and using existing and new sensor data from infrastructure, traffic and users, this cockpit will generate a new base for innovation to support a new generation of management, control and policies. The aim is to eventually monitor the status and the impact of various measures in real time as well as simulate short and long term scenarios in more detail to improve the quality of decisions. This way, a city can manage the environmental and other impacts more efficiently as well as be open for new generations of policies and accelerate innovation of new services based on the open and available data. The platform will form a base for dialogue with citizens and the business community via a more transparent management.

With the help of the Urban COCKPIT it is possible to explain the Horizon 2020 20/20/20 goals, what the City of Cologne is doing to fulfill them and to show the current impact of these measures. This information is helpful for mayors of other cities or other stakeholders or institutes who are looking for measures to make their cities smart or smarter.

The information can also be used to support the city to manage and optimize traffic flows, energy consumption and production, and pollution outputs for future city planning as well as to find out which measures have the largest impact on achieving the Horizon 2020 goals. This can also help to work out which measures could be the most interesting ones for replication in follower cities.

Implementation

8.1: M7 – M36, July 2015 - December 2017

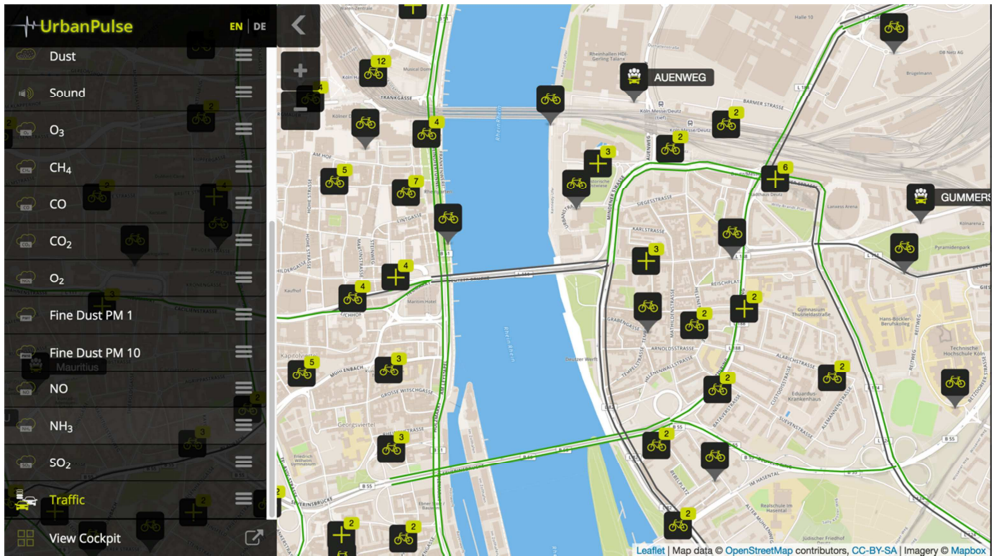
8.2: M26 – M36, February - December 2017

8.3: M29 – M36, May - December 2017

8.1: Due to delays installing measures in WP2 and WP4 some data sources are delivered at a later date. Especially not all APIs in WP2 are developed yet. Furthermore Cologne has ordered a new traffic computer which will be installed and configured in the second or third quarter of 2018. Thus these data sources can be integrated when available. However, 11 different data sources have been implemented so far.

8.2 & 8.3: The original idea was to integrate the semantic layer into Cologne's UrbanPulse and apply it on Cologne's data. It turned out that the number of data types is too small in order to generate an added value for Cologne. We also defined a few query candidates for energy data provided by RheinEnergie but were not able to generate an added value. On the other hand we identified a need for a semantic urban message specification. By using this specification the integration of data sources can be simplified. Hence, we developed a message specification concept.

urban cockpit tile view



urban cockpit map view

Stakeholders & Business Model

For 8.1 [ui!] improved, adapted and extended its Open Urban Big Data Platform UrbanPulse in accordance to GrowSmarter requirements. [ui!] is the platform provider of UrbanPulse and the City of Cologne is the platform operator and is responsible for hosting. The business model used in this measure is Software as a Service (SaaS – B2B).

Results of 8.2 and 8.3 will be non-technical results and are owned by [ui!].

To make the UrbanPulse run, data sources and APIs are necessary. The City of Cologne is organizing the data sources and APIs and [ui!] is integrating these data into the UrbanPulse, and is designing and developing the Urban COCKPIT.

Cologne is paying the hosting costs for UrbanPulse instance. In GrowSmarter the Microsoft Azure Cloud solution is used as cloud platform. These costs are funded 100% by the EU funding for GrowSmarter. The efforts of [ui!] are funded by 70% by the EU funding for GrowSmarter because of the 70% funding quota for [ui!]. After the GrowSmarter project, Cologne has to finance the hosting costs on its own.

The Urban Software Institute GmbH ([ui!]) is developing the UrbanPulse and the Urban COCKPIT and offering them to cities and urban management companies. Furthermore [ui!] is analysing the data to determine which information can be sold. Cities could sell the urban data and information to interested parties. The business models have to be adapted for the cities to fit their needs and requirements.

Achievements

Overall, the team had a difficult time finding acceptance from all partners in using data in the urban cockpit. Slow acceptance and the unavailability of data have been challenging. There will be less data than originally thought and almost no real-time data available, which makes the approach harder to test in real scenarios, but we have included potential demonstration of data in case it can still be included.

8.1:

- An initial UrbanPulse Platform instance together with the Urban COCKPIT as monitoring tool was installed and enabled in 2015. The first results were shown on the Smart City forum in Germany, Frankfurt in October 2015.
- In 2016 more data sources were integrated and the solutions were extended and adapted. Furthermore the UrbanPulse and the Urban COCKPIT were upgraded to the newest version. The Microsoft Azure Cloud instance was slightly reconfigured.
- In 2017 more data sources were analysed and integrated into the solution. More data have been integrated and for the COCKPIT another upgrade is planned. Some modules of the UrbanPulse backend have been replaced by more efficient ones. The concepts of the Urban COCKPIT were extended and refactored.

8.2 & 8.3:

The main idea was to apply the solutions developed by Barcelona and for Barcelona on Cologne as well. Because of the delays and the fact, that the number of data sources which can be integrated during GrowSmarter are not high enough to produce an added value for Cologne, an integration of the Barcelona semantic layer cannot be done for Cologne. Additionally, we learned that the semantic layer would not create an added value because the result of our investigations into useful queries for Colognes energy data did not lead to successful use cases and could not be applied.

Thus, [ui!] developed a concept where urban messages will be specified semantically. This concept will be applied on the data integration level. It supports the integration of data type related to each other. For example public transport data consisting of vehicle stop locations, time schedules for the vehicles and disturbances of elevators and lifts.

Lessons Learned / Conclusions

- City administrations are structured hierarchical and not all city departments with necessary data are involved in the projects. Hence, it is important to start as soon as possible to meet the employees of the departments to give them an overview what you have to do in the project and what kind of data you need.
- Industrial project partners are often not familiar with integration and combining urban data to develop value added data services. Hence it is important to conduct workshops in order to teach the basic ideas and to develop all win solutions.
- Developing ideas what data scenarios could be useful to archive your smart city goals.
- Discover what data is or could be available in your city provided by city departments or industrial partners.
- Pursue contractual regulations with partners early on to share data with the city's open data platform.

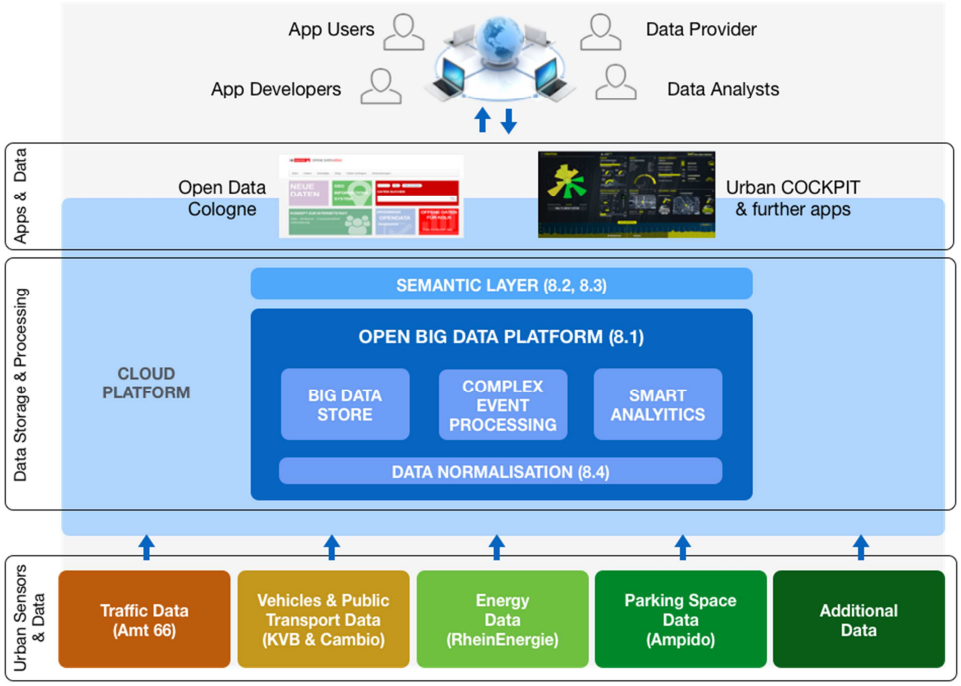
- Understand what suitable data service APIs need to be in place or have to be developed.
- Verify the legal requirements, especially regarding data protection

Recommendations

- Establish a vision about the use of the platform to be able to concentrate on the required and essential data collection as soon as possible (e.g. parking management, bike paths etc.)
- Identify all required actors (e.g. city departments owning important data you need) and conduct workshops with them, teaching the ideas and goals and developing data scenarios in cooperation. Identify the necessary data sources and actors you have to cooperate with.
- Affected departments and agencies and/ or companies need to be included in the process at an early stage. This allows for early understanding and acceptance of the solution, time for discussion and individual special requests as well as including expert knowledge. The acceptance of sharing data is a task not to be underestimated.

Next Steps

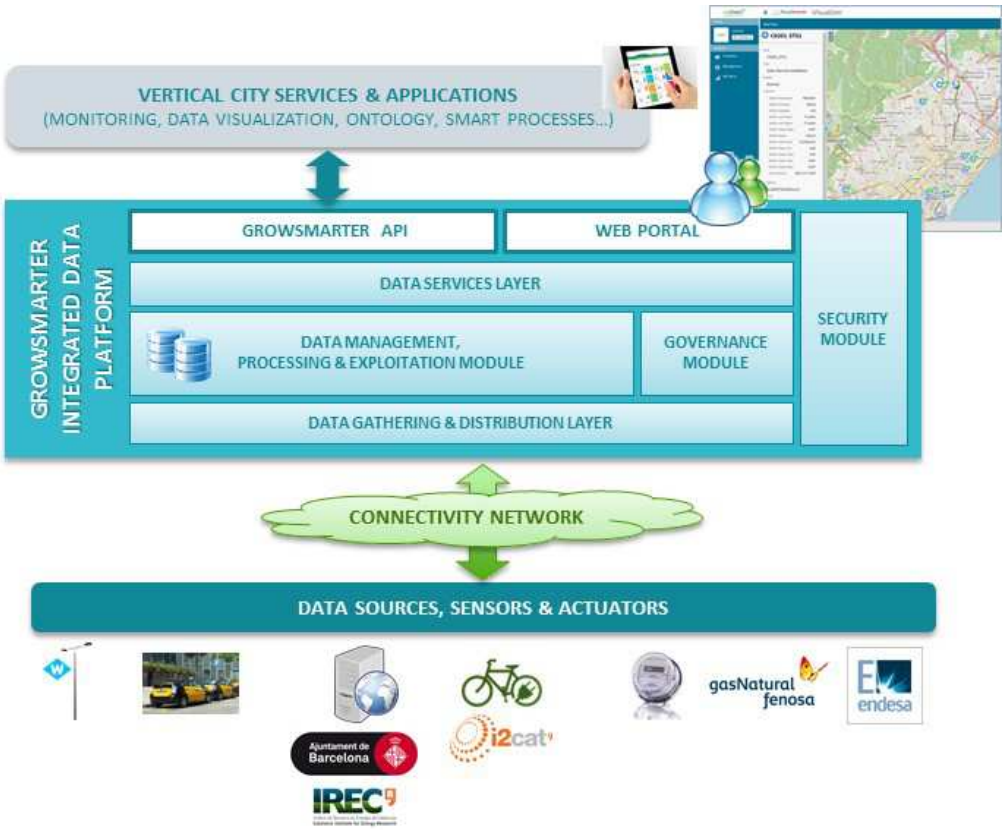
- Integration of the remaining data sources as soon as they are available and adapt the design of the COCKPIT in accordance to the data sources.
- Finishing the concept of how to integrate Barcelona's research work of 8.2 & 8.3 for Cologne.



Schematic overview of the IT structure

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

The horizontally organized platform that Retevision has designed and implemented in the GrowSmarter project aims at managing and sharing data from the Smart Measures that have been deployed in the City of Barcelona. The platform, which is called "Integrated Data 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 Integrated Data Platform exhibits the heterogeneous data provided by different urban resources through a set of normalized APIs. Additionally, the Integrated Data Platform has a web portal that hosts several applications like: inventory of resources, documentation, API store, etc.

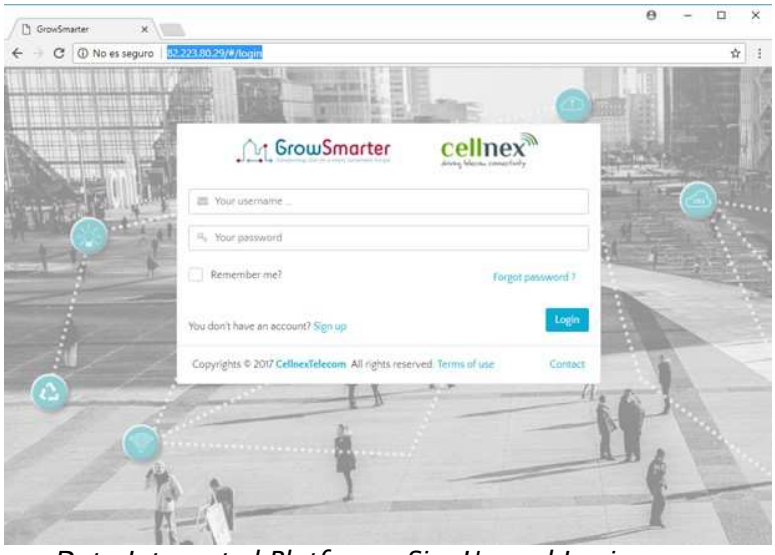
Implementation

Implementation of this measure started in Dec 2015 and ended in Dec 2017. The evaluation phase starts 2018. This measure is on track and there were no changes to the original plans, but it is dependent on the other GrowSmarter measures because only implemented measures can provide data, others cannot. Thus, Retevision will perform several support and

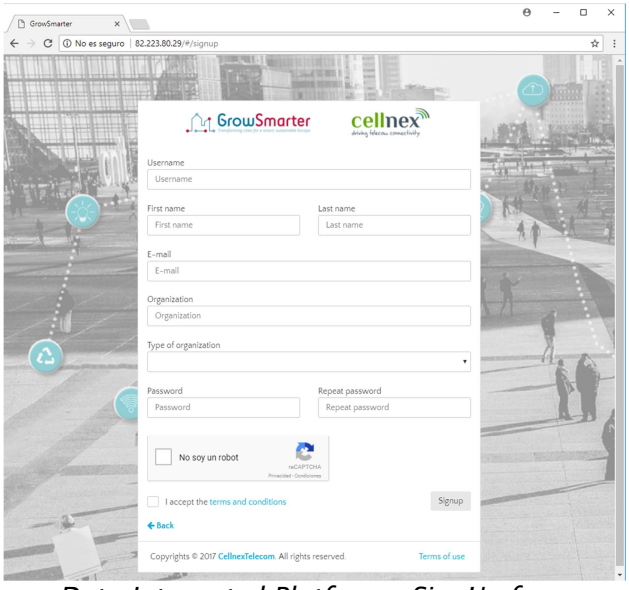
maintenance tasks during the evaluation phase in order to accommodate new integrated data or capabilities into the platform.

Main activities carried out for the implementation have been:

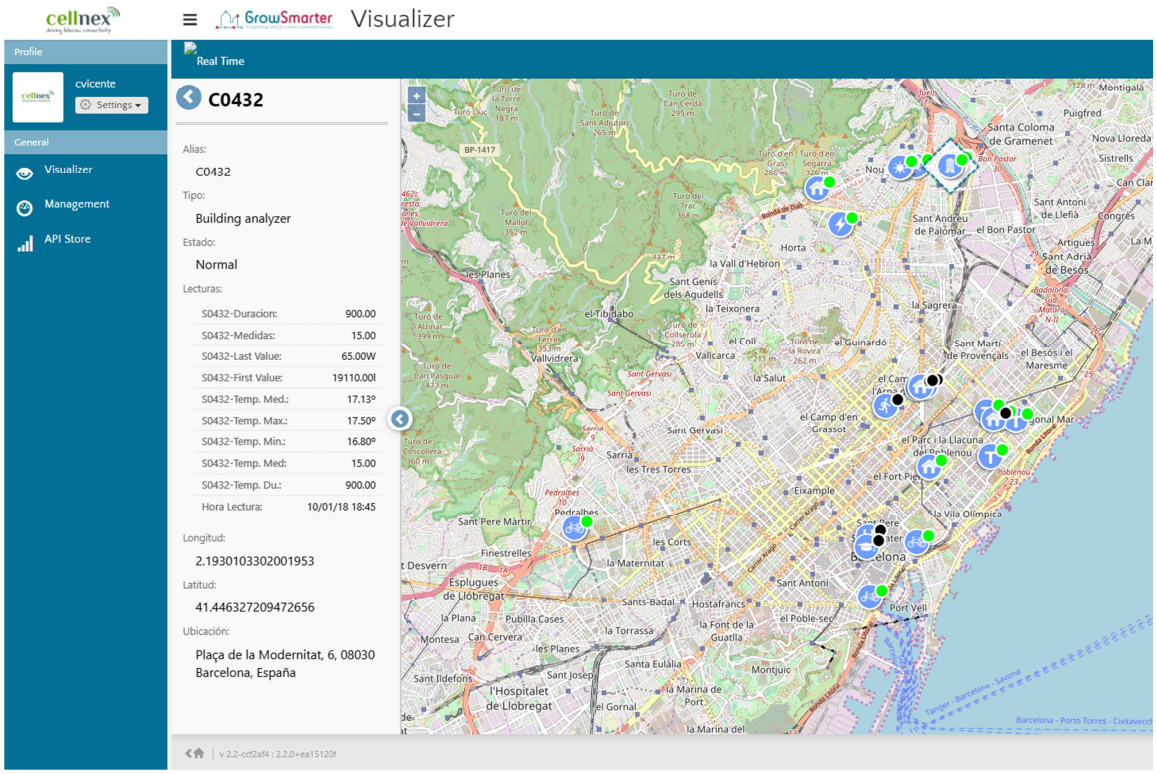
- Meetings with stakeholders (data providers and data consumers)
- Definition of functional requirements and the common data model of the Integrated Data Platform.
- Design and definition of the computational architecture.
- Deployment of functional components and APIs.
- Platform set-up and provision of APIs and demonstration web applications for users



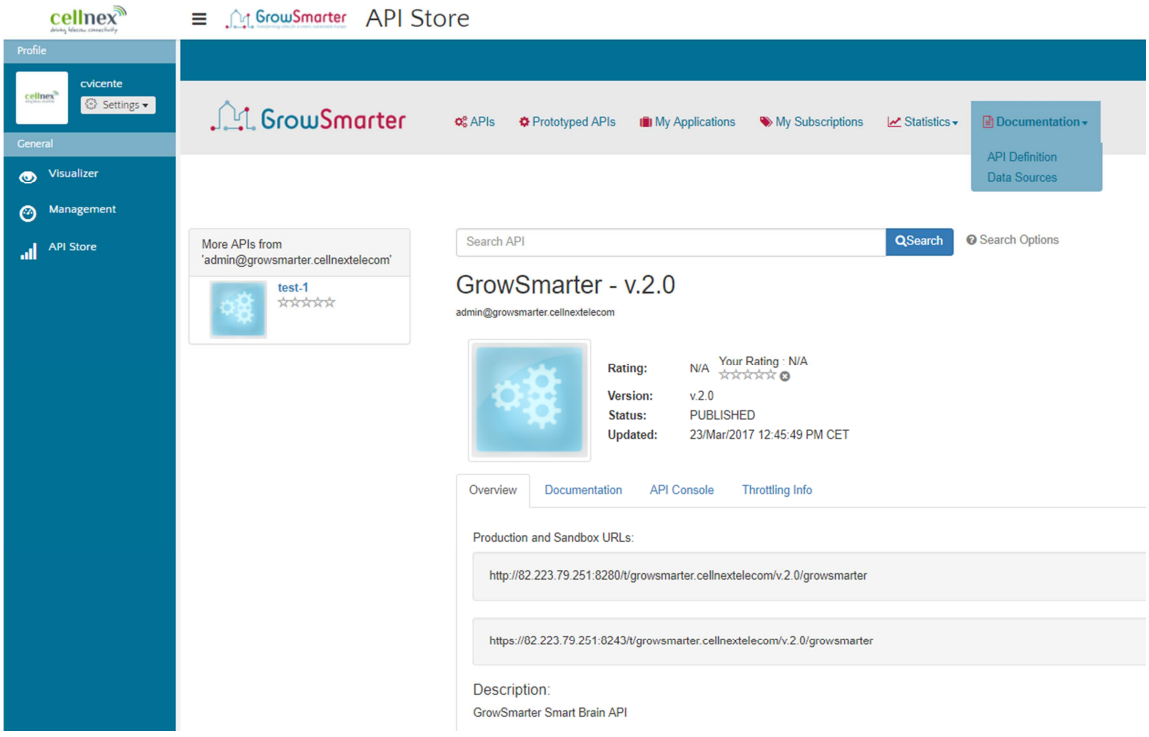
Data Integrated Platform - SignUp and Login access



Data Integrated Platform - SignUp form



Data Integrated Platform – Resource Visualizer application



Data Integrated Platform - API Store application

Stakeholders & Business Model

Main stakeholders of this measure are data providers and data consumers: the municipality, other GrowSmarter partners, the platform operator and 3rd parties.

The owner of this integrated data platform is Retevision, although data ownership is for data providers. Retevision works as platform operator, who supports, operates and maintains the integrated data platform during the project life. The measure is financed by Retevision and the EU funding for this measure. In the future, it will be financed by the stakeholders linked to the Integrated Data Platform. The price will depend on the use of the platform.

After the GrowSmarter project has been completed and to keep the platform alive, there will be a contractual partnership (B2B or PPP) to get "Platform as a Service". The outcome will depend on whether other partners want to keep the solution going and form a partnership. There will be a modular cost system, in order to facilitate the adaptation to different entities' needs. There will be: a fixed fee to support O&M, hosting computational infrastructure, and the use of basic capabilities; another fee per integrated data set; and extra-fees per use of extra-capabilities of the platform.

Achievements

It has been a great achievement to create a platform that provides standardized access to normalized and integrated data through a GrowSmarter API, but it has been difficult to get the data into the platform because the measures don't provide enough information and data. It may be difficult to evaluate applications.

Main achievements have been:

- Data Integrated Platform SetUp
- GrowSmarter API REST provision, with real time queries and subscription methods
- GrowSmarter Integrated Data sets: BigBlue sensors, e-bike sensors, MSCs, SmartTaxi stands, GNF refurbished buildings

Lessons learned / conclusions

The main challenge has been to implement the platform with undefined data sets and consumer applications, while having a low level of commitment on the use of the integrated data platform by the other partners.

It has been useful to hold several meetings with stakeholders in order to explain benefits of horizontal platforms vs vertical ones, and give the confidence to connect their data. These meetings have also been useful to define the standardized API set and the common data model that allow "consumer applications" to process the GrowSmarter data.

Recommendations

The integrated data platform is a horizontal platform solution easy to be adapted anywhere, in any context.

The main recommendation is to assess the context situation and try to adapt the solution to the specific needs of your users: data providers and data consumers. Holding meetings with

the potential users in the early stages of the implementation provides confidence on the use of the platform, and allows early definition on the common data models and interfaces for systems interconnection.

Next Steps

Retevision will operate and maintain the platform for the time of the GrowSmarter project integrating new data sets when ready from the remaining smart measures.

Measure 8.5 - Sustainable connected lighting to enhance safety and mobility, Barcelona

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. Actually, street lighting poles are managed by their own lighting management systems following a vertical/silo solution. This makes it difficult to have an integrated view and a common lighting management system for all.

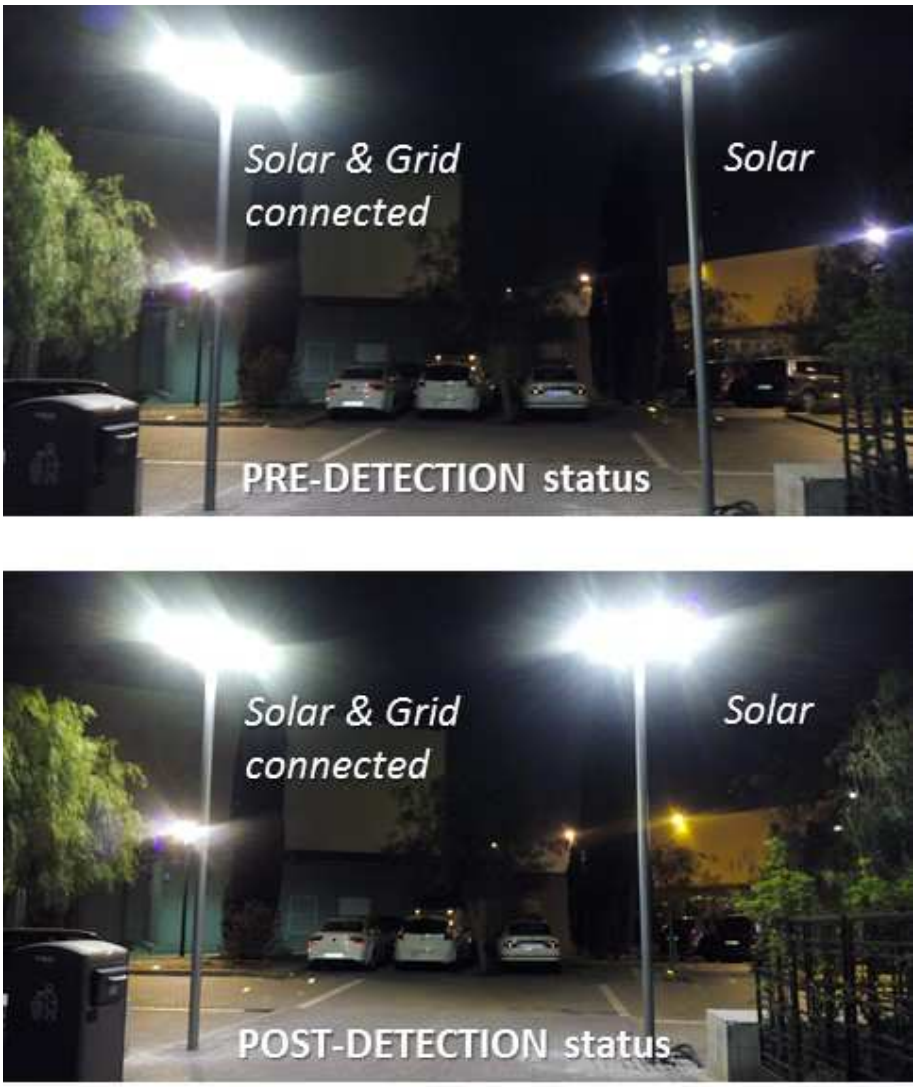
Implementation

Implementation of this measure started in Feb 2016 and ended in Dec 2017. Main activities have been:

- holding meetings with street lighting providers as well as the Municipality and other landlords where the Smart Towers of measure 5.2 could be deployed
- the analysis of different smart-lighting actuators and IoT platforms to design a global solution for remote control of the street lighting
- the design and deployment of the Smart Lighting API.

As it has not been 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 deployed in Cellnex' premises in measure 5.2, please also refer to the information above.

Solar HUB for communications system



SmartLighting - Lighting levels depend on people detection

An agreement with the Solar Hub solution provider has made it possible that Retevision developed a customized module that, thanks to an IoT solution, 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, Opentrends and the Barcelona City Council now allow easy and interoperable management of different urban resources like sensors and actuators. Currently, there are several public administrations that have adopted and now use the Sentilo solution to manage their urban devices. Additionally, there are several sensor and actuators manufactures that have made their devices "Sentilo compatible", in order to facilitate the implementation in Smart Cities that work with the Sentilo solution.

Stakeholders & Business Model

This business model of the Smart Lighting API is a B2B/PPP market oriented solution. Main stakeholders are street lighting service operators and street lighting solutions providers.

Smart Lighting API offers interoperable remote management as a service that can be connected to any Smart City management system by using the Sentilo component solution.

Achievements

Despite the difficulty to come to an agreement with the Barcelona City Council, the Smart Lighting API measure has been implemented for the two Solar Hubs that were built on Cellnex' premises by the Smart Towers in measure 5.2, please see above. Thus, Retevision has designed and developed a customized IoT solution that allows remote real-time management of both Solar Hubs via Sentilo. Then, the Smart Lighting API is a Sentilo "enabler" component that can work easily in any platform that implements the Sentilo solution, enabling horizontal management of different urban resources.

The solution is also easily scalable and replicable in other Smart city environments.

Lessons learned / conclusions

Barcelona is a big city with a complex city council. It has a lot of departments and the one that manages the street lighting service subcontracts several entities to perform the operation and maintenance of different city areas. Therefore, in order to assure the quality of the street lighting service in the city, they refrain from collaborating and working on open interfaces or connecting with horizontal third parties' Smart City management platforms.

The main conclusion is that the Smart Lighting API should be a requirement defined by the own street lighting service management area of the Municipality. This avoids mistrust when external actors propose the deployment of horizontal solutions to get interoperable management of several legacy systems, even when the solution is based on secured interfaces for systems interconnections.

Recommendations

It is mandatory to involve street lighting service stakeholders (operators, solution providers and the municipality) in early stages of the project. This leads to defining a smart solution that agrees with everyone.

It is also recommended to deploy 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.

Next Steps

A connection to the platform needs to be built in order to provide measures for evaluation.

3 LESSONS FROM IMPLEMENTATION

This section presents the main lessons learned from the Smart solutions' implementation in WP3, Integrated Infrastructures.

A variety of very different measures has been implemented in the three cities within this GrowSmarter Integrated Infrastructure Work Package. The topics range 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. We hope the lessons learned from the implementation of each smart solution are helpful to initiate market roll outs in the Follower cities, take up cities and the rest of Europe.

This chapter contains the analysis and reflections on the implementation phase in two sections – the first presenting **lessons per Smart Solution**; the second presenting **lessons per Lighthouse City**.

3.1 Lessons per Smart Solution

This section gives an overview of the lessons learned during the project implementation for their consideration of the GrowSmarter measures' replication. A summary of the challenges encountered by all partners involved in WP2 measures is also given on the Tables 2-4.

Table 2:

Overview of the challenges faced for the implementation of the Smart solution 5

Technical challenges	Implementation challenges
- Low maturity of some hardware components - Communication protocols had to change in order to keep the measure compatible to the existing network - Size and fragmentation of data sets higher as expected	- Higher complexity as expected - Scope was extended during project runtime
Regulatory challenges	**Business model challenges**
- Embedding the GrowSmarter strategy into the city strategy was difficult because more personal recourses were needed as expected - High delays while waiting for suppliers' offers	- High licencing fees

Model your system before you start implementing to manage complexity

It can be very hard to work on new systems and different technologies that are new to everyone. Even the contractors don't always know how to handle them at first. If the systems get too complicated, it may pose a problem because even more consultants need to be involved who can keep the systems going. It is important for the planning to know about issues that are adding complexity to each measure. Things may sometimes be harder to implement than it looks or sounds in the planning phase.

Keep in mind that organisational efforts can take more time than the actual implementation

Cities often don't have a smart connected city strategy and processing horizontal processes is not always common in city departments. It can be helpful to form a smart city group at the beginning of a project, representing personnel and representatives from various sectors (street lights, traffic lights, parking, traffic analytics, IT etc.). Keep in mind that such a group needs personal time and budget.

Gain a clear overview about involved actors and stakeholder of your Smart Towers measure

In the case of Municipalities, it is needed to know very well how the Municipality works, which areas or departments will be the "promoters" of the Smart Towers, which areas will be the "users", and which areas will operate and maintain the solution. It is needed to involve all of them in early stages of the project, in order to gather all the requirements and deploy a solution that agrees with all of them.

It is also recommended to assess a mock-up of the Smart Tower solution before proceeding with the installation in order to check both mechanical and operative requirements.

When executing refurbishment works in streets, it is recommended to expand also the FO backbone network of the Municipality and provide street cabinets. Routers and edge communication devices can be stored here, in order to prepare the city for future connectivity services.

Spend enough time to find suitable positions for charging stations

While retrofitting existing lighting poles with charging stations, it is essential to find suitable positions of the poles near parking spaces. These parking spaces must be in public areas in order for the public to be able to use them. A sign needs to indicate that this parking spot is only available for electric cars.

The RheinEnergie had the great advantage of the lamp poles being in their possession. This allowed their technicians to easily integrate the charging stations into the lamp poles' power grid.

The lamp poles should not be too packed with other electronics to allow for enough space for the charging station cables.

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 implementation report**.

Smart Solution 7. Smart waste collection, turning waste into energy

Table 3:

Overview of the challenges faced for the implementation of the Smart solution 7

Technical challenges	Implementation challenges
- Components need more power as expected	- Scaffolding on the ground where pipes were supposed to go, couldn't be rerouted
Regulatory challenges	**Business model challenges**
- Law issues for the statistical data base (personal data not allowed without consent):	-

- Most importantly, list top 5 stakeholders and make early contact as well as early planning of civil works and electrical infrastructure.
- Plan for educating tenants.
- Be aware of juridical restrictions in waste collection.
- Find space for pipes.
- Optical sorting station needs to be in place.

Smart Solution 8: Big open data platform

Table 4: Overview of the challenges faced for the implementation of the Smart solution 8

Technical challenges	Implementation challenges
- Quality of some data sources was bad. Took more effort for integration.	- Delay in getting access to relevant data sources - Less number of real time data sources available than expected
Regulatory challenges	**Business model challenges**
- Leverage mobile phone data had to be abolished due to the Swedish legal considerations and decision by the TelCo legal department	-

Consider planned legal changes when you select sensors

The legal situation for sensor data and privacy rules is changing over the years. If possible clarify what changes are planned and estimate the impact on your planned data processing steps.

Use semantic models when you have to deal with many data sources or / and many data use cases

Without many sources of data and/or applications that will use it, it´s harder to make the case for a semantic technology despite the many great advantages.

Identify actors and stakeholders early and do workshops with them

City administrations are structured hierarchical and not all city departments with necessary data are involved in the projects. Hence, it is important to start as soon as possible to meet the employees of the departments to give them an overview what you have to do in the project and what kind of data you need.

Industrial project partners are often not familiar with integration and combining urban data to develop value added data services. Hence it is important to do workshops with them in order to teach the basic ideas and to develop all win solutions.

3.2 Lessons per Lighthouse city

In general terms, the partners' responsibility for the implementation of the GrowSmarter integrated infrastructure measures have highlighted the importance of the following topics to be considered in replication:

Stockholm

- Find ways to manage complexity.
- If not already in place, form a smart city group where personnel from a wide spectrum of topics (street lights, traffic lights, parking, traffic analytics, IT etc.) is represented.
- Many law issues for different types of data.

Barcelona

- When many stakeholders have to be involved, it is hard to gain a solution that compiles and includes all the requirements.
- It was important to understand that the solution for Smart Meter information analysis and actuators can be used as a model to digitalize all the company's network and at the same time advise the public administration on how to implement a new network.
- Intensive cooperation between stakeholders and actors is important.
- It has been useful to hold several meetings with stakeholders in order to explain benefits of horizontal platforms vs vertical ones, and give the confidence to connect their data.

Cologne

- It is essential to find suitable positions of existing street lighting poles near public parking spaces in order to allow for extending street lighting poles with electric charging stations.
- The involvement of tenants is a large component because without them, it is impossible to implement many solutions.
- The teams needed to take into account the very strict German legislations and regulations concerning privacy of data.
- If well-defined data scenarios are not in place, start to develop some early, identify stakeholders and actors and start cooperating early on.

4 CONCLUSIONS AND NEXT STEPS

One of the key lessons learned on the project is the importance of communication and the planning of the planning phase before implementing. In the field of big data, it is highly important to define data scenarios as well as find, include and involve all stakeholders from the very beginning with a lot of information building. This effort may be larger than the actual implementation and will help with the success of each measure. Stockholm for example established a Smart City Group, which can be considered a "kick-off body" for all following smart city activities occurring in the city.

It has become evident, that current city government structures as well as large corporations are not always set up to have the individual departments cooperate together in a way to implement smart solutions or their measures. This leads to delays and to the following two recommendations:

- Initiate early workshops with all parties involved in order to establish early understanding and consensus.
- EU funding should focus more on co-creation and co-production of solutions.

A second key lesson learned is the difficulty of collecting urban performance data being more complicated than expected. Main reasons are the following:

- Actors are not aware of the existence of the data or not willing to share.
- Suited sensors are not always available. Prototypes could be developed in two ways: out of existing professional solutions, which are most probably over budget or non-professional solutions that are financially viable, but do not provide the adequate quality and maturity needed. This leads to delays during installation and evaluation of the data. The team then needs to re-adjust or repair the system or use a different solution by another provider.
- A similar situation exists for the various hardware systems' transfer-technologies in order to transport the data from the sensors to the smart city platform.

The work in all GrowSmarter solutions described above continues as the last components are implemented. After the implementation phase in the first three years from 2015-2017, we are now entering the two-year technical and economic evaluation phase until the end of 2019.

5 SOURCES / REFERENCES

This is a list of key GrowSmarter project documents available at www.grow-smarter.eu

List of key GrowSmarter project documents		
Name of document	**Link**	**Finalised**
Fact sheets	http://www.grow-smarter.eu/solutions/	2016-2017
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
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
Concluding reports, D2.4, D3.4, D4.4, D2.6, D3.6, D4.6	http://www.grow-smarter.eu/inform/reports/	Feb 2019 Oct 2019
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

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement no 646456. The sole responsibility for the content of this document lies with the author and in no way reflects the views of the European Union.