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Designing smart, resilient cities for all

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Executive summary

This deliverable 1.3 is the second out of three reports discussing the 'lessons learned' from the cities and within the Liaison Groups. This report reflects on the smart solution implementation process in the Lighthouse cities and analyses the lessons learned with the Overarching Innovation and Implementation Framework (RUGGEDISED, 2017). The main body of the deliverable provides a reflection on and synthesis of the outcomes and functioning of the implementation process so far. The data about the lessons learned and implementation process is obtained through interviews with the smart solution leaders of the three lighthouse cities.
Besides this, the deliverable contains guidance on EV-charging and urban data platforms. This guidance is based on the needs of the lighthouse cities that came up during the last Liaison Group meetings.

The implementation process

The cities made a good start with the implementation of smart solutions. In most cases it appears that the technology is not the problem for the implementation of the smart solutions, but that it's more about managing different factors with mainly a social, economic, legal and institutional character. In this same line, governance and stakeholder management are two often mentioned factors by the cities. To deal with these factors adequately, the cities need to work on a stable collaboration between all (public and private) partners and to ensure continuity of the involved staff. Especially Rotterdam and Umeå dealt with several personnel changes. Glasgow honestly stated that they underestimated the time and effort that it takes to form a stable collaboration.
Rotterdam and Umeå mentioned both the internal connection with their own organisation as an important factor for future upscaling. For upscaling of the RUGGEDISED innovations political support is needed, but it turns out that this is often hard to get. Rotterdam also mentions that it's important to set up a broad smart and sustainable vision and Umeå noticed that it's needed to embed the innovations on different levels in the organisation. Therefore, Umeå decided to focus on organisation-broad learning, to scale up the valuable lessons that they've learned during the implementation phase.
The last factor – that is mentioned a lot – is the impact on the energy grid and the ICT smart grid. Most cities had some difficulties with the implementation of the grids. The consortium in Rotterdam struggled to realise the smart grid, however, their consistency was strong enough to overcome the barriers and clear the way to implement this solution. Umeå and Glasgow followed another pathway in the implementation process of the smart grids. They examined the different options and contractual models first and implemented the best option later.

If we take a look at the 'Overarching Innovation and Implementation Framework', almost all partners learned lessons that are related to the first level in the framework: realisation and output of smart solutions. Also, some of them are already looking forward to the second level: embedded outcomes of multiple smart solutions. Nobody works on the third level of upscaling and replication yet. During some of the interviews, some smart solution leaders mentioned that they (carefully) set some first steps in the process of upscaling the solutions.

The Liaison Group meetings and guidance's

The Liaison Groups provide lighthouse cities with a seamless knowledge brokerage service to transfer and translate state-of-the-art knowledge into practice. To ensure that the local consortium partners in the lighthouse cities do not work in isolation, the groups are meant to engage peers in the other lighthouse cities, including those working in the follower cities. This peer to peer learning enriches the design of smart solutions and improves their implementation processes.

Furthermore, the lessons taken from the cross-city learning also facilitates replication and upscaling of the solutions in the follower cities (Brno, Gdansk and Parma) and other EU-cities. From each lighthouse city (and local consortium) participants exchange their challenges and experiences and by doing so learn from each other. At the same time, they help each other to analyse the key elements that facilitate or hinder implementation and to jointly articulate additional knowledge questions. The function of the Liaison Groups in that sense is not only on a practical level but also on a more fundamental level of collaboratively building capacity to deal with complexity and urban innovation processes.

Based on the LG-meeting in Leiden (the Netherlands) in 2018, this report contains the knowledge needed for a large-scale rollout of the EV-charging system in cities. An overview is given of the different angles of approach, such as markets, business models, stakeholders, opportunities/threats and the connection with smart grids. It can be very helpful for cities to have a selected overview of all the options and aspects they need to take into account.
Besides the knowledge for rollout of EV-charging, this deliverable also includes the knowledge to set up an urban data platform. This section dives deeper into the different options and choices that cities need to make when they create an urban data platform. It provides theoretical and practical information about creating values, technical and management components, and strategies for deployment on every aspect.

In the conversations with the cities and their partners, they indicated a need for cross-city learning, especially about data and urban data platforms. In one of the next Liaison Groups this topic will therefore be addressed. In this way, we can improve the capacity to deal with urban data platforms and their challenges, especially regarding governance and business models. The aim is to identify knowledge gaps and filling these with collaboratively developed knowledge.

Recommendations
Based on the lessons learned and the ‘Overarching Innovation and Implementation Framework’, we have the following recommendations:

1. Ensure the success of the project beyond the life span. Within the ‘Overarching Innovation and Implementation Framework’ this means that there is a need to shift the focus from level 1/2 (realisation and embedded outcomes) to level 3: upscaling and replication.
2. Train colleagues that are not involved in the project and spread the lessons learned and knowledge that is gained during the project. These processes are important for continuing of the smart city transition.
3. Upscale the lessons learned to new strategic goals. Upscaling requires support from the strategic level within the organisation, such as directors or aldermen. Support from them will enhance the attention for the innovation capacity of the organisation. An overarching strategic vision will improve the coordination/collaboration between departments and partners in the city.

Contents

Figures

Tables

1. Introduction and reading guide

In Work Package 1 of the RUGGEDISED project, the main task is to "prepare the ground for innovation and implementation of measures in the lighthouse cities". Following this aim, the WP1 develops a process to facilitate the lighthouse cities' implementation of smart solutions. This process is based on learning across the cities by exchanging experiences, discussing challenges and articulating the need for support from their knowledge partners (TNO for Rotterdam, RISE for Umeå, and the University of Strathclyde for Glasgow). Cross-city learning takes place in Liaison Groups. At the beginning of the project, three thematic Liaison Groups on hardware, software, and orgware aspects of the implementation of smart solutions were formed. In each group, at least one person from each lighthouse city participates. Moreover, the knowledge partners (TNO, RISE and University of Strathclyde, AIT) are also part of the Liaison Groups. The local implementation partners are also welcome to join the discussions. The lighthouse cities take the lead in inviting them to the discussions. This is to ensure that the cities themselves orchestrate the process. The Liaison Groups meet at least twice a year during the implementation phase of the smart solutions, i.e. the first three years of the project. Sometimes the three groups meet all together and sometimes only the specialists of one of the tracks meet.

The Liaison Groups provide lighthouse cities with a seamless knowledge brokerage service to transfer and translate state-of-the-art knowledge into practice. To ensure that the local consortium partners in the lighthouse cities don't work in isolation, the groups are meant to engage with peers in the other lighthouse cities, including those working in fellow cities. This peer to peer learning enriches the design of smart solutions and improves their implementation processes. Furthermore, the lessons taken from the cross-city learning will also facilitate replication and upscaling of the solutions in the follower cities (Brno, Gdansk and Parma) and other EU-cities. From each lighthouse city (and local consortium) participants exchange their challenges and experiences and by doing so learn from each other. At the same time, they help each other to analyse the elements that facilitate or hinder implementation of smart solutions and to articulate additional knowledge questions. The function of the Liaison Groups is not only on a practical level but also on a more fundamental level of collaboratively building capacity to deal with complexity and urban innovation processes.

After the three year period, the lessons learned and experiences will be condensed in guidance and easy to read documents (Deliverables 1.5: 'Prototype Smart Energy District planner', 1.6: 'Guidance on Smart City Design and Decision Platform', and 1.8: 'Guide on ruggedized implementation and innovation of smart solutions'). These deliverables are due in month 40, at the end of the implementation phase of the smart solutions and will be developed by the Liaison Group members, led by TNO (D1.5), Rotterdam (D1.6) and University of Strathclyde (D1.8).

1.1 The aim of this deliverable and reading Guide

This deliverable 1.3 is the second out of three reports discussing the 'interim lessons learned' from the Liaison Groups. This report reflects on the three Liaison Group meetings that took place in 2018 (section 2). Based on the discussions and related smart solutions it presents initial ideas on city guidance documents on two specific topics: Urban Data Platforms (section 3) and EV-charging (section 4). These sections prelude on the development of deliverables D1.5 and D1.6. Section 5 provides in-depth insights into the implementation process of the smart solutions in the lighthouse cities. Together with the smart solution leaders, we defined the main lessons learned so far. The concluding section 6 translates the lessons learned into an update of the Implementation Framework that the RUGGEDISED partners collaboratively developed at the beginning of the project in D1.2. The minutes of the Liaison Group meetings have been included in the Appendix.

2. Progress in cross-city learning

In the previous interim lessons learned report (D1.1) we built a framework to describe the functioning and impact of the Liaison Groups on collaborative capacity building to deal with complexity and urban innovation processes. Ambitious innovation and implementation projects, such as RUGGEDISED, have at least two challenging features:

1. The smart solutions that the cities and their local consortia implement are highly innovative. That means that the involved actors can't rely on daily routines, but rather require processes of continuous pilots, learning, trial and error.
2. The involvement of several partners and cities, that are experimenting with more or less the same innovations, allows examining the success of different ways of implementation of smart solutions and the influence of different institutional contexts.

In order to fully exploit the potential of these two main project's features, dealing with knowledge is crucial. In that sense, the Liaison Groups function as knowledge brokers where different types of knowledge are confronted with each other and collaborative knowledge gaps are identified and filled. The overall aim is to encourage the rethinking of dominant mental models and action models, particularly of theoretical insights and deeply rooted values and convictions (second order learning) through various knowledge brokering strategies. This means that the Liaison Groups are successful in the longer term if participants not only exchange practical facts and experiences (explicit knowledge) but also participate in a dialogue in which they reflect on what they do and what drives them (implicit knowledge).

The detailed minutes of the Liaison Group meetings are included in the annex of this deliverable. In this section we reflect on 1) different types of knowledge that the Liaison Groups brought together; 2) what boundaries were there to span and what knowledge needed to be brokered?; and 3) the different knowledge brokerage strategies that were applied.

2.1 EV-charging (5th Liaison Group meeting in Leiden on 20 February 2018)

The participants of the Liaison Group meeting in Leiden discussed Glasgow's challenges and considerations regarding the smart EV charging infrastructure. Glasgow prepared a detailed document on the proposed scenarios for their smart EV solutions (such as central smart charging, local smart charging or load balancing), including pros and cons and several considerations (see Appendix 2). The aim was to discuss the technical operability and data ownership (DNO, DSO, etc) in depth, and the measurement issues that come along with each of the defined scenarios.

Types of knowledge

The knowledge that was exchanged focussed primarily on technical and operational details of – and experiences with alternative architectures of EV charging infrastructure (quite a lot of explicit knowledge). However, the participants also discussed the governance of EV charging infrastructure and the incentives that partners within the system have to optimise their architecture. Moreover, the role, instruments and responsibility that the local government has, determines how they intervene in designing the optimum architecture. For example, there is a significant difference between the UK and the Netherlands. In the Netherlands, the local governments have more power to force large urban mobility partners (such as taxis and public transports) to be sustainable and invest in sustainable transport. Discussing these cultural and institutional differences opened new perspectives.

Spanning boundaries and brokering knowledge

As technical aspects and challenges are quite generic, there were no real ‘boundaries to span’ other than exchanging experiences and know-how on technical, operational and data issues.

However, a major challenge was to seek well-prepared counterparts for every participant from Glasgow. Especially the network operator has a crucial role in EV charging challenges. In order to stimulate the conversation and add value to the meeting the TNO team also invited the Dutch network operator (STEDIN) from the Rotterdam region (which is not part of the RUGGEDISED consortium).

Knowledge brokerage strategies

TNO invited experts from its own organisation, as well as external EV-charging experts from its network to the session. Apart from Glasgow, also Umeå and Rotterdam participated in the session. The meeting was a success. Primarily due to the thorough preparation from the Glasgow team. Their considerations and questions where very clear and prepared well in advance. This allowed the TNO team to invite dedicated internal and external experts and send them the information beforehand. The experts could prepare answers to the specific challenges and questions. In terms of knowledge brokerage strategies, the strategy pursued here looks like a consulting strategy in which experts help other parties with dedicated knowledge.

2.2 Systemic urban systems (6th Liaison Group meeting in Umeå on 8 March 2018)

Types of knowledge

The aim of this part of the Liaison Group meeting in Umeå was to stimulate the exchange of implicit knowledge. The lighthouse cities are implementing smart solutions and sometimes it’s necessary to deepen reflection on the current innovation processes in the Lighthouse Cities. Do not only answer the question “are we doing things right?” but also try to discuss and answer the question “are we doing the right things?” We stimulated the discussion on implicit knowledge (such as values and beliefs) by asking the cities to reflect upon the urban innovation process in RUGGEDISED, highlighting three pillars: (1) the city as a complex system, (2) innovations as system transformations, and (3) new coordinating mechanisms.

Complex urban systems → urban projects are embedded in a complex system, which is built up from district systems and is in itself part of a regional/national system. This requires continuous reflection on the interdependencies between the elements of the system. Urban systems deal with wicked problems, due to scientific uncertainty, institutional and social diversity. The key is to increase urban learning capacity to cope with uncertainty and adapt to new trends and movements. Municipal organisations and their partners face self-organising stakeholders. That’s why continuous reflection and awareness of the role of public authorities is essential. Methodology development to stimulate such self-organising initiatives may help. The challenge is to build flexibility in policies, contracts, and procurements. This will enable municipalities to deal with unexpected events and initiatives, however, accountancy and control processes can complicate this.

Innovation → to meet the Paris goals we need radical innovations on a system level. However, existing coordinating mechanisms often only stimulate incrementalism. Cities are built up from many socio-technical systems. These systems consist of highly interdependent ‘components’ such as actors, regulation, policies, financing mechanisms, culture, physical infrastructure etc. For innovations to succeed and to be radical, the entire socio-technical system needs to change.

Coordinating mechanisms → if we take the perspective of coordinating mechanisms, the key focus is what is often called as the ‘rules of the game’. Accepting that urban systems and innovation within these systems are the outcomes of collaborative efforts of actor networks. The question here is “what structures” the relations between actors in the city?

And through what means is a desired outcome of the urban system reached? In general, there are three coordinating mechanisms possible: markets, regulation and cooperation. Markets rely on pricing mechanisms to solve urban challenges. Regulation is based on the principle of compliance and enforcement, and regulation is often prescriptive. The final type of coordination is based on cooperation, where trust and reciprocity are the most important drivers. In practice, almost every challenge or situation shows a complicated mix of drivers and coordinating mechanisms. Innovation and the complexity of the urban system requires reflection on existing and new coordinating mechanisms. These mechanisms should be able to cope with changing roles, new forms of cooperation, and fragmented knowledge and information.

Spanning boundaries and brokering knowledge

The transition towards smart cities requires both incremental (step by step) and radical ('game changers') innovations. However, current policies, institutional frameworks and practices most often only allow for incremental changes to take place. What coordinating mechanisms (such as markets/prices, regulation and cooperation mechanisms) have to be in place to encourage radical changes in city systems and governance? And how can partners collaboratively engage in successful radical innovation projects? We asked the Lighthouse city coordinators to reflect on the following questions:

1. Looking at the current practices in RUGGEDISED, what kind/level of innovation and what sustainability goals are likely to be realized at the end of the project in your city?
2. If you had the chance to rewrite the RUGGEDISED proposal, especially your energy system smart solutions (with the knowledge you gained so far), what level of innovation and sustainability ambition would you aim for?
3. 'Dream Scenario'. What kind of innovations and sustainability goals would you ideally aim for regarding the energy system? If you were not being influenced by existing infrastructures, policies, laws, contracts, financing mechanisms, etc.
4. What is needed to actually realise such a Dream Scenario in terms of how current energy markets work and energy prices are established?
5. What is needed to actually realise such a Dream Scenario in terms of changes that have to be made in existing laws and regulations?
6. What is needed to actually realise such a Dream Scenario in terms of how partners/stakeholders cooperate?

Knowledge brokerage strategies

The knowledge brokerage strategy applied here was based on capacity building. Using dream scenario thinking allows to collaboratively build an understanding and reflection perspective on how the implementation process of smart solutions is proceeding. From the discussion, it appears that the lighthouse city partners reflect on several factors that would improve the success of RUGGEDISED. Most of these factors are beyond the scope of RUGGEDISED. Glasgow reflected on the existing infrastructure capacity and the consequent incentive to innovate and invest. Umeå reflected from a European policy perspective. Fair quantification and monetisation of CO2 impact would heavily infuence willingness of the partners to (financially) share in investments and life-cycle costs of smart solutions. Rotterdam reflected most on the impact of the current governance of heat infrastructure networks. The current governance has an impact on the business case and the pace of implementation. Innovation thinking can be a driver to build collaborative capacity and to overcome these barriers.

2.3 Matchmaking (6th Liaison Group meeting in Umeå on 8 March 2018)

Types of knowledge

The aim of the second part of the Liaison Group in Umeå was to intensify the connections between the partners and stimulate knowledge exchange. In advance, TNO asked the partners to formulate (knowledge) questions that they wanted to ask the consortium. Based on this inventory we grouped the participants and let them discuss their questions and see how they can help each other.

Very explicit knowledge came to fore on the following topics: (1) Business Model Innovation, (2) Visualization of energy performance and behavioural change, (3) Energy Management, (4) EV charging, and (5) ICT and data platforms.

Knowledge brokerage strategies

This Liaison Group explicitly applied the matchmaking strategy. Beforehand several partners had indicated the wish to have an overview of available expertise within the consortium and explicitly discuss challenges with dedicated experts. The overall structure of the session and preparation in advance made it possible for the participants to lead their own table session.

2.4 Innovation platforms (7th Liaison Group meeting in Gdansk on 11 September 2018)

Types of knowledge

Within the RUGGEDISED project (WP6), the lighthouse cities will put effort into improving their urban innovation capacity. They will either set up a new ‘innovation platform’ or strengthen existing platforms and innovation initiatives and corporations. How such an innovation platform will look like, and what focus it will have, depends on the particular context of the lighthouse city and different elements of the innovation capacity that needs special attention. The Liaison Group meeting in Gdansk was the first opportunity for the Lighthouse cities to exchange lessons learned and discuss the challenges about setting up innovation platforms. As the chosen focus and form of the innovation platforms can differ significantly across the lighthouse cities, this first discussion shed light on the differences and the argumentation behind the chosen structure.

Spanning boundaries and brokering knowledge

What immediately surfaced during the discussion was a shared awareness that innovation projects can only be successful and upscaled if the city organisation allows individual team members to experiment and make mistakes. Very often, it turned out people are afraid of making mistakes.

From the pitches and the discussion that followed, the cities concluded that they can stimulate their urban innovation capacity in several ways. Dependent on current challenges and ‘gaps’ in their urban innovation ecosystem the lighthouse cities chose different ways and foci to tailor their RUGGEDISED innovation platforms and corporations. In Glasgow, RUGGEDISED seeks to attach to the existing innovation initiative ‘Sustainable Glasgow’, which already is an institutionalized forum in which public and private stakeholders meet and exchange knowledge and expertise. The aim of this forum is to organize a broad range of internal and external expertise around specific societal sustainability challenges. Sustainable Glasgow has an explicit link to the City Council in terms of policy advice.

Rotterdam focusses on improving the network of (externally) enterprises and institutes and (internally) different departments and units. The ambition is that a better connection between these elements of the innovation ecosystem, both physically as well as digitally, will result in a continuously learning and experimenting city.

Umeå also focusses on physical connection, but also pays explicit attention to the behavioural aspects of the ‘learning city’. Making mistakes is part of innovation. The 1-year learning-on-the-job training program that city employees are following will result in ‘learners’ and ‘knowledge brokers’ in the city.

They learn how to connect experiments, draw lessons learned from these new practices and aim to consolidate and embed these lessons learned into the city's organization.

Knowledge brokerage strategies

The setting up of innovation platforms in RUGGEDISED is further being facilitated in the WP6. The Liaison Group in Gdansk was the first opportunity to share the differences and similarities about how to deal with urban innovation with each other. It was explicitly meant to 'inform' each other. Innovation platforms or other innovation initiatives within the lighthouse cities will have a significant role in achieving the impact of RUGGEDISED in the long-term. Improving the innovation capacity of the lighthouse cities helps the uptake and upscaling of RUGGEDISED lessons learned.

The topic of 'urban innovation' is the 'umbrella of reflection' on the overall process of RUGGEDISED within the lighthouse cities. The discussion on making mistakes and the 'position' of innovation within the city's daily policies and organisation proofed to be very valuable. The openness with which people talked about their share in the urban innovation process was greatly appreciated by the participants. It allows applying more capacity building techniques in future Liaison Group sessions on this topic.

2.5 ICT and digital city (7th Liaison Group meeting in Gdansk on 11 September 2018)

Types of knowledge

The lighthouse cities presented the value propositions of their Urban Data Platforms (UDPs). The discussion was centred on the *Value Case*, *Outreach*, and the *Data (services) model*. This resulted in a discussion in which the cities explicitly clarified why they have chosen specific pathways and alternatives.

Spanning boundaries and brokering knowledge

Each lighthouse city aims at different services and targets. The platforms that are being developed serve different purposes and fill different 'gaps' for each city. There's a difference between the more short term, bottom-up results-based approach of Glasgow - driven in part by financial austerity measures, and the longer term, higher level vision of Rotterdam where the first benefits of the 3D based platform are expected to be delivered a little further down the road (3 years or more). Umeå is in the middle being very citizen-driven while allowing some time to develop the right UDP to enable this. Under the hood, there are many similarities in using 3D approaches and open data. To achieve results in the short term Glasgow seems to have a slightly more pragmatic stance on open data and open solutions, instead relying more upon proven, industry standard solutions.

Knowledge brokerage strategies

Because the differences between the cities are significant, there's a risk of only informing each other. However, the idea is that Urban Data Platforms is a topic that is suitable for more collaborative types of boundary spanning. D1.6 (Guidance on Smart City Design and Decision Platform - due February 2020 and led by Rotterdam) will serve as a 'boundary spanning object' and should be the collaborative synthesis of the three lighthouse cities. Exactly because the Urban Data Platforms in the cities show much difference, it's interesting to collaboratively develop guidelines on how to set up ICT platforms in cities, in general. D1.6 will include such a blueprint, based on choices that cities have to make and reflections on underlying arguments. Chapter 3 of this current deliverable D1.3 anticipates on D1.6.

3. Urban Data Platforms – towards guidelines for cities

Most Smart Cities aim for some form of data-platform or portal to capture and valorize the flow of data emanating from increasingly intelligent, connected infrastructures. This includes the Lighthouse and Fellow cities in RUGGEDISED. Based on workshops, discussions, interviews with stakeholders in RUGGEDISED, as well as a review of practices elsewhere, this chapter aims to provide guidance on strategies to conceive of and deploy a so-called *Urban Data Platform***.**

3.1 Introduction

Smart Cities across Europe are designig and implementing *data portals and platforms* aiming to capture and valorize the flow of data emanating from increasingly intelligent, connected infrastructures. Lighthouse and Fellow cities in the RUGGEDISED project are no different. Based on workshops, discussions, interviews with stakeholders in RUGGEDISED, as well as a high-level review of practices elsewhere, this chapter aims to provide strategies to conceive and deploy an Urban Data Platform or UDP.

A recent study on Urban Data Platforms by the Rotterdam School of Management (RSM, 2018) collected data and views on 18 UDPs via questionnaires, interviews and desk study. The study proposed the following working definition: UDPs are modalities that *exploit digital technologies to capture data flows across city systems, enabling their exchange, exploitation, and augmentation by many city actors, including third parties and citizens*. This definition is adequate for the purposes of our review.

The (Data-) Platform Economy

The rising interest in UDPs has to be seen in the context of a world increasingly dominated by data-driven platforms and business models. AirBNB and Uber rule the sharing economy, Amazon and Alibaba dominate retail, and Spotify, Apple and Netflix control music and video distribution. More recently driven by massive investments of Softbank's AI-driven Venture fund, real estate startup WeWork became the single biggest real estate tenant in cities such as New York and Washington. At the heart of all Softbank backed companies is data and AI. The datafication and 'servitisation' of traditional industries have already transformed our world. In 2017 the four internet platforms Apple, Google, Facebook and Amazon together with Microsoft became the top-5 of most valuable companies, a testament to a transition from Oil to Digital. Internet platforms are the *super-intermediaries* of our time. They facilitate a rising tide of economic and social 'transactions' between people and machines, generating revenue from services that draw on the data and insights acquired in the process. The platforms facilitate consumption (Amazon, Alibaba), entrepreneurship (Google Adwords, Facebook Pages, AWS), payments (Google Pay, Alipay, ...) as well as assist in managing your personal and professional contacts (Facebook, LinkedIN).

With the advent of AI and the Internet of Things (IoT), itself a major driver of Smart City strategies, data platforms receive a fresh impulse. Sensors, actuators and Machine2Machine (M2M) networks lace a physical world of people, machines and infrastructure with internet capability. This expands the reach of internet platforms intermediaries even further. The availability of high-resolution data coupled with high-performance computing have recently set developments in Artificial Intelligence (AI) in overdrive. Self-learning algorithms rapidly increase the range and scope of their application. Increasingly complex and abstract human tasks can now be automated. The Machine Learning methods of AI create an insatiable hunger for ever more data. This mutual reinforcement of big data and self-learning machines, in the virtual and the physical world, usher in a new phase of Andreesen's 'Software is eating the World'. In his Online Manifesto, Floridi (2016) speaks of the ***Hyperconnected Era***: *a world where objects and machines communicate with each other without interference by humans*.

While data-driven startups such as WeWork aim to disrupt Smart City services, the focus of City operated data platforms is still largely on *optimizing* existing city operations. In most cities, the business (or *value*) case of the UDP is still a work in progress. Few UDP KPIs are actually being measured at the moment and use-cases are limited to description and diagnosis (RSM, 2018).
In contrast with the practice of large internet platform operators, the dominant view of city-based UDPs is, unsurprisingly, that data generated on the platform should not be controlled by a single platform operator. But here too, data-access and data-rights models are still under development. In fact, in spite of efforts at the European level, no Smart City reference architecture exists that dictates data-exchange protocols at the interface of different Smart City Infrastructures and services. However, significant progress is made in key areas through European Smart City projects such as Espresso, CityGML/SDK, OASC, and ETSI/FIWARE.

In the sections below we will explore the following key aspects of UDPs in RUGGEDISED and elsewhere:

1. Value propositions
2. Data model
3. Technical design
4. Strategies for deployment

The chapter concludes with a set of recommendations for the development and deployment of city-operated UDPs.

3.2 Value propositions: How cities aim to create value with data portals

The RUGGEDISED Lighthouse cities have very different rationales for their UDP development. The Glasgow UDP is primarily designed to identify efficiencies in service delivery, to identify new business models, to support SME's, and to foster new relationships. The financing of the platform itself is not factored in. Due to fiscal austerity, Glasgow needs short term results to be able to continue developing the UDP. Financial benefits/impacts are expected to come from individual projects. This is reflected in the fourfold aim of the Glasgow UDP: to provide an interface that enables query-based analysis of multiple datasets to support policy, strategy, investment, etc; to enable complex data analysis without the need for expensive resources; to utilise existing datasets and software applications; and finally, to minimise legacy costs. This strategy favours a pragmatic, bottom-up approach where the eventual UDP is built up out of smaller projects each addressing a concrete need.

Figure 1: Presentation Digital City Rotterdam (Roland van der Heijden, 2018)

In contrast, Rotterdam is working towards a more grand term vision of 'an innovative municipality led open data and services ecosystem'. The development phase (3-5 years) of the UDP is led by the municipality and centres on the development of a comprehensive 3D interface. Returns on investments are expected in the mid to long term (up to 10 years). Use cases and pilots are underway to elaborate the value case. Rotterdam foresees a 3 year period to complete the initial platform and yield the first tangible results. In the design of the UDP, it builds on recent insights from the EU Espresso Smart City project in which the city participated. Compared to Glasgow the design of the Rotterdam UDP is little more top-down.

In Umeå, there is a strong emphasis on supporting citizen services delivery and engagement as is the main value case for the UDP. The 3D interface will boast zoning plans designed to invite engagement of citizens. Here Umeå mirrors the pragmatic approach of Glasgow in design UDP services that are of immediate use to its citizens, for example, to assist them in advancing the overall sustainability goals of Umeå, a top priority for the city.

The gold standard of 3D based city UDPs seems to be Helsinki. The detail and accuracy of their data model rivals and exceeds the Helsinki 3D models of Google and Apple. The entire dataset is released as Open Data to invite third parties to build service on top of it. Promising initiatives such as Energy Building data & a Solar Atlas are initiatives emerging as key applications. In the near future, many more applications are expected to be developed on the 3D model. Helsinki had been working on information model since the 80s so in some ways they are showing the way. Even so, the value case and business model of many UDP based applications still need to be validated.

In the RSM study, feedback from respondents on the value case of UDP confirm that value is often sought in network effects and volume rather than in new, more disruptive business models. This finding underlines that it is early days for city UDPs: wider deployment should ultimately produce a wider range of innovative value cases.

3.3 Managing Data: access, ownership, security, privacy

With the increasing availability of high resolution (big-)data from an increasing array of Smart City objects, the management of data is the foremost challenge in designing a City-operated UDP. Access rights, data-sharing, security and of course privacy are the key concerns.

In Rotterdam, the details of the data sharing model are still under development but the emphasis is on open data models and open sdk's. The core components of the platform architecture are meant to be open source to avoid vendor lock-in and to enable the exchange of data between city sub-systems and sub-services.

Data are also at the heart of the Glasgow RUGGEDISED solutions. The UDP (or DBDP as they call it) will be the central point for all data within the Council. Their data architecture comprises four pillars: integration of data from many sources (sensors, SQL and API); storing data, analyzing it and presenting/reporting on it (see diagram below). The components include industry standard database solutions like the Microsoft Azure Cloud homegrown tools, showing a mix of open and proprietary components is a testimony to the outcome-oriented Glasgow strategy. Data is captured through the use of APIs.

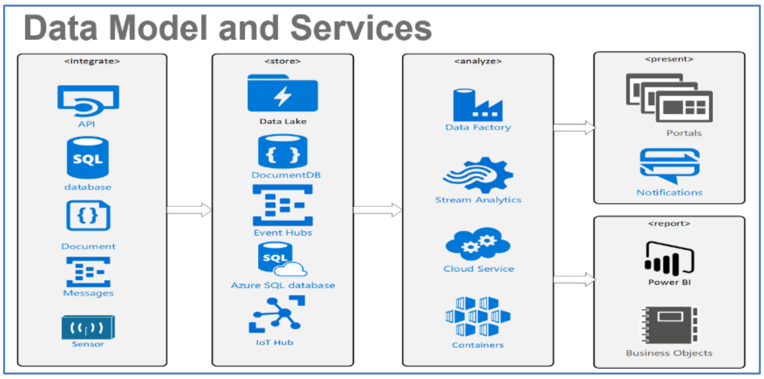

Figure 2: Data Architecture (showed in Gdansk, 2018)

Glasgow Data model

The UDP will also collect all the data available in Umeå. Services that draw on data collected through the platform include energy applications (such as based on block-energy consumption, AR feedback on buildings, PV potential maps, consumption vs CO2 emission) but also derived services such as crime heat maps. The default strategy is to (re-)use Open Data and Open Standards.

The RSM study collected general views on data-ownership and UDPs. The view of the majority of respondents is that data generated on the platform should not belong to a single platform operator. Overall, more in-depth research on data-rights models is needed.

3.4 Technical considerations: (3D-) Interface, standards, competition, evolution, data model

The main difference in technical design and standards of the UDPs in RUGGEDISED is the degree to which they are based on Open Source and Open Standards. Rotterdam and Umeå advocate a fully open source stack and open standards-based 3D model while Glasgow mixes in industry standard proprietary solutions to ensure they can deliver robust services from the start in an overall approach that is more operational.

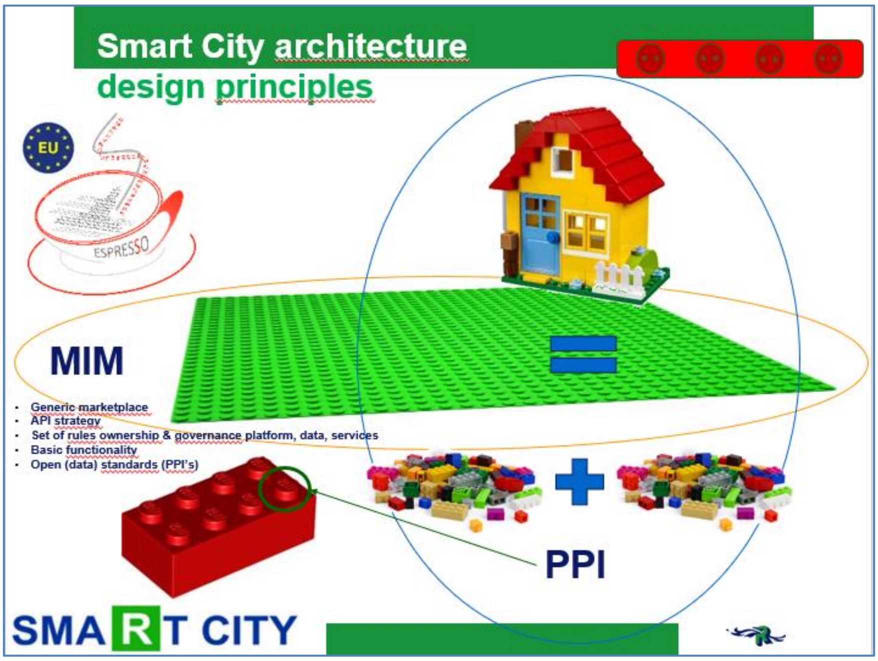

Figure 3: Smart City Design Priciples (showed in Gdansk, 2018)

Rotterdam UDP design principles

Following the approach they helped develop in the EU Espresso project, Rotterdam employs a modular, ´lego block', in line with the OASC (Open & Agile Smart Cities) concept of Minimal Interoperability Mechanisms (MIMs). It adheres to the main EU Open Smartcity standards (Pivotal Points of Interoperability PPI, CityGML, etc.).

The Umeå UDP is similarly based on based on Open Data and IoT Common standards and also envisages a 3D Model as the main interface reaching out and engaging citizens. The UDP will support decision-making processes as well as more long term city planning.

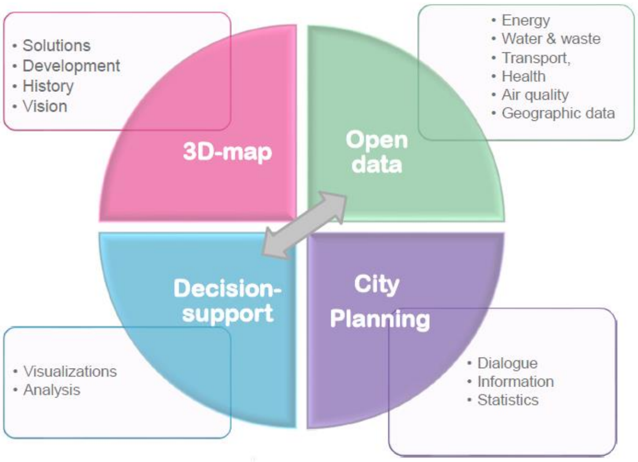

Figure 4: Overview of the Umeå UDP design (showed in Gdansk, 2018)

Overall, overlapping or fragmented technical standards are a key challenge in UDP design. EU projects such as Espresso and OASC have started to address this but much remains to be done. An important bottleneck are the proprietary vendors, large (Google) and small, offering fast to market solutions that fragment the data-sharing space. With IoT/AI Smart City services markets booming, this will not go away soon.

Apart from their Data model-driven design (UDP/DBDP), the technical design of Glasgow is also inspired on a number of practical use cases including the RUGGEDISED smart grid and EV charger pilot solution.

3.5 Strategies for Deployment

Strategies for design and development of the UDP cover a diverse range of issues such as partnership building, governance, ownership, sustainability.

The Glasgow outreach

The main emphasis of the Glasgow UDP campaign was to reach out to citizens, private companies, public agencies, and planners. One of the challenges they experience was that their initial Smart City board included many key actors but it had no decision making power to address bottlenecks in developing Smart City solutions, also given the limited budget due to austerity measures.

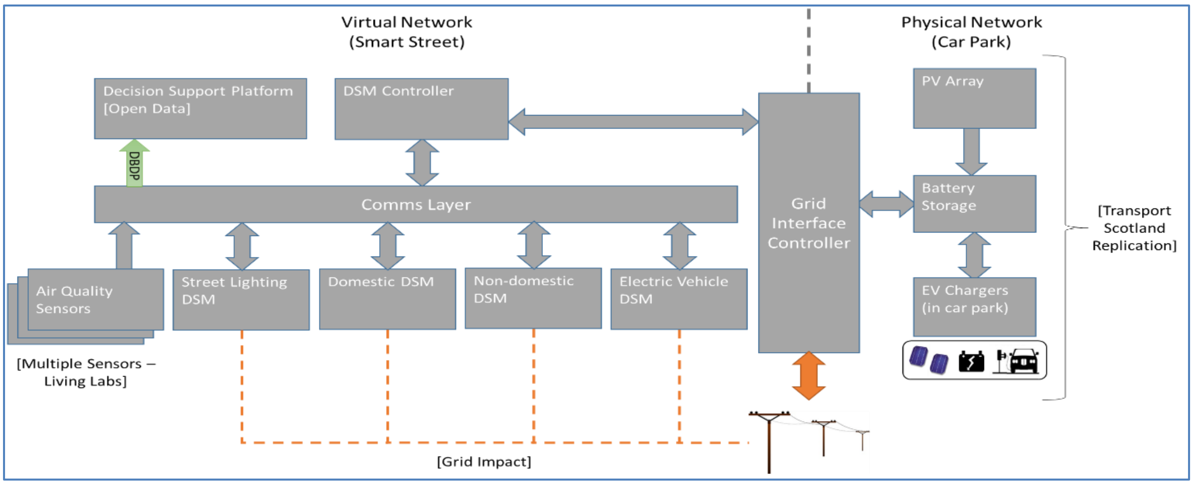

Figure 5: UDP Glasgow (showed in Gdansk, 2018)

The Rotterdam UDP did contract in-house financing for an initial round of development but so far experienced difficulties attracting any external funding. EU Risk finance Instruments such as the European Investment Bank and Fund (EIB/EIF) require relatively short term Return On Investment models that are incompatible with the long term ROI approach foreseen in the case of the Rotterdam UDP. In the RUGGEDISED pilot an innovative Public-Private Partnership is operating some of the facilities in Rotterdam South, however, they don't extend to the UDP. Through RUGGEDISED a partnership with the National Telco (KPN) is pursued to outsource the hosting of the 'data-bus'. Network Data management is a core expertise. The ultimate cost model is not yet agreed.
In Umeå, the focus of the RUGGEDISED interventions and the UDP is squarely on facilitating the citizens and planners in on the road to becoming a fully sustainable, smart city. Financing of the UDP is thus primarily through city funds.

The UDPs in RUGGEDISED are thus primarily financed through city means and internal budgets. This may ultimately limit the speed of development of the city operated UDP vis-à-vis commercial solutions. The ideal mix of the partnership is not yet in place.

3.6 Recommendations for a sustainable UDP deployment strategy

From the experiences in RUGGEDISED, the 18 UDP reviewed in the RSM research and key practices emanating from EU projects the following key recommendations can be made:

- *On value propositions*. City-operated UDPs at present should include business/value case in the short term to maintain the interest of key stakeholders and audiences while developing a long term, sustainable UDP model in tune with developments in the market
- *On Managing data*. Given the rapid development of the Smart City Dataspace, the focus should be on adhering as much as possible to implementing existing open data standards such as developed in the main EU projects (Espresso, CityGML) and programmes (ETSI/FIWARE, AIOTI). They should also emulate emerging best practices on ensuring *security and priva*cy of data. EU (Big) Data privacy frameworks are currently being developed for example in the EU Big Data PPP (e.g. through the projects K-Plex and E-sides[1]).
- *On technical considerations*. 3D models are a key strategy in developing Smart City UDPs. The state of the art Helsinki 3D city model shows that a city-operated, open standards-based initiative can – for now- rival global players in this field with the main advantage of guarding control of public data and services. However, for many cities, the available resources may limit efforts in this direction. Collaboration among cities may provide the answer, especially with advancing standards in Smart City services and potential re-use of service components and data. In the mean-time efforts should concentrate on incremental development with concrete outcomes and milestones such as through the development of micro-services.
- *On deployment strategies and partnership*. In spite of the potential for private partnership and financing gave the wide scope of application and reach of UDP services, current platforms have not yet attracted many external commitments. This is a crucial stage in a successful, long term deployment of UDPs in the dynamic environment that will be the Smart City. It is recommended to redouble efforts to work with external partners on the one hand to limit parallel developments and fragmentations, and on the other hand to ensure cities retain a say in the amalgamation of Urban Data Spaces across Europe.

[1] More information can be found here: http://www.bdva.eu/?q=ppp-projects

4. EV-charging – towards guidelines for cities

This chapter entails the different options, possibilities and considerations that cities need to think of by a large-scale rollout of EV-infra. This chapter goes further into the development of EV infrastructures, types, stakeholders, behavioural aspects, opportunities and threats.

4.1 Development / Timeline / Roadmap of infrastructure (i.r.t. growing fleet of EV)

Emerging Market

Infrastructure for recharging EV and PHEV is necessary to make the "plugged" vehicle options attractive and realistic for prospective users. The recharging facilities can be installed at the home of the EV user (low power, slow recharging), at work or in the public domain, providing recharging opportunities to visitors from elsewhere. Particularly Rapid charging facilities help to overcome range anxiety with users and gives a boost to confidence amongst existing and prospective EV users, leading to much better usage of the vehicles, particularly for the early adopters (Anegawa Takafumi, 2009). Inevitably, utilization levels of public charging facilities will be low in the beginning, when public charger to electric vehicle ratio will be relatively high (approximating 1:1). In early markets, many of the first users will have opportunities to charge the vehicles at home or at work.

Growth Market

After the successful introduction of electric vehicles, with the fraction of plug-in vehicles in the fleet of passenger vehicles being a per cent or so of the total, electric vehicles will become a more attractive option for mainstream car users. By then the public charging infrastructure is already widespread, and visible at many places. In such a market, the public charger to electric vehicle ratio will be dropping to levels approaching the "ideal" ratio of 1:10 as recommended in the EU (Transport & Environment, n.d.). At present typical ratio's in various countries ranges from 1:4 (NL) to 1:18 (N) (EAFO, n.d.). In densely populated areas, where many people have no private parking spot, it may be necessary to provide many more public charge points though (the Dutch ratio given above reflects this). These could, for example, be realized in (semi-) public parking garages. Just as in the case of the early, emerging market, there will still be a need for rapid charging facilities to enable longer trips by electric vehicle (en-Route or at the destination). The business case for these rapid chargers will start becoming better due to a much-improved utilization level (due to larger numbers of EVs and users getting comfortable with making long trips in their EV).

Mature market

The situation where electric vehicles have become very common with a high electric vehicle market share is not realized yet. With an electric vehicle market share of 40%, (EAFO, 2019) Norway is possibly being the only exception. All other countries, including trendsetters like Sweden and the Netherlands, are still at market share levels below 10%. (EAFO, 2019).

The charging infrastructure in a mature market, with large numbers of electric vehicles, is likely to become more diverse. Next, to slow (3-7 kW), fast (11-22 kW), and rapid (50 -150 kW) chargers, higher powered ultra-fast chargers (> 300 kW) may be introduced. At present, just a few electric car batteries are able to connect to such power levels. With the surfacing of more electric buses and trucks, the introduction of high powered EV supply Equipment is stimulated and may serve future generations of electric vehicles. At present, vehicles that are capable of ultra-fast charging have not been introduced, but it may come up with new battery generations entering the market.

4.2 Business Models and Subsidy schemes

Making a charging infrastructure profitable can be difficult in the beginning. The entrepreneurs providing charging points need to ask relatively high prices for the charging service to the few buyers, which prevents the growth of the EV fleet. Governments wanting to improve local air quality and reduce the impact on climate change are therefore often offering or at least subsidising charging infrastructure in the early markets. And the same goes for electric vehicles: they often have attractive tax exemptions or other measures to reduce the initial cost price of the vehicles, in order to support market adoption of electro-mobility. Once the market is mature enough, several business models are possible for the charging infrastructure:

- EV user subscribes to an E-Mobility service provider and gets access to a variety of charging points in a geographic area. Apart from support for finding charging points, the EMSP often provides extra services such as enabling access for unregistered users or providing access to third-party charging stations through roaming. The income from the EV users (subscriptions + current consumed) pay the costs in the total value chain.
- Providing Charging Infrastructure without billing is an option popular in the hospitality sector: by providing free charging current, new, relatively wealthy customers are attracted. At the same time, the hospitality enterprise presents itself as being modern and climate- and environmentally conscious. If the charging facilities are on private property (i.e. not accessible by others) it can even be that the current charged is not registered but is simply added to the total consumption of the enterprise (e.g. hotel). The owner pays and gets publicity / commercial exposure in return.
- Commercial EV charging: retailers, shopping centres, hotels, fast food outlets, car parking providers and all kinds of business with off street parking could offer EV charging with low effort. EV charging technology and connectivity, have advanced significantly. This means that EV charging capabilities are now within reach of smaller businesses and individual sites, with limited risk and low investments. Benefits for the entrepreneur include new, higher value customers, increasing time in the store, referral sales, reaching sustainability goals, and improving customer satisfaction. Perhaps there is a competitive advantage from being a green company.
- In larger enterprises, E-fleet adoption is increasing. The drive to meet sustainability targets and demand from employees make fleet managers turn to electric vehicles. The biggest driver of fleet EV adoption is the lower overall cost.
- Municipalities across Europe are under pressure to demonstrate their commitment to E-Mobility and encourage the transition to electric vehicles for residents and businesses. Many city councils have their own vehicle pools and provide facilities to taxis, private hire firms and couriers. Car clubs, in partnership with local authorities, can be used to support EV adoption, while sharing the risk, and outsourcing the day-to-day business expertise. Tourism and communications benefits of environmental commitment can be important. Switching to electric vehicles and providing EV charging can cut costs and even become a source of income.

4.3 A mix of various types of charging infrastructure (distribution, locations etc.)

In this paragraph, the main categories of charging infrastructure as well as typical locations to install them are presented. For simplicity's sake, the nomenclature as used in Ricardo (Ricardo, 2019) is adopted.

- Slow charging (< 3.5 kW or up to 11 km driving energy/hour). This type of charge points could typically be implemented widespread throughout residential areas (on private properties), but could just as well fit in car parks for offices, factories, 'park and ride' hubs (near public transport), and shopping centres.
- Medium powered charging (≈ 7 kW or electric range gain typically 24-32 km/h). This type of charge point would typically fit very well for Park & Ride, supermarkets, private car parks (including multi-storey garages in city centres), hospitals, transport hubs and leisure centres.

- Fast charging (approx. 22 kW and up to 80 km driving energy/hour). These chargers are well suited for places where a parking time of 1 to 3 hours is expected. This would apply for shopping malls, hospitals, leisure centres and the like.
- Rapid charging (up to 50 kW and approximately 160 km driving energy/hour). This type of charge point is in many cases fast enough to wait for the charging process to be over. Could be suited for charging stations anywhere, but especially alongside busy roads. Because of the higher costs for the user will be used only occasionally by most users so fewer chargers are needed.
- Ultra-fast charging (100-350 and beyond kW or approx. 320-800 or more km range /hour). Fast enough to approximate the filling time traditional drivers are used to for pumping petrol. This type of charger would be very well suited for charging service alongside a motorway or near a taxi hub.

4.4 Overview of Stakeholders

- Electric Vehicle user (EV user): their main interest is full functionality of the vehicle for the typical purposes. It was intended for including accessible charging points for when they are needed to reach their destination.
- Distribution System Operator (DSO): their main interest is to have a reliable prediction in the present and foreseeable future of the overall and peak demand, and possibly buffering capacity (V2G) as well, directly associated with electric vehicles use in a certain area.
- The energy Provider or energy retailer wants to know how much additional demand for energy can be expected and where due to the use of electric vehicles.
- EVSE Operator (EVSEO): their main interest is to provide reliable charging facilities to the users at a place that is convenient for the user.
- E-Mobility Service Provider (EMSP) wants to provide a complete package of services to users of electric mobility ensuring that the needs of the EV users are covered without troubles or delay (e.g. navigation to and reservation of fast charger on the way to a destination).
- Standards Organisations such as CEN-CENELEC wants to provide a uniform and safe standard that ensures safety, broad acceptance and usefulness of electronic interfaces, communication protocols, etc.
- Operators of parking facilities may want double as -or team up with an- EVSE Operator. Because the cars will be some time in the car park, this is a perfect place to provide charging services. Because of the large numbers of cars (assuming a sizeable car park), the load can be spread out and resulting flexibility may be sold to Esco or DSO to help stabilize the grid and provide additional revenues.
- Employers/shops/hospitality may want to provide charging facilities on or near their property as a distinctive convenience or benefit (recharge for free).
- Petrol companies and stations may want to find alternatives to petrol sales with the distribution of ultra-fast charging and zero emission energy carriers such as hydrogen.
- Municipalities: their main interest is providing a basis for uptake of zero-emission vehicles with clear advantages for air quality and noise in densely populated areas. Also interested in providing charge spots at the locations that fit with all other public spatial requirements.
- Higher governments want to enable the uptake of zero-emission mobility and it's infrastructure in conjunction with the goals and ambitions in the policy areas of the economy, climate, mobility and health.
- Electric vehicle manufacturer wants to make a success of a radically new concept that enables the traditional car makers to comply with ever stricter emission standards, particularly in China (by far the largest automobile market in the world) and Europe. Some manufacturers are pushing electric vehicles with more enthusiasm than others.

4.5 E-Mobility system architecture, standards and interoperability

E-Mobility is maturing and the number of E-Mobility stakeholders and roles are steadily increasing. From very initially just buying an EV by the EV user and charging worst case on an EVSE (EV supply Equipment, i.e. charging point) on own premises, to a local EVSE Operator (EVSEO) giving access to its infrastructure, to a E-Mobility Service Provider (EMSP) enabling access to different national and international EVSE Operators via roaming interfaces or a roaming hub (clearing house). The car manufacturer is more and more directly connected to the car, and also navigation companies start playing their role in this new electric mobility landscape. Further, EVs can play a role in better embedding sustainable electricity in the electricity system, see also the section on smart grids below.

Several standardisation activities have and are being performed in the E-Mobility and smart grid domain, often from standardisation related organisations like:

- M/468: E-Mobility Coordination Group and WG Smart Charging [M/468 E-Mobility];
- M/490: Smart Grid Coordination Group [M/490-NAM];
- IEC TC 69 Electric road vehicles and electric industrial trucks;
- eMI3: E-Mobility ICT Interoperability Innovation Group [eMi3 standard];
- OCA: Open Charge Alliance;
- STF: Sustainable Transport Forum;
- NKL: The Netherlands Knowledge Platform for Public Charging Infrastructure EV (see also NKL https://www.nklnederland.com/).

In the European project COTEVOS (COTEVOS-WB, 2016) a reference architecture has been developed based on earlier E-Mobility projects and architectures, as shown in the figure below. This architecture has been adopted by the European STF SGEMS (STF: Sub-Group to foster the creation of an Electro-mobility Market of Services) in their final report (STF-SGEMS, 2016).

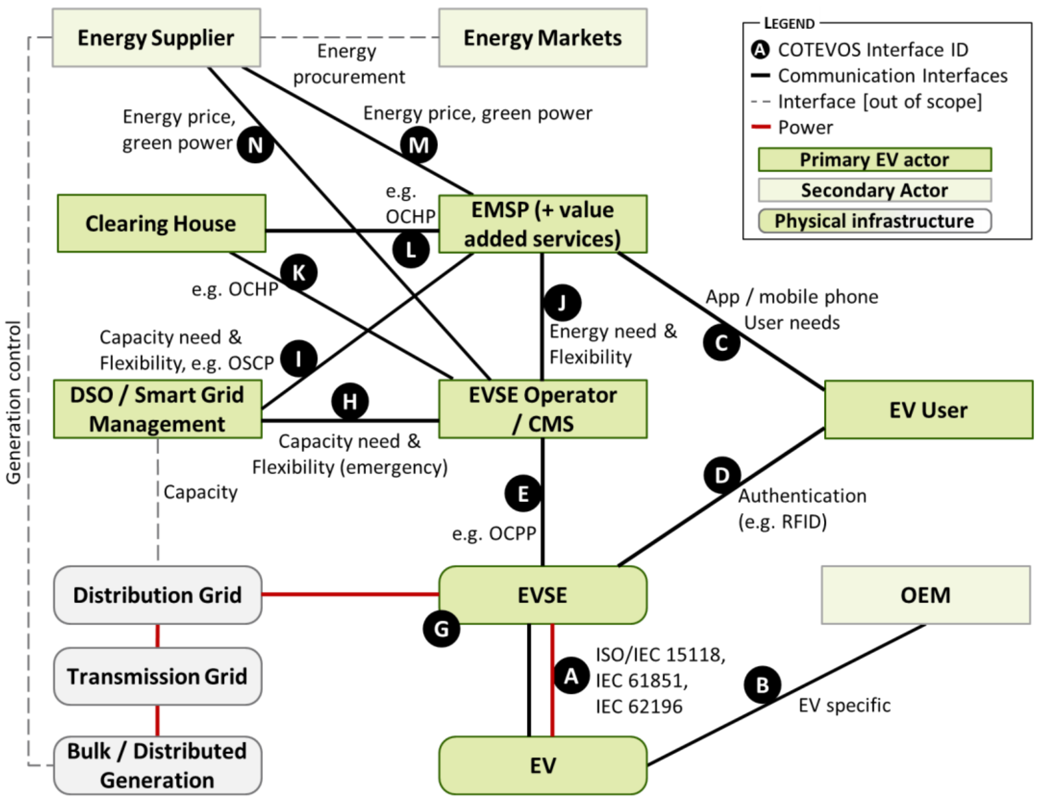

Figure 6: COTEVOS Reference Architecture, Layer 1 Actors/Interfaces (from COTEVOS-WB, 2016)

Several standards are mentioned and needed for this architecture. The most important current and future standards are (this list is still constantly evolving):

- IEC 62196, CCS/Combo2;
- IEC 61851;
- OCPP [OCPP-OPCA], (new IEC 63110 is in development);
- OCPI [OCPI-NKL], OCHP, OICP;
- ISO/IEC 15118;
- USEF, OSCP;
- IEC 61850.

The (not anymore up to date) COTEVOS deliverable 2.1 (COTEVOS, 2015) gives a good overview of different standards and developments.

Other topics in standards and interoperability that are appearing and need attention are:

- Accessible and open data: where are charging points located (static data)? Are they (dynamic data) available now?
- Privacy, security, data exchange, access and ownership.
- Smart charging, which is further worked out in the section on smart grids.

When procuring charging infrastructure or other E-Mobility infrastructure or services, demand the use of open standards. To allow innovation also allow alternative or new (emerging) standards, but to prevent vendor-lock in, demand the provider to show that other vendors are also (planning to) adopting these new standards (or easy capable in doing so).

4.6 Behavioral aspects: educating users to smart charging

TNO has conducted a by ElaadNL assigned literature study on behavioural aspects of EV users focused on smart charging, but also other aspects on adoption of electric mobility have been found. This has led to the development of an Innovation Adoption Framework (see figure below), partly based on literature (Ellabban, 2016; Frambach, 2002). Initially, the biggest issue was related to range anxiety: "can I reach my destination and come back?" This is slowly fading away now ranges of EV increase and charging infrastructure networks become denser.

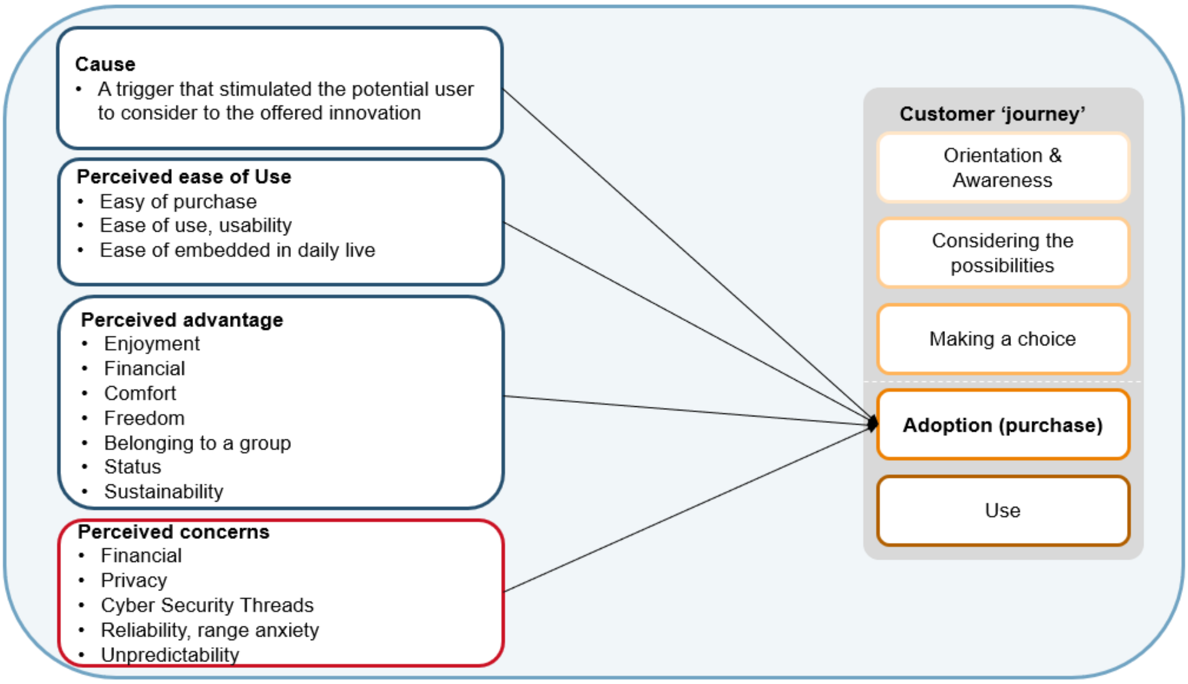

Figure 7: E-Mobility Innovation Adoption Framework (see also Ellabban, 2016; Frambach, 2002)

Based on this study the recommendations in this EV consumer behavioural field are (in this particular case for smart charging):

- Conduct research to segment the consumers in target groups.
- Design one or more propositions for these target groups.
- Verify these propositions, e.g. with customer panels.
- Technically design the proposition, e.g. a working application or solution.
- Validate proposition in experiments or pilots. Are the propositions working and accepted? Why or why not?
- Research the proposition as part of a larger E-Mobility application for a longer time. Does the proposition still fit? Which functions are used a lot, sometimes, never?
- Regular monitor use and progress, repeat previous steps.

Due to the limited charging infrastructure, it's becoming socially less accepted to occupy a charging point when the EV is already charged. In The Netherlands already exits a term of abuse for that: "laadpaalklever" ('charging point glue-er'), which became the word of the year in 2018 (Genootschap Onze Taal, 2018). Even special tariffs are being created when one is at a charging point but not actively charging. In future for smart charging, it will be beneficial to stay long connected to a charging point to enable different times and schedules of charging. So, one should be careful to steer to some behaviour that maybe later needs to be changed. Solutions can be found in clearly making difference (e.g. with colours) between fast charging locations, and slower (future smart) charging locations. Careful consideration of what to deploy as signals and required behaviour to consumers is necessary to also achieve a long-term and stable adoption of E-Mobility, it's applications and increased use of it.

4.7 Technology shifts: opportunities and threats

The present E-Vehicles became a viable option due to a breakthrough in battery technology: the rise of the Lithium-ion batteries. Designed as rechargeable energy storage for portable electronics like laptops and phones, they enabled (in larger pack-systems) electric driving. As good as the batteries in the present cars are, they are also a bit the Achilles' heel of the present EVs. The batteries are relatively expensive and relatively heavy. And while Lithium-ion technology is likely to remain dominant in this field, there are some new developments that may impact the charging infrastructure in the future. Below are some of the upcoming technologies that may influence charging infrastructure, listed:

1. Magnesium or Aluminium-ion batteries (Zhang, 2018), are, just like Li-ion, of the intercalation type (in which the electrodes behave as an ion "sponge"). A Magnesium ion being 2+ and Aluminium 3+, could -in principle at least- double or triple the charge density of the batteries compared to Li-ion. The trick is to find a host electrode material that can successfully store magnesium (slightly larger than Lithium-ion) or Aluminium ions (somewhat smaller than Lithium-ion). If development will be successful, these batteries could increase the specific storage capacities (in kWh storage/kg of battery) of batteries with a factor of two or three. If they are introduced, nothing changes for the charging equipment, although possibly the charging speed could be increased a bit.
2. Solid state batteries. This type of battery is in principle a lithium-ion battery with a very thin polymer acting as the electrolyte between the electrodes. This makes the batteries much more compact, lighter per amount of storage capacity and more rugged (and therefore also safer). Quite likely they would become an enabler for electric aeroplanes. The more rugged construction enables much higher current capacities of this type of battery. Therefore, if this type of battery will be introduced in electric vehicles, it will likely pave the way for extremely fast charging. The solid state battery hardly degrades from it and maximum charging speed could go up to 500 kW (roughly equivalent with 1800 km range/hour) for the typical battery pack in an EV. The existing lower power charging infrastructure stays the same and is still perfectly usable.

Only "fast" charging would be redefined if these batteries are introduced on large scale.

3. Hydrogen. An electric vehicle using a hydrogen fuel cell as the main energy storage is also an option. At this point in time, the advantages of hydrogen versus charging Lithium-ion batteries are only small: somewhat faster-refilling speed is counteracted by higher weight/ lower power, higher price and thrice (!) as bad energy efficiency. Still at some point hydrogen might become attractive as an energy carrier for passenger vehicles. This would particularly become the case if a hydrogen economy developed, in which hydrogen would be distributed through pipelines the same way natural gas is distributed nowadays (Bockris, 2013). Also, storage of the hydrogen in a carrier molecule such as formic acid, ammonia or sodium borohydride would be much better than 700 bar hydrogen (its present form). At present, a complete cross-over to hydrogen seems very unlikely. Even if hydrogen becomes an important transport energy carrier, there will remain a good base for battery electric vehicles. Therefore the charging infrastructure will remain very useful.
4. Wireless charging (inductive power transfer) could become an extra option. The advantage would be that no cables are necessary, and the inductive field can be guided to exactly the right spot. The EV must be fitted with a receiving coil and likewise, emitter coils must be installed either in or on the floor/pavement or in /on the wall. The method of power transfer leads to a few per cent loss. The additional electronics (basically a powerful medium frequency transmitter) are expensive though, and it remains to be seen whether car manufacturers and city councils or private parties will adopt the technology at any point.

4.8 Paving the way

"Creating a knowledge/service desk with answers to the most important questions in this field."

In order to accelerate the adoption of E-Vehicles in a country, it is very much worthwhile to create an information hub, where all knowledge on the subject is available in one place. At the knowledge service desk information about everything that is needed to start rolling out electric vehicles and charging infrastructure can be found. In the civilized West-European world, there are many stakeholders and procedures involved, and showing in a concise manner how to organize the electrification of cars in a region really pays off. Also, technically there are many options to choose from, and can be helpful for all new to the field to have a concise overview of the various options, their implications for the further roll-out of electric driving and the implications for the electric grid. As an example, and possibly inspiration, please have a look at the Dutch Knowledge centre for charging Infrastructure (https://www.nklnederland.com).

4.9 Smart Grid and the role of E-Mobility

As mentioned above several Smart Grid stakeholders and roles are becoming active in E-Mobility. Besides Energy Utilities supplying electricity, also the Distribution System Operator (DSO) becomes involved to prevent overloads of their network, ESCO's become involved in providing locally generated (PV) electricity to EVs, and aggregators collecting charging flexibility of EVs to exploit on various electricity markets. Although these players in principle are active in the broad smart grid domain, E-Mobility plays for them a crucial role since it are new and additional electricity loads. The load is relatively flexible but can generate high charging peaks, the EVs are mostly already connected via ICT and the initial users are not afraid of new technology and fast adopting new innovations.

Figure 8 sketches the likely relations between these and other smart grid roles, and toward the device (EV in this case) distinguishes energy from flexibility from power capacity (grid load).

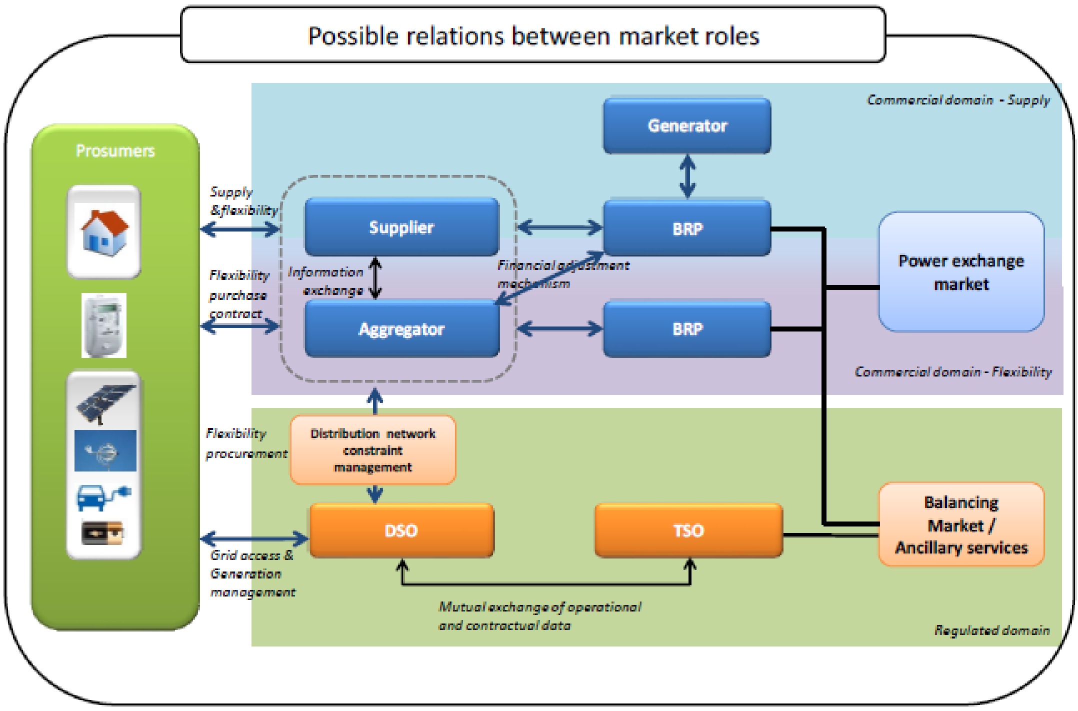

Figure 8: Possible relations between market roles (from SGTF-EG3, 2015)

Several actors and roles in this figure are also used in the multi aggregator Interflex architecture (Interflex-WP7, 2017) that is also using USEF (USEF, 2015), EFI (EFI-FAN, 2015) and OCPI (OCPI-NKL, 2017) as main interfaces and protocols. EV will be a key flexible asset, especially in summer because a lot of PV solar energy is then available and not much flexibility from heat demand (although in some southern countries flexibility from air condition systems is available). With smart charging, the surplus of PV energy can be charged into EVs and the peaks caused by EV charging in the evening can be omitted.

Smart Grid technology will enable Smart Charging. Valid business cases can enable or frustrate the take-off of smart charging. Depending on regulation and tariffs self-consumption of PV can become profitable. In that case, the EV charging will depend on local (e.g. PV) generation. When electricity markets offer real-time-prices to also consumers, smart charging on varying prices can become attractive.

In areas were a lot of EVSEs are available and used (like parking garages and shopping malls) the grid load can become high, and even overloads can occur, in these areas, smart charging will be applied to prevent peaks in the electricity networks.

Temporary storage of electricity in the battery of the EV can also be done. This is called V2G (Vehicle to Grid) since electricity flows from the EV to the grid. This is not yet often done, it requires bidirectional energy flow in the EV and charging infrastructure, but also attractive business models.
In smart grids, we will see a different combination of all these smart charging use cases and concepts. For that reason also innovations in smart grid technology need to be monitored while being active in E-Mobility scaling up and deployment.

5. Cross-city analysis of implementation factors

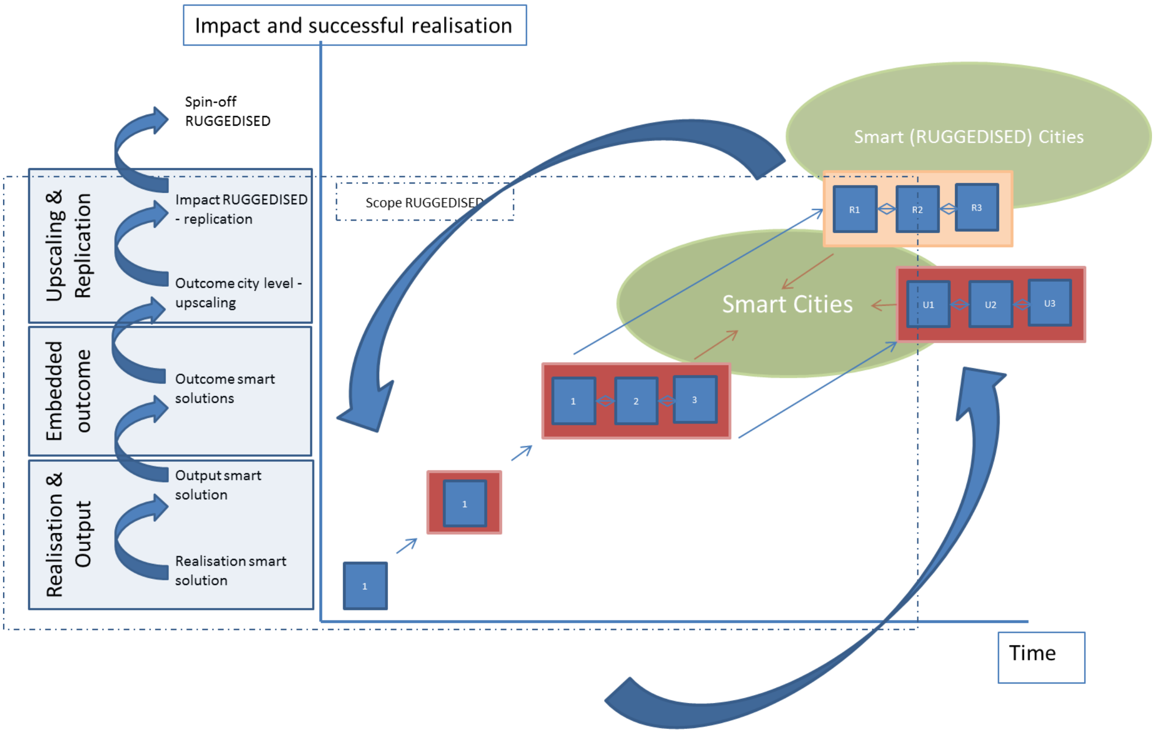

Figure 9: Overarching Innovation and Implementation Framework (RUGGEDISED, 2017)

At the beginning of 2017, the Liaison Groups were involved in developing an ‘Overarching Innovation and Implementation Framework’ for smart cities (RUGGEDISED, 2017). For the Liaison Groups, the framework serves two main aims. First, it identifies the areas where the lighthouse cities require expert support and cross-city knowledge transfer. These are the enhancing and suppressing factors that the participants will continuously discuss. The knowledge partners will make sure that state-of-the-art knowledge feeds into the cities’ processes. Moreover, they will enrich the (academic) literature on smart cities by analysing and embedding the lessons learned from the Lighthouse cities. Secondly, the different impact levels (see figure 4: realisation and output, embedded outcome and replication and upscaling) and different components (hardware, software and orgware) serve as a structure to improve the integrated smart city design The structure of the framework challenges the participants (of the Liaison Groups) to think of how the implementation of smart solutions can be embedded in the broader context of the sustainable impact. The framework should stimulate a smooth knowledge brokerage process, and therefore it’s crucial to jointly identify the issues at stake. A detailed subdivision between levels of impact and different components allows for such knowledge development and exchange.

Through distinguishing the steps of realisation, we can structure the factors that influence the implementation of smart solutions and their level of impact. For instance, some factors primarily affect **realisation and output** and some specifically enhance or suppress that several solutions together result in **embedded outcomes**. Other factors are in particular relevant for **upscaling and replication**. The framework ideally works in such a way that each RUGGEDISED smart city solution can be assessed on its potential impact on different levels while analysing in detail how enhancing and suppressing factors play a role for that particular solution. On the basis of such assessments, city planners and other actors can design a successful implementation process, assess the potential impact, and select specific aspects that need further consideration. It also works the other way around. Upscaling and replication is not something that comes after successful implementation. If real impact through upscaling and replication is pursued, then factors that influence the success of upscaling and replication should be taken into consideration early in the process.

For example, it might be problematic if a smart solution is fully-implemented without considering the requirements for successful upscaling or replication. From a RUGGEDISED or smart city perspective, the impact of successful implementation would then be rather limited. During the Liaison Group meetings, the framework serves as a reference. It allows TNO, as an organiser, to reflect on the progress of the different implementation factors. Moreover, it legitimises participants to broaden the discussion towards embeddedness, upscaling and replication, instead of discussing implementation hurdles on a very operational level.

Level of impact 1: Realisation and output of smart solutions		
Hardware	**Software**	**Orgware**
Pre-deployment assessment	Privacy	Business models
Technology assessment	Security	Data and data ownership
Impact on the energy grid	Smart Grid ICT	
	User Interfaces	
Level of impact 2: Embedded outcomes of multiple smart solutions		
Hardware	**Software**	**Orgware**
Communicating infrastructure	Interoperability	Integrated vision on the smart city
Robustness of the system	Dashboards	Smart governance
Existing infrastructures and vested interests		Windows of opportunity
Project boundaries		Stakeholder management
		Ownership
		Business models and split incentives
Level of impact 3: Upscaling and replication		
Hardware	**Software**	**Orgware**
		Integrated planning
		Innovation platforms
		Conditions for upscaling: finance, regulation (including standardisation), access to information and social aspects

Table 1: Implementation Factors defined by the Liaison Groups (RUGGEDISED, 2017)

The next three sections present the main lessons learned so far in the RUGGEDISED project, for each lighthouse city. The lessons learned have been discussed in telephone and face-to-face interviews with smart solution leaders. The lessons shed light on the implementation factors that have been listed above. Based on the lessons learned, chapter 6 discusses potential updates of the overarching innovation and implementation framework and sets out guidelines for the future Liaison Group meetings.

5.1 Rotterdam

Overall reflection on the process so far

The past two years have been difficult for most parties in Rotterdam. Especially for the ones who worked on solution R1. The implementation process of most smart solutions in Rotterdam is on track due to the intensive work form the city and partners.

Based on interviews with the smart solution leaders, this section presents and reflects on overall lessons learned so far per smart solution. Overall reflections on the lessons learned so far include:

- A good and clear collaboration makes the implementation of smart solutions easier. After the consortium was formed, all the partners started with lots of energy to work on their solutions, instead of figuring out what the right type of collaboration would be. A strong partnership between the parties can lead to a smoother implementation of the smart solution, because roles, expectations and deliverables will be more clear.
- A good collaboration in the RUGGEDISED team is also depended on the continuity of the personnel. It takes time to get to know a new face in the team, exchanging the latest information and building mutual understandings.
- Working on a smaller project in a bigger project can be challenging. RUGGEDISED is executed in the area of the greater project Heart of South. The latter project has a different planning, other parties who have nothing to do with RUGGEDISED and has other contracts. New agreements between the project leader from Heart of South and RUGGEDISED partners are recently made. Structured meetings have to improve the relationship between these two projects.
- The implementation of the smart solutions relies partly on the right connection between different levels and departments within the municipality. For the implementation of the smart solution the cooperation of other operational departments is necessary. For an overall strategic vision to become a smart city it is necessary to have the strategic levels in the organisation on board. A good horizontal and vertical coordination in the organisation could improve the speed of the implementation phase. But this is a challenging point to accomplish.

5.1.1 R1 Geothermal heat-cold storage and heat pumps

Description and aimed innovation

From the DoW: One of the main goals of the project is to connect the large buildings in the area e.g. the existing and new parts of the exhibition centre Ahoy and the adjacent Congress Center (ICC) to one thermal grid to enable local heat and cold exchange with a lower total cost of ownership. The buildings are connected by a low-temperature grid and each building will get a heat pump to provide in the heat needed. Thereby, it's still the plan to connect other buildings e.g. the new to build cinema and hospital, and the hospital to this grid, as well as a variety of other energy sources, will be connected.

Current status

The development of the geothermal grid has been delayed due to negotiations about the collaboration between the involved parties, and about contract details and finances. Eneco had to take over the existing heat-cold system from Ahoy, and Eneco had to open up the existing contract between the ICC and Ballast-Nedam to make contractual adjustments to install their installation. It took one and a half year to agree on a contract for collaboration between the parties, and it took another half year to agree on all the details in the contract. The emphasis of the negotiations was on jurisdiction, insurances and finances. All the contracts have been signed by the city council, Eneco, construction parties and Ahoy on the 28th of November last year. It's the expectation that the installation between Ahoy and the ICC will be up and running in 2020.

There was also a small change in the plans. The intention was to connect the 50-m swimming pool with the thermal grid. Due to a mismatch in the planning, it wasn't possible to connect the swimming pool anymore. And because of the long distance, it turned out that a connection with the arts centre wasn't profitable enough. There would be too much heat loss along the way.

Lessons learned on the most important implementation factors

- The learned lesson here is that if one works on a smaller project in the area of a larger project, you don't have the full control of your planning. Because of the planning and closed contracts of the larger project 'Heart of South', it isn't possible anymore to connect the swimming pool to the heat-cold installation.
- It also turned out that the current concession of another energy company (Nuon) in the area had a greater influence than everyone thought. The legal aspects of this concession were underestimated by all the parties.
- Another lesson that the parties learned, is that it is a challenging process to break existing contracts open. Especially the ones in which the finances are already fully arranged.
- The last lesson that has been learned is that it's better to find the right contact persons for negotiations before the process starts. This can save time during the negotiation process.

5.1.2 R2 Thermal energy from waste streams, R3 surface water heat-cold collection and R4 Pavement heat-cold collector

Description and aimed innovation

From the DoW:
R2: Besides the use of other thermal waste streams (RES) will be stimulated as much as possible by making further connections to the thermal smart grid. On building scale, the thermal energy from the wastewater of the showers in the swimming pool is retrieved to preheat the hot tap water without storage. On large scale, the district sewage water from nearby households is used to distract heat or cold from it and use it in the geothermal smart grid.
R3: A monitoring project on the energy potential of district sewage water in a direct combination of pavement heating and cooling is set up. With 1 m2 sewage heat exchanger, around 40 m2 of pavement can be kept frost free. Together with putting a heat exchanger under the surface in the pavement/road, heat and cold can be extracted from the surface and stored in the heat-cold storage system.
R4: Which at the same time leads to a frost free kept pavement in winter times, especially at the intensively used slopes of the bus station to prevent the bus from sliding. Also, a walking trail "red carpet" can be heated from the bus station to the Ahoy exhibition centre. In summertime the pavement is cooled, which raises its lifetime and contributes positively to the city climate and related heat island effect.

Current status

The execution of the solutions R2, R3 and R4 are delayed due to several reasons. At this point in the process the ideas for the solutions are clear, and the parties are aware of what they need to accomplish. Eneco finished their plan for solution R2, and is waiting for the approval from the city council. Solution R3 (sewage water) is almost ready to be implemented. The only thing that Eneco needs to develop is a water filter that prevents that waste from events goes into the system. Solution R4 is delayed because of the delayed design for the parking lots, cinema and hotel.
This design is crucial to Ahoy because they will lose some parking lots when the cinema and hotel are built, but they need to keep the same amount of parking lots for (future) events. There are several options to achieve this, such as a double parking garage or to integrate the parking lots with the cinema and hotel building. The plan should have been ready in December 2018, but this is rescheduled to the begin of 2019.

The planning of these solutions is also dependent on the event program of Ahoy. Because the carpark in front of Ahoy is partly closed to build the ICC, they can't close another part to build the other solutions at the same time. So the ICC has to be almost finished, and then all the parties can try to find a moment to implement all the solutions when there aren't any concerts or events.

Lessons learned on the most important implementation factors

- Since the implementation of these solutions is delayed, there aren't many learned lessons yet. But what already came out of this process is that it is a complex organization. Especially for R2 and R4 where many parties have to work together and are dependent on each other, and they need to match their planning.

5.1.3 R5 DC grid, PV and storage for mobility

Description and aimed innovation

From the DoW: There will also be a development of an electric smart grid. This electric smart grid by using PV-panels and Solar thermal panels on the surface of the roofs of the heart of south buildings will be installed. For feeding in RES in the grid, the challenge is the unpredictable production of PV and poor production in winter. To optimize and prevent gaps in the production of RES, it's necessary to install systems independent of sun radiation. Urban wind is a good choice there since with shaded weather it's often windy especially on the location of Rotterdam since it's close to the shore.
Since the existing grid at the bus station cannot provide all the power for quick charging electric buses of the RET, a challenge is how to make this in a low carbon and cost-effective way. Since there is a suited roof nearby the bus station, PV can be placed there and deliver the energy directly off-grid to battery storage at the bus station via a DC cable.
Integrating large numbers of electric vehicles as well as RES into the grid will doubtlessly have an impact on the grid itself. The challenge that ROT takes on is to realise a connection with a substantial amount of electric vehicles to the grid, as well as to feed this grid as much as possible with alternative energy sources. The commissioning of electric vehicles (mainly public transport) through the use of appropriate software (and data), will be the focus during the project. The impact will be described and analysed thoroughly.

Current status

The implementation of this solution is delayed due to a couple of reasons. First, the RET didn't install the solar panels yet. They are in the lead to place them on the rooftop of the bus/subway station. It's their ambition to install solar panels on every station together with the Metropol region. Second, the first supplier of the windmills has gone bankrupt, so the city council had to find another supplier for the mills.
The third reason has much to do with the electrical grid, smart charging battery and the busses from the RET. In an early stage in the process, the parties found out that the law doesn't allow to exchange energy between buildings via a closed electric grid. So, when the parties noticed this, Eneco started to look in two different areas 1) the south side with Ahoy and the ICC, and 2) the north side; the Heart of South area with the bus/subway station. For the north side, they conducted a feasibility study to batteries in general. The main result of this study is that the battery is technically achievable, but only when it is executed from some base assumptions. This means that maximal 13 out of 55 electrical RET-busses can load from different sources at the same time in the station:

- 5/6 busses can load from the local dc-subway net;
- 5 busses can load from the energy net;
- 1 or 2 busses can load from the smart charging battery.

In this time, it's up to the RET to decide when they want to realise the battery, and when they do they need to set-up a tender. Therefore it is still uncertain whether the RET will choose Eneco to realise the battery. But with the current assumptions, Eneco can provide a positive business case.

Lessons learned on the most important implementation factors

- The legislation about electric dc-grids formed a greater barrier than everyone first thought. Also, the governance between parties turned out to be difficult. Especially when there is tender in the process and parties are therefore less transparent to each other.
- The last thing that has been learned here is that it's difficult to set-up a business case for applications without subsidy. The subsidy takes the insecurities with innovation away, so it makes it easier for parties to invest.

5.1.4 R6 Smart charging parking lots

Description and aimed innovation

From the DoW: Since the area electricity grid is almost at its maximum capacity, it is efficient to use regular power but with 2-way energy flow. By foreseen smart charging at parking lots, peak loads are thus minimised. If in the future variable electricity prices are there, the car can be charged for the lowest energy prices, which indirectly stimulates a better usage of RES production.

Current status

The description from the DoW has changed in the last two years. The idea was that Eneco could install 25 bi-directional charging stations in the 'Heart of South' area. But because of another tender from the municipality, Eneco wasn't allowed to install these charging stations in the public area. Therefore, they came up with the idea to install the charging stations on the carpark of Ahoy. This will reduce the number of charging stations from 25 to 10, but Eneco wants to expand this amount in the future.

Another change is that Eneco won't install bi-directional parking stations, but the normal (one direction) charging stations. Eneco found out that the Dutch market isn't ready for bi-directional. Only Japanese car brands that are obligated to produce cars that can load and discharge are suited for bi-directional charging. So, most automobiles in the Netherlands (and even Europe) aren't ready for this way of charging, and therefore Eneco will place the normal charging stations.

Lessons learned on the most important implementation factors

- The lesson learned here is that it's hard to innovate when the market isn't ready for the innovation. Also, Eneco found out that selling bi-directional charging stations to carpark owners is not easy because of the uncertainties that the innovation brings along. With the current charging stations has everyone many years of experiences, and with bi-directional charging has no-one experience. So, it is hard to sell this when you don't know how long the charging stations will last without (technical) failures.

5.1.5 R7 Optimising the E-bus fleet of RET

Description and aimed innovation

From the DoW: The regional public transportation company, the RET needs to renew his bus fleet (now over 250 buses mostly conventional fossil fuel buses) from 2018/2019 and the target is to change the bus fleet significantly into a zero-emission bus fleet. Within this project, the upscaling to electric mobility of bus lines in the new concession period will be prepared. The challenge and innovation is to introduce zero-emission buses successfully on a large scale, while at the same time the reliability of the timetables of the public transport at all situations and at all times has to be guaranteed.
The RET needs to discover and explore the logistic variables which will be introduced by using e-buses on a large scale. A complex upgrade of the planning software used nowadays, therefore, is a necessity and this software will be purchased. The ICT system has to correspond with the charging infrastructure and the vehicles itself.

Current status

The development of the software took a little longer than planned because the RET didn't include all the relevant factors in earlier versions of the software. Examples of these factors were 1) the energy that the busses use when they aren't driving, and 2) the coupling of the employee work schedules and the schedule of the vehicles. So, when the RET found out that these factors also influence the energy levels, they improved the software. The RET is also waiting on a decision from the city council for the exact location of the charging station. This decision takes a little longer because of all kinds of procedures.
The MinBus module is ready now, and it has become an adaptive software that can handle new developments very well. In December 2019 the RET wants to introduce 55 electric busses and after two/three years another 50. In this way, the whole fleet can become electric, and the RET can start with the planning of shifts and routes.

Lessons learned on the most important implementation factors

- The main lesson learned here is that it's important to have an overview of which elements play a role in the operation of electric busses at the beginning of the process and to adjust the functionality of the software to this. Examples of important factors that influence the use of energy are driving style, cooling and heat, and the use of energy when the bus is not driving.

5.1.6 R8 Energy Management

Description and aimed innovation

From the DoW: A lot of data gathered as effects from all the different activities and energy measures come together and can and will be analysed thoroughly. Smart ICT-solutions will ensure that the demand and the supply of energy of all buildings and the public space (including sub-surface structures) involved are managed excellently. By connecting the gathered data to a data-exchange platform (defined server or cloud-application) subsequently the overall energy management system can operate the energy flows between the different assets (buildings and public space!) in the most efficient way. A dynamic continuously matching equilibrium between assets with a need of energy and assets with a demand of energy will become active. This approach yields deeper insight resulting in efficient and effective energy management of the entire area (but also maintenance). And with the knowledge of EUR-models, concerning also the economic analysis of energy consumption behaviour, the energy management will be fully optimised. Preventive maintenance and energy efficient behaviour is promoted.

Current status

Ahoy has recently agreed to use the energy management system form Symex (daughter company of Eneco). This system translates technical data to understandable graphics and key performance indicators so that users can use this information for managing their energy in an efficient manner.

Eneco is also talking with the companies of the swimming pool, the new to build ICC and Arts building to see if they are also interested in using the energy management system. If all the buildings are connected to the thermal grid, the information can be used for scientific research. This data will also be used for solution R3, the 3D city operations model.

The energy management solution is on track, but it is very easy for this solution to get a delay. It looks like a simple process, but it's pretty unique and complicated to get all the owners of the properties along. The owners must benefit from the system when they implement it and when they are willing to share their data. If they don't, they won't install the system, and the implementation of solution will be delayed.

Lessons learned on the most important implementation factors

- Since the agreement between Ahoy and Symex is recently made, there aren't any learned lessons yet. In this stage in the process, it's mostly about convincing users to implement the solution.

5.1.7 R9 3D-city operations model

Description and aimed innovation

From the DoW: The data concerning movement of the energy flows of the involved assets are furthermore transported to a newly developed 3-D city operations model. This innovative model is specially developed for and with the City of Rotterdam by SME Future Insight and is ready for implementation on a broader scale. The 3-D model in this proposal shows in 3-D the energy-aspects of the buildings in the Heart of South area. The use and savings of energy of each building will be made visible in real time. An energy surplus or deficit as well as the development over a period of time of the individual buildings as well as the whole area can be made visible.

Current status

This solution is right on track because the 3D model for the built environment is ready. The energy data for Heart of South is not delivered yet, but agreements that the data will be delivered through the main open data standard are made (see solution R8). The application of the 3D model in RUGGEDISED is a small part of a larger ambition of the municipality: the digital city program. In this program, Rotterdam wants to expand the model with more layers and functions, and this needs to be finished in 2020.

A first issue with the 3D operations model is that all kinds of data need to be included. It is hard to get the data, though, because most companies don't use open data standards. When the city council sets up a tender, they most often forget that they are (and will remain) owner of the data. A positive aspect is that more civil servants are becoming aware of the importance of the right agreements and start to use it more often. It must be said that not only the government is struggling with this topic. Most private companies also don't have the right knowledge about open data standards. A second issue is that private companies don't always want their data to be shared on the open web. This is because of privacy aspects and economic competition. A third upcoming issue here is that the 3D model itself doesn’t have a positive business case yet, the municipality is looking for a financial way to keep the model up and running in the future.

Lessons learned on the most important implementation factors

- The city council needs to arrange contracts in which they are the owner of the data and that the data needs to be delivered in specific open data standards. They need to make arrangements with the data source about the terms of agreements. What data can be made public and what needs to stay private? It's about making considerations in the privacy and security of the data. Oficials and private companies need to have more knowledge about this topic, in order to make the right choices.

5.1.8 R10 LoRa-network and R11 Efficient and intelligent street lighting

Description and aimed innovation

From the DoW: an important aspect of the project is the introduction and unroll of the KPN-LoRa network. The introduction of this network operated by KPN makes all kind of sensor techniques in the Heart of South area possible (and later on in the entire city and furthermore). At low costs, because the used technique ensures that therefore Wi-Fi or nowadays still expensive 4-G is not required and needed. One of the main first users of the LoRa network will be the public lighting system. Transport of data generated by the sensors in the public lighting will be made possible in an economic feasible way. And together with the newly developed and introduced ICT protocol AliS (Astrin Lighting interoperability Standard), all the public lighting hardware from multiple vendors can be controlled through a single portal. Measurements of all types of sensors can be read and analysed. The LoRa-network will invite both the public as private sector to develop and operate sensor techniques at large scale.

Current status

This solution is right on track because the LoRa network is not only developed for RUGGEDISED but as a new service that KPN provides. The LoRa network is already rolled-out in the country and can be used everywhere in the Netherlands.
The development of the network went smoothly, but now that it's ready to be used it is hard to find the right users. The LoRa network can be used for more than just street lights or waste management. KPN finds it challenging to get in touch with the right persons (who are willing to try something new/innovative) within the municipality. This has much to do with the internal knowledge about the possibilities of the LoRa network.

Due to personal reasons, it wasn’t possible to get in touch with the solution leader for intelligent street lighting within the municipality of Rotterdam. TNO will conduct an interview in a later stage of the process to make sure all information will be taken into account in 3/3 deliverable on the lessons learned.

Lessons learned on the most important implementation factors

- The lesson learned here is that it's essential to create awareness about sensor techniques and the Lora network within the municipality. People need to know what the benefits of the network are otherwise it's difficult to convince them to use the network. This is necessary for the further exploration of innovative applications.

5.1.9 R12 High-performance servers in homes

Description and aimed innovation

From the DoW: A final example of application is also to utilize high-performance servers in nearby homes, thereby creating highly distributed computing power (computing facilities, data centres) while heating homes for free at the same time and drastically reducing overall CO_2 emissions.

Current status.

A small start-up company named Nerdalize was designing the high-performance servers in homes. But last December they went bankrupt when an angel-investor pulled back their investment. The implementation process of the solution was in an advanced stage. Nerdalize and Ballast-Nedam almost signed the contracts when the news came. At the moment it's uncertain whether Nerdalize will make a new start.

It was a successful process to install the high-performance servers (cloud box) in 85 newly built (private owned) houses. The success was due to building strong relationships and understanding each other's wishes. For this solution, Eneco worked as a sort of mediator between the parties and brought them closer to their goals.

Another success was that Nerdalize succeded in finding a proper business model. They could offer a cloud for storage and calculation capacity for companies when all the cloud boxes were connected.

Lessons learned on the most important implementation factors

- The main lesson learned here is there was a window of opportunity to connect the real estate project to this solution. The parties took this opportunity and saw that relationship management is a critical aspect of the implementation process. Only in this way, they could overcome the uncertainties around innovations and create a new business model.

5.1.10 R13 Smart waste management

Description and aimed innovation

From the DoW: For garbage disposal, in total, in Rotterdam, 2,600 kilometres per day are driven (R4B). Smart waste traffic is achieved by using sensors to measure the degree of filling of the containers. For transporting these data the possible use of the LoRa-network will be explored and the data will be monitored via a central portal. The purpose of the measure is a reduction of 20% of the number of kilometres driven. This results in a CO2 reduction of 280 kilograms of CO2 / driving day (728.000 kilograms per year), besides of course a saving of, still mostly fossil, fuel costs. After the pilot in Rotterdam South for a route to retrieve waste paper and after analysis and any amendments thereof, the system is provided to roll out the measure to the other types of waste by the end of 2018.

Current status

The smart waste management solution is on track. The solution is part of a larger ambition from the city of Rotterdam. This ambition started in 2015 with a pilot with 250 underground paper bins that were connected with networked sensors that can measure the level to which each container is filled. The aim was to examine if fill-level information could lead to a more efficient collection with environmental and cost benefits for the city and citizens. During the pilot, a dynamic waste collection system was developed and tested.

The pilot went great, collections reduced from 5 days to 3 days per week and from 10 routes per week to 6. After the pilot, the Municipality took a decision to fully implement the system for all underground waste containers in Rotterdam, and in January 2017 the Municipality issued a public procurement process. The ‘Best Value Procurement’ method was used for this. It was set up in such a way that the Municipality will buy the ‘service’ of providing a system that leads to cost reductions.

Currently, 6500 containers are provided with sensors and new routes are being developed. In 2016, there were 207 routes per week now there are 30 dynamical routes, and this needs to extend to 160. The new dynamical routes have to be ready in the third quarter of 2019.

Eventually, the municipality (together with KPN) didn't choose to use the LoRa network. After an exploration, they determined that the use of the Lora network was too risky because the results of the sensors of the LoRa network were not stable enough. And KPN had to pay a fine for each day that the system wouldn’t work, so KPN decided not to invest in this network. So, now the 'normal' GZ-cards are used for the sensors. In the future, it's the ambition to use the data from the sensors for the strategic positioning of the containers. A dense infrastructure of containers must lead towards more separation of waste and therefore the ability to reuse materials.

Lessons learned on the most important implementation factors

- A cultural aspect: involvement and engagement of employees are crucial. Engaging and communicating with truck drivers whose work was affected by the new approach turned out to be one of the key enablers of the success of this pilot. The new approach required more flexibility from the truck drivers and the ability to learn new routines. The pilot, therefore, started with some volunteers that were used in a later stage as ambassadors for the approach.
- Well defined pilot conditions are crucial to observe the benefits of the pilot. The pilot was carried out in an area that didn't change during the pilot. So, the changes in collecting waste were related to the pilot and not to other factors.
- It's necessary to precisely define the frequency of data communication by the sensor. Initially, the frequency was set on once a day, which led to situations in which the container became full after the route was planned. Also, the suggested routes were based on minimum levels of fullness for the containers. However, with more advanced algorithms, it can also be determined when it can be efficient to empty half-full containers along the planned routes.

5.2 Umeå

The implementation process of the smart solutions in Umeå is well on track. Based on interviews with the smart solution leaders this section presents overall lessons learned so far and reflects on lessons learned per smart solution. Overall reflections on the lessons learned so far include:

- The development of a very strong partnership is crucial. Specific technologies and innovations are complex, however, it is really challenging to connect all elements with each other. That means that smart city development is based on understanding the interests that are at stake. A successful implementation relies on co-creation and optimising the whole, instead of aiming for partial gains. Everybody can see that this is true; however, in real life real co-creation is a complicated challenge.
- Political support is very important. This strengthens the position of the innovation project within the entire city administration, but also in a relationship with other investment partners. In Umeå, there is lots of political support. While working on the project it keeps being important to fully appreciate the political interests. This is also a co-creation exercise and requires collaborative framing.
- Successful implementation relies on smooth connections between different levels of the city administration. Becoming a smart city is a strategic decision and should be coordinated from a strategic department (this also counts for other partners). However, most smart solutions will be implemented by operational departments and teams. Continuous dialogue and mutual understanding are challenging. Ideally, the people implementing the smart solutions should have also been involved in the proposal phase. However, due to time constraints this was not possible everywhere. The advantage of involving people at an early stage is that implementation could be faster. However, a potential risk is that the bid would be less innovative.
- Personnel continuity. Developing a team is crucial. Changes in personnel are always hard to deal with, due to the time it takes to again build a mutual understanding.
- Continuous learning and upscaling. The people working on the RUGGEDISED project learn a lot on urban innovation processes. There is a need to share these learnings and to educate the entire organisations that are involved. That is a crucial step in making RUGGEDISED a success for the entire city, now and in the future.
- RUGGEDISED is based on a holistic way of working. This way of working is already 'upscaled' in terms of planning processes. Basically, in Sweden, the city government has a planning monopoly. The government decides what it wants and invites partners to implement. The sharing economy idea surfaced the necessity to involve integrated views, creativity and openness at the beginning of the planning process. This is what Umeå is currently changing, based on the lessons learned from RUGGEDISED.

5.2.1 U1 Smart City connection to 100% renewable energy and U3 Geothermal heating/cooling storage and exchange

Description and aimed innovation

Demonstrate business model to add value of shared energy solutions, to optimize PV/solar energy production and battery storage, possibilities for control and optimization based on a smart grid concept. A challenge is the quality issues and optimization from an overall perspective, how could we further develop the monitoring, power quality, prevent disruptions etc. All actors have to be involved in the process of optimization in a cooperative manner. Actions include an analysis of peak load and energy durations at an aggregated level of the district, define and establish optimization boundaries for top load shaving, energy optimization and more. We will establish a business model testbed: Identify value proposition, cash flow, Stakeholder dependencies, risk mitigation and more. This will be monitored and measured for evaluation and conclusions. Business model(s) for sharing of a new geothermal heating/cooling storage in the area will be tested in order to secure the delivery of heat and cold during the extreme variations of climate/temperature of the four seasons in Umeå (+30C to -30C).

One operation may have an excess of heat/cold when the other is in need of it. The underground storage could be loaded from all operations/buildings and used by all when needed. The advantage is that the need for heating and cooling vary as different buildings in the innovation area operate at different times during the day and also during the year. The impact of this is both energy and maximum power savings and includes a business model that builds on sharing economy instead of the traditional ownership of the production. Activities will include the mapping of the exchange of heat & cold and to identify how the small scale production in the area could integrate with the large scale production of local district heating grid, in order to achieve the most effective and efficient outcome for the whole district/city.

Current status

The smart solutions have delivered a complete set of theoretical options of how an optimised neighbourhood energy grid looks like in terms of economic and climate performance. These options are paralleled with organisational and business models that are founded on the idea of sharing costs and benefits. The actual investment does not fit in the RUGGEDISED time frame. The partner emphasises that it is a lot of work to implement the innovative business model in the different companies. The business model is not a traditional way of contracting. The partners are thinking of introducing smart contracts, perhaps using blockchain.

The partners established different cases in which they were interested (which could lead to 100% fossil free energy consumption – for example, a boiler, heat storage, geothermal storage). Parallel they made three business models, using different buy-sell relations and hardware ownership: 1) Traditional buy-sell model relation with individual ownership of investments, 2) JV – model with mutual commitment and investment between shareholders, and 3) Cooperative model- a local energy market of individuals cooperating in sharing energy. These three business models have very specific characteristics around ownership, risks, interest rates, and values. The partners analysed these different models in different cases on their environmental impact and financial parameters. The result is a holistic matrix of all cases, business models and all partners. Next step is trying to establish how the business architecture should change to promote this business model. It's quite an extensive challenge.

Lessons learned the on most important implementation factors

- An area oriented business model, based on sharing economy ideas, really is a novelty and differs significantly from how partners (in Umeå, and elsewhere) used to think. Collaboratively partners analyse the entire energy value chain and try to understand each other's interests. It is a holistic approach towards the value chain and the aim is to see if it is possible to recover and reuse energy along the value chain.
- The original focus was on 100% renewable energy. This ambitious goal was important for two reasons:
    - The main goal was 100% renewable energy. This gave the partners another view on how to manage the process. If one wants to go into this partnership, everybody needs to be very transparent on their interests, otherwise, 100% renewable energy is not possible. You can't hold information for your own. 100% renewable energy is only possible if you seek win-win situations.
    - Partners understood that focus should be on understanding the interests at stake and exploring different scenarios of cooperation. The process learned that exploring the cooperation models (without a focus on and stress of concrete implementation) helped the process of mutual understanding.
- The partners realised very soon that one of the main obstacles was the lack of data. Traditional ways of speculation, statistics and forecasting do not suit flexible market exchange. The system needs to change automatically based on needs and tell how much money one gets.

This process can't be noted in a contract (all these different hours and prices, etc). The partnership hired a PhD student to get the data right. First thing was to establish a baseline by collecting a lot of data from the production units of all partners. Exchange models should be based on real data, to improve trust and certainty.

- Different 'languages' are always a challenge. This is also true for valuing the environmental gains. Some of the business models show high environmental gains. It has a value for climate purposes, but in economic terms, the value is not that high. For decision makers, it is important to have a full overview. The partners try to list all the values for different solutions.
- VLL and Umeå Energy are currently experimenting in another project with the sharing business case. Every discussion will be about who has the best benefit of this solution. The challenge within RUGGEDISED is to upscale to three partners (including Akademiska Hus).
- One needs to calibrate the internal interest/investments/interest rates and be very transparent on this. The partners have been looking at different investments cases in which they are all involved. Umeå Energy is selling energy to Akademiska Hus and VCC, and energy reductions will therefore lead to lower energy revenues for Umeå Energy. The benefits are for VCC and Akademiska Hus. However, if you opt for a joint venture, you can share values and it becomes more promising. Then one needs to calibrate. Interesting thing is that the business model that opens up for new investments – joint venture – is most likely to make it happen. In a joint venture, you are tied up and not free to leave. But the partners are most likely to exist in the long term – so it's not a to big risk (comparable, for example, to a startup). A joint venture is more likely to produce more relations and more energy savings.
- Moreover, once implemented such flexible business models should also be 'educated' to every user within the organisation: including maintenance etc. Everybody involved has their own way of controlling the system. It can be a challenge for them to give this up and embrace the new system. As long as there is leadership that points the direction of a flexible and holistic value case, everybody must follow.
- The partners are all publicly owned. They are not profit maximising partners.

Suggestion for the Liaison Group meeting. The business models are interesting but also the digitalization of the business models and how they are implemented. A real-time software tool that shares information/data with some kind of blockchain.

5.2.2 U2 Peak load variation management and power control

Description and aimed innovation

By using the buildings as thermal energy storage it is possible to even out peak load variations of the buildings, whose structure itself functions as an accumulator of heat energy. Depending on the composition of the structure of buildings, more or less heat can be stored and used for "load shaving". Within this solution, additional monitoring (sensors) and energy management units will be installed in the buildings and programmed according to the building physics, weather conditions, tenant activities and other parameters. The energy management units are also configured to communicate with other buildings in an open network cluster where a web-based information platform will be developed and results shared for benchmarking purposes. The information platform will involve parts of the campus area, the hospital and the students' apartments. In terms of impact, this measure can guarantee a reduction in energy consumption for heating of about 2-8%, depending on building physics and the type of activities of tenants (living, health services, trade, academia, etc.).

Current status

This smart solution is up and running. The campaign started off saving heat in the campus/hospital area. The campaign is in full progress (up to March 2019) then the partners will sum up and evaluate the test runs.

Lessons learned on the most important implementation factors

- The partners have tested this technique in residential buildings in other projects. RUGGEDISED will gain knowledge on the difference between the application of the technique in residential areas compared to office buildings and hospitals. It will have different heat and ventilation requirements, with different user times. Ultimately the smart solution will shed light on heat loads in different types of buildings and see how this influences the optimization mechanisms of peak load variation.
- The smart solution helped the partners to install sophisticated power measurement tools - a service for investors or customers to analyse their electrical grid. Predicting and avoiding peak loads significantly improves the quality of the grid and, reduces costs and improves climate impact.
- In terms of upscaling: without RUGGEDISED VCC wouldn't have experimented with this technique. In financial terms, VCC is not really benefitting from it now. The only partner that benefits from lower peak loads is Umeå Energy. However, if it works on a larger scale, in all hospitals of VCC, it should be posible to make a positive business case for them.

5.2.3 U4 Intelligent building control and end-user involvement

Description and aimed innovation

An intelligent and integrated control system for the internal climate will be installed in new apartment buildings (Lilljansberget) in the university city demonstration area, with the potential to allow for the continuous analysis of energy performance as well. By modifying ICT suited for commercial buildings, in private homes, the purpose of this action is to involve private homes in the improved energy performance of the whole area. The energy consumption attributable to end users makes up about 50-70% of the total energy usage in a building. The integrated control system will enable exploring how incentives can make the tenant choose to put their flat in "home or away- mode". As the flats are mainly student flats and guest scientist homes, the "away-mode" would at times be long-term and the potential for savings large. Sensors will be installed in order to better measure the outdoor climate in combination with the internal activity of the building, allowing the optimisation of the indoor climate depending on the weather, thus reducing energy use. An analysis tool in the building monitoring system is aided by sensors in building and HVAC systems to evaluate current status in relation to perceived optimum.
An implemented system enables fast building energy status appraisals. With this experience, a model for end-user involvement at workplaces will also be tested, well aware of the constraint that it is difficult to find direct incentives as the action does not directly affect the end user. In addition, Akademiska Hus AB will install automatic smart control equipment to control air volumes, room climate and lighting for the presence and needs of 130 offices at the University area. The rooms connected to a parent monitoring where settings can be made and the current status reported and stored. This action will reduce heating demand, electricity use for fans and lighting and better room control resulting in a better climate for the workers.

Current status

Smart Solution U4 is divided into part A (private apartment buildings) and part B (office buildings). The smart solutions were delayed. The smart flats were planned on a specific location, but the partners needed to switch locations. Umeå Energy is installing software and hardware and developed a game to show energy consumption and behavioural change.

Lessons learned on the most important implementation factors

- Choice of the technical system. So far the partners have decided what system they want to use. They decided to choose the one that is already being used in Sweden and that can easily be applied in all VCC's real estate. No need to develop an newly tailored system.
- Baseline data and control group. Since the houses were recently built, no control data was available. Due to that reason, the evaluation of the smart solution was postponed until next year.
- Behavioural change in Sweden. Sweden is very good in technical solutions regarding smart buildings. So the problem is not to become even better, the problem is to let people use the system in the way you want it to be used. The focus is on educating technical or maintenance people, to learn them about temperatures and how to change behaviour. Partners are building a lab where people can try out some scenarios with the installation (air, heat, cooling and lamps). Moreover, instructions have been written on how to optimally use the system.

5.2.4 U5 Energy optimised electric BRT-station

Description and aimed innovation

From the DoW: The demonstrated electric buses are designed to operate in the cold climate of northern Europe, but a challenge is the heat and energy loss during the boarding procedures and the bus needs to be heated inside. In order to handle the heat loss, consequently and ensure range capabilities, every time the bus stops to let people in and out in the busy innovation area, a new electric "Bus rapid transit station" hub will be developed within the campus area. These will be provided with shelters, heating systems, an intelligent ticket identification system using smartphones before boarding and an insulation structure to minimize energy loss from the boarding procedures. A new partnership will be formed for this business case to happen, as the area where the bus needs to pass and stop, has two different landowners (VCC & AH) and another owner of the road (UME).

Current status

This solution is well on track, because the buses have been procured.

Lessons learned on the most important implementation factors

- Umeå had a solution to the problem of buses losing to much heat during transfers. However, in the new procurement phase a Dutch company won the bid. Their buses do not fit the innovative transfer station that had been designed and developed. The doors of the buses are not at the same position. This design requirement was not made explicit during the procurement phase.
- The new buses are different in many ways. They are better, so Umeå does not care so much about the doors any longer. Moreover, the busses need different charging infrastructure as well.
- This solution is also focussed on getting more people to use public transport. Umeå is experimenting with free bus tickets that are included in rental agreements of houses. For instance, related to U4. If people indeed save energy they get rewarded by free bus tickets.

5.2.5 U6 E-charging hub/charging infrastructure

Description and aimed innovation

E-charging facilities will be essential to ensure the rollout of E-Vehicles in the area. A charging hub for E-vehicles will be tested, with charging facilities for E-bikes, E-cars and car-share. By installing PV plants along with energy storage, advanced monitoring and governing systems and charging points of electric vehicles within the innovation area, good results will be gained in terms of reducing building energy consumption, as well as systemic effects such as decreasing peak loads. Different batteries and storage solutions will be tested within the project. One example is that the area holds of a large number of workplace parking spaces and every parking has an electric engine-preheater that all start running around 3 pm, a few hours before people are planning to leave work – and the power system is already under strain at these hours. Additional E-Vehicle charging adds strain to the system. Therefore a smart power control management system, including a dynamic payment system for the charging, will be tested. We will also seek to explore how these small-scale PVs can integrate with the overall system in the best way and how the battery storage can be upscaled.

Current status

This smart solution has been delayed due to technical reasons. The original location was not suitable for parking (not enough space) and there were some issues with the existing energy grid.

Lessons learned on the most important implementation factors

- It is crucial to get a clear and shared idea of the aim that is pursued and showed in a smart solution. For this smart solution it was not quite clear from the start. It has been a long process to work out what the partners wanted. The local combination and optimisation of EV charging, solar panels and battery storage can have several configurations. It is very interesting to optimise this value chain, taking into account that summer and winter time differ significantly in Umeå.
- For Umeå Energy decreasing peak loads is an important factor as well. Batteries can significantly improve the quality of power.
- In terms of the benefits – to have a huge battery and rapid charging station, it's more expensive – who is going to benefit? What is the business case? This is an actual search. There are lots of taxis outside the hospital waiting for a customer. It's a really good opportunity – when giving them a place to charge when they are waiting, that the taxi company would see it as a possibility to change from fuel to electric cars. They need more chargers in the place to charge their cars.
- For the city of Umeå, it is important to experiment with different configurations of EV charging and to be keen on learning the lessons. In order to upscale EV charging it is wise to pick the best configuration. The city is the initiator of mobility hubs in new areas. EV is an important part of the overall mobility strategy. There should also be charging stations at the service hubs where people can change from their own car to shared vehicles.

5.2.6 U7 Energy-efficient land use through flexible green parking pay off

Description and aimed innovation

The activity will focus on implementing a new business model in the campus/university city area, enabling a reduction of car parking spaces and directing developer investments from parking towards sustainable mobility solutions (E-car sharing, E-buses, E-cycling etc), thus reducing the climate impact and overall energy use. The business model will be an extended version of the Green Parking Pay-Off model that has been developed for commercial buildings in Umeå, and will now be applied to residential buildings as well. The evaluation model designed for a pilot study indicates a 41% potential for modal change from car to car sharing, public transport, cycling or walking when all the foreseen sustainable mobility measures are implemented. According to the evaluation model, similar energy savings on fossil fuels (40+ %) is expected from the introduction of this new business model. This will be enhanced by the integration to the Smart Open Data Infrastructure (T2.4). Some of the data collection needs to be complemented by traffic and movement sensors that will be analysed to monitor the progress – but also processed into information services (by web &app) for people living-, working- or visiting in the area. A multi-storey car park will be built during the project and the planning for this (and later two other) will build on the results from this solution. As part of the Pay-off model, the property builders will invest in, for example, E-car chargers and E-car share system for the new residential areas.

Current status

This smart solution is on exploring business models that are suitable to use revenues of building in higher densities for smart and sustainable mobility applications. The aim is to really implement the suitable business models, however, it is not yet clear whether that will succeed within the RUGGEDISED time frame.

Lessons learned on the most important implementation factors

- Building partners will not be obliged to participate in these new business models. They will be offered several deals (small, medium, large) in terms of green/parking payoff. If they invest in large projects to stimulate smart and sustainable mobility (or put money in the city's mobility fund), they get to build higher density.
- It is hard to really monitor the impact on the mobility flows in the city, especially due to current roadworks that are being undertaken.
- It is hard to influence the types of households and people that are going to live in a particular neighbourhood. A particular area was meant for students. However, due to its central location, young families started to live there. The challenge is to know the exact deals that suit each area as Umeå does not know who the people are that will move in there.
- There is also a time element. People can choose to not buy a car when buying a house (including public transport access), however, it is hard to say that these people still do not have a car within three years. This is a huge political and financial risk.

5.2.7 U8 Smart Open Data city Decision platform

Description and aimed innovation

From the DoW: The solution aims at the integration of existing and new ICT solutions into a Smart City Data infrastructure based on Open Data principles, and connection to a City Decision Support platform. Smart Cities have a strong dependence on data. At present, strategic data is locked-in in different operational systems making it hard to reuse. Hence, the more data that becomes available, the easier it will be to integrate it with other data. Moreover, the more predictable the business logic is for the re-user, the more smart innovations will see the light of day. This will be achieved by the Smart City Data infrastructure. The infrastructure will provide data of the city's energy consumption, energy production, buildings and technologies involved and human behaviours, complemented by non-technical artefacts such as business models, support processes etc. The local lighthouse partners collect huge amounts of information and data, for example on buildings energy performance, land use, planning, human behaviour etc. Separately from each other they are used for smaller improvements of energy performance etc, but integrated with each other they have huge potential to improve energy savings through collaboration and knowledge, cost etc. on a district- and city level, as an input into urban planning and co-creation processes. Some of the data are collected and some are missing so there is also a need to set up new sensors for the missing data to be connected to the innovation area.

Current status

The development of the open data platform has been delayed due to personal reasons. It took a long time to convince everyone in the city administration that this smart solution is important. From January 2019 onwards, Umeå has hired a new IT project manager for this smart solution who is able to bridge these gaps.

Lessons learned on the most important implementation factors

- In Sweden people are not used to the concept of open data in the urban context and there is a public discussion going on about personal integrity issues around open data. RUGGEDISED will arrange discussion forums and workshops for citizen involvement in order to overcome these general public barriers. The city believes that in practice these barriers will be lowered by not only making the data open, but also make it understandable and user-friendly to the public through the web and mobile applications as smart city services to the community.

- People's need to access the data, as well as automatic integration and interpretation (for machines/PCs) based on the meaning/definition of the data created with different semantic techniques, will be considered in the infrastructure's design.
- It was a long process because everything that one does with IT in an urban environment is considered complicated (security, launching a new system, open data is 'scary'). So in order to well develop such a solution, it is important to bridge the 'language' and 'vision' gap between the strategic city level and the implementation at IT department level.

5.2.8 U9 Demand-side management

Description and aimed innovation

From the DoW: Floor space drives energy use, and is thus a strategic decision-making criterion in area management. Umeå University with its 250 000 m2 of floor space, will test multivariate analysis tools for predictive analytics which will support the decision process concerning tenant area use is the most powerful way to reduce energy consumption by the end user. Facility services adaption trough predictive analytics derived from the flow of students connections to the wireless net. Facility services such as cleaning of floors, technical standby and waste management traditionally operate on schedules and contracts. By studying the flow of people through connections to the wireless system and validating data by behavioural and informatics studies the adaptive possibilities increase enormously. If we can predict and adapt the services to actual behaviours and/or manage behaviour we can lower energy consumption the hours when facilities are off-peak. The University will work together with a contractor to set up the Smart monitoring system and the area manager will develop the tool for maintenance and power control. One challenge is to be able to meet the growing number of students and scientists, thus the need for more area space in the University, without building new buildings and therefore increasing the need for energy. Caution has to be taken in order to avoid the solution becoming a surveillance activity only the flow of groups of people will be monitored and the students will be involved.

Current status

This solution fits solution U4b - offices. This solution is on track, because the software is developed and sensors are installed and this should lead to an optimised use of floor space and priority use of those rooms and spaces that are best in terms of energy performance and air quality. Moreover, cleaning staff will be optimally deployed by cleaning only those rooms that have been used recently.

Lessons learned on the most important implementation factors

- Partners work closely together with the students and university to understand how the demand side management system can optimally be designed according to the latest insights of behavioural change (theory). The hardest challenge is to change people's behaviour and to find the right incentives and information provision for people to change their daily (work)patterns.

5.3 Glasgow

The implementation process of the smart solutions in Glasgow is well on track. Based on interviews with the Glasgow coordinator and several smart solution leaders this section presents overall lessons learned so far and reflects on lessons learned per smart solution. Overall reflections on the lessons learned so far include:

- Most smart solutions are 'invisible'. The time and effort that should be put in communication and engagement with stakeholders (for instance the potential users of the smart solutions) was under estimated. Smart city development requires a careful stakeholder strategy to improve the success of smart solutions.

5.3.1 G1 Heat and Cold Exchange

Description and aimed innovation

Within smart solution G1, two business models facilitating the connection and heat/cold transfer between facilities in the district: one between the University of Strathclyde and the City Chambers Complex, and the second between Tennents Caledonian Brewery and a housing complex of the Wheatley Group. In addition, as part of the smart solution, the effectiveness of the connections will be verified by monitoring the facilities before and after the connection to the district heating. Last, a suitable battery and battery/grid interface controller for deployment in the district will be identified and developed to maximise local use of renewable sources.

Current status

This smart solution has delivered a confidential report D4.1 Business Model Allowing Buildings to Sell Heat in Glasgow. This report contains the final contractual model template that has been developed in tandem with growing national support and regulatory development in Scotland and the UK. This contractual model template has also been developed through consultation with local stakeholders and provides the basis upon which future district heating connections will be based on a contractual perspective. Finally, the report also contains guidance documents to support the use of the contractual model template for connecting district heating consumers and generators and ensure continuity of its application across developing networks in Scotland, the UK, and across Europe.

Lessons learned on the most important implementation factors

- The contractual model template produced in collaboration with stakeholders serves as a foundation upon which to start any discussion around potential district heating projects involving Glasgow City Council in the future. In addition to the contractual model template, notes were produced to provide additional guidance to users when utilising the template contract.
  These notes are intended to guide users to identify and select the most appropriate set of options for a particular heat requirement, and to facilitate a tender process that encourages competition on elements that deliver real value. The notes rely heavily on the work done by Scottisch Futures Trust [SFT] in analysing the relevant issues and reflected in 'Guidance on developing Heat Supply Agreements for District Heating schemes' published by SFT in February 2018
- In addition to providing Glasgow City Council with an informed proactive position and a set of reasoned contractual expectations upon which commence any negotiations in forthcoming district heating projects, the intention of the final contractual model is to focus prospective parties on the key issues, reduce the scope for extensive negotiation, improve the prospects of early agreement and overall deliverability, and minimise the time and cost spent in getting a heat supply contract in place.

- The contractual model template reflects an allocation of risk that an external lender should, in general, find acceptable, in that allocated risks can then be passed down to and appropriately managed by contractors and others. However, amendments may be required to deal with project-specific issues and specific lender requirements. However, these cannot be known at this stage.
- Lastly, an agreement based on the contractual model will be the product of a procurement. An additional guidance note, covering heat supply related issues, has been obtained which identifies the relevance of procurement regulations to the supply and purchase of heat, and possible structures that ensure compliance while facilitating early project delivery.

5.3.2 G2 Battery Storage technology as a grid balancing mechanism

Description and aimed innovation

The development of an electric vehicle parking hub, utilising space within an existing multi-storey car park in the city (Duke Street) will incorporate innovative solar PV canopies, creating renewable energy for the charging of the electric vehicles. When demand for charging is low, the power generated by the solar canopies will be stored in batteries for later use. The aspiration is to minimise the amount of energy being fed back into the local electricity grid and ensure that power generated is either consumed immediately or stored locally for consumption when demand is high or local generation is low. There is potential to use the battery for grid support, and the project will further explore the extent of the grid balancing opportunity in relation to the connected assets and the existing electrical grid infrastructure.

Current status

This smart solution is currently in its procurement stage. A lot of effort has been put in modelling the optimum set-up of the infrastructure and battery size. All current options are compatible with DSMC and GIC technology. Two procurement lots will be run to allow the best mix of delivery partners and technology. The procurement was planned to begin in September 2018, however, the process requires a detailed procurement process which takes up time.

Lessons learned on the most important implementation factors

- Battery technology is a rapidly changing field. As the investment in the battery is subject to procurement, the procurement team of Glasgow City Council is currently involved in this smart solution. It is a search to bring together the significantly different rationales of strategic urban innovation projects on the one hand and - inherently risk-averse - judicial expertise on the other hand. The idea came up to develop an urban innovation education module to intensify the cooperation with procurement and contractual affairs within smart city public administration.
- A lesson learned here is that it is better to explore different possibilities with the batteries and grid, before choosing an option and not knowing the consequences. Therefore, they want to see how various battery services, such as grid balancing, work out in practice and influence the business case. Based on these results upscaling to the other public car parks will be considered.

5.3.3 G3 TCB CHP surplus power storage in EV charging hub battery storage

Description and aimed innovation

In addition to the storage of electricity generated by the solar canopies, the potential to store surplus electricity from the neighbouring TCB energy centre exists and the project will look at the detailed feasibility of doing so in addition to the technical and financial project development required by TCB. The technical and financial arrangements that will allow this local transfer of power will be identified, along with the financial benefits it would bring and the regulatory hurdles that may need to be overcome.

Current status

Upon closer considerations and detailed calculations it was realised that the CHP was impossible to be delivered. Therefore, the team started to focus on the options to change the focus of the task and deliverable to be about power transfer from GCC battery to GHA battery.

Lessons learned on the most important implementation factors.

- One of the lessons learned is that smart solutions significantly impact the existing (energy) infrastructure. Very often the details on the exploitation, contracts and performance of existing infrastructure are not fully analysed during developing strategic smart city goals and smart solutions. After having had a detailed look at the existing electricity grid it turned out that the fault level was already too high to have additional feed in from the CHP. Scottish Power is working on improving the grid, however, these additional investments cannot be done in the timeframe of RUGGEDISED.

5.3.4 G4 Optimisation of the integration of near-site RES, potentially linked into battery storage

Description and aimed innovation

This task seeks to significantly increase the deployment of suitable renewable energy sources in the project district and ensure that as much of the renewable energy generated is used locally within the district thus ensuring that the maximum benefit is delivered to residents and businesses in the district.

A. Roof-mounted Solar PV Canopies. Completed technical feasibility works have identified that the Duke St car park roof will house a 200kWp solar PV array of approximately 1,600m2, delivering 177MWh of renewable energy, which will be installed using a non-standard canopy mounting structure on the roof of the existing multi-storey car park, to feed renewable energy into the electric vehicle charging infrastructure as well as into the proposed on-site battery storage.

B. Innovative urban Vertical Axis Wind Turbines In addition to the solar panels, we aim to deploy innovative urban Roof Mounted Ducted (RMD) or Vertical Axis Wind Turbines (VAWT) in suitable locations within the district. The renewable electricity generated by these VAWTs will be supplied – either directly or in a Complex Site arrangement - to the battery storage in the district. By effectively storing all of the local generation in the battery, to be used by various assets in the district, the maximum financial benefit, both for the recipients of the power and the generators of the power, can be achieved. Furthermore, ensuring 100% of the power generated by the VAWT is consumed in the district, we can ensure the carbon savings created by the VAWT impacts directly and positively on the City of Glasgow's carbon emissions reduction target.

Current status

The procurement began in September 2018.

Lessons learned on the most important implementation factors.

- One of the key lessons here is that local RES optimisation and netting off solutions hold the risk for the city government of becoming an energy company in itself. GCC is not very keen on taking up this role. Apart from the fundamental question of whether the government should play an active role on the energy market and generate own revenues, it will create lots of bureaucracy and administration efforts.

5.3.5 G5 EV Charging in City centre car park

Description and aimed innovation.

The car park in which the EV Charging Hub will be deployed is within 0.5 kilometres of a major motorway network, the M8 Motorway. The M8 is the busiest motorway in Scotland and one of the busiest in the United Kingdom, connecting Glasgow and Edinburgh. Bringing both electric vehicle commuters and longer-distance electric vehicle users into the city to charge in a contained charging area will allow for improved planning of the electricity network in the city, via a clear understanding of the demands on the electricity network to ensure that the required network resilience is available. It will also promote economic growth in the area as more electric vehicle owners look for somewhere to spend their time while their vehicle charges, thus offering economic opportunities to existing and prospective business in the area.

Current status

This smart solution is well on track. The EV charger installation was started in September 2018 and completed In October 2018. Moreover, the project includes the development of a hosted API that will implement 'Profile Calculator'. The scope was agreed and data requirements were agreed during a meeting with Transport Scotland.

Lessons learned the on most important implementation factors

- EV charging infrastructure is often perceived as merely a mobility/transport issue. However, the optimisation of EV charging infrastructure depends on various interacting domains, such as planning (locational choice and locational attractiveness), energy (grid infrastructure), social (energy poverty and behavioural change, charging behaviour), and economics (urban job growth). It appears that EV is an integrated policy topic which is, according to Transport Scotland, a valuable lesson learned.
- From a technical perspective, the choice between rapid, fast and slow chargers depended on the estimate of types of people that will use the charging infrastructure. GCC and Transport Scotland chose rapid chargers, despite the fact that these chargers are less valuable in terms of grid balancing and vehicle 2 grid applications. This extra application was considered less necessary in this particular location.

5.3.6 G6 Intelligent LED street-lights with integrated EV charging functionality, wireless communications network, and air pollution monitors

Description and aimed innovation

This smart solution aims at incorporating electric vehicle charging points into the already planned (and financed) installation of new LED street lighting columns. The infrastructure will be linked to the M8 motorway access to complement plans to address a known traffic congestion area which occurs at peak times where commuters leaving the city cause heavy traffic and poor air quality.

Current status

In the summer of 2018, it was agreed to undertake a soft market test to learn more about the various technological options and their impact and suitability on existing columns. Soft market testing of EV chargers commenced in August 2018. The procurement of EV chargers was planned to commence as soon as column numbers and requirements are known. During the summer, the GCC Lighting Teamwork to ensure that the chargers procured were in line with their maintenance requirements, etc. The specifications were completed in October 2018.

Lessons learned on the most important implementation factors

- This smart solution is well on its way.

5.3.7 G7 Smart Open data Decision Platform

Description and aimed innovation

RUGGEDISED builds upon the existing open data platform and Energy App by creating a 'Data-Based Decision Platform' (DBDP). The DBDP will integrate data from RUGGEDISED smart solutions and existing data in the city to create a platform where diverse users can run queries based on analysis of the available data. Furthermore, the capture of 'open data' generated by RUGGEDISED will add value to the project by ensuring an efficient method of monitoring activity linked to the project deliverables. A City Data Team was created within the Glasgow City Council to deliver the approach to the DBDP. The City Data Team will be responsible for the development of the Smart Solution G7.

Current status

Use case requirements were determined as the basis of the use cases to demonstrate DBDP. Furthermore, plans have been discussed to integrate the DBDP into the wider Council system discussed. The list of use cases was developed. The top three cases were issued to the internal development team to begin testing. In September the first visualisations were completed and prepared. The first demo of the DBDP was shown during the General Assembly in Gdansk and at the GCC "Design with Data" show and tell event. In October 2018, further use cases were developed to demonstrate the value of DBDP including the inclusion of 'Smart Bins' project. The project was presented to the City Parking Board to demonstrate its upscaling potential.

Lessons learned on the most important implementation factors

- The main aim of the Glasgow UDP is fourfold: to provide an interface that enables query-based analysis of multiple datasets to support policy, strategy, investment, etc; to enable complex data analysis without the need for expensive resources; to utilise existing datasets and software applications; and finally, to minimise legacy costs. The UDP campaign reaches out to citizens, private companies, public agencies, and planners.
- Data are at the heart of the Glasgow RUGGEDISED solutions. The UDP (or DBDP as it is called) will be the central point for all data within the Council. The data architecture comprises four pillars: integration of data from many sources (sensors, SQL and API, ..); storing data, analyzing it and presenting/reporting on it (see diagram below). The components include industry standard database solutions like Azure Cloud homegrown tools. Data is captured through the use of APIs. The UDP/DBDP is designed to identify efficiencies in service delivery, to identify new business models, to support SME's, and to foster new relationships. The financing of the DPDP is not factored. Financial benefits/impacts are expected to come from individual projects.

5.3.8 Implementation of demand-side management technology in (G8) street lighting (G9) domestic properties, and (G10) non-domestic properties

Description and aimed innovation

One of the demonstration projects developed through the Future Cities Glasgow project was the application of demand-side management (DSM) technologies in local authority buildings. This project installed demand-side management apparatus, linked to existing building management systems (BMS) across ten buildings owned by Glasgow City Council, representing a cross-section of buildings uses (offices, depots, schools, etc). The aim of the Future City - Glasgow demonstration was to show how, through the use of DSM apparatus, savings could be made at both network and building level, by enabling buildings to lower their demand from the electricity network, via the shutdown or reduction of certain pieces of equipment, to freeload for the network to use to cover a high-demand event. RUGGEDISED will be the next evolutionary step in DSM by integrating not only more non-domestic buildings – Council owned or otherwise – but electric vehicles, domestic properties and street lighting into an overall DSM controller, which will have links to the local electrical network. Through connection to smart control and smart appliances, such as washing machines or refrigerators that can communicate via a smart meter, DSM will deploy in a domestic scenario. The use of local storage will also look at the opportunities for domestic premises to participate in energy arbitrage. DSM equipment will be installed in 10 domestic properties and a. 5 additional non-domestic properties, as well as connect to b.4 EV charging points on street lighting columns and a network of c.2500 LED street lights (which will expand as the lights continue to be retrofitted with LEDs), all controlled through the Glasgow City Council's Central Management System with will have a DSM Controller connected via an API. The large storage device in the EV Charging Hub will also be connected into the central DSM controller, therefore providing DSM services as well as grid support.

Current status

The system architecture is well-designed, connecting the IoT Edge Router between the CMS and Comms. Various elements and alternative scenarios are being developed in terms of use cases. Moreover, the hardware is currently being procured.

Lessons learned on most important implementation factors

- Demand-side management is, in the end, a political topic. Especially the command protocols, control regimes, and hierarchy of decisions within use cases reveal that interests of different policy domains and actors should be carefully weighed against each other. Moreover, to exploit the full potential of demand-side management (in terms of behavioural change based on full information and the development of data-driven services) requires careful consideration. At the moment, demand-side management is often only applied to lower costs for grid operators and energy providers. However, it still is a challenge to get a full overview of the benefits (especially for households and companies) of far-reaching, and radical, demand-side management.

6. Conclusions next steps

The aim of WP1 is to draw generic lessons and formulate collaborative RUGGEDISED contributions to smart cities. Based on the Overarching Innovation and Implementation Framework, this interim report 2/3 presents and structures the main lessons that RUGGEDISED lighthouse cities (Rotterdam, Umeå and Glasgow) have learned in the past two years. There are three reasons why TNO conducted this deliverable. First, to create a base for guidelines for reflection and input for individual smart solution deliverables to be provided by the lighthouse cities. Second, it sets the scene to formulate the contribution of RUGGEDISED to smart city practices, to be elaborated in next year's 3/3 report. Third, it sets the scene for the development of next year's WP1 deliverables: D1.5 Prototype Smart Energy District planner, D1.6 Guidance on Smart City Design and Desicion Platform and D1.8 Guide on RUGGEDISED implementation and innovation of smart solutions.

Progress

An overview of this deliverable shows that the Lighthouse cities considerably progressed their implementation. Some solutions have been harder to implement than others, but the cities do everything they can to implement their smart city solutions. There are already some successful implementations of the smart solutions. In Rotterdam R7 (electrical bus-fleet), R10 (LoRa network), and R13 (Smart Waste Management) are in a highly developed stage. In Umeå U2 (Peak load variation management and power controll), U3 (Geothermal heating/cooling storage and exchange), and U9 (demand-side management) are right on track. In Glasgow G1 (Heat and Cold Exchange), G2 (battery storage technology), and G4 (charing in city centre car park) are also right on track.

Implementation factors

By implementing the smart solutions, the cities and partners learn a lot of valuable lessons. In this deliverable, TNO set out the learned lessons that reflect the factors of the three levels of impact that were explained in deliverable 1.2. The table below shows the factors each solution had to deal with.

Level of impact 1: Realisation and output of smart solutions					
Hardware		**Software**		**Orgware**	
Pre-deployment assessment	[R7], [G3]	Privacy	[R8], [R9], [U8]	Business models	[R5], [R12], [U6], [U7], [G1], [G2], [G7]
Technology assessment	[U2], [G3], [G5]	Security	[R9]	Data and data ownership	[R9], [U8]
Impact on the energy grid	[R5], [R7], [R8], [R12], [U1/3], [U2], [U4], [U5], [U6], [G3], [G5]	Smart Grid ICT	[R1], [R5], [R6], [R7], [R8], [U1/3], [U2], [U4], U5], [U6], [G3], G5]		
		User Interfaces	[R9], [R13], [U4], [G7]		
Level of impact 2: Embedded outcomes of multiple smart solutions					
Hardware		**Software**		**Orgware**	

Communicating infrastructure	[R9], [R10]	Interoperability		Integrated vision on the smart city	[G5]
Robustness of the system		Dashboards	[U8]	Smart governance	[U8], [G2], [G8/9]
Existing infrastructures and vested interests	[R1, [G3]], [G8/9]			Windows of opportunity	
Project boundaries	[R1], [G4]			Stakeholder management	[R1], [R2/3/4], [R5], [U6], [U9], [G1],
				Ownership	[R1], [U1],
				Business models and split incentives	[U1],
Level of impact 3: Upscaling and replication					
Hardware		**Software**		**Orgware**	
				Integrated planning	
				Innovation platforms	
				Conditions for upscaling: finance, regulation (including standardisation), access to information and social aspects	

Table 2: Implementation Factors defined by the Liaison Groups (RUGGEDISED, 2017)

The richness of the information that the cities provide shows that in this stage of the process almost all the partners learned lessons about the level 1: implementation and outcome factors. The main topics are the impact on the energy grid, smart grid ICT and business models. Also, some of the solutions look forward to the level 2 factors: embedded outcomes. Stakeholder management is essential for the solutions, followed by existing infrastructures and vested interests, and smart governance.

Integrated concept

Smart cities are an integrated concept, based on the connections between smart solutions and the grid. The cities noticed that it is not the technology that makes the implementation of a solution/the grid successful or difficult, it's more about managing different factors with mainly a social, economic, legal and institutional character.

The cities suggest for future projects to take significant time to build an intensive partnership, before implementing the solutions. In this way, some of the social and economic factors can be strengthened or overcome. Building partnership is most often about collaborative governance and interdisciplinary collaboration. Involving partners in a transparent process is not only a task for the city councils. Semi-governmental organisations and private companies have to step up and find a new role for themselves in these partnerships.

Vertical integration

A new factor that has been mentioned by the cities and their partners has much to do with vertical integration. All the lighthouse cities and partners have to deal with (upcoming) procurement and tender issues. When another department within the municipality must procure the solution, it’s hard to convince them to do it in a specific way. The strategic level in the organisation can help by setting up a vision to align the procurements of different departments, in order to pursue the same goals and visions. And besides that, it's not possible either to demand that these solutions need to be implemented by one of the RUGGEDISED partners. So, once a solution is implemented and ready to scale up (or out) it isn’t possible to choose the same partners. This has to be done by tenders. It is therefore important to involve other contractual and tender departments in the organisation to find creative solutions.
In line with these procurement and tender issues, TNO wants to formulate urban innovation / smart city governance masterclasses, especially linked to integrating the strategic and operational level in the organisation.

Overview

The overview of relevant aspects and lessons learned in this report shows a wide variety of implementation factors that influence the implementation of smart city solutions. In order to successfully link smart solutions with each other and to upscale and replicate, cities can especially take factors as ‘stakeholder management’, ‘smart governance’, business models’, ‘existing infrastructures and vested interest’, and the ‘impacts on the energy grid’, into consideration. Not only before the implementation phase, but during the whole process of planning and implementing.

This deliverable shows that it’s the time to shift focus to:

- Ensure the success beyond the life span of the project. In the Overarching Innovation and Implementation Framework this means that the focus needs to shift from level 1/2 realisation and embedded outcomes to level 3: upscaling and replication.
- Train colleagues that not yet have been involved in the lessons learned. Spreading knowledge is important for continuing the smart city transition.
- Upscale lessons learned to new strategic goals. Upscaling requires support from the strategic level within the organisation, such as directors or aldermen. Support from this level can enhance both the innovation capacity and implementation capacity. An overarching strategic vision will improve the coordination/collaboration between departments and partners in a city.

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8. Appendix List

1. Interviews held with Lighthouse Cities
2. Minutes of the Liaison Group meeting in Leiden (20 February 2018)
3. Minutes of the Liaison Group meeting in Umeå (8 March 2018)
4. Minutes of WP 1 – WP 5 Workshop in Glasgow (10 September 2018)

Appendix 1 – Interviews held with Lighthouse City partners

WP 2 - Rotterdam		
Name (affiliation)	**Related smart solution(s)**	**Date**
Albert Engels (coordinator) and Katelien van den Berge (Rotterdam - WP 2 management)	Overall implementation process of smart solutions	7 December 2018
Nico van den Berg and Rutger Borst (KPN)	R9 - R10	17 December 2018
Roland van der Heijden (Rotterdam)	R9	18 December 2018
Wouter IJzerhorst (Eneco)	R1 – R2 – R3 – R4	19 December 2018
Virgil Grot (RET)	R5 – R7	21 December 2018
Roland van Rooyen (Rotterdam)	R1-R5	8 January 2019
Rick Klooster (Future Insight)	R9	8 January 2019
Jasper Feuth (Eneco)	R5 – R6 – R8 – R12	15 January 2019
Wim Kars (Rotterdam)	R13	18 January 2019
Peter Wijnands (Rotterdam)	R11	
WP 3 - Umeå		
Name (affiliation)	**Related smart solution(s)**	**Date**
Carina Aschan (City of Umeå – WP 3 management)	Overall implementation process of smart solutions	3 December 2018
Annelie Hansson (Akademiskahus)	U1 – U2 – U3 – U4 – U6 – U8 – U9	5 December 2018
Kristofer Linder (VLL)	U1 – U2 - U3 – U4 – U6	12 December 2018
Jorgen Carlsson (Umeå Energi)	U1 – U2 – U4 – U6	17 December 2018
WP 4 – Glasgows		
Name (affiliation)	**Related smart solution(s)**	**Date**
Gavin Slater (GCC – WP 4 management	Overall implementation process of smart solutions	20 December 2018
Colin Reid (Wheatley Group)	G1 – G9	8 January 2019

Laura McCaig (Transport Scotland)	G2 – G5	8 January 2019

Appendix 2 – Minutes of the Liaison Group meeting in Leiden (20 February 2018)

Glasgow EV Charging Proposals
The Use of OCPP / OSCP for *Central Smart Charging*
Author: Ciaran Higgins, Technical Lead

Contents

Figures

1. Introduction

- RUGGEDISED meeting on charging infra structure for Glasgow.
- Held on 2018 February 20 in Leiden at TNO, location Schipholweg.

During the liaison group meeting in Amsterdam, a short introduction on EV charging infrastructure in the Netherlands (with an example of the host city Amsterdam) was given. The presentation got a lot of response and evoked many questions. The most questions about EVs and the charging infrastructure came from Glasgow and could be answered through the Dutch experiences with EV charging. Besides the short introduction, there was also a pressure cooker session (suggested by Graham Colclough) together with the key knowledgeable parties from the Dutch electro mobility practice.

Take-away findings from Ciaran Higgins (Derryherk / Glasgow) are:

1. The problem of EV control we identified in Glasgow was also an issue in partner countries.
2. The means by which we would control it (OCPP) was also what was planned in other countries, so this gave us confidence that the approach was correct.
3. Charging infrastructure for communal developments – common to both Glasgow and Rotterdam – could be controlled via local controllers, which would allow many more chargers to be connected than would normally be allowed. Local OCPP control would ensure that cable limits would not be

exceeded as the diversity of use of EV chargers is not yet fully understood. This information came from the local Rotterdam DNO.

4. The need to have API 'middleware' was identified, which would create a gap between utilities and EV charger providers (and their back offices). It was not clear who should be responsible for that middleware initially, but after much consideration it was agreed that this is really a utility responsibility acting in the capacity of a DSO, rather than DNO.
5. Glasgow, through the local DNO SP Energy Networks (SPEN, also a RUGGEDISED partner), has created the API middleware for EV control. This brings EV charger data back into SPEN's LV connectivity model, which annotates the EV data to the network to understand any network issues that may arise. The output of this analysis is the creation of EV charging constraints (OCPP instructions) that throttle back the chargers at time of peak consumption. The result: more changers will hopefully be rolled out on LV networks that would previously have been allowed as the DNO (DSO) has a means to protect the network via remote OCPP control. It should be noted that we are still very much at the demonstration phase with this control, but if successful it is the intention that this becomes a genuine measure that the SPEN could use to control devices on its network.

The following document and presentations were used for the programme:

1. Introductory report, to define the challenge and as preparation document for participants not from Glasgow: "Glasgow EV Charging Proposals" *The Use of OCPP / OSCP for Central Smart Charging* → Ciaran Higgins.
2. Introduction presentation Glasgow Challenges → Ciaran Higgins. Presentation to recap thee most important questions at the beginning of the session in Leiden.
3. Presentation Dutch best practices → Lutske Lindeman (Rotterdam): programme manager E-Mobility of the municipality of Rotterdam.
4. Presentation Dutch best practices → Roland Ferwerda (NKL): managing director of Nationaal Kennisplatform Laadinfrastructuur (short hand NKL, in English: National Knowledge Platform Charging Infrastructure).
5. Presentation Dutch best practices → Michel Bayings (E-Mobility consulting). Michel is an independent market consultant translating end-user needs in technical solutions and ensuring that the technical solutions fit to the user needs. Also in the field of EV related product management and business development.
6. Presentation on Interflex → Joost Laarakkers (TNO) presented in the afternoon, to further elucidate the ins and outs of using EV charging infra-structure as a possible source of flexibility in a modern electric energy supply system.
7. Actually not part of the programme on February 20 2018 itself, but included for completeness sake: "Introduction on charging infra structure" presented by Mark Bolech (TNO) at the RUGGEDISED Liaison group meeting in Amsterdam 2017-11-08. This presentation triggered the organising of the in depth knowledge transfer session in February.

2. Project area

Rapid EV chargers will be installed within the EV Charging Hub in Duke Street Car Park, marked as a red square in the figure below. Lower rated (c.3-5kW) street lighting column-mounted chargers will be installed in a number of streets within the project area, marked as red stars. These locations are highlighted in figure 1 below.

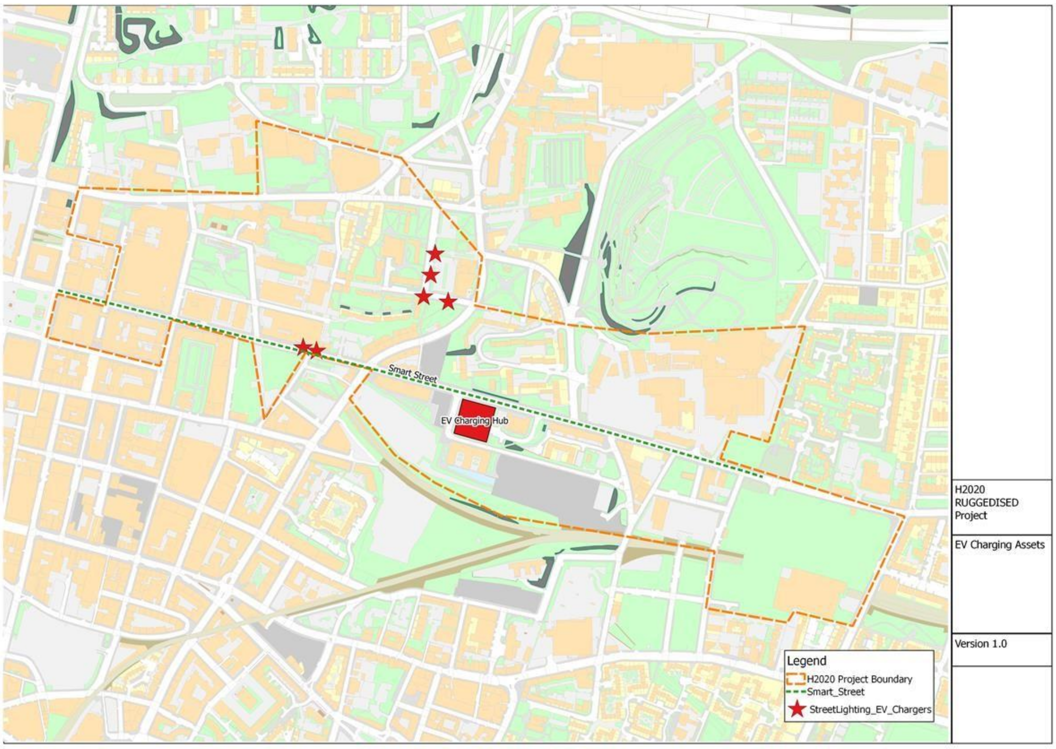


Figure 1: Project Area – EV Charging Hub & On-Street EV Chargers

3. Charging Setup Proposed: Central Smart Charging

After a series of workshops, Glasgow has opted to deploy Central Smart Charging (as defined in the Open Charge Point Protocol 1.6 specification), where control signals are sent to EV chargers via the OCPP back-end, or the 'Central System'.

Within this setup, it is proposed that the grid operator – SP Energy Networks in the case of Glasgow – will interface with OCPP back-end (presumably via an API or similar?) providing network limits for the circuits onto which Glasgow's RUGGEDISED chargers will be installed. The proposed setup, taken from the specification, is illustrated in figure 2 below.

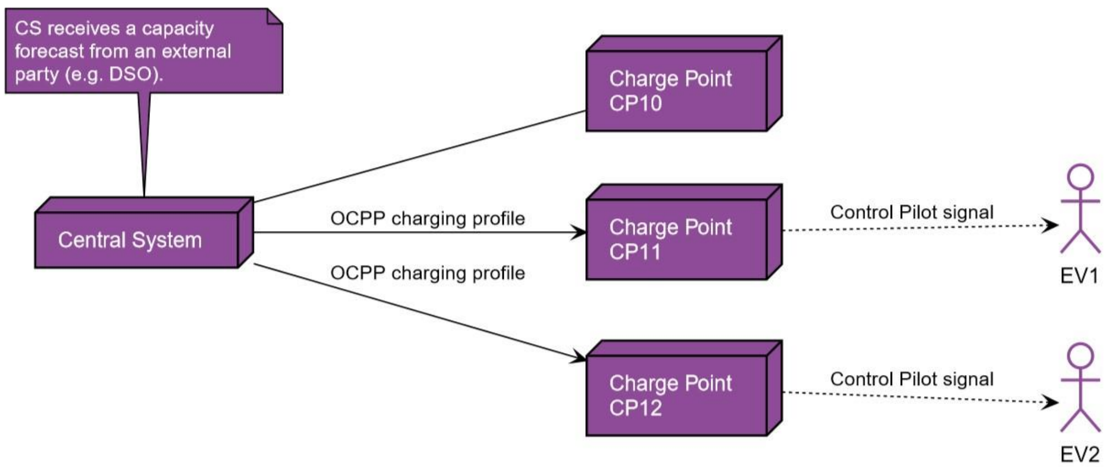


Figure 2: Central Smart Charging

These control signals will initially be sent to any OCPP v1.6 chargers connected to the software backend that are within the RUGGEDISED project area (as illustrated in Figure 1 above).

- Question number 1: What Smart Charging Scenario has been implemented in Rotterdam? Central Smart Charging, Local Smart Charging or Load Balancing?

4. Central Smart Charging: Place within RUGGEDISED system architecture

The following system architecture (found in Figure 3 below) has been proposed, in order to:

1. Fit within the existing RUGGEDISED system architecture;
2. Allow the DNO (acting as DSO) to interface with the OCPP back-end / Central System;
3. Allow 'ad-hoc' DSM requests to be made by Demand-Side Management Controller (DSMc), which is also responsible for initiating DSM requests to a number of sub-tended resources within the RUGGEDISED projects area – domestic properties, non-domestic properties and LED lighting.

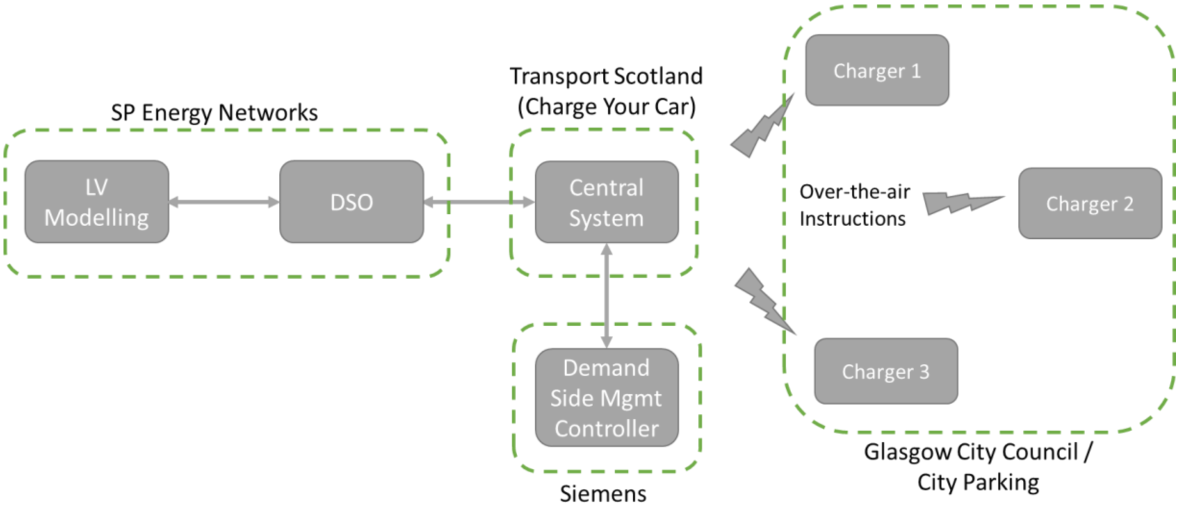


Figure 3: Possible implementation of Central Smart Charging (Design A)

Note that it is assumed that all interactions with the Central System are done via a defined API.

Within this model it is assumed that the calculation of the charging profiles that satisfy the network limits set by the DSO and demand-response requests made by the Grid Interface Controller, is done by the Central System. However, this may create a system bottleneck given the Central System is also responsible for all metering, back-office functions, payments, etc. To overcome this potential issue, another possible architecture is shown in Figure 4 below.

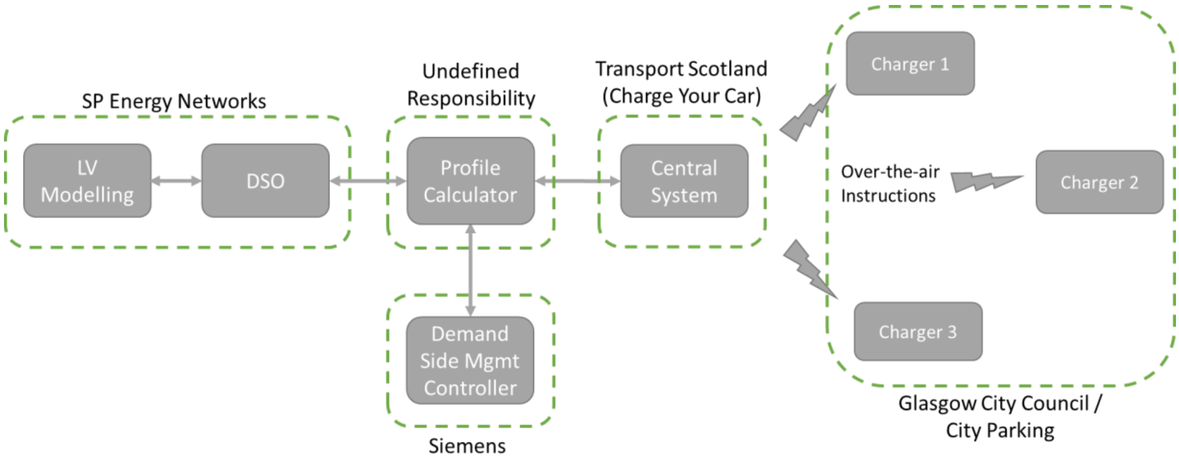


Figure 4: Possible implementation of Central Smart Charging (Design B)

In this setup, a separate processing function is dedicated to profile generation for each and every charger connected to the Central System that is at least OCPP v1.6 compliant. This can take network limits from the DNO/DSO, charger status from the Central System (via, for example, GetConfiguration.req) and combine to create the following signals for each charger:

- ChargePointMaxProfile – max power/current that charger is allowed to charge at (fixed value)
- TxDefaultProfile – typical charge profile for a particular charger, defining periods where full charge is permissible and when it is necessary to 'throttle' charge rate. These can be habitual profiles that cover a period of a week/month/season/etc.
- TxDefault – charge profile for a specific charge session/transaction. Only applies to a single charger session, after which charger reverts to either TxDefaultProfile or ChargePointMaxProfile.

The system proposed is close to that found within the Open Smart Charging Protocol 1.0 specification, but with the charger profile generation being done external to both the Central System (or 'Charge Spot Operator' as referred to in the specification document) and the DSO.

- Question number 2: Is the architecture proposed for Glasgow similar to that implemented in Rotterdam?
- Question number 3: What information is extracted from the chargers and provided to the DSO?
- Question number 4: How is information from chargers transferred to the DSO?
- Question number 5: How is network information used to create charge profiles?
- Question number 6: Who has responsibility for creating charger profiles and where in the system is this done?

It should be noted that the Glasgow system has 2 key actors interfacing to the charge Profile Calculator: SP Energy Networks (DSO); and Siemens (Demand Side Management Controller - DSMc). The DSO will be setting limits that are likely to be recurring – i.e. weekly, monthly, seasonal – whereas the DSMc will be initiating 'ad-hoc' DSM events based on market conditions, local PV availability, excess of energy stored in Duke Street battery, etc.

- Question number 7: Does Rotterdam have a system that allows for multiple actors to provide limits for charger profile generation, or are all projects limited to a single actor – i.e. a DSO or an Energy Supplier?

5. Dealing with Electric Vehicle Limitations

It is understood that not all cars can take charge > 3.5kW and not all chargers can supply more than this, therefore the nature of the car & charger must be known before an estimate on the potential reduction is calculated.

- Question number 8: Do any of the Rotterdam projects take into consideration the nature of the EV connected to the charger, so that DSM requests can be altered?
- Question number 9: How is the connected car type taken into consideration when creating charge profiles?

6. Customer Profiles

It is understood that not all users of EVs will be happy with their charging period being prolonged as a result of a demand-side event. To accommodate for this, customer profiles must be created detailing users (for example):

- That are happy to accept a long charge period as a result of a demand-side event;

- That are happy to accept a medium charger period as a result of a demand-side event;
- That do not accept any level of disruption to their charging session (i.e. the charger must operate at 100% for the charger duration.

- Question numer 10: Do any of the Rotterdam partners use customer profiles to define different levels of service?
- Question number 11: How are the customer profiles created and managed?
- Question number 12: How are these linked to financial incentives (if at all)?

7. Financial Incentives

In order to achieve flexibility of charging, it is accepted that financial incentives will be necessary. Within the UK there are well-established balancing mechanisms, primarily to deal with supply excesses or shortfalls at the transmission level, and it is thought that aggregated EV chargers with OCPP control could play into these markets successfully. From a network perspective, however, there are currently no mechanisms to recognise the benefit flexible load could bring to local networks and this is one the challenges that RUGGEDISED seeks to investigate.

- Question number 13: Does Rotterdam have any grid incentives that are directly linked to the use of flexible charging?
- Question number 14: How are customers reimbursed for providing grid flexibility by the DNO/DSO?
- Question number 15: What level of success has been achieved through these financial incentives? Have many users signed up to flexible EV charging tariffs?

8. Specification of OCPP functionality in EV Chargers

In the Glasgow workshop sessions, it was noted that simple OCPP compliance when procuring EV chargers is not sufficient to ensure we have the required functionality for the level of control proposed in this document. This is primarily due to many of the functionalities described as 'options' and so are not core OCPP functionality – i.e. you can be OCPP v1.6 compliant with only a subset of functionality. Therefore, when procuring any equipment, we must ensure the following options are specified (list not exhaustive):

- Firmware Management.
- Local Authentication List Management.
- Reservation (some questions arose whether or not this would be needed).
- Smart Charging.
- Remote Trigger.

- Question number 16: When procuring EV chargers, what minimum requirements did the Rotterdam partners specify?
- Question number 17: Did the Rotterdam partners implementing the OCPP Central System have oversight or control of the EV chargers being procured?

9. Role of the DSO in EV charger rollout

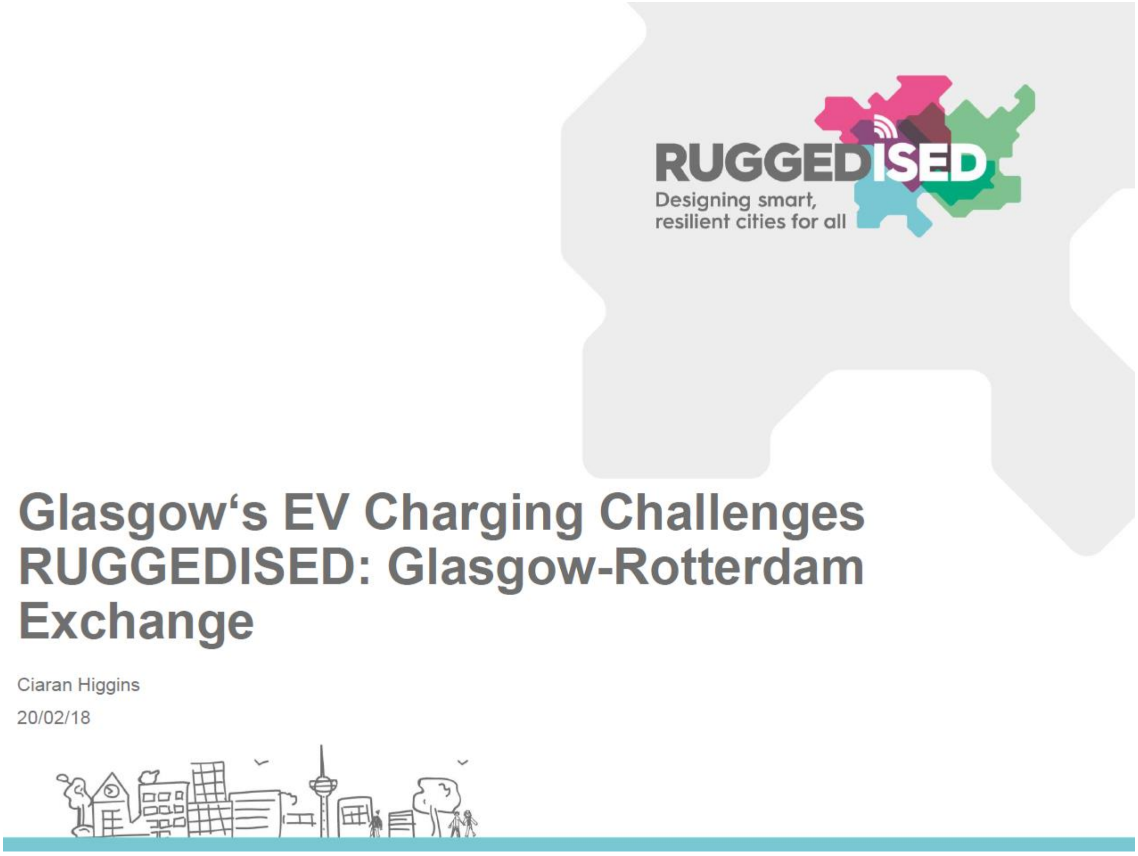
The RUGGEDISED project provides a unique opportunity to bring the charger installers – namely Transport Scotland & Glasgow City Council – and the DNO (SP Energy Networks) together so that the chargers can be specified and installed in a manner that allows the level of control suggested in this document. In practice, however, EV chargers are normally rolled out without significant involvement of the DNO, other than to facilitate grid connections when required.

When chargers are installed in homes, it is possible that the DNO has no idea that they exist, so there is a danger that the electrical network load will increase over time and certain networks saturate.

If the chargers installed have no control (i.e. they are not OCPP compliant), there is virtually nothing that can be done to reduce network peaks, other than punitive tariffs or expensive grid upgrades.
To overcome this situation, it is suggested that the DNO/DSO must be more involved in EV charger rollouts and the Glasgow partners are keen to understand what has been done elsewhere to find a model that could apply to the UK setup.

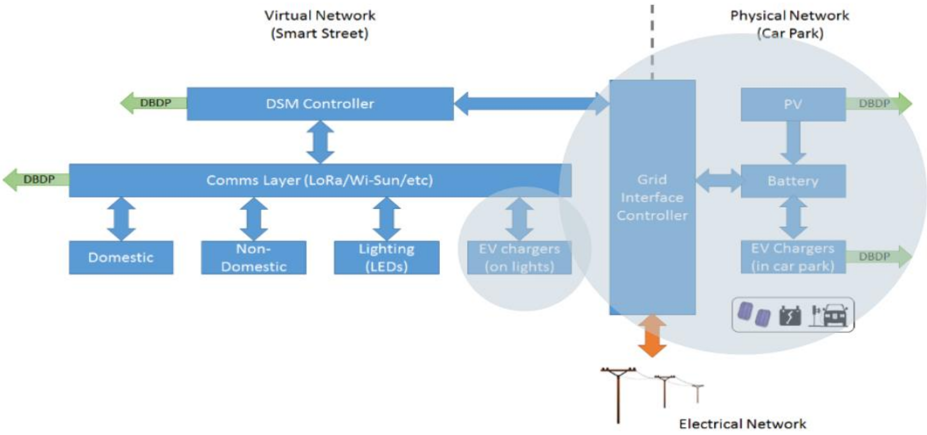
- Question number 18: What involvement does the DNO/DSO have in the EV rollout in Rotterdam and/or The Netherlands?
- Question number 19: Does the DNO/DSO have the right to specify a minimum level of control in the installed chargers so that Smart Grid control can be applied?
- Question number 20: What are the plans for the future rollout of EV chargers in Rotterdam and what is the role of the DNO/DSO in this plan?

10. Presentation Ciaran Higgins (Derryherk / Glasgow)



Designing smart, resilient cities for all

EV Charging: Place within Project



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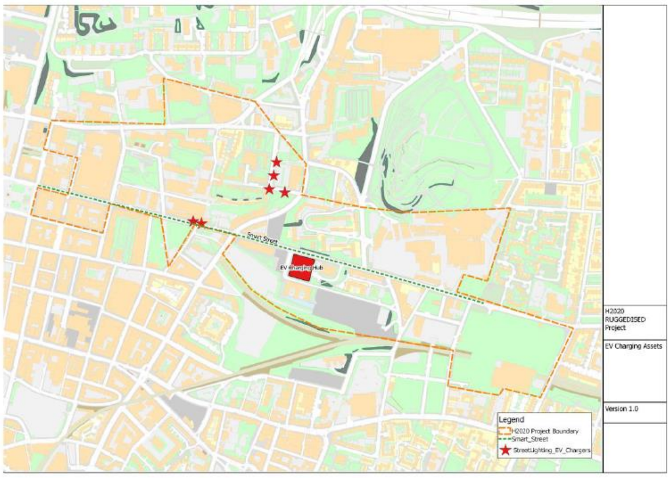
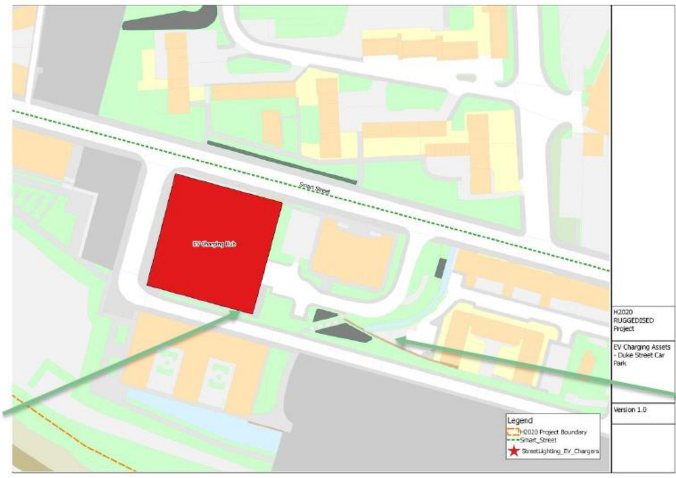
EV Charging Locations



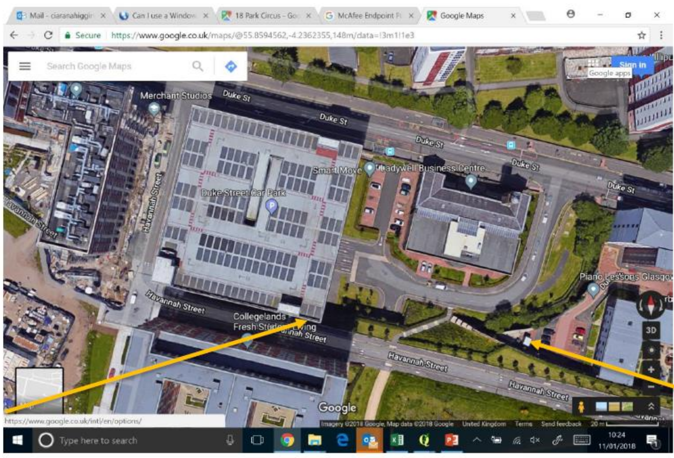
Designing smart, resilient cities for all

Duke Street Car Park: OS Map View

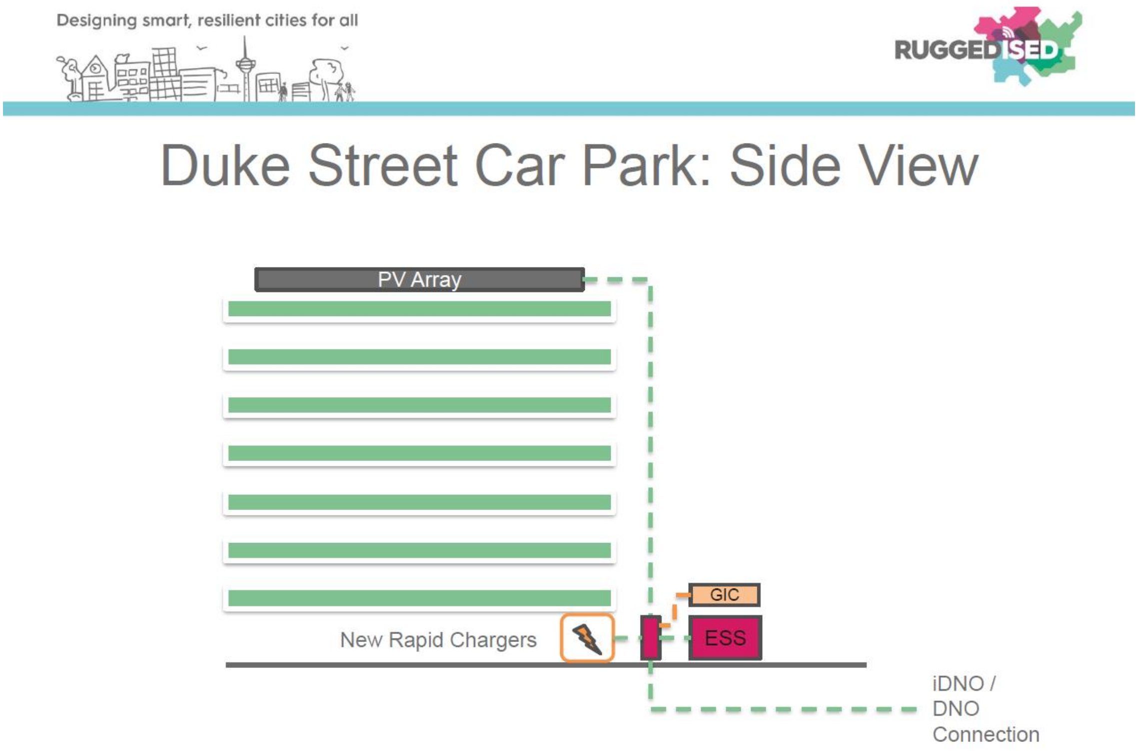


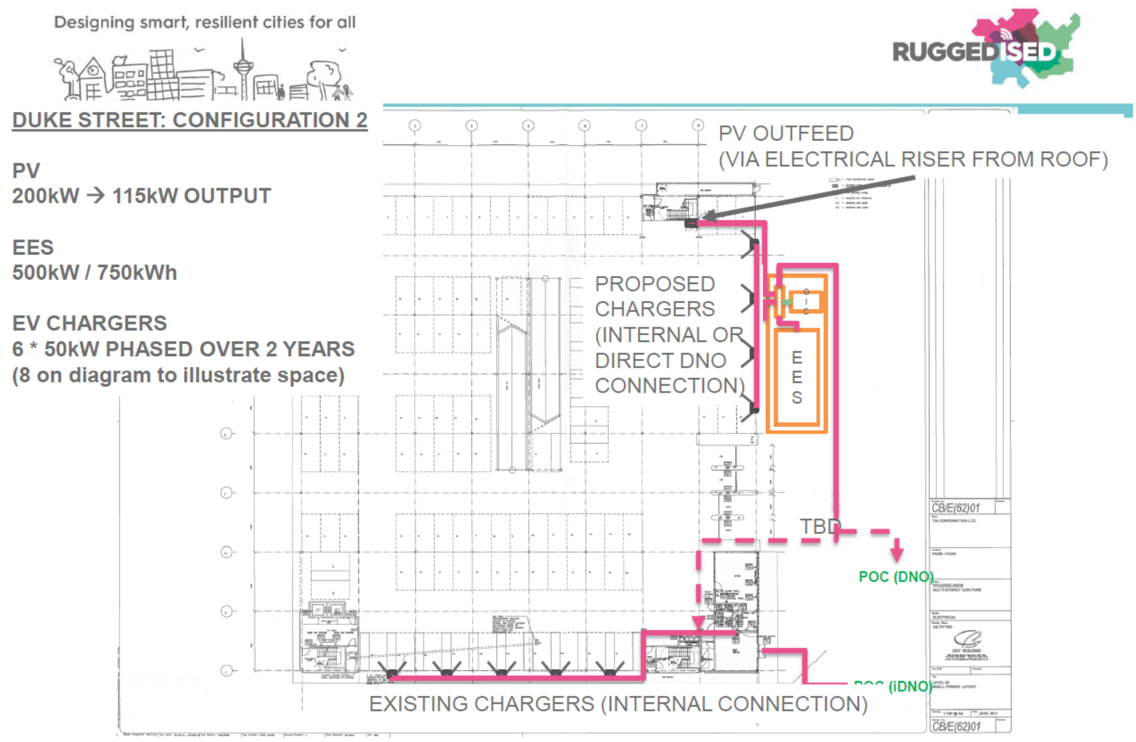
Designing smart, resilient cities for all

Duke Street Car Park: Satellite View




Designing smart, resilient cities for all
RUGGEDISED
Duke Street Car Park: Plan View (Aerial)
PV Array
ESS
Car Park Entrance / Exit
iDNO Sub
DNO Sub


Designing smart, resilient cities for all
RUGGEDISED
Duke Street Car Park: Side View
PV Array
GIC
ESS
New Rapid Chargers
iDNO / DNO Connection



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RUGGEDISED

Duke Street Car Park: DSM Ambitions

Local load balancing to match local energy supply (PV)

- OCPP ‘throttle’ function could help reduce overall EV charger load at certain times

Load reduction to meet network constraints

- Reduction in import of electricity at peak times
- Reduction of overall load to respect load limits (substation limit)

Load shifting to maximise use of battery stored energy

- Schedule EV charger loads

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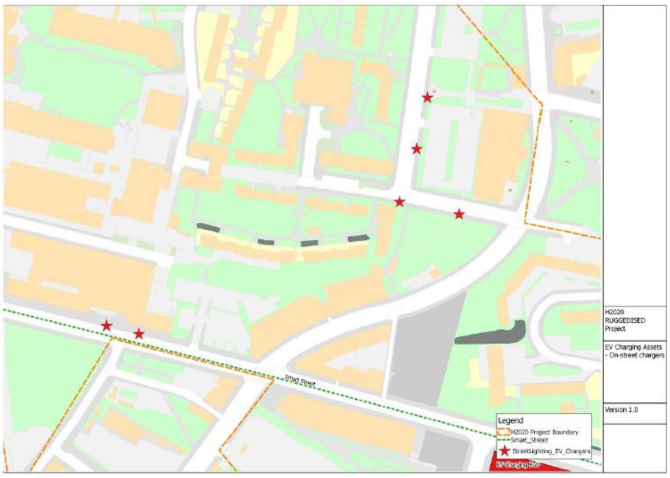
RUGGEDISED

On-street Charging: OS Map View



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On-street Charging: Typical Unit

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RUGGEDISED

On-Street Charging: DSM Ambitions

- Local load balancing to match local energy supply
  - OCPP 'throttle' function could help reduce overall EV charger load at certain times
- Load reduction to meet network constraints
  - Balancing of chargers to prevent cable limits being exceeded

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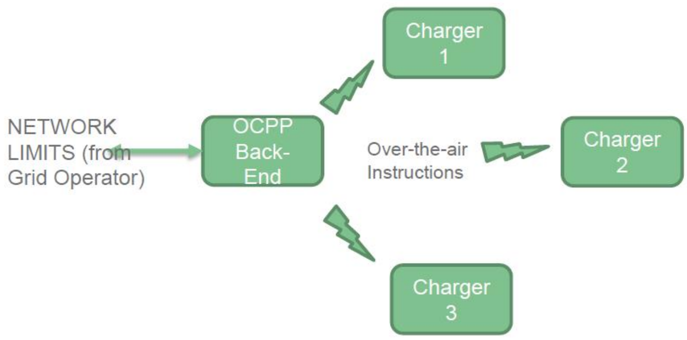
OCPP: Central Smart Charging



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OCPP: Central Smart Charging (+) - OSCP

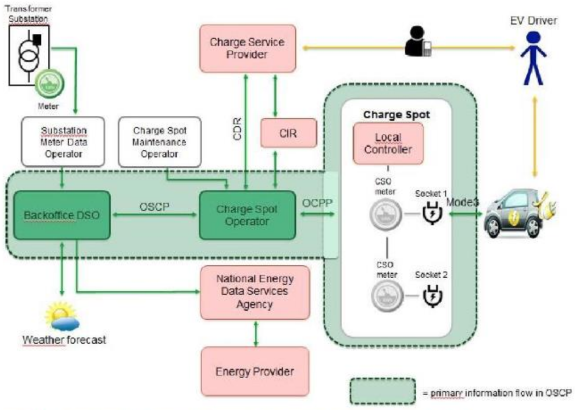

Figure 3 – Actors involved in smart charging and primary information flow in OSCP

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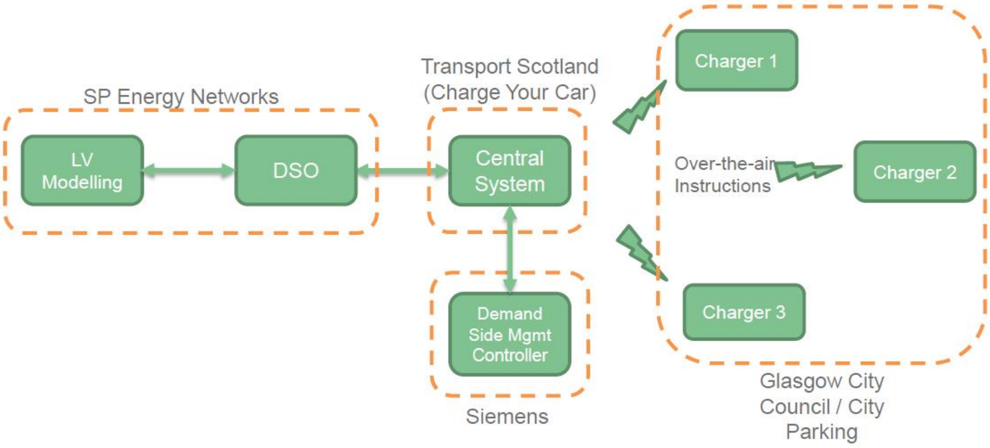
RUGGEDISED

OCPP: Central Smart Charging (+) - OSCP



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Key Considerations

- Technical Solution
  - Central Smart Charging
  - Physical Chargers
- Dealing with EV limitations (lower rates of charging)
- Customer Profiles
- Financial Incentives
- Specification of OCPP functionality in EV Chargers
- Role of DSO in EV Charger rollout
- Role of Local Authority (GCC) in EV Charger rollout

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RUGGEDISED

Starting Point

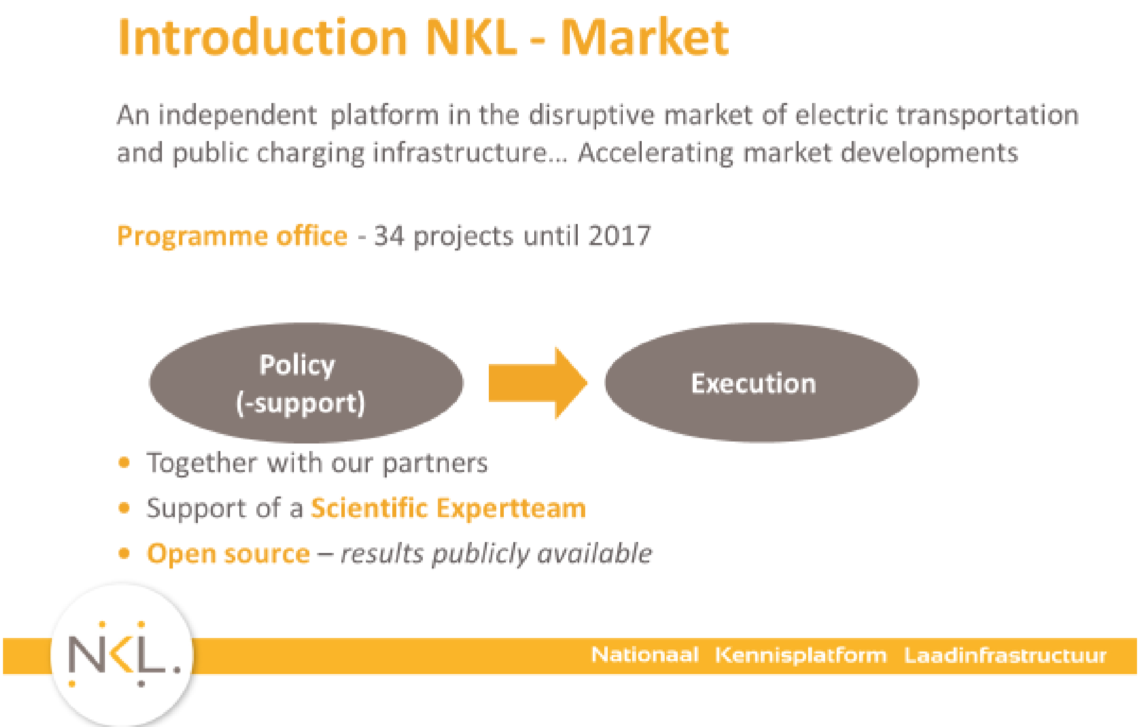
RUGGEDISED

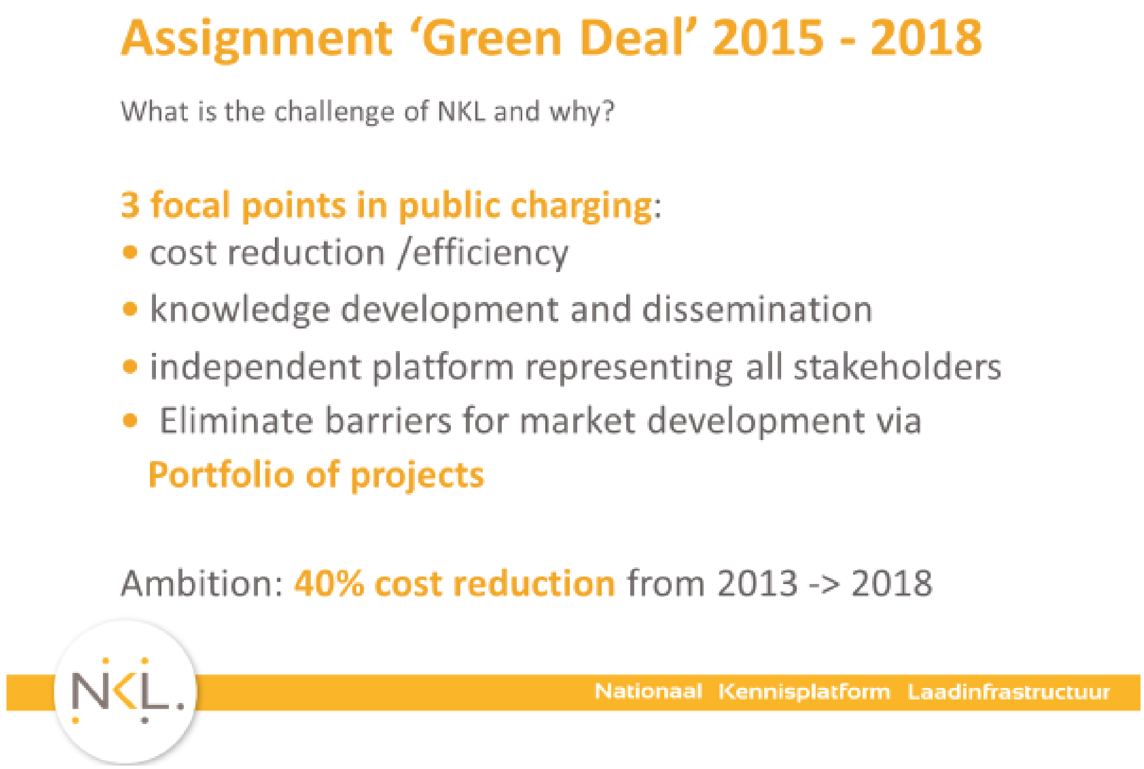
Glasgow EV Charging Proposals

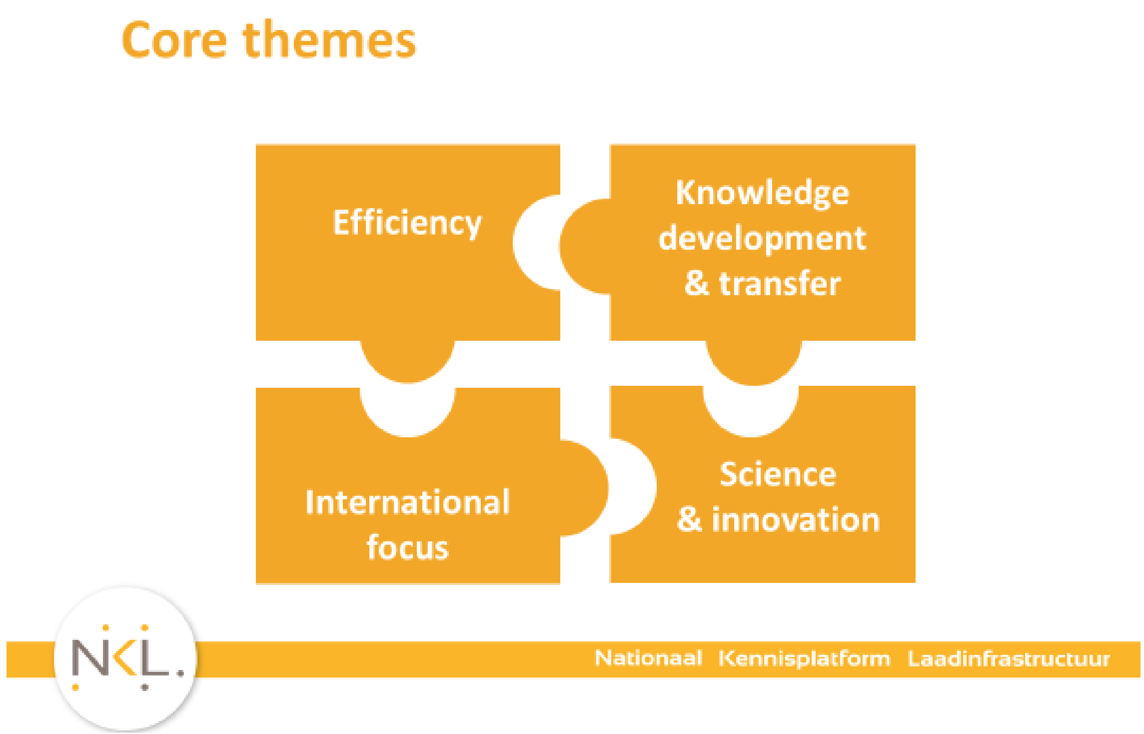
The Use of OCPP / OSCP for *Central Smart Charging*

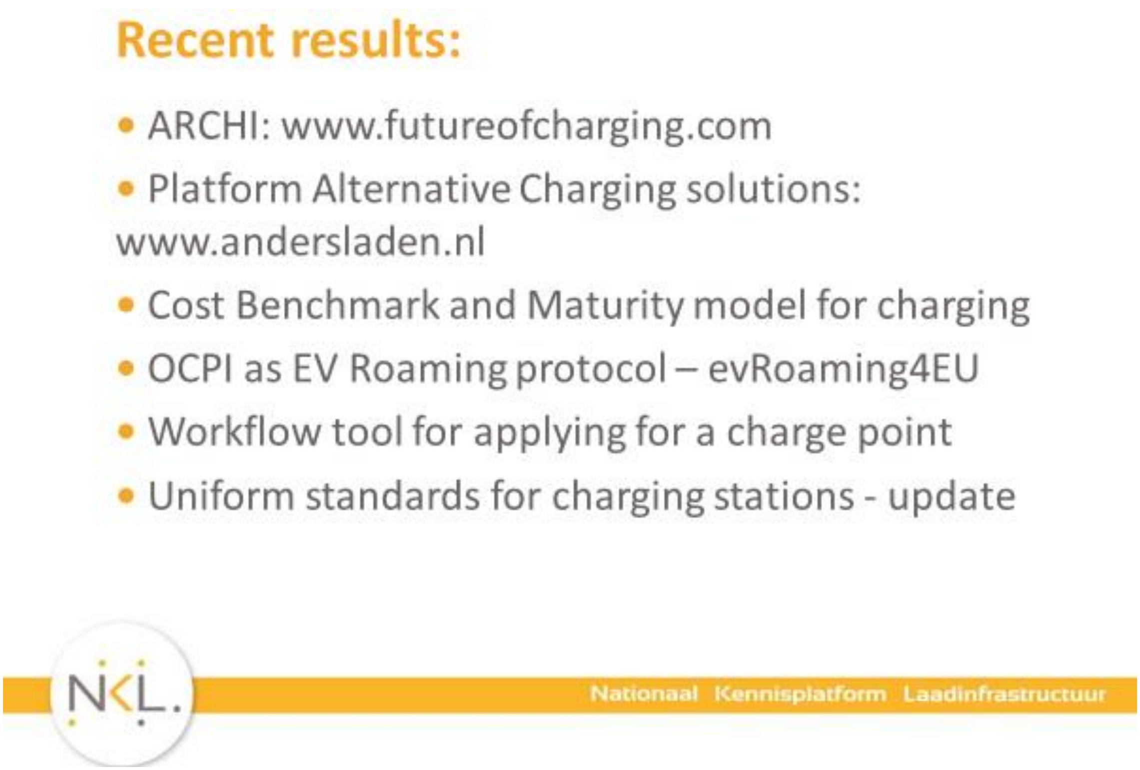
Author: Ciaran Higgins, Technical Lead
Version: Draft
Date: 12/02/18

11. Presentation Roland Ferwerda (Nationaal Kennisplatform Laadinfrastructuur, The Netherlands)

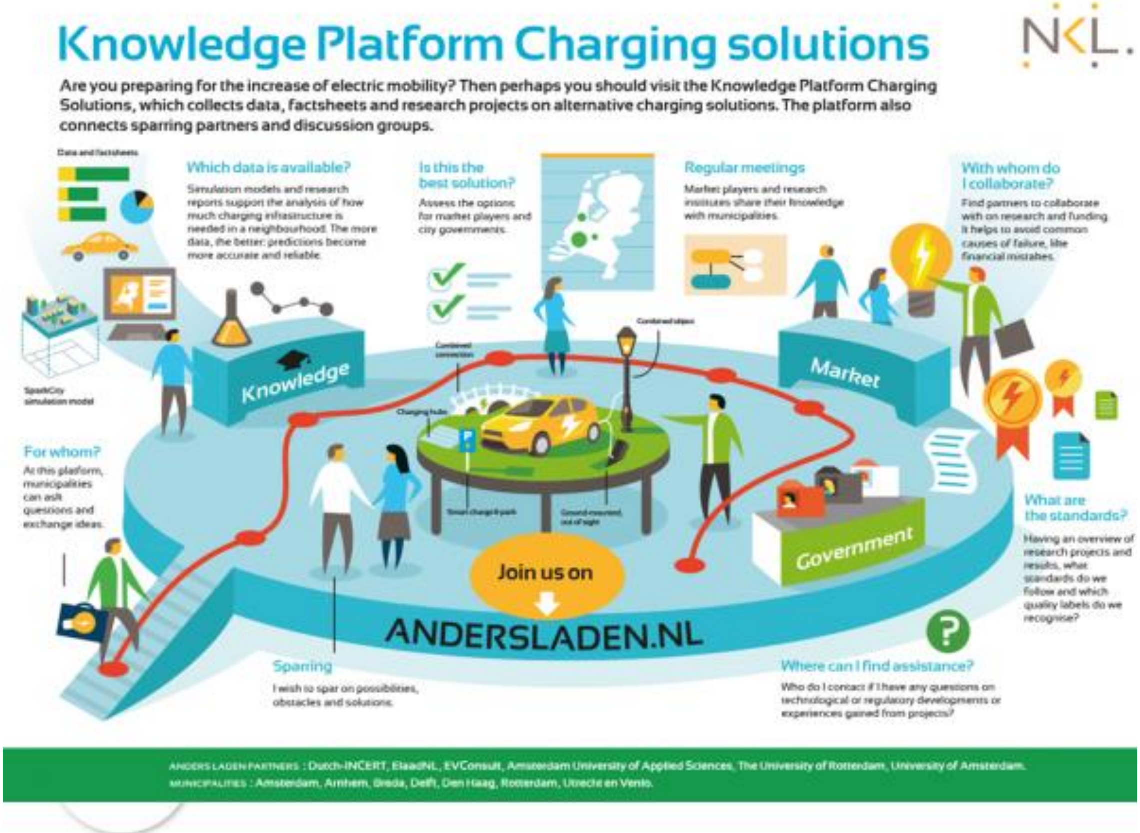



Assignment 'Green Deal' 2015 - 2018
What is the challenge of NKL and why?
3 focal points in public charging:
• cost reduction /efficiency
• knowledge development and dissemination
• independent platform representing all stakeholders
• Eliminate barriers for market development via
Portfolio of projects
Ambition: 40% cost reduction from 2013 -> 2018
NKL.
Nationaal Kennisplatform Laadinfrastructuur

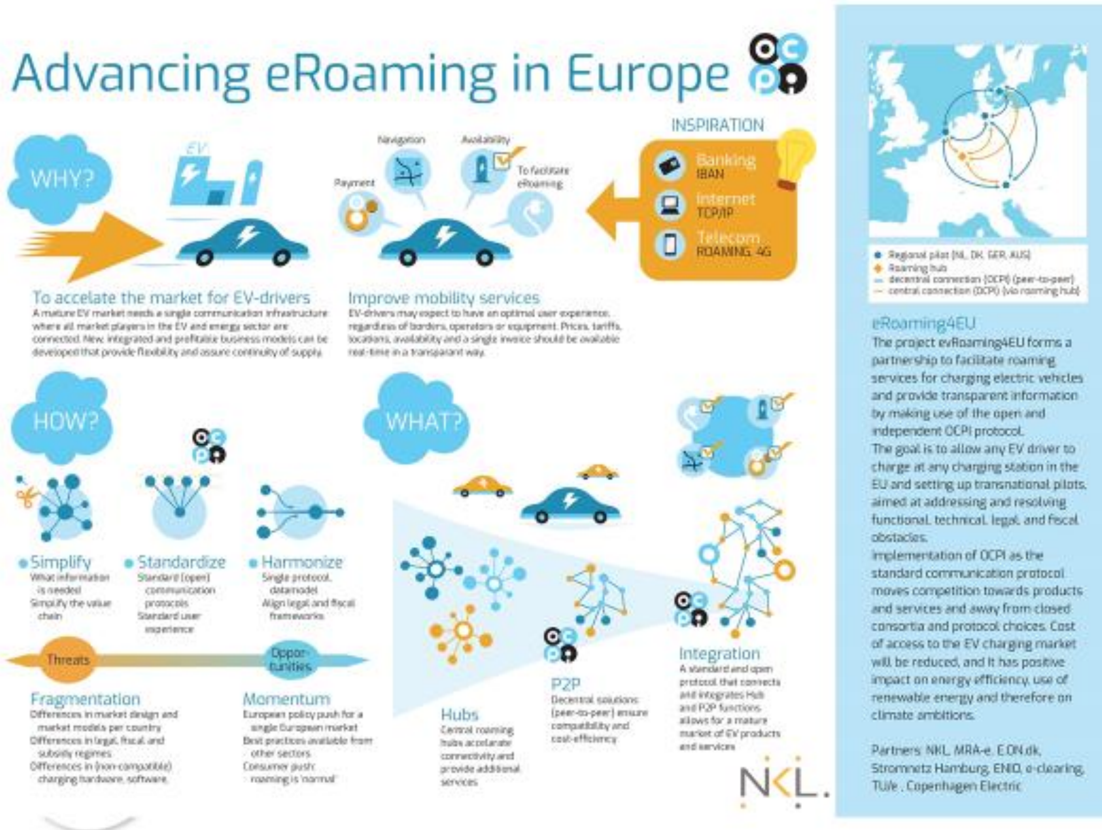

Core themes
Efficiency
Knowledge development & transfer
International focus
Science & innovation
NKL.
Nationaal Kennisplatform Laadinfrastructuur


Recent results:
• ARCHI: www.futureofcharging.com
• Platform Alternative Charging solutions: www.andersladen.nl
• Cost Benchmark and Maturity model for charging
• OCPI as EV Roaming protocol – evRoaming4EU
• Workflow tool for applying for a charge point
• Uniform standards for charging stations - update
NKL.
Nationaal Kennisplatform Laadinfrastructuur

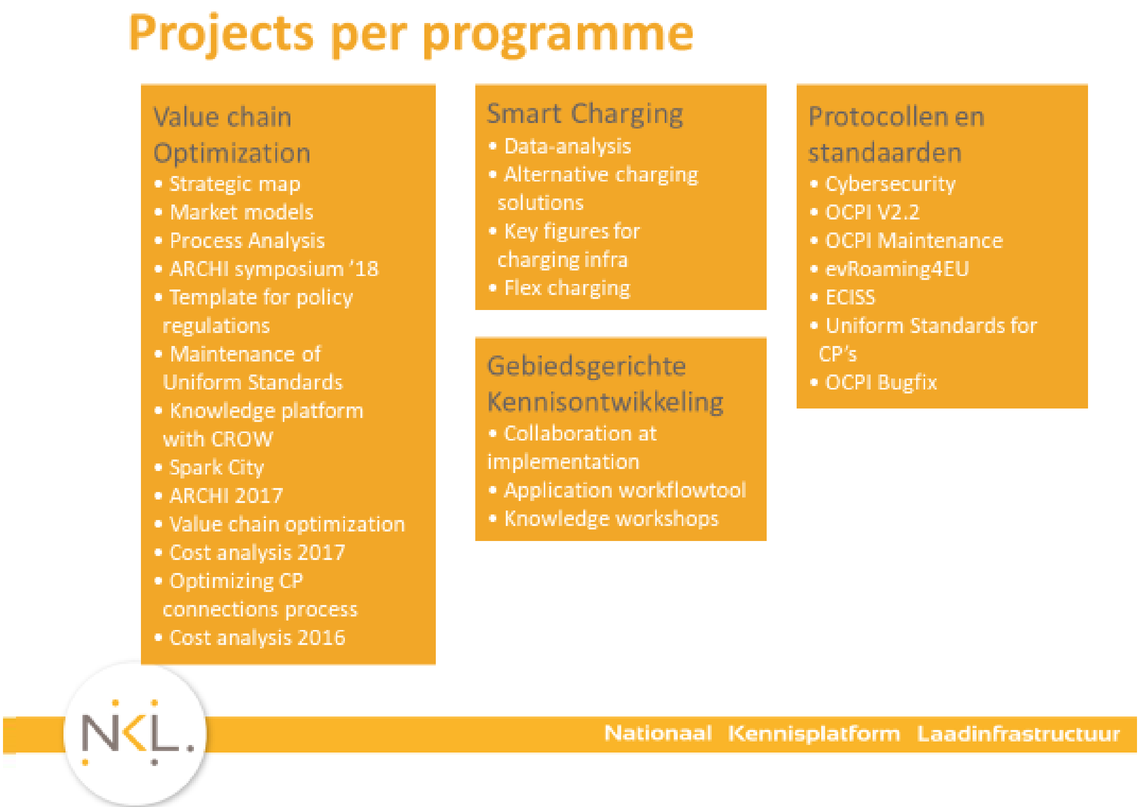

ARCHI
Science Meets Market
FUTURE OF CHARGING
Electric vehicles and charging infrastructure
Trends & Research
INNOVATIVE TECHNOLOGY
SMART CHARGING
SIMULATION MODELS
CONSUMER BEHAVIOUR
NKL.
Nationaal Kennisplatform Laadinfrastructuur


Knowledge Platform Charging solutions
NKL.
Are you preparing for the increase of electric mobility? Then perhaps you should visit the Knowledge Platform Charging Solutions, which collects data, factsheets and research projects on alternative charging solutions. The platform also connects sparring partners and discussion groups.
Which data is available?
Simulation models and research reports support the analysis of how much charging infrastructure is needed in a neighbourhood. The more data, the better: predictions become more accurate and reliable.
Is this the best solution?
Assess the options for market players and city governments.
Regular meetings
Market players and research institutes share their knowledge with municipalities.
With whom do I collaborate?
Find partners to collaborate with on research and funding. It helps to avoid common causes of failure, like financial mistakes.
Knowledge
Market
Government
For whom?
At this platform, municipalities can ask questions and exchange ideas.
What are the standards?
Having an overview of research projects and results, what standards do we follow and which quality labels do we recognise?
Join us on
ANDERSLADEN.NL
Sparring
I wish to spar on possibilities, obstacles and solutions.
Where can I find assistance?
Who do I contact if I have any questions on technological or regulatory developments or experiences gained from projects?
ANDERS LADEN PARTNERS : Dutch-INCERT, ElaadNL, EVConsult, Amsterdam University of Applied Sciences, The University of Rotterdam, University of Amsterdam.
MUNICIPALITIES : Amsterdam, Arnhem, Breda, Delft, Den Haag, Rotterdam, Utrecht en Venlo.


Maturity model: Public Charging of Electric Vehicles
Working towards a professional market
NKL.
The market for public charging infrastructure is entering a new phase. Focus is shifting from costs to professionalization. The goal: to realize an efficient, independent and service-oriented market with lower prices. Together with government, market and scientific parties, NKL has developed a maturity model.
1 Policy & Organization
2 Application & Realization
3 Management & Monitoring
4 Charging infrastructure
5 Financing
6 Focus on EV drivers
7 Market forces
8 Development of knowledge and people
9 Connection to energy transition
Complete the model for yourself:
Current status and ambition
Current
2020
Level
Optimized
Predictable
Deployed
Initial
Reactive


Advancing eRoaming in Europe
INSPIRATION
Banking
IBAN
Internet
TCP/IP
Telecom
ROAMING 4G
WHY?
EV
Navigation
Availability
Payment
To facilitate eRoaming
To accelate the market for EV-drivers
A mature EV market needs a single communication infrastructure where all market players in the EV and energy sector are connected. New, integrated and profitable business models can be developed that provide flexibility and assure continuity of supply.
Improve mobility services
EV-drivers may expect to have an optimal user experience, regardless of borders, operators or equipment. Prices, tariffs, locations, availability and a single invoice should be available real-time in a transparant way.
HOW?
WHAT?
Simplify
What information is needed
Simplify the value chain
Standardize
Standard (open) communication protocols
Standard user experience
Harmonize
Single protocol, datamodel
Align legal and fiscal frameworks
Threats
Oppor-tunities
Fragmentation
Differences in market design and market models per country
Differences in legal, fiscal and subsidy regimes
Differences in (non-compatible) charging hardware, software
Momentum
European policy push for a single European market
Best practices available from other sectors
Consumer push: roaming is 'normal'
Hubs
Central roaming hubs accelarate connectivity and provide additional services
P2P
Decentral solutions (peer-to-peer) ensure compatibility and cost-efficiency
Integration
A standard and open protocol that connects and integrates Hub and P2P functions allows for a mature market of EV products and services
NKL.
Regional pilot (NL, DK, GER, AUS)
Roaming hub
decentral connection (OCPI) (peer-to-peer)
central connection (OCPI) (via roaming hub)
eRoaming4EU
The project evRoaming4EU forms a partnership to facilitate roaming services for charging electric vehicles and provide transparent information by making use of the open and independent OCPI protocol.
The goal is to allow any EV driver to charge at any charging station in the EU and setting up transnational pilots, aimed at addressing and resolving functional, technical, legal, and fiscal obstacles.
Implementation of OCPI as the standard communication protocol moves competition towards products and services and away from closed consortia and protocol choices. Cost of access to the EV charging market will be reduced, and it has positive impact on energy efficiency, use of renewable energy and therefore on climate ambitions.
Partners: NKL, MRA-e, E.ON.dk, Stromnetz Hamburg, ENIO, e-clearing, TU/e , Copenhagen Electric


Open source in practice
Overview of Communication results nov 2017
17.000
visitors website until Nov 2017
40
Newsletters to 1500 recipients
500
Tweets to 524 followers
1
Digital magazine and several similar publications
388
Municipalities Received the Standards for Charge points
25+
Workshops, Presentations, events
NKL.
Nationaal Kennisplatform Laadinfrastructuur


Projects per programme
Value chain Optimization
• Strategic map
• Market models
• Process Analysis
• ARCHI symposium '18
• Template for policy regulations
• Maintenance of Uniform Standards
• Knowledge platform with CROW
• Spark City
• ARCHI 2017
• Value chain optimization
• Cost analysis 2017
• Optimizing CP connections process
• Cost analysis 2016
Smart Charging
• Data-analysis
• Alternative charging solutions
• Key figures for charging infra
• Flex charging
Gebiedsgerichte Kennisontwikkeling
• Collaboration at implementation
• Application workflowtool
• Knowledge workshops
Protocollen en standaarden
• Cybersecurity
• OCPI V2.2
• OCPI Maintenance
• evRoaming4EU
• ECISS
• Uniform Standards for CP's
• OCPI Bugfix
NKL.
Nationaal Kennisplatform Laadinfrastructuur

12. Presentation Presented by Michel Bayings (E-Mobility consulting)

Setup INVADE project NL pilot

GreenFlux – ElaadNL - eSmart

Meeting 13th June 2017 INVADE TAG meeting

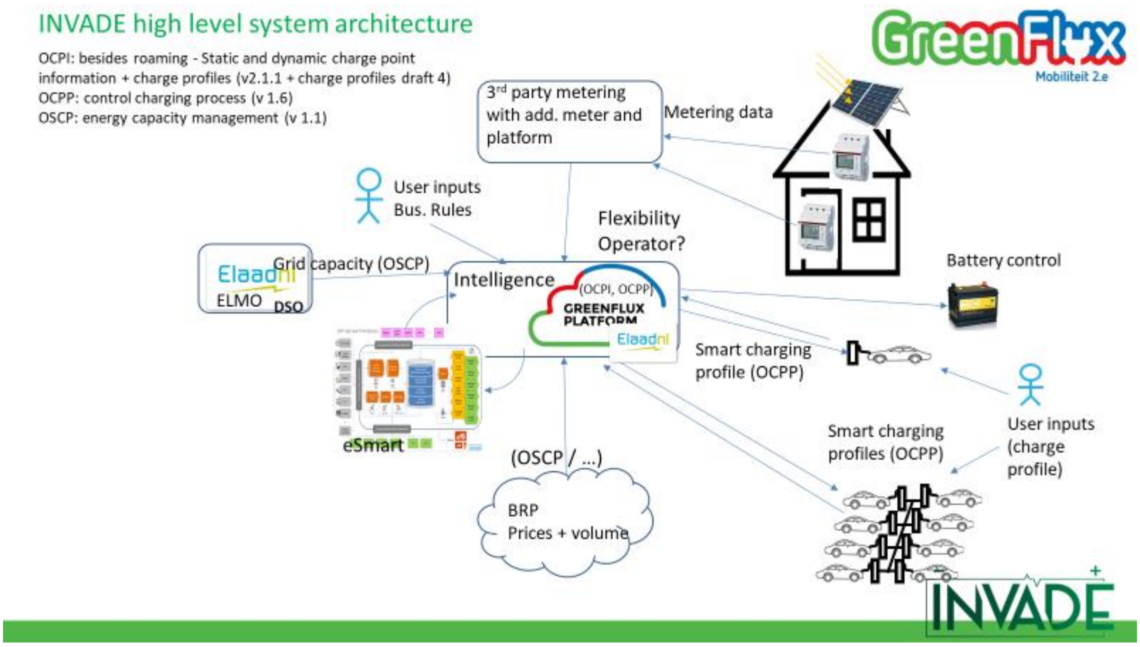
Scope INVADE GreenFlux-Elaad-eSmart

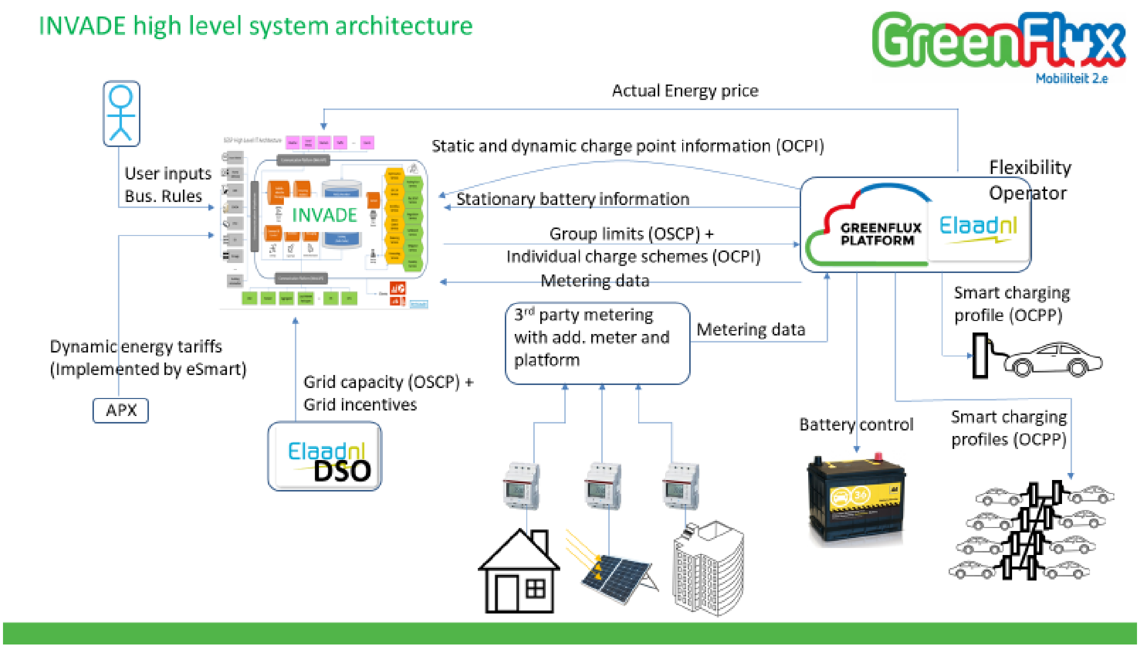
	What we do on large scale	What we do on small scale
At home	-	• 25 charge points • Smart charging (see use case) • Data analytics **Greenflux**

At the office	• 200 - 400 charge points
	• Customer experience research, including app
	• Passive user involvement (thousands)
	• Smart charging (see use case)
	• Data analytics
	Greenflux
		• Vehicle to grid (1 EV at Elaad premises)
		• State of Charge determination (Elaad)
		  • 5 cars at Elaad
		  • Retrofit measuring device in the EV
		• Stationary battery
		• Active user involvement
		• Development DSO capacity forecasting system / flexibility signals

Public charging	• 500 – 1000 charge points • Passive user involvement (10.000+) • Smart charging (incl. use renewable energy, see use case) • Smart charging ready charge stations • Data analytics **Elaad**	• 15118 is not in scope (no cars, no chargers, no final version of the standard) **Elaad - Greenflux** **Location Elaad**

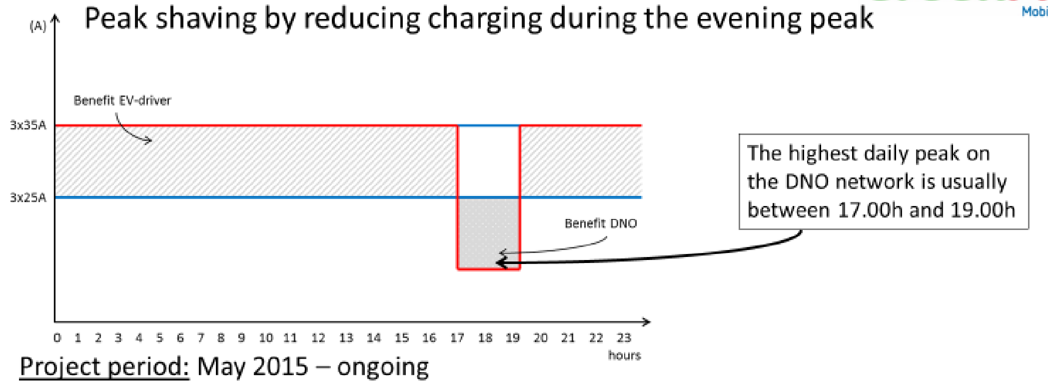
PV usage if available
dynamic energy prices
Protocol learnings


INVADE high level system architecture
OCPI: besides roaming - Static and dynamic charge point information + charge profiles (v2.1.1 + charge profiles draft 4)
OCPP: control charging process (v 1.6)
OSCP: energy capacity management (v 1.1)
3rd party metering with add. meter and platform
Metering data
User inputs
Bus. Rules
Flexibility
Operator?
Grid capacity (OSCP)
ELMO
DSO
Intelligence
(OCPI, OCPP)
GREENFLUX PLATFORM
Battery control
Smart charging profile (OCPP)
eSmart
(OSCP / ...)
BRP
Prices + volume
Smart charging profiles (OCPP)
User inputs (charge profile)
INVADE


INVADE high level system architecture
Actual Energy price
Static and dynamic charge point information (OCPI)
User inputs
Bus. Rules
INVADE
Stationary battery information
Flexibility
Operator
GREENFLUX PLATFORM
Group limits (OSCP) +
Individual charge schemes (OCPI)
Metering data
3rd party metering with add. meter and platform
Metering data
Smart charging profile (OCPP)
Dynamic energy tariffs
(Implemented by eSmart)
APX
Grid capacity (OSCP) +
Grid incentives
DSO
Battery control
Smart charging profiles (OCPP)

Example

Peak shaving by reducing charging during the evening peak



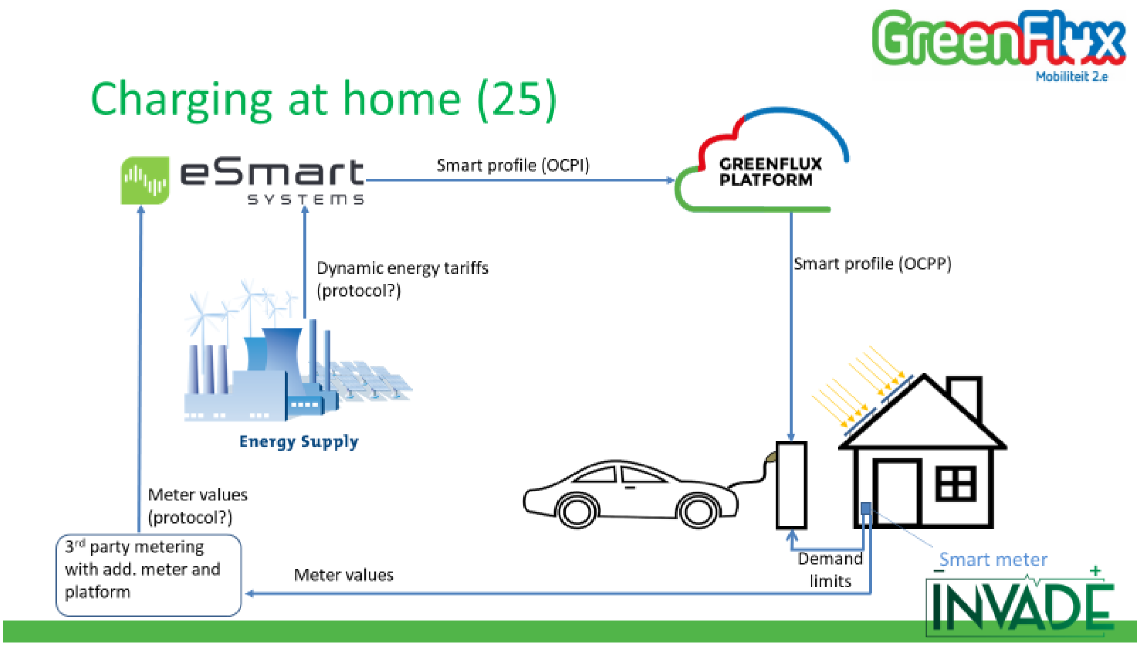
Project period: May 2015 – ongoing

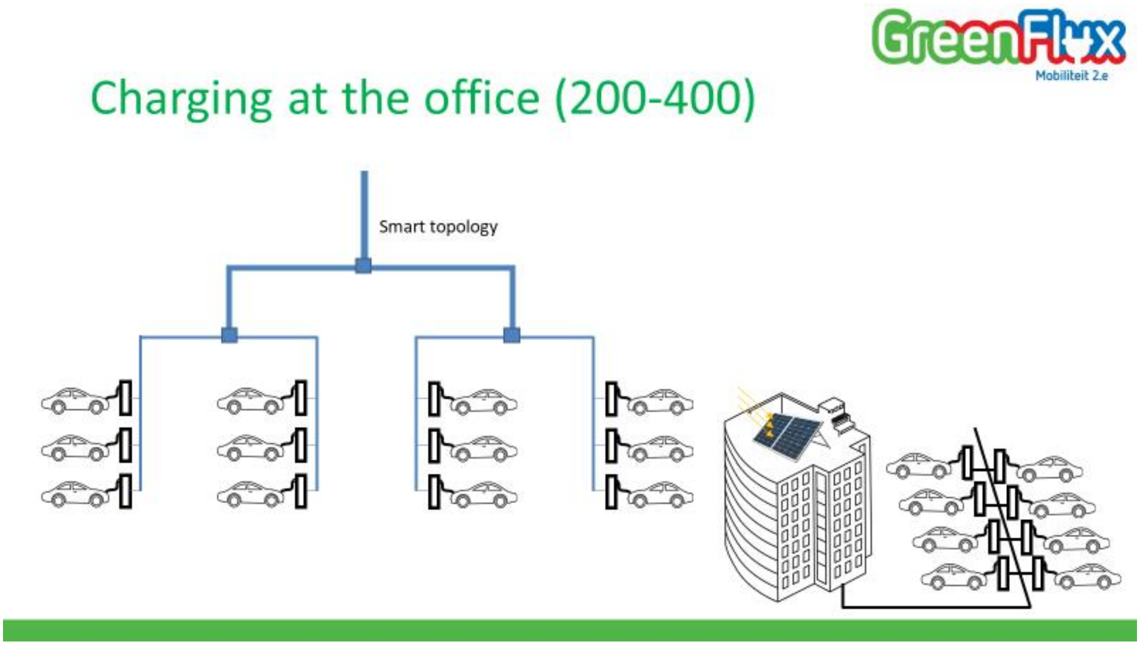
Project participants: Alliander, EVnetNL, The New Motion, Delta, GreenFlux

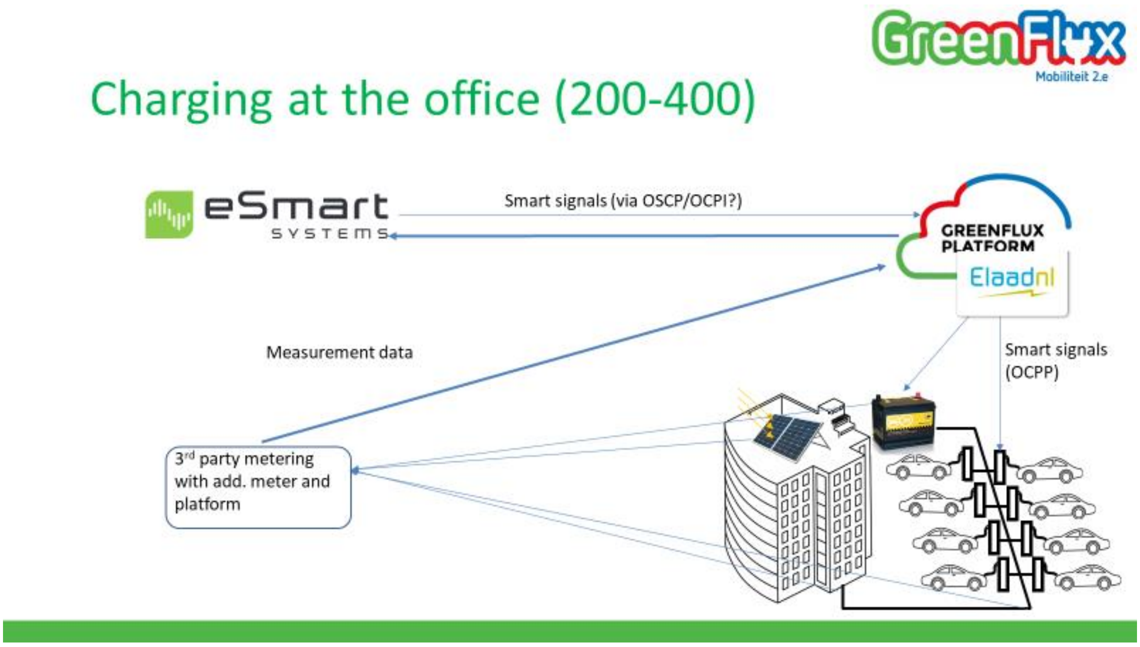
Project goal: In this project, the DNO offers a 'flexible' grid connection. It gives a higher maximum power with a large discount on the annual fee. In return for this discount, charging needs to be lowered during peak hours. GreenFlux took care of steering the charging.

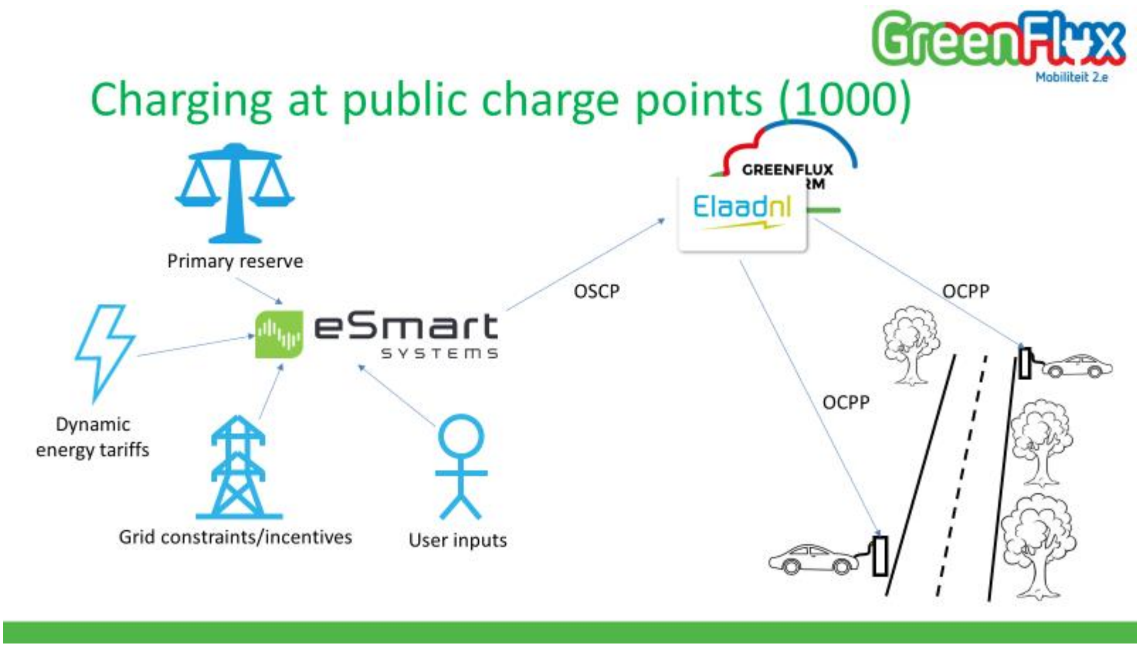
Confidential

Flexibility customer	Flexibility service	Selected flexibility service			Selected flexibility sources						
		Yes	No	Not sure	Load shifting	Load curtailment	Generation control	Centralized storage control	Distributed storage control	EV control	EV control with V2G
DSO	Short term congestion management	LO, LP			YES	YES				YES	
	Voltage / Reactive power control		X								
	Controlled Islanding		X								
BRP	Day–Ahead portfolio optimization	SH, LO			YES	YES				YES	
	Intraday portfolio optimization			X							
	Self-Balancing portfolio optimization			X							
Prosumer	ToU Optimization	LP, LO			YES	YES				YES	
	KWmax Control	LO, LP,SH, SPSO			YES	YES			YES	YES	YES
	Self-Balancing		X								
	Controlled Islanding		X								
	LO = Large scale office										
	LP = large scale public										
	SH = Small scale home										
	SPSO = Small scale public & office										

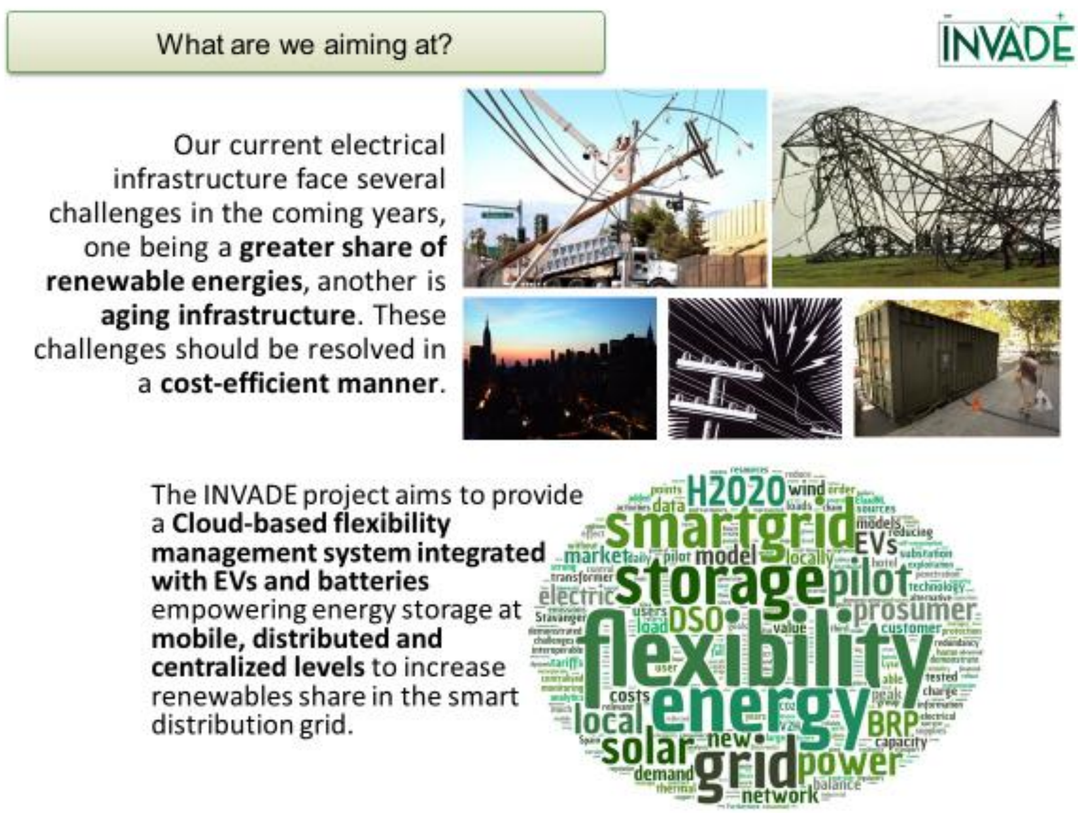

Charging at home (25)
Smart profile (OCPI)
GREENFLUX PLATFORM
Dynamic energy tariffs (protocol?)
Smart profile (OCPP)
Energy Supply
Meter values (protocol?)
3rd party metering with add. meter and platform
Meter values
Demand limits
Smart meter

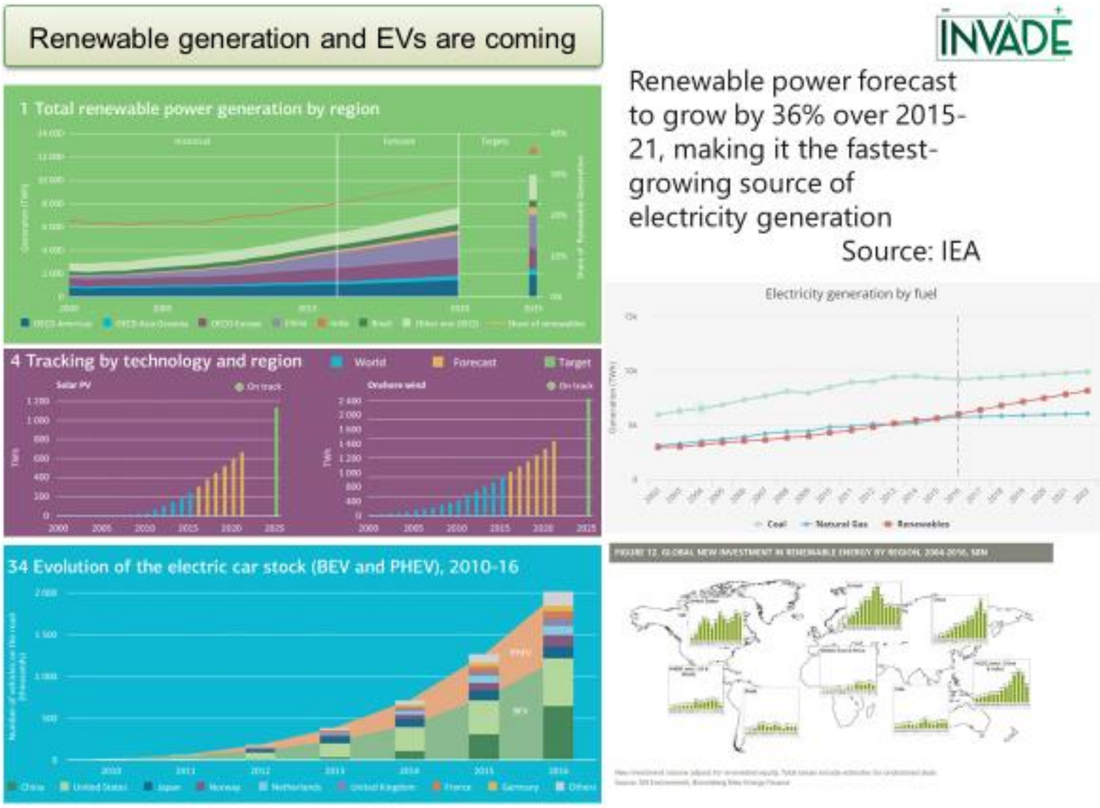

Charging at the office (200-400)
Smart topology

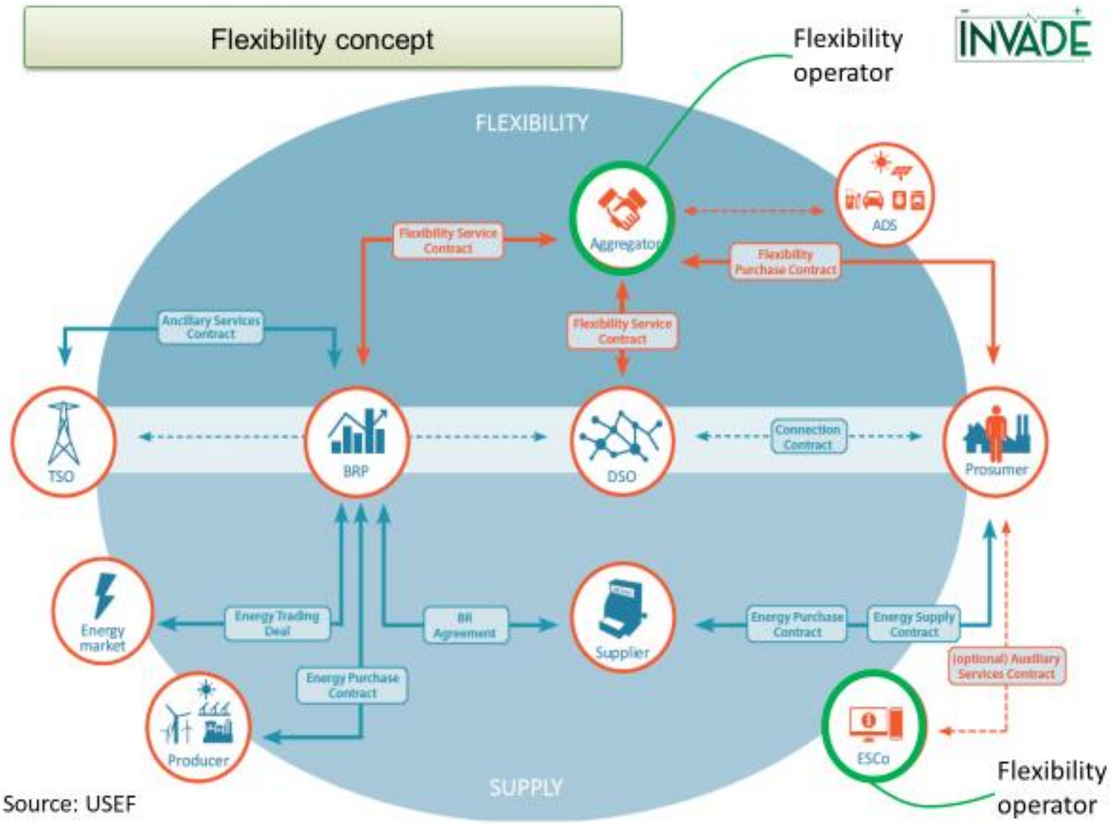

Charging at the office (200-400)
Smart signals (via OSCP/OCPI?)
GREENFLUX PLATFORM
Elaadnl
Measurement data
Smart signals (OCPP)
3rd party metering with add. meter and platform


Charging at public charge points (1000)
Primary reserve
OSCP
OCPP
OCPP
Dynamic energy tariffs
Grid constraints/incentives
User inputs

13. Presentation Michel Bayings (E-Mobility consulting)




Renewable generation and EVs are coming
INVADE
Renewable power forecast to grow by 36% over 2015-21, making it the fastest-growing source of electricity generation
Source: IEA
1 Total renewable power generation by region
4 Tracking by technology and region
World
Forecast
Target
34 Evolution of the electric car stock (BEV and PHEV), 2010-16
Electricity generation by fuel
Coal
Natural Gas
Renewables


Flexibility concept
INVADE
Flexibility operator
FLEXIBILITY
Aggregator
ADS
Flexibility Service Contract
Flexibility Purchase Contract
Ancillary Services Contract
Flexibility Service Contract
TSO
BRP
DSO
Connection Contract
Prosumer
Energy market
Energy Trading Deal
BR Agreement
Supplier
Energy Purchase Contract
Energy Supply Contract
(optional) Auxiliary Services Contract
Energy Purchase Contract
Producer
ESCo
SUPPLY
Flexibility operator
Source: USEF

System description

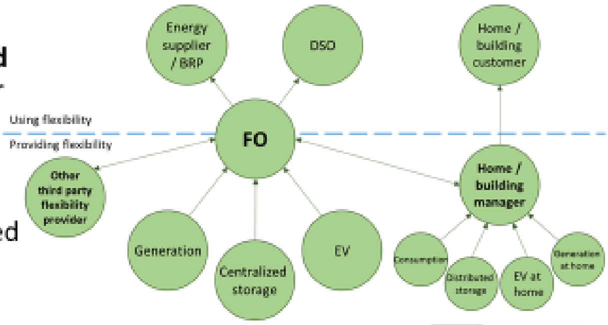
The system is a peer-to platform **based on direct control of demand and supply.** The flexibility operator (FO) takes decisions based on **flexibility contracts**. Third party platforms can be integrated.

Flexibility resources to be controlled are:

- Batteries
- Electric vehicles
- Photovoltaic panels
- Water heaters
- Heat pumps

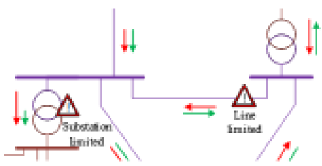
Flexibility services for:

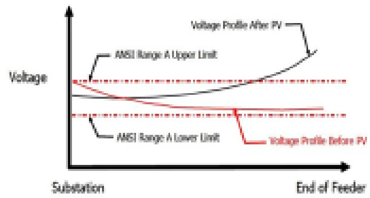
- End-users/prosumers reducing the electricity bill
- BRP to reduce imbalance penalties
- DSO to control grid congestions

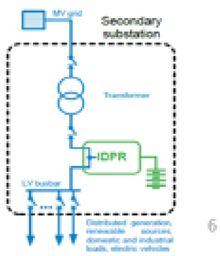


Flexibility services for DSO

- **Congestion management**:
  - Avoiding thermal overload of system components by reducing peak loads where failure due to overloading may occur.
  - Flexibility may defer or even avoid the necessity of grid investments.
- **Voltage / Reactive power control**:
  - Typically requested when solar PV systems "push up" the voltage level in the grid.
  - Increasing the load or decreasing generation is an option to avoid exceeding the voltage limits.
  - It can reduce the need for grid investments (such as automatic tap changers) or prevent generation curtailment.
- **Controlled islanding:**
  - To prevent supply interruption in a given grid section when a fault occurs in a section of the grid feeding into it.



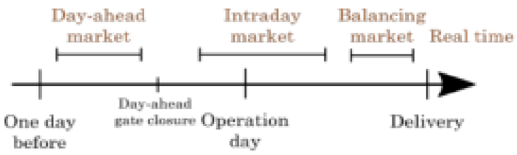




6

Flexibility services for BRP

- **Day-ahead portfolio optimization**
  - It aims to shift loads from a high-price time interval to a low-price time interval before the day-ahead market closure.
  - It enables the BRP to reduce its overall electricity purchase costs.
  - This service is used by BRP to prepare day-ahead market bids.
- **Intraday portfolio optimization**
  - It resembles day-ahead optimization after closing of the day-ahead market.
  - This enables intraday trading and flexibility can be used to create value on this market, equivalent to the day-ahead market.
  - This service is used by BRP to prepare intraday market bids.
  - Intraday optimization, once the day-ahead market prices have been announced, is our preferred option rather than Day-ahead
- **Self-balancing portfolio optimization**
  - It aims to reduce imbalance of the BRP portfolio to avoid imbalance charges.
  - BRP does not actively bid on the imbalance market using its flexibility, but uses it within its own portfolio.



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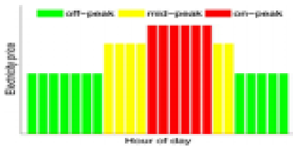
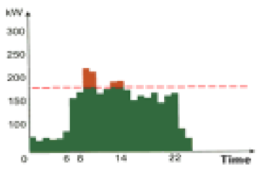
Flexibility services for prosumers

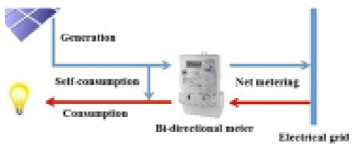
- **ToU optimization**
  - Based on load shifting from high-price intervals to low-price intervals or even complete load shedding during periods with high prices.
  - It requires that tariff schedules are known in advance to lower prosumer's bill.



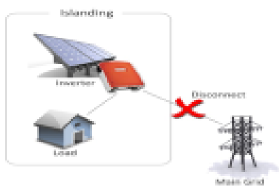
- **kWmax control**
  - Based on reducing the maximum load (peak shaving) that the Prosumer consumes within a predefined duration (e.g., month, year), either through load shifting or shedding.
  - By reducing this maximum load, the prosumer can save on tariff costs.



- **Self-balancing**
  - It is typical for prosumers who also generate electricity (PV or CHP systems).
  - Value is created through the difference in the prices of buying, generating, and selling electricity (including taxation if applicable).
  - Note that solar PV self-balancing is not meaningful where national regulations allow for administrative balancing of net load and net generation.
  - It can include zero-net injection optimization.



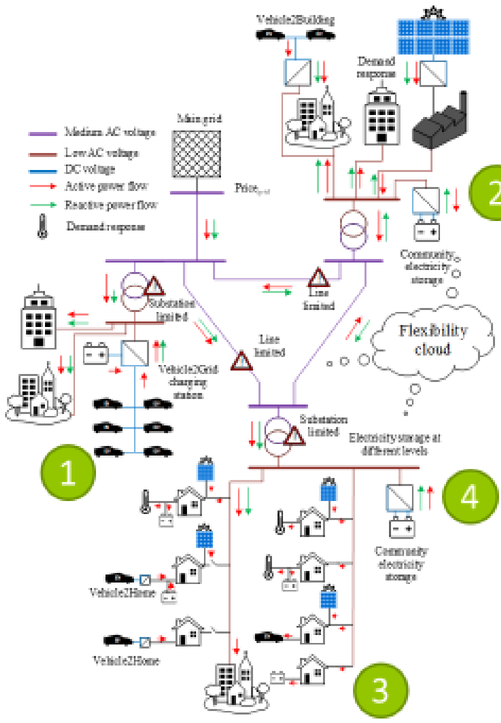
- **Controlled islanding**
  - It provides supply during grid outages.
  - Added value to the Prosumer depends on the grid's reliability and the potential damage from a grid outage.
  - Islanding may require additional investments, such as storage and synchronization systems.



Use cases

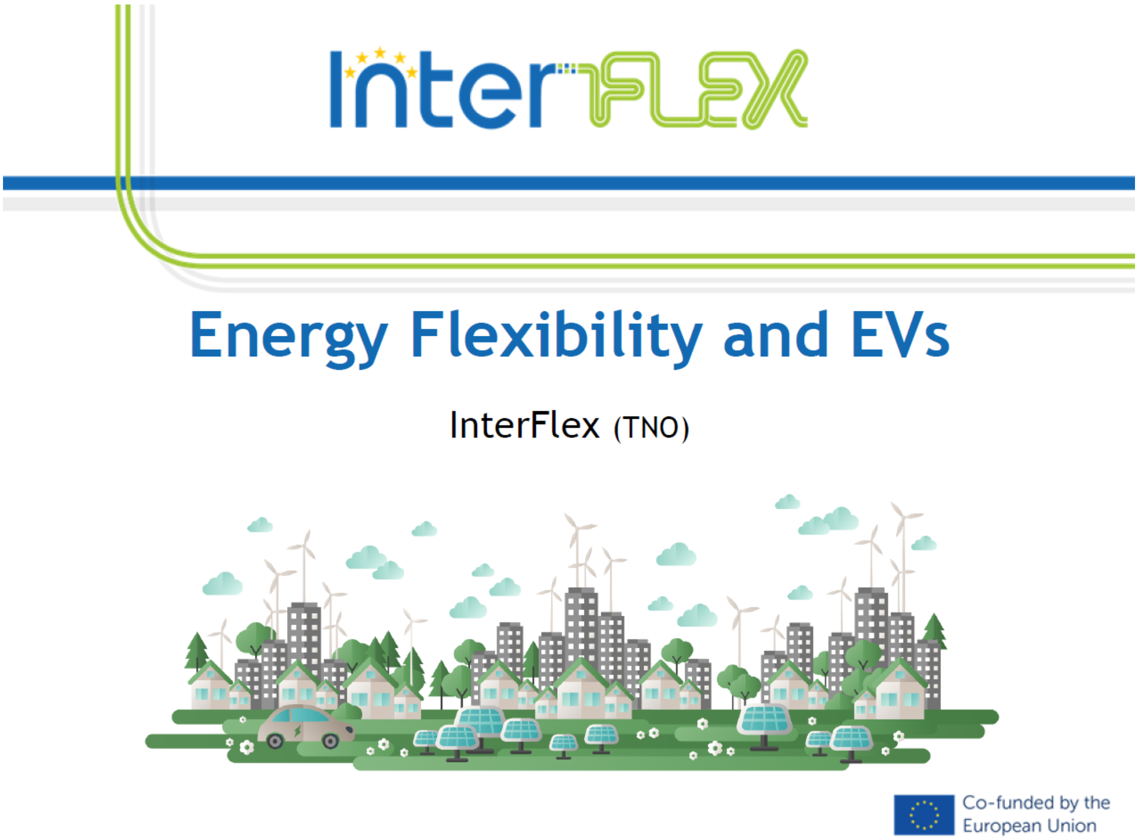
Use cases (UC):

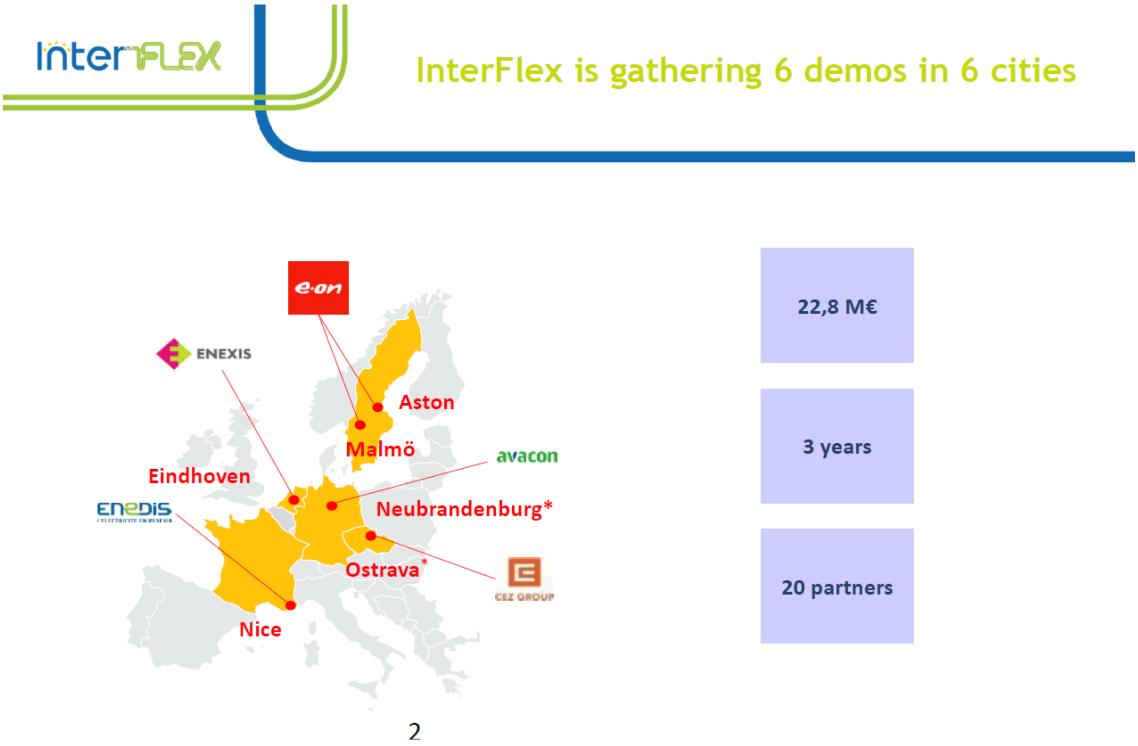
1. Mobile energy storage using EVs for V2G, V2B and V2H operations
2. Centralized energy storage using an array of batteries at the sub-station or street level
3. Distributed energy storage using individual batteries at the household level
4. Hybrid level energy storage solutions addressing a combination of use cases 2 and 3



Partners involved

14. Presentation Joost Laarakkers (TNO)





3

InterFlex is addressing several use Case

Member state	Germany	Czech Republic	The Netherlands	Sweden	France
DSO	Avacon (E.ON Group)	CEZ Distribuce	Enexis	E.ON Sverige/ E.ON Elnät	ERDF
Population density	Rural	Semi-urban / urban	Urban	*Malmö / Aston* Urban / Rural	Urban
Demand-response					
Smartening the distribution grid					
Energy storage technologies and connections with other energy networks					
Smart integration of grid users from transport					

Enexis in Interflex

3 Use cases

Use case 1;

Enabling ancillary services, congestion management, and voltage support for PV integration using, grid connected storage systems which improve grid observability of prosumers, while promoting batteries in a multi-service approach

Goal; To validate technically, economically and contractually the usability of a central storage unit

Use case 2;

Enabling the optimal activation of all available local flexibilities, using interactions between the DSO and the Charge Point Operator, in the role of aggregator using local installed EVSE's for congestion management and voltage control

Goal; To unleash EV flexibility (also V2G)

Use case 3;

Validate technically, economically and contractually the usability of an integrated flex market based on a combination of static battery storage and EV

Goal; Create an integrated flex market >>> create an energy management system that unlocks available local flexibility >> enabling business models for EV, STORAGE...

4

4

InterFLEX

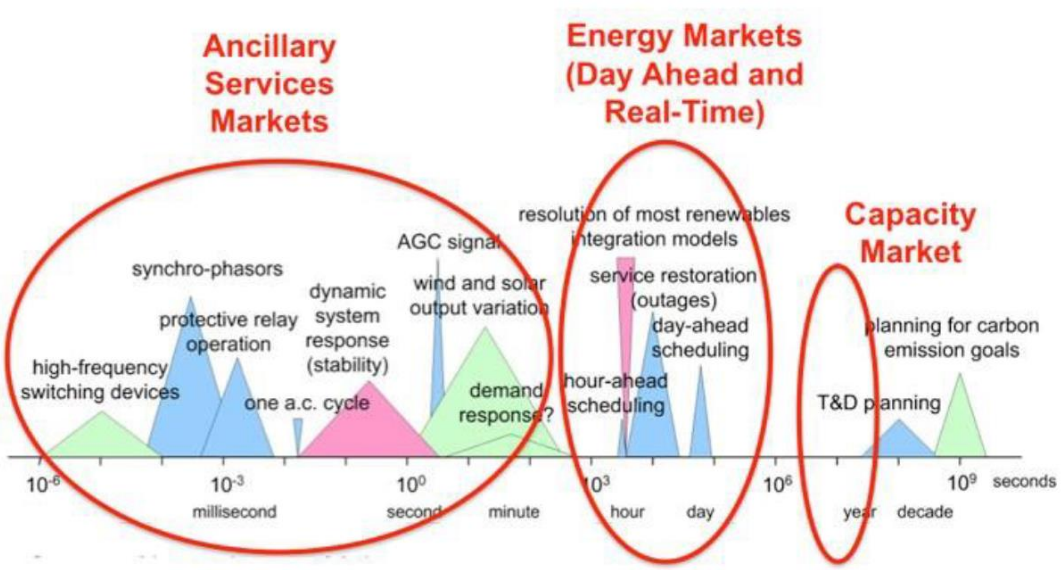
AGENDA TOPICS

- Time scale axis
  - balance on energy
  - congestion limits
- Flexibility needed
  - types of flexibility
  - uncertainty of flexibility
- Markets
  - some less
  - some more regulated
- Market role picture
  - seems simple
  - But has many and multiple actors
- Need a well designed system
  - Scalable architecture with
  - Open interfaces

5

InterFLEX

Grid timescales and markets



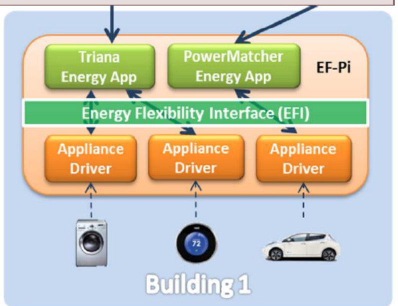
InterFLEX

Flexibility types and uncertainties

- There are different flexibility types
  - Uncontrollable (PV)
  - Time Shiftable (EV)
  - Buffer (Battery)
  - Unconstrained (generator)

Categorie	Description	Examples
Uncontrollable	Has no flexibility, is measureable and may provide forecast	Solar panel, Wind Turbine, TV, indoor lighting
Time Shiftable	Operation can be shifted in time, has a deadline	Washing machine, Dishwasher
Buffer	Flexible in operation for either production and/or consumption and operation is bound by a buffer	Freezer, Heat Pump, CHP, Battery, Electric Vehicle, Cooling systems
Unconstrained	Flexible in operation for production. The operation is not bound by a buffer	Gas Generator, Diesel Generator

- Flexibility sources have different certainties
  - Battery flexibility offer can be guaranteed
  - Flexibility from EVs still to arrive cannot be guaranteed
- Energy Flexibility Information Standard/Interface needed
  - Will use Energy Flexibility Interface (EFI)
  - Source White paper:
    - http://flexiblepower.github.io/EF-Pi-Whitepaper/



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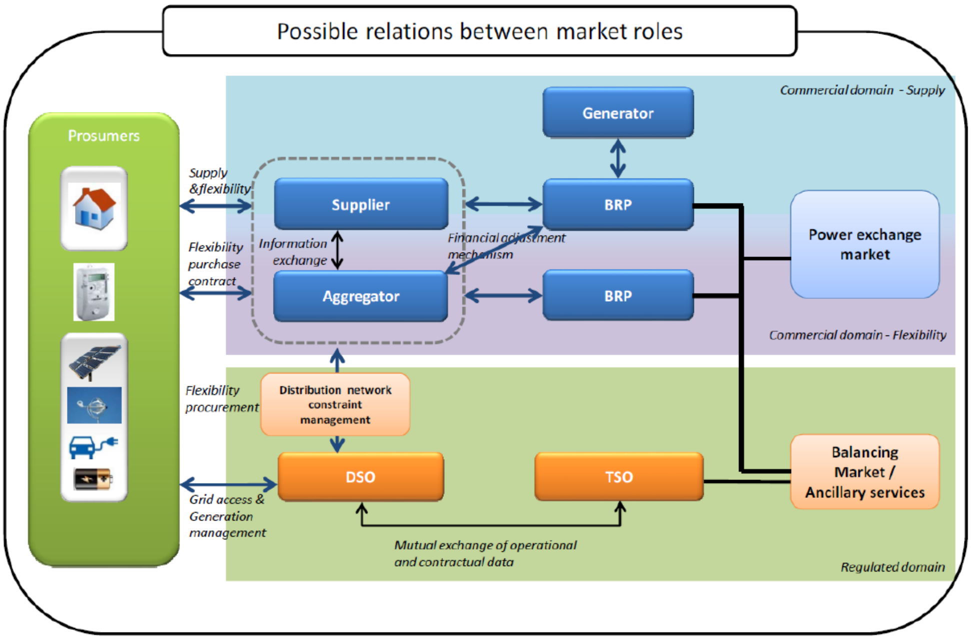
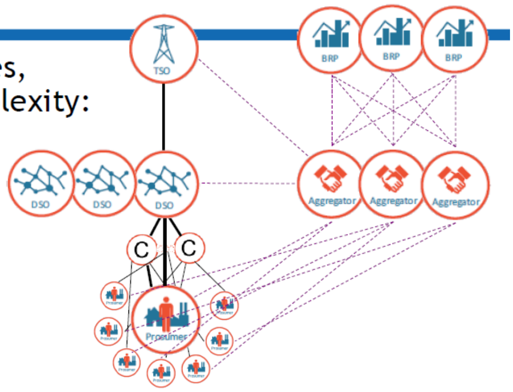
InterFLEX

Market role relations



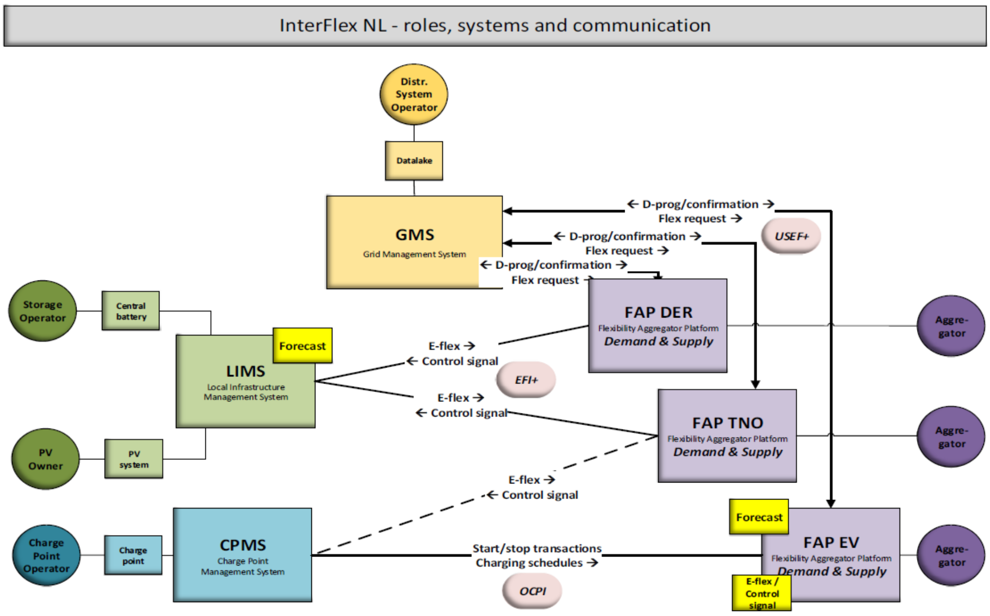
- Possible relations between market roles, from Smart Grid Task Force Grid report: ‘Regulatory Recommendations for the Deployment of Flexibility

Multiple actor complexity



- Open market for aggregator services, introduces the multiple actor complexity:
  - Multiple **A**ggregators (A)
  - Multiple **B**RPs (B)
  - Multiple **C**ongestion Points (C)
  - From different **D**SOs (D)
  - Many **E**nd Users (E)
- Possible relations is = **A x B x C x D x E**
- We want ‘freedom of choice’ for all stakeholders
- We want to keep it maintainable and manageable
- How to keep an AxBxCxDxE eco system maintainable, manageable and future proof?
  - Clear separations of concerns!
  - Well designed, documented and open interfaces (USEF, EFI, …)
  - Scalable architecture and technologies

The Dutch flexibility model

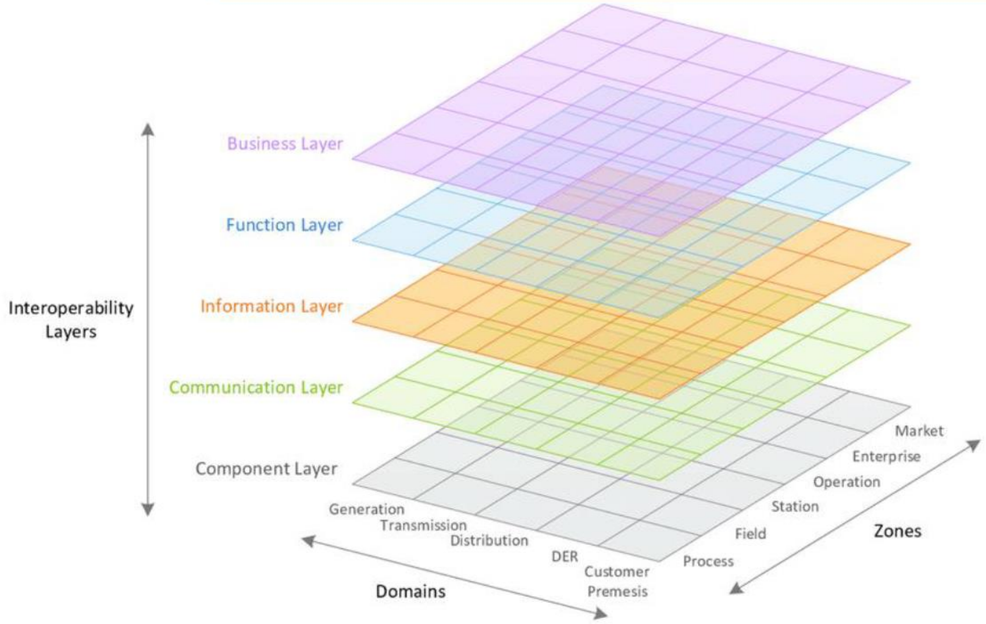


10

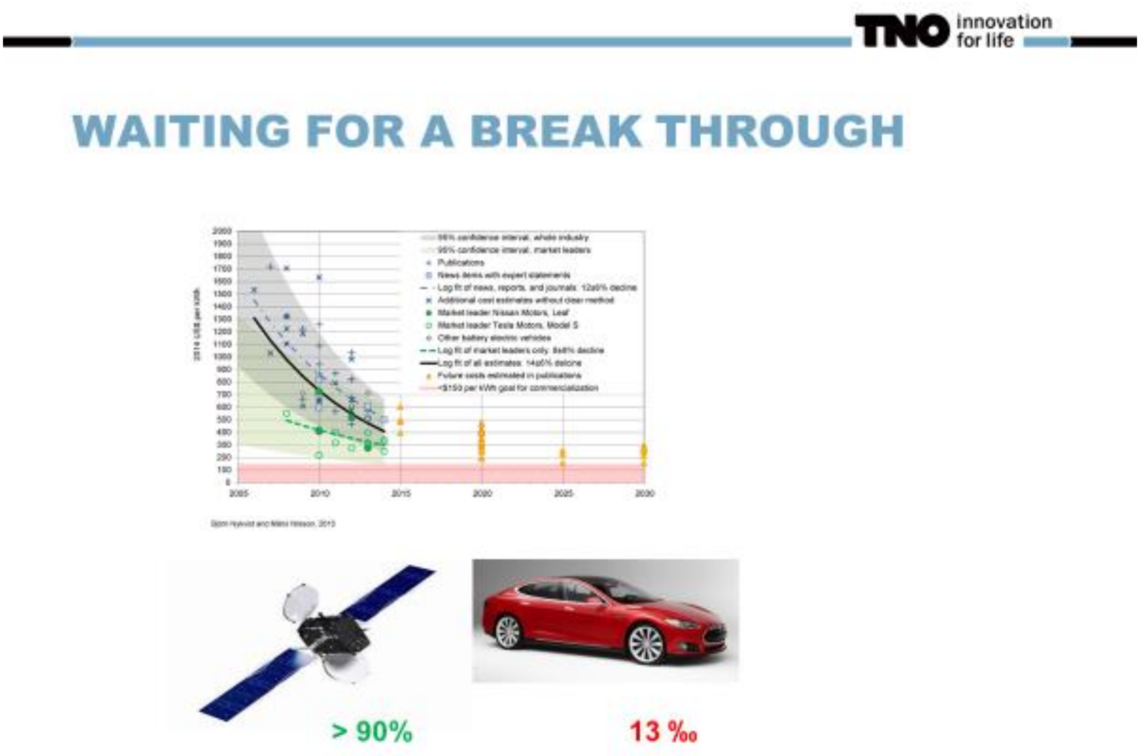
Conclusion

- So, to maintain balance on all timescales and grid limitations, we need to use all types of flexibility, also those with uncertainty
- The different markets have many and different types of stakeholders
- Needs a scalable architecture with well designed open interfaces that can deal with the A*B*C*D*E complexity

Interflex systemen & pilot – Smart Grid Architecture Model



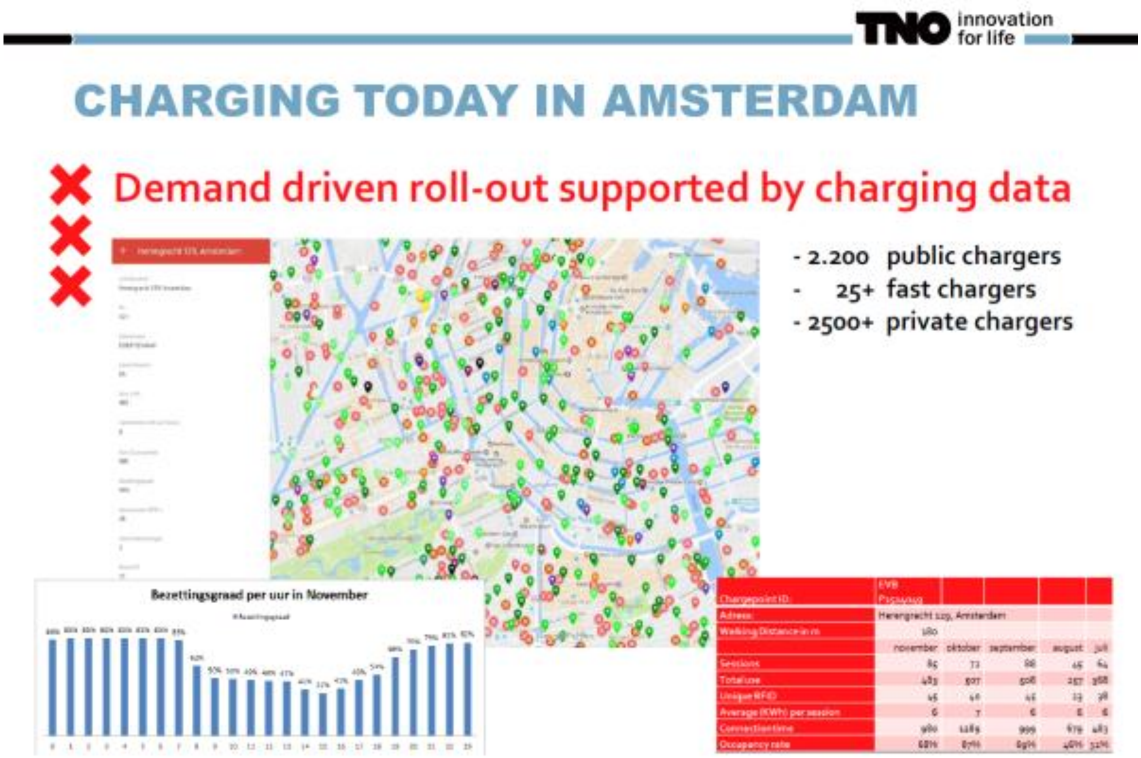
15. Presentation Mark Bolech (TNO)

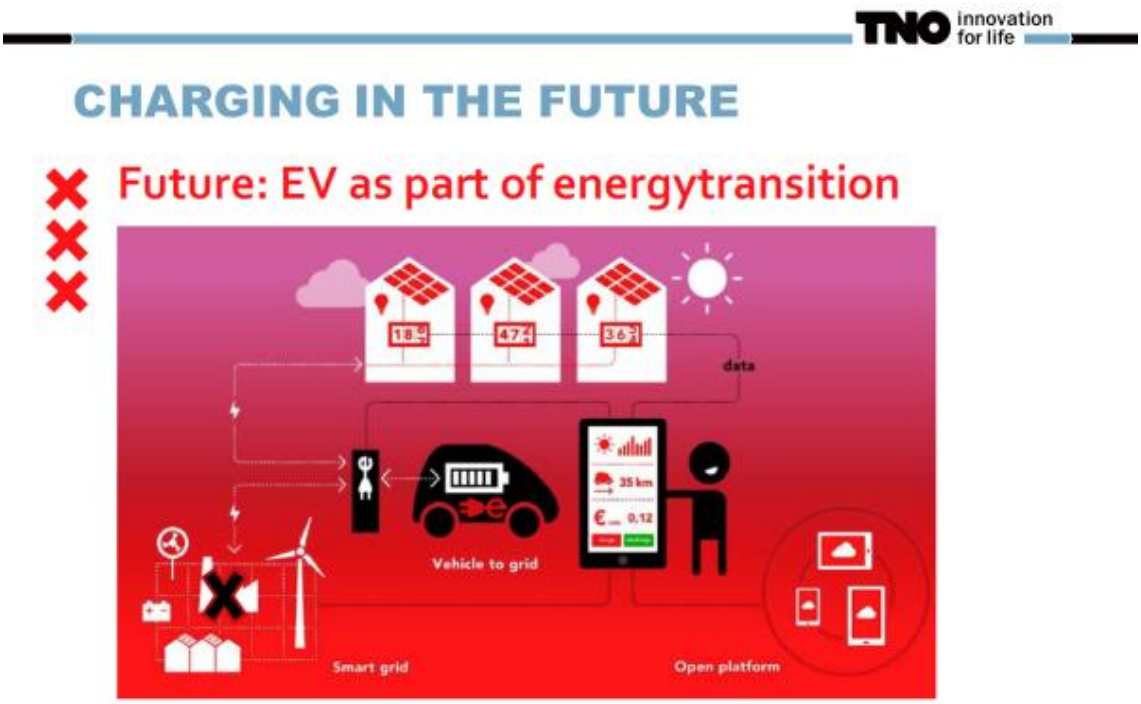


WAITING FOR A BREAK THROUGH

RAPID GROWTH EXPECTED

- Now mainly driven by government: for example taxis and busses on and around Schiphol or busses in Eindhoven
- Sooner than you realise also entrepreneurs and private owners

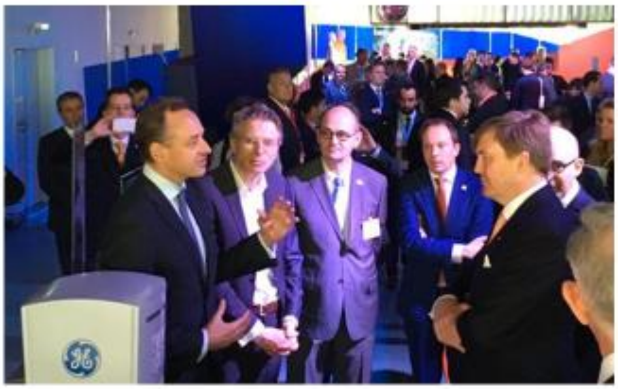

TNO innovation for life
CHARGING TODAY IN AMSTERDAM
Demand driven roll-out supported by charging data
- 2.200 public chargers
- 25+ fast chargers
- 2500+ private chargers
Bezettingsgraad per uur in November


TNO innovation for life
CHARGING IN THE FUTURE
Future: EV as part of energytransition
data
Vehicle to grid
Smart grid
Open platform

TNO innovation for life

WHERE IS THE EXTENSION CORD?

- Enormous growth EV → enormous growth of charging infra
- Simultaneous enormous growth in PV systems and electric heat pumps.
- Formidable challenge for the distribution net <u>and</u> an opportunity to do it smart



Appendix 3 – Minutes of the Liaison Group meeting in Umeå (8 March 2018)

1. Program

2. Introduction TNO on innovation processes in cities

Te aim of this introduction is to set the scene to deepen reflection on the current innovation processes in the Lighthouse Cities. Do not answer the question “are we doing things right….?” but instead answer the question “…..are we doing the rights things?”. Reflection on innovation processes in cities builds on three pillars: (1)the city as a complex system, (2) innovations as system transformations and (3) new coordinating mechanisms.

Complex urban systems → urban projects are embedded in a complex system, which is built up from district systems and is in itself part of a regional/national system. This requires continuous reflection on the interdependencies between the elements of the system. Urban systems deal with wicked problems, due to scientific uncertainty, institutional and social diversity. Key is to increase urban learning capacity to cope with uncertainty and adapt to new trends and movements. Municipal organizations and their partners face self-organising stakeholders. That’s why continuous reflection and awareness of the role of public authorities is essential. Methodology development to stimulate such self-organising initiatives may help. Challenge is to build in flexibility, in policies, contracts, procurement. This will enable municipalities to deal with unexpected events and initiatives, however complicates accountancy and control.

Innovation → to meet the Paris goals we need radical innovations on a system level. However, existing coordinating mechanisms often only stimulate incrementalism. Cities are built up from many socio-technical systems. These systems consist of highly interdependent ‘components’ such as actors, regulation, policies, financing mechanisms, culture, physical infrastructure etc.. For innovations to succeed, and to be radical, the entire socio-technical system needs to change.

Coordinating mechanisms → If we take the perspective of coordinating mechanisms, key focus is what is often called the 'rules of the game'. Accepting that urban systems and innovation within these systems are the outcome of collaborative efforts of actor networks: question is "what structures" the relation between actors in the city? And via what means is a desired outcome of the urban system reached? In general there are three coordinating mechanisms possible: markets, regulation and cooperation. Markets rely on pricing mechanisms to solve urban challenges. Regulation is based on the principal of compliance and enforcement. Regulation is often prescriptive. The final type of coordination is based on cooperation, where trust and reciprocity are the most important drivers. In practice, almost every challenge or situation shows a complicated mix of drivers and coordinating mechanisms. Innovation and the complexity of the urban system require reflection on existing and new coordinating mechanisms. These mechanisms should be able to cope with changing roles, new forms of cooperation and fragmented knowledge and information.

3. Presentations by the Lighthouse Cities

The transition towards smart cities in general requires both incremental (step by step) and radical ('game changers') innovations. However current policies, institutional frameworks and practices most often only allow for incremental changes to take place. What coordinating mechanisms (such as markets / prices, regulation and cooperation mechanisms) has to be in place to encourage radical changes in city systems and governance? How can partners collaboratively engage in successful radical innovation projects?
We asked the Lighthouse city coordinators to reflect on the following questions:

7. Looking at the current practices in RUGGEDISED, what kind/level of innovation and what sustainability goals are likely to be realized at the end of the project in your city?
8. If you had the chance to rewrite the RUGGEDISED proposal, especially your energy system smart solutions (with the knowledge you gained so far) what level of innovation and sustainability ambition would you aim for?
9. 'Dream Scenario'. What kind of innovations and sustainability goals would you ideally aim for regarding the energy system? If you were not being influenced by existing infrastructures, policies, laws, contracts, financing mechanisms etc.
10. What is needed to actually realise such a Dream Scenario in terms of how current energy markets work and energy prices are established?
11. What is needed to actually realise such a Dream Scenario in terms of changes that has to be made in existing laws and regulations?
12. What is needed to actually realise such a Dream Scenario in terms of how partners/stakeholders cooperate?

Rotterdam – André Houtepen

Designing smart, resilient cities for all

RUGGEDISED

1. Looking at the current practices in RUGGEDISED, what kind / level of innovation and what sustainability goals are likely to be realized at the end of the project in your city?

- Rotterdam 2015 - 2018: ***Sustainability closer to the people.*** Citizens have a right to a clean, healthy and green city, with dry feet and low energy bills.
- In the last 4 years with a sustainablity budget of M€ 26.5 the city generated over M€400 sustainable investments in city and harbour.

- In 2035: - 150.000 houses on NUON heating system (hot water, no gas)(50% of total) - 7000 rental houses - 3000 private houses - 1500 appartments energy efficient.

- Together with Rabobank special loans for citizens for sustainability. City target: € 600,- less energy costs/year per household (= 40% of total costs).

- In 2025: 350 MW windenergy (50 MW city, 300 MW harbour)(= 200.000 households).
- 63.317 tons less CO2/year.

- Rotterdam: 8,5 km2 flat roofs = 70% of total roof area. → PV potential ± 1.500 GWh. = 60% of total electricity needs.
  Target 2018: 20 GWh sun energy. In 2030: 1.000 GWh.

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RUGGEDISED

Smart solution	Decrease in energy consumption (kWh/year)	CO2 reduction (ton/year)	% of total Rotterdam
Geothermal heat-cold storage	924.167	200	
Thermal energy from waste streams	215.967	44	
Surface water heat-cold collection	39.667	19	
Pavement heat cold collector	39.667	19	
PV panels	1.785.101	857	
Urban wind	150.000	72	
DC grid, PV and storage for mobility	66.226	32	
Smart charging parking lots	5.750	3	
Optimising E-bus fleet of RET	1.900.000	150	
LoRa network KPN	338782	104	
Efficient & Intelligent street lighting	124.487	60	
Smart wast management	315.667	72	
Rest of the smart solutions	8.934.744	373	
TOTAL	14.840.175	2.005	3,2% of 63.317

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- RUGGEDISED only 3,2% = small part of total sustainability targets in Rotterdam.
- But: the <u>first integrated approach</u> on thermal and electrical energy grids combined with sustainable buildings, e-mobility and use of big data.
- It's a showcase for the **Roadmap Next Economy** for the entire The Hague-Rotterdam Delta and therefor very important!
- Sucess of RUGGEDISED is very important for the city

Designing smart, resilient cities for all

2. If you had the chance to rewrite the RUGGEDISED proposal, especially your energy system smart solutions (with the knowledge you gained so far) what level of innovation and sustainability ambition would you aim for?

- <u>Present problems:</u>
  a. integration with PPP contract Hart of South which is not very profitable
  b. thus strong desire to achieve positive business cases for the grids
  c. stepping out of BN, stepping in of Eneco for the smart thermal grid

- <u>Contribution to solution:</u>
  1. Local budget available to make buca positive
  2. No integration with existing public contracts
  3. In a contract that's not a cooperation contract but a client and supplier contract

  4. <u>At the beginning</u>: same level of innovation but start small with only a few smart solutions (not 13) and two buildings connected (not 6)
     <u>At the end:</u> same sustainablity ambition realized

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3. Dream Scenario'. What kind of innovations and sustainability goals would you ideally aim for regarding the energy system? If you were not being influenced by existing infrastructures, policies, laws, contracts, financing mechanisms etc.

The same ones.

We are aware of the above mentioned influences but need to solve them within RUGGEDISED.

That is the big challenge!

That makes the project so interesting
and sometimes so frustrating.

Designing smart, resilient cities for all

4.5.6. What is needed to actually realise such a Dream Scenario in terms of

- how current energy markets work and energy prices are established?
- Changes that has to be made in existing laws and regulations?
- How partners/stakeholders cooperate?

In Rotterdam: close cooperation between the 2 Energy companies working in the Heart of South district

More sustainably driven companies in stead of commercially driven companies?

tegenstroom voor Haarlemmermeer

Since 2014: First dutch sustainable energy company owned for 100% by Municipality of Haarlemmermeer

Umeå – Carina Aschan

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RUGGEDISED

Sustainability goal:
"development without increased climate impact"

- 100% renewable energy supply
- A long term contract between the partners
- Thorough and mutual understanding of the necessary measures

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RUGGEDISED

Looking forward…

- Implementation of the business model
- Extend the local partnership
- Explore possible impact/consequences outside the innovation area
- The Market place
  – block chain solution

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Dream Scenario

- Sharing is in everyone's interest
- Active involvement of customers - prosumers
- ”4th generation of district heating”
- Investments in the system are made for the sake of the environment

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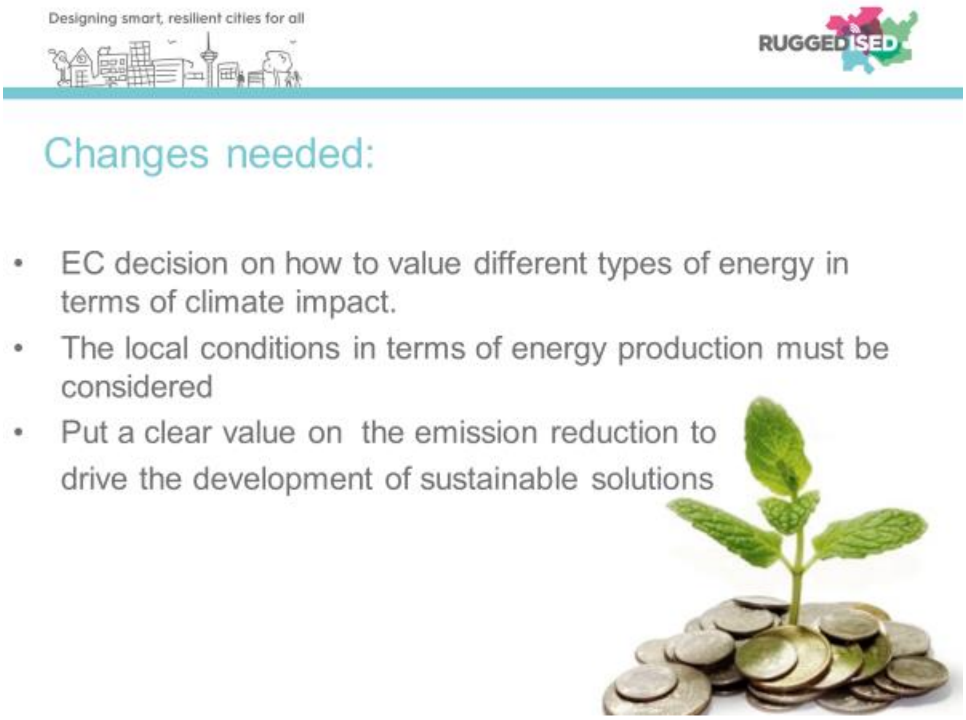
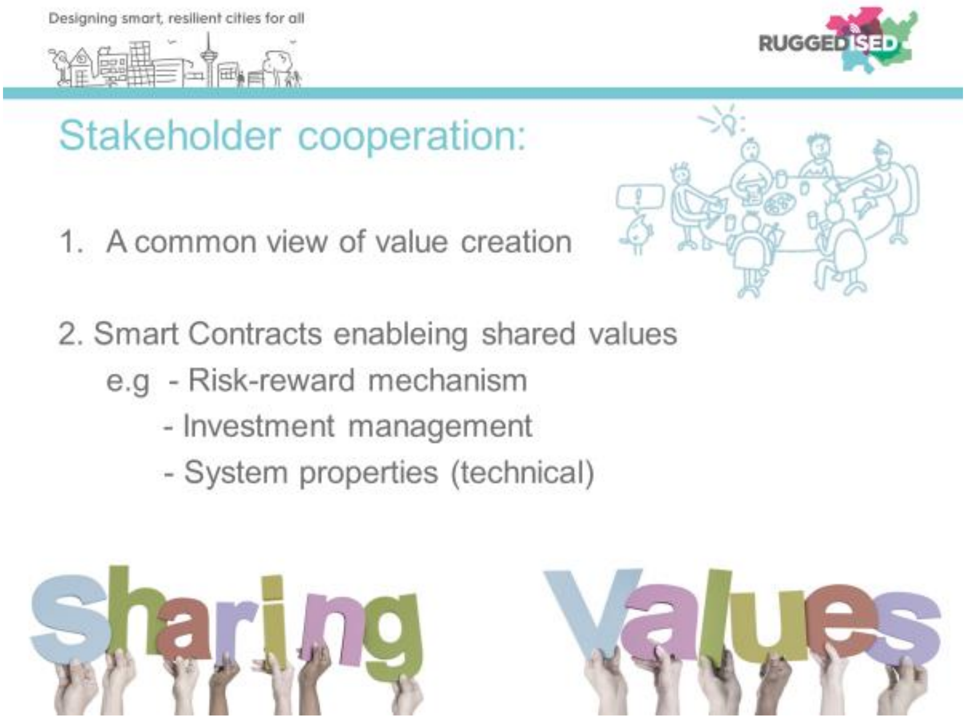
What is needed?

- Clarity in the trade of carbon credits
- Emission trading must trigger the development
- Standards for the district heating (access is allowed)
- Enhanced utilisation of the temperature in the system
- Establish the cost for climate impact!


Designing smart, resilient cities for all
RUGGEDISED
Changes needed:
• EC decision on how to value different types of energy in terms of climate impact.
• The local conditions in terms of energy production must be considered
• Put a clear value on the emission reduction to drive the development of sustainable solutions


Designing smart, resilient cities for all
RUGGEDISED
Stakeholder cooperation:
1. A common view of value creation
2. Smart Contracts enableing shared values
e.g - Risk-reward mechanism
- Investment management
- System properties (technical)
Sharing Values

Glasgow – Gavin Slater & Nick Kelly

Designing smart, resilient cities for all

RUGGEDISED

Current Practices in RUGGEDISED

- Reduced CO_2 through increase of renewables and energy storage, both on a domestic and non-domestic scale with high level of replicability
- Innovation in the management and distribution of energy across a local network, controlled via local network management, and integrated with the wider city distribution network.
- Level of innovation is high, integrating known technologies with bleeding edge control systems, facilitating the dynamic management of locally generated energy from sustainable sources.

29/04/2018 2

Designing smart, resilient cities for all

RUGGEDISED

Rewriting the bid

- Innovation level is high
- Sustainability potential is high
- Integration with other innovation, infrastructure and redevelopment projects in the city is very strong
- At this point, we are satisfied with the ambition and, due to the level of potential upscaling, are confident of achieving a meaningful impact.

29/04/2018 3

Designing smart, resilient cities for all

RUGGEDISED

Dream Scenario

- Biggest obstacle to innovation and sustainability in project is currently associated with distribution network fault level
- This has inhibited project progress and could reduce scope for growth
- Dream scenario would be that the fault level issue either didn't exist or that innovation existed to ameliorate the issue.
  - However, getting around this problem may be one of RUGGEDISED biggest successes in Glasgow.

29/04/2018 4

Designing smart, resilient cities for all

RUGGEDISED

How to achieve Dream Scenario

- Perhaps – Reduce electrical demand in city to free up capacity on the network reduce fault level issue.
- Difficult – even in dream scenario, the decarbonisation of the electricity grid is one of Scotlands great achievements of late in relation to climate issues, leading to movement towards more electrical demand through heat pumps, EV, etc.
- This increasing demand is not expected to slow down any time soon.
- Smart grid essential.

29/04/2018 5

4. Matchmaking

The Liaison Groups are a good opportunity to engage in matchmaking with international expertise. We have asked the consortium partners to present a specific challenge that they want to discuss and find expertise to help them further. on. We aimed to have two rounds (30 min. each) of discussions in small groups on specific topics. In five groups all participants exchanged their expertise and knowledge and also listed issues that can be addressed in following Liaison Groups or side-meetings.

Group 1 on Business Model Innovation

Names Nick Kelly – US; Jörgen Carlson – Umeå Energi; Jasper Feuth – Eneco; Marcel van Oosterhout – RSM; Albert Engels – Rotterdam; Klaus Kubeszko – AIT; Alexander Woestenburg – TNO
Challenges discussed Business Model Innovation – What are the preconditions for the scaling-up or replication of smart grid/smart energy projects?
Expertise matches and next steps The key is to find models on how to share future benefits of today's investments. Transparency and "open books – approach" are key to build trust for the cooperation among the stakeholders. Kickback of future value creation. Think in terms of supply chains. How to distribute future benefits on the different players and engage them in long term contracts. Risk/reward balance. Perhaps crowdfunding of applications.

Group 2 on visualization and behavioural change

Names Annelie Hansson – Akademiskahus; Romana Jalůvková – Municipality of Brno; Joanna Tobolewicz– City of Gdansk; Mario Gualdi – Isinnova; Carina Aschan – Umeå; Adriaan Slob - TNO
Challenges discussed How to get the scientists to share spaces in their offices? Why are people not sitting together in the rooms?
Expertise matches and next steps Ask students at ICT, Design, Social Science departments to facilitate with surveys. Survey why they behave like they do? How do they react on information that is given to them to change behavior?

Group 3 on Energy Management

Names Joanna Zbierska - Gdansk, Jacek Tomaszewski – Gdansk; ThomasOlofsson – Advisory Boards , Lisa Redin – Umeå University, Kristofer Linder – Västerbotten County Council, Machiel Karels and Roland van Rooyen - Rotterdam
Challenges discussed 'demand-side' management (Umeå): how to use sensors for optimizing energy consumption & improve indoor comfort. Rotterdam: how to implement area thermal & electric smart grid – energy management.
Expertise matches and next steps Umeå: modelling with historical data, scenario analysis to test robustness thermal energy system. Gdansk: experience with combining heat from wastewater to pavement collector to keep ice-free. The same as Rotterdam has set up in 1,5 years ago as monitoring project Umeå-Rotterdam: optimize energy use within building with sensors and domotics. Work together with Umeå & Rotterdam with using/making models for thermal grid and heat and cold storage. Exchange experience with heat from sewage & pavement collector between

Rotterdam & Gdansk.

Group 4 on EV charging

Names Jiri Drinovsky – University of Brno, Ghazal Etminann - AIT; Laura McCaig – Transport Scotland; Graham Colclough – Urban DNA advisory board; Mark Bolech - TNO
Challenges discussed on street charging, tariffs, costumer profiles, future proofing, battery life
Expertise matches and next steps switched w/ Scotland framework/urban innovation framework hexagon for design integrated happy cities. Across all projects not just city 'silos'. Laura will write up discussions "circulate" to team, to keep the discussions going.

Group 5 on ICT and data platforms

Names lead: Christoffer Ainek – City of Umeå, and Bas Kotterink – TNO
Challenges discussed Open data for innovation: Smart and alternative ways to collect data via social medio Position of tech-giants Expertise within municipalities – data buddy in Brno
Expertise matches and next steps Solutions to educate: Independent expertise within municipalities → Espresso project Organise data hackathons Start small and build up → first build the fabric Deal with data sharing (which is a slow process) Data is driving organizational change.

TNO will keep track of the progress of the 'next steps' by asking the group leaders on new insights and shared expertise. If new challenges arise, they are scheduled to discuss in following Liaison Group meetings.

Appendix 3 - Minutes of the Liaison Group meeting in Gdansk (11 September 2018)

1. Program

The 7th RUGGEDISED Liaison Group meeting took place during the General Assembly of RUGGEDISED in Gdansk, 11 September 2018. Both lighthouse lity consortium partners as well as fellow cities attended the meeting. The program facilitated the plenary discussion on two topics: (1) digital and ICT platform solutions based on the work that is being done in the WP 2,3 and 4 and (2) initial lessons learned from setting up innovation platforms (WP 6).

2. Urban Data Platforms

2.1 Summary and agenda

The objective of the Liaison Group session on urban data platforms was to present and discuss the value propositions of Urban Data Platforms (UDPs) as championed by the three Lighthouse cities, Rotterdam, Glasgow and Umeå. The discussion centered on the *Value Case*, *Outreach*, and the *Data (services) model*.

Box 1. Agenda and format of the session

Urban Data Platforms – Value propositions

Introduction by Marcel van Oosterhout on Erasmus University study on Urban Data Platforms

15:00 – 15:30 Presentations by Lighthouse cities (3X 10 mins) based on the following template:

- 1 minute Pitch of your UDP *value-proposition*: “what is new?”, “what is great about it”?
- *Outreach*: Who are the partners? Who will be the users. How are citizens involved?
- *Data ‘model’ and services*: *Sharing and access*, who is providing what to whom?
- *Value case*: Where (and how) is value generated and what is the financial model?

15:30 – 16:15 Plenary Discussion on Outreach, Data and services, Value Case;
16:15 – 16:45 Short Feedback and discussion

2.2 Presentation Marcel Oosterhout, Erasmus/RSM

The Pitch

Marcel van Oosterhout presented the results of a 2018 study by the Rotterdam School of Management (Erasmus University) extending earlier EIP work related to "organizing and using data in the context of European smart cities and specifically urban data platforms". The study collected data and views on 18 UDPs via questionnaires, interviews and desk study.

The study posits UDPs as modalities that exploit digital technologies to capture data flows across city systems, enabling their exchange, exploitation, and augmentation by many city actors, including third parties and citizens. It found that although the interest is growing many are still under development with few operational use cases. Most use-cases focus on description and diagnosis. Current focus is on optimizing city operations, in line with SCC objectives. Commercial business models are still few and far between. Overall there is little information available on performance; very few KPIs are actually being measured at present. Finally it describes the main barriers to successful deployment of UDPs to be privacy, technical standards, and effective collaboration.

Outreach

The study does not address outreach and partnerships directly. It does, however, discuss the importance of trust in the data-ecosystem. It finds – based on the limited data available to date – higher performing UDPs to be municipality led.

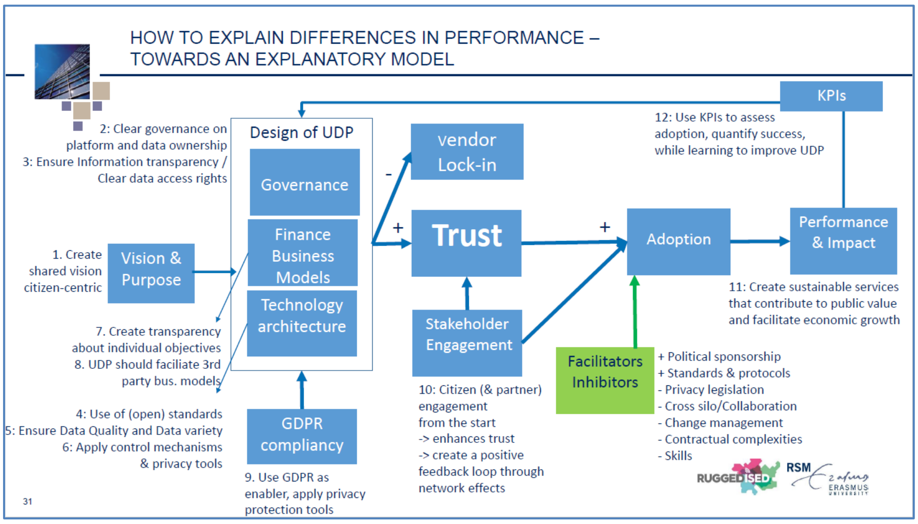
Data model

On the data-model the study collected general views on data-ownership that shows a majority of respondents and UDPs views data generated on the platform should not belong to a single platform operator. More in-depth research on data-rights models is still needed.

Value case

Feedback from respondents on the value case of UDP reveals that value is often sought in network effects and volume rather than in new, more disruptive business models. This finding underlines that it is early days for city UDPs: wider deployment should ultimately produce a wider range of innovative value cases. A limited number of UDPs are centered on a 3D model of the city.

The information and analysis of the study resulted in a first framework for UDPs (shown below).



Next we will present the discussion on the UDP value cases presented by the three lighthouse cities in RUGGEDISED: Rotterdam, Glasgow and Umeå.

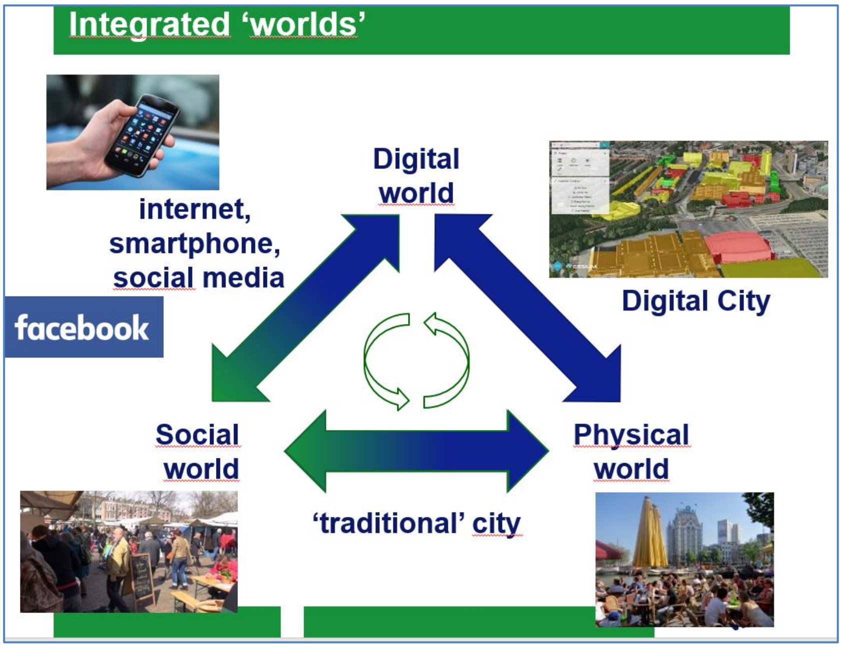
2.3 Rotterdam

Pitch

The centerpiece of the Rotterdam UDP is the development of a novel 3D environment based on open standards in which (near-) real-time operational and social sensing data on the physical city is projected on an accurate 3D digital, topological map of the city, creating a digital twin of the physical city infrastructure and functions. In time this should allow third parties to develop or augment services drawing on the UDP data streams and functions through APIs contributed by city actors, both the municipality and third parties. In developing the platform Rotterdam builds on the modular (Lego) design principles conceived in the H2020 Smart City project Espresso. The basic design of the system is completed and the first pilots are underway.

Outreach

The Rotterdam UDP is a partnership between the municipality, key corporates such as KPN for data management and private utilities and operators such as ENECO. When ready the system will include a layer that enables citizens to access key city services as well as services provided by third parties (including citizen operated).



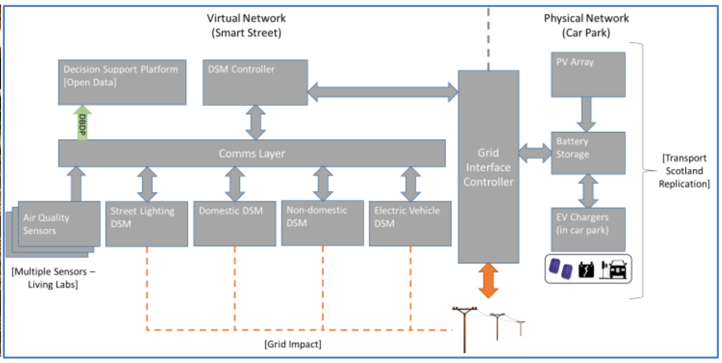
Data model

The details of the data sharing model are still under development but the emphasis is on open data models and open sdk's. The core components of the platform architecture are meant to be open source to avoid vendor lock-in.

Value case

The approach to creating value with the UDP is to develop an innovative municipality led open data and services ecosystem. The development of phase financing is led by the municipality. Significant value (ROI) is expected in the mid to long term. Use cases and pilots are underway to elaborate the value case. Rotterdam foresees a 3 year period to complete the platform and yield tangible results.

2.4 Glasgow Urban Data Platform



The Pitch(er)

The main aim of the Glasgow UDP is fourfold: to provide an interface that enables query-based analysis of multiple datasets to support policy, strategy, investment, etc; to enable complex data analysis without the need for expensive resources, to utilise existing datasets and software applications; and finally, to minimise legacy costs.

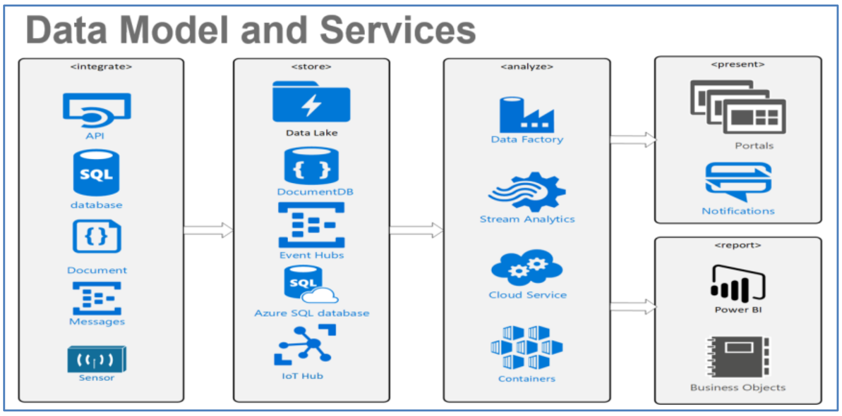
Outreach

The UDP campaign reaches out to citizens, private companies, public agencies, and planners (see logo's below for a sampling of partners, source Glasgow Ppt presented in Gdansk).

Data model

Data are at the heart of the Glasgow RUGGEDISED solutions. The UDP (or DBDP as it is called) will be the central point for all data within the Council.

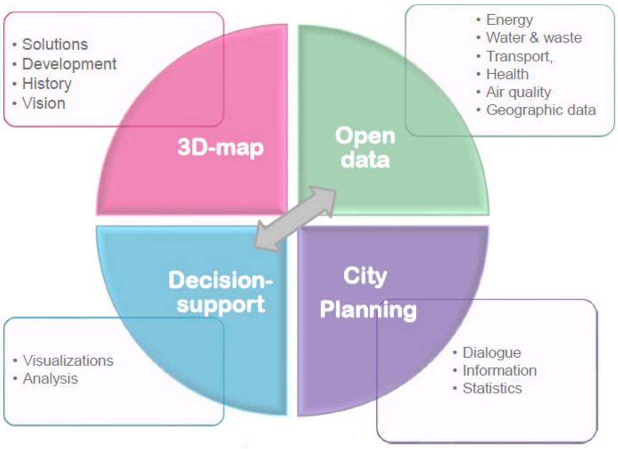
The data architecture comprises four pillars: integration of data from many sources (sensors, sql and api, ..); storing data, analyzing it and presenting/reporting on it (see diagram below). The components include industry standard database solutions like Azure Cloud homegrown tools. Data is captured through the use of APIs.



Value case

The UDP/DBDP is designed to identify efficiencies in service delivery, to identify new business models, to support SME's, and to foster new relationships. The financing of the DPDP is not factored. Financial benefits/impacts are expected to come from individual projects. Glasgow needs short term results due to financial austerity.

2.5 Umeå



Pitch

The Umeå UDP is based on Open Data and envisages a 3D Model as the main interface reaching out and engaging citizens. The UDP will support decision-making processes as we as well as more long term city planning.

Outreach

The focus of the RUGGEDISED interventions and the UDP is on facilitating the citizens and planners in and on the road to becoming a fully sustainable, smart city.

Data model

The UDP will collect all the data available in Umeå. Services that draw on data collected through the UDP include energy applications (based for example on block-energy consumption, AR feedback on buildings, PV potential maps, consumption vs CO2 emission) but also derived services such as crime heatmaps. As much as possible based on the (re-)use of Open Data.

Value case

Supporting citizen services delivery is the main value case of the UDP. Zoning plans in the 3D interface are designed to invite engagement of citizens.

2.6 conclusion

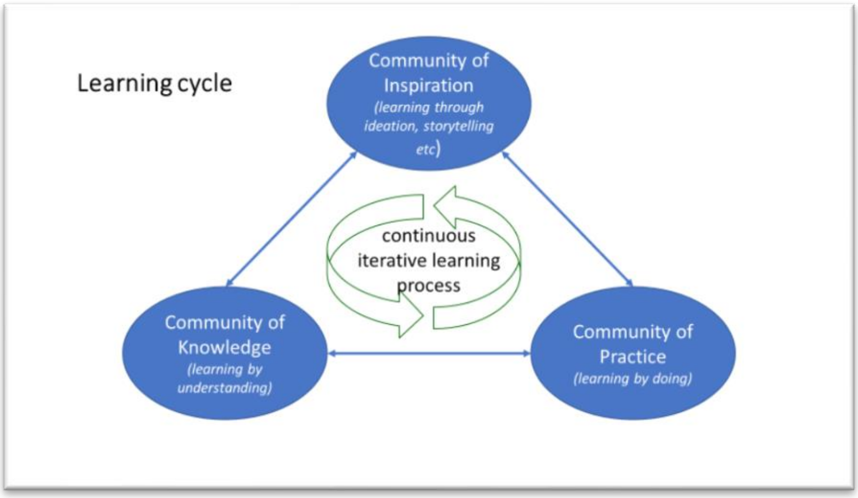
There is a difference between the more short term, bottom-up results based approach of Glasgow - driven in part by financial austerity measures, and the longer term, higher level vision of Rotterdam where the first benefits of the 3D based platform are expected to be delivered a little further down the road (3 years or more). Umeå is in the middle being very citizen-driven while allowing some time to develop the right UDP to enable this. Under the hood there are many similarities in using 3D approaches and open data. To achieve results in the short term Glasgow seems to have a slightly more pragmatic stance on open data and open solutions, instead relying more on proven, industry standard solutions.

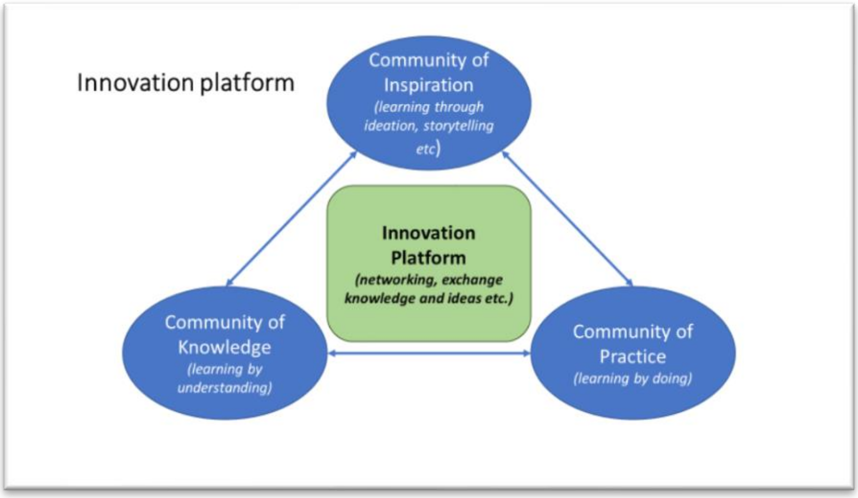
3. Innovation Platforms

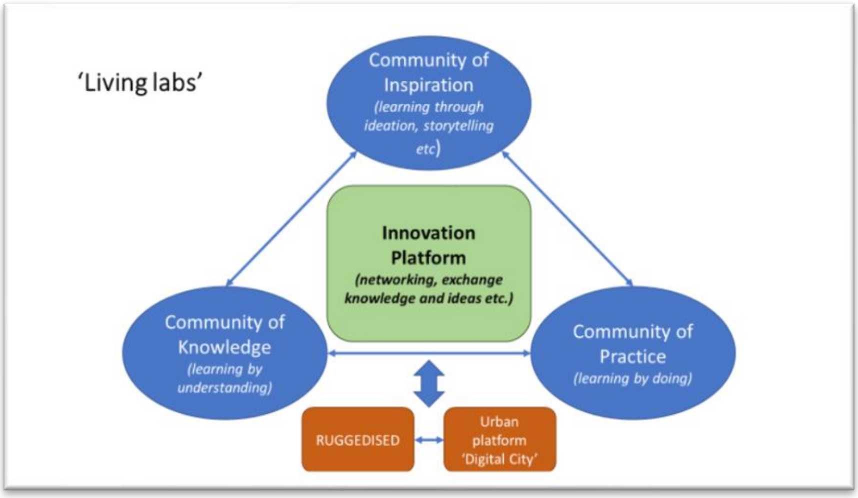
Within the RUGGEDISED project (WP6) the lighthouse cities will put effort in improving their urban innovation capacity. They will either set up a new 'innovation platform' or strengthen existing platforms and innovation initiatives and corporations. How such an innovation platform will look like, and what focus it will have, depends on the particular context of the lighthouse city and different elements of the innovation capacity that needs special attention. The Liaison Group meeting in Gdansk was the first opportunity for the Lighthouse cities to exchange lessons learned and challenges on setting up innovation platforms. As the chosen focus and form of the innovation platforms can differ significantly across the lighthouse cities, this first discussion shed light on the differences and the argumentation behind the chosen structure.

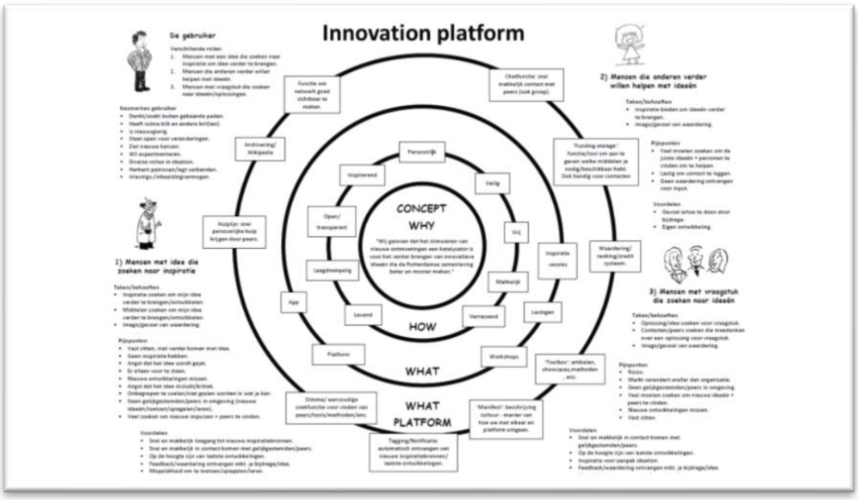
3.1 Rotterdam

Roland van der Heijden presented the view of Rotterdam on the setting up of an Innovation Platform. The core rationale of the Innovation Platform in Rotterdam is connecting three different communities: the Community of Inspiration, Community of Knowledge and Community of Practice. An innovation platform should explicitly be both a physical and a digital place. Cities that have a meeting place on a small scale have succeeded. It should be a market place in solving problems and connecting ideas. The innovation platform should result in an urban living lab in which experiments and pilots can be defined, conducted and coordinated. One of the main challenges in Rotterdam (also based on the workshops held within the WP6 context) is to meaningfully connect the different departments within the organization of Rotterdam.




Innovation platform
Community of Inspiration (learning through ideation, storytelling etc)
Innovation Platform (networking, exchange knowledge and ideas etc.)
Community of Knowledge (learning by understanding)
Community of Practice (learning by doing)

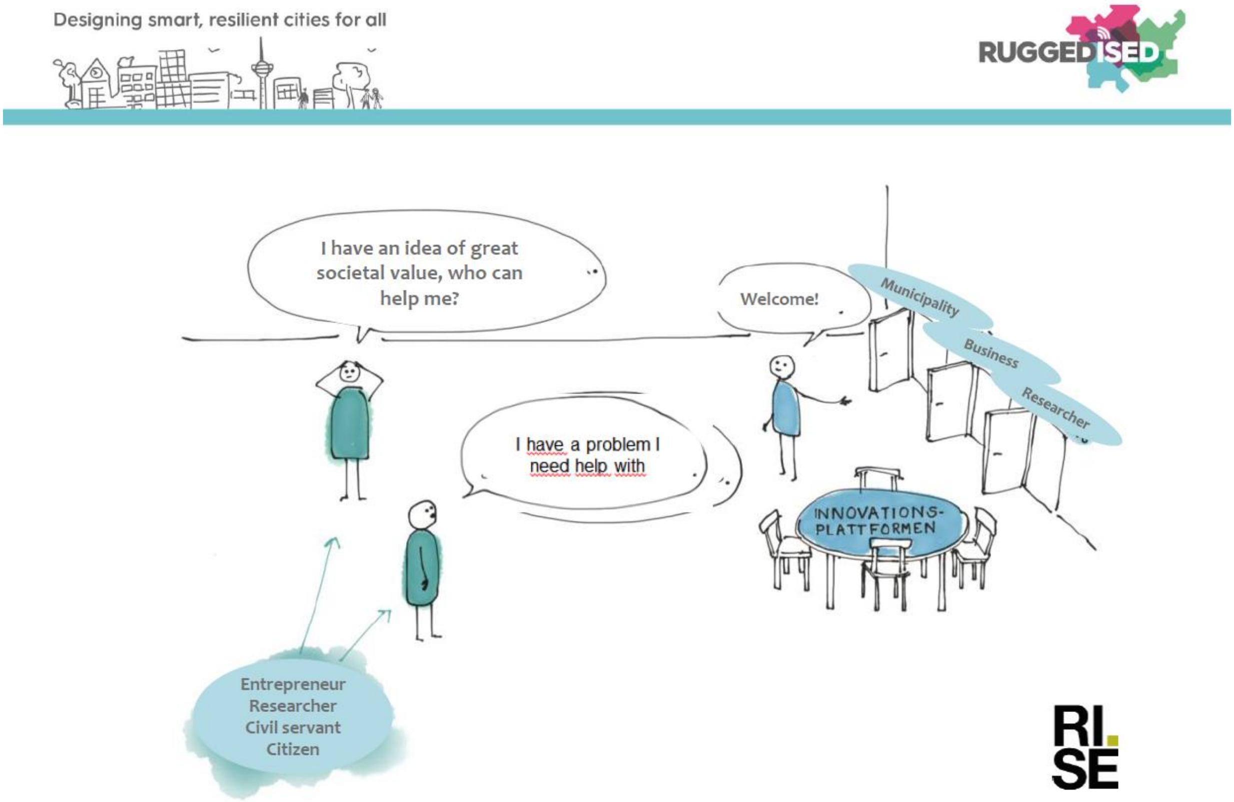

'Living labs'
Community of Inspiration (learning through ideation, storytelling etc)
Innovation Platform (networking, exchange knowledge and ideas etc.)
Community of Knowledge (learning by understanding)
Community of Practice (learning by doing)
RUGGEDISED
Urban platform 'Digital City'


Innovation platform
CONCEPT
WHY
HOW
WHAT
WHAT PLATFORM

3.2 Umeå

Carina Aschan presented the first lessons learned of Umeå in setting up the innovation platform. The innovation platform activities in Umeå have two different focus areas.

1. Umeå mapped the innovation landscape of the city and is focusing on the 'weak' links. What needs to be improved is the culture within the city hall as it regards innovation. Innovation is about experimenting, learning from mistakes and adaptively dealing with new insights. People working in the Umeå government do not feel comfortable making mistakes. Together with RISE they set up an educational program for every department can choose their person that can become an innovation person! Working together internally is very important. It is a training in creativity!
2. An innovation platform should also be a physical place where citizens and enterprises can come to if they have ideas, challenges and expertise to share. An innovation platform, in that context, has the function of a knowledge broker.



3.3 Glasgow

Christine Downie presented how the Glasgow partners attach their innovation platform ambitions within RUGGEDISED to the already existing urban innovation initiative: sustainable Glasgow. The council-led initiative was formed in 2010 to make Glasgow a world-leading centre for sustainable policy, innovation and action. It has partners from housing, communities, business, universities, enterprise and education. Sustainable Glasgow is an institutionalized way of involving stakeholders' and citizens' knowledge and expertise in dealing with societal challenges. Usually they are being dealt with in Task & Finish Groups. One of the challenges is to deal with procurement rules.

If urban partners collaboratively define projects and solutions to societal challenges in Task & Finish Groups, procurement rules may prohibit that these partners are also part of the implementation of these projects.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WP1 Liaison Group – Gdansk G.A.
Sustainable Glasgow Innovation Platform
Christine Downie


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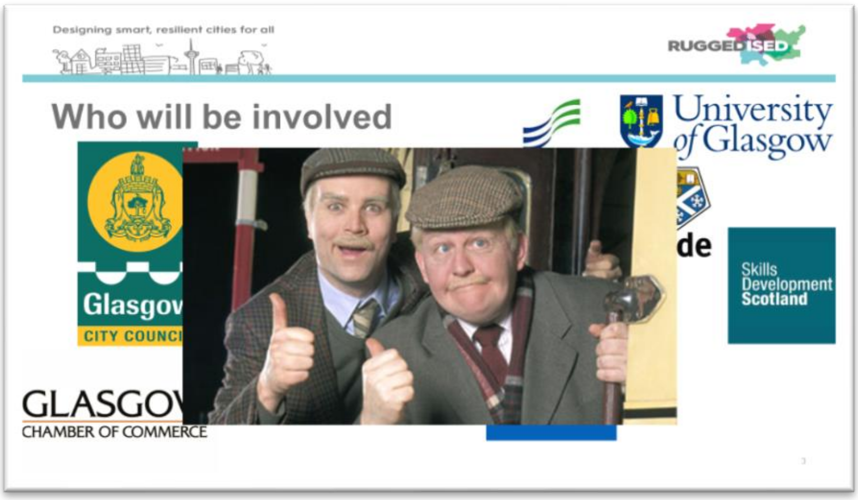
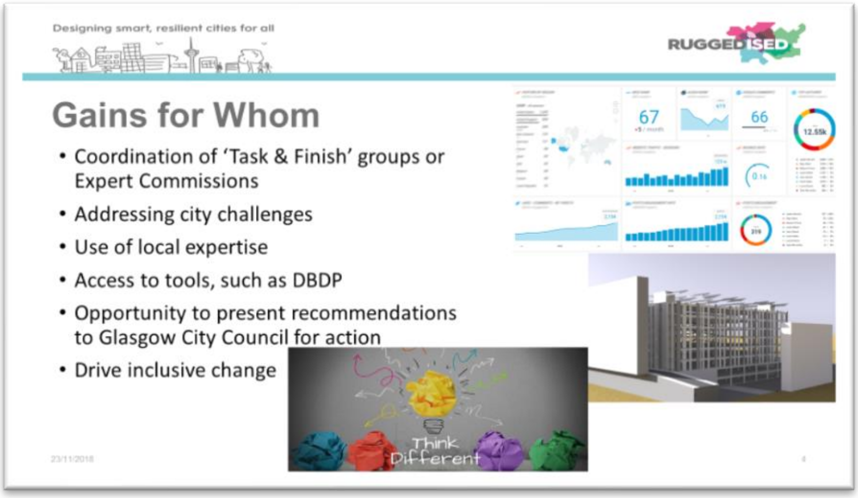
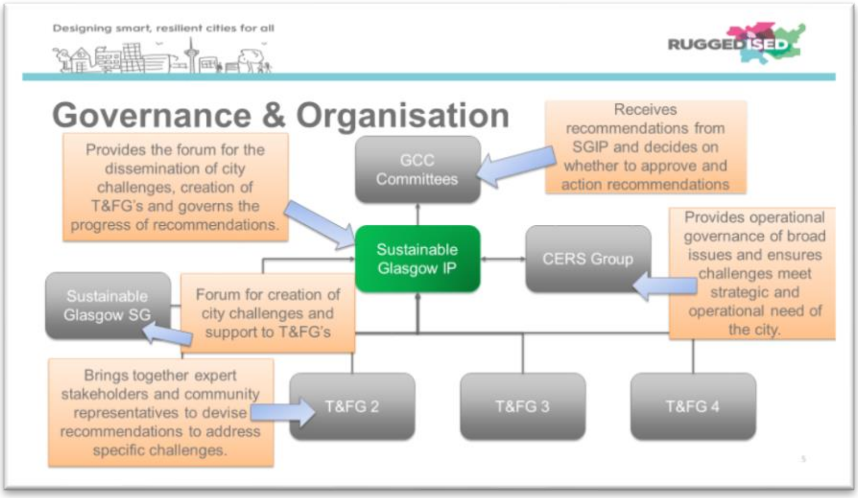
Aim of Sustainable Glasgow
• Reduce CO2 emissions
• Develop low-carbon energy systems
• Address city wide issues of:
• Air quality
• Fuel poverty
• Sustainable transport
• Green economic growth
• Adaptation to climate change
• Circular Economy
• Recycling & waste
• Resilience
• Sustainable design
• Greening the city & biodiversity
sustainable glasgow
23/11/2018


Designing smart, resilient cities for all
RUGGEDISED
Who will be involved
University of Glasgow
Skills Development Scotland
CHAMBER OF COMMERCE





3.4 Synthesis

From the pitches and the discussion that followed the cities concluded that they can stimulate their urban innovation capacity in several ways. Dependent on current challenges and 'gaps' in their urban innovation ecosystem the lighthouse cities chose different ways and foci to tailor their RUGGEDISED innovation platforms and corporations. In Glasgow RUGGEDISED seeks to attach to the existing innovation initiative 'Sustainable Glasgow', which already is an institutionalized forum in which public and private stakeholders meet and exchange knowledge and expertise. The aim of this forum is to organize a broad range of internal and external expertise around specific societal sustainability challenges. Sustainable Glasgow has an explicit link to the City Council in terms of policy advice.

Rotterdam focusses on improving the network of (externally) enterprises and institutes and (internally) different departments and units. The ambition is that a better connection between these elements of the innovation ecosystem, both physically as well as digitally, will result in a continuously learning and experimenting city. The city as a living lab.

Umeå also focusses on this element of physical connection, but also pays explicit attention to the behavioral aspects of the 'learning city'. Making mistakes is part of innovation. The 1 year learning-on-the-job training program that city employees are following will result in 'learners' and 'knowledge brokers' in the city. They learn how to connect experiments, draw lessons learned from these new practices and aim to consolidate and embed these lessons learned into the city organization.

The setting up of innovation platforms in RUGGEDISED is further being facilitated in the WP6. The Liaison Group in Gdansk was the first opportunity to share with each other the differences and similarities in how to deal with urban innovation. Innovation platforms or other innovation initiatives within the lighthouse cities will have a significant role in achieving the impact of RUGGEDISED in the long-term. Improving the innovation capacity of the lighthouse cities helps the uptake and upscaling of RUGGEDISED lessons learned.