RUGGEDISED
Designing smart, resilient cities for all

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Executive summary

This report is the third and final RUGGEDISED lessons learned deliverable as part of WP 1 “Cross-city learning and implementation”. In WP 1 of the RUGGEDISED project, the main task was to “prepare the ground for innovation and implementation of measures in the lighthouse cities”. The overall objective was to guide, coordinate and facilitate the implementation of smart solutions in the three lighthouse cities. Following this, WP 1 developed a process to facilitate the lighthouse cities’ implementation of smart solutions. This process was based on learning across the cities by exchanging experiences, discussing challenges and facilitating support from their knowledge partners (TNO for Rotterdam, RISE for Umeå, and the University of Strathclyde for Glasgow). Cross-city learning took place in Liaison Groups.

The Liaison Groups aimed to secure the coherency of the implementation of smart solutions and to maximise their impacts. The Liaison Groups met at least twice a year for the past three years and provided the lighthouse cities with a knowledge brokerage service. This peer to peer learning enriched the design of smart solutions and improved their implementation processes. The function of the Liaison Groups was not only on a practical level. The Liaison Group meetings also aimed to build capacity to deal with complexity and urban innovation processes. Furthermore, the lessons taken from the cross-city learning will facilitate replication and upscaling of the solutions in the fellow cities (Brno, Gdansk and Parma) and other EU-cities in the future.

The Liaison Group meetings started in November 2016 and recently stopped in November 2019, after a running period of three years. This third and final lessons learned report reflects on the main implementation hurdles and evaluates the functioning of the cross-city learning process in the Liaison Groups.

Regarding the implementation hurdles, this report especially focusses on:
- The framing of projects such as RUGGEDISED as innovation programs, instead of urban development projects
- The importance of a joint and binding vision to create trust and guidance within regional consortia
- Strategic positioning of the innovation program within the (municipal) organisation
- Cooperation between project partners
- Vertical alignment and the necessity to intensify the cooperation between strategic and operational levels
- The embeddedness of smart solutions in the existing urban (infrastructure) configuration
- The capacity to build in flexibility
- Ways to ensure the success of the project beyond its life span

This report addresses the following issues regarding cross-city learning processes:
- A system perspective on technical -, ICT – and governance challenges
- Timing of cross city learning activities
- The characteristics of the themes that have been discussed in the Liaison Group meetings and that were addressed by the Lighthouse Cities themselves
- Ways to explicitly seek and define both context-specific and generic factors in determining the success of integrated smart solution implementation
- The complexity of connecting fundamental reflections to everyday practice
- Difficulties to articulate knowledge gaps and – questions, and brokerage strategies to deal with these difficulties
- The importance of well-prepared cross-city learning sessions

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1 Introduction and reading guide

This report[1] is the third and final RUGGEDISED lessons learned deliverable as part of WP 1 "Cross-city learning and implementation". In WP 1 of the RUGGEDISED project, the main task is to "prepare the ground for innovation and implementation of measures in the lighthouse cities". The overall objective is to guide, coordinate and facilitate the implementation of smart solutions in the three lighthouse cities, to support the Lighthouse cities with knowledge and processes to streamline and guide these smart solutions. Following this, WP 1 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 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 and knowledge brokerage is conceptualised in the following three main topics: knowledge management, knowledge brokering and windows of opportunity (RUGGEDISED, 2018).

The Liaison Groups aim to secure the coherency of the implementation of smart solutions and to maximise their impacts. In the past three years, the Liaison Groups met at least twice a year and provided the lighthouse cities with a knowledge brokerage service. This peer to peer learning enriched the design of smart solutions and improved their implementation processes. The function of the Liaison Groups was not only on a practical level but also on a more fundamental level of capacity building to deal with complexity and urban innovation processes. Furthermore, the lessons taken from the cross-city learning facilitate replication and upscaling of the solutions in the fellow cities (Brno, Gdansk and Parma) and other EU-cities in the future. The sub-objectives of the Liaison Groups are to:

- Develop an overarching innovation and implementation framework to guide and coordinate the implementation of the smart solutions on Energy and E-mobility, ICT, and Innovation and new business models in the Lighthouse cities;

- Sustain coordination and enhance coherency of implementation (of smart solutions) among the lighthouse cities by ensuring that relevant knowledge and experiences are shared in a facilitated fashion, which allows for extracting relevant lessons learned;

- Develop tools and guidance for decision support and implementation of smart solutions in follower cites, and other EU-cities, based on lessons learned.

The Liaison Group meetings started in November 2016 and the last session took place in November 2019. In this third and final lessons learned report we will evaluate the past three years. As this is the final report, we will address the developments of the cities on a meta-level and reflect on the functioning of cross-city learning process in the Liaison Groups. Moreover, in the beginning of the process, the Lighthouses developed the Innovation and Implementation Framework (deliverable 1.2). We will also reflect on the added value that this framework had in the process of cross-city learning. Parallel to this current deliverable, TNO, RISE, the University of Strathclyde and the Lighthouses wrote four smart city guidance documents in which RUGGEDISED lessons learned have been translated into easy-to-use steps to deal with challenges in becoming a smart city.

- D1.4 – Guide on Innovation Platforms
- D1.5 - Prototype Smart Energy District planner
- D1.6 - Guidance on Smart City Design and Decision Platform
- D1.8 - Guide on ruggedized implementation and innovation of smart solutions

1.1 Reading Guide

This deliverable starts with a reflection on the Liaison Group meetings that recently took place (8th meeting in Amsterdam, May 2019; and final meeting in Rotterdam, November 2019). Chapter 2 discusses the outcomes of these meetings and put them in the perspective of a knowledge brokerage framework. Chapter 3 uses the recently published Implementation Reports to reflect on the Overarching Innovation and

[1] This deliverable D1.7 corresponds with the deliverable description D1.5 from the Description of Work. Unfortunately, the numbering and description of deliverables got mixed up.

Implementation Framework that was collaboratively built in D1.2. Based on the proceedings, this chapter analyses the implementation factors that were distinguished at the start of the RUGGEDISED project and reflects on the way in which these factors have enhanced or suppressed the implementation process of the smart solutions. The deliverable concludes with Chapter 4 that takes the reader along the three-year journey of cross-city learning in the Lighthouses.

2 Progress in cross-city learning

As mentioned in the first lessons learned report (D1.1), the Liaison Group meetings focus on exchanging and sharing practical facts (explicit knowledge), but they also engage participants towards reflection on experiences, and on actions they are taking and the reasoning behind that (implicit knowledge). As the participants of the Liaison Group meetings indicated, the collective and high-level knowledge brokerage function is vital to stimulate learning. Here the definition of first order and second order learning is important. The following definitions were already introduced in D1.1 (p.9):

> "First order learning: Learning within the context of a given problem definition and about the analysis of the chosen solution for that problem, while retaining the underlying theoretical insights or deep convictions and values. Second order learning: The rethinking of dominant mental models and action models, particularly of theoretical insights and deeply rooted values and convictions. The overall aim of the Liaison Groups within RUGGEDISED is to build a setting in which second order learning can be established. Additionally, the goal 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."

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 the Liaison Groups different types of knowledge were confronted with each other and collaborative knowledge gaps were identified and filled (RUGGEDISED, 2018).

Knowledge brokerage strategies
During the past three years, in the Liaison Groups, we used various knowledge brokerage strategies, categorised and defined by Magnuszewski et al. (2010), see figure 1. In the next section we will discuss the main findings of the recent two Liaison Group meetings in the perspective of these knowledge brokerage strategies. Earlier Liaison Group meetings were addressed in the Lessons Learned reports (1/3) and (2/3).

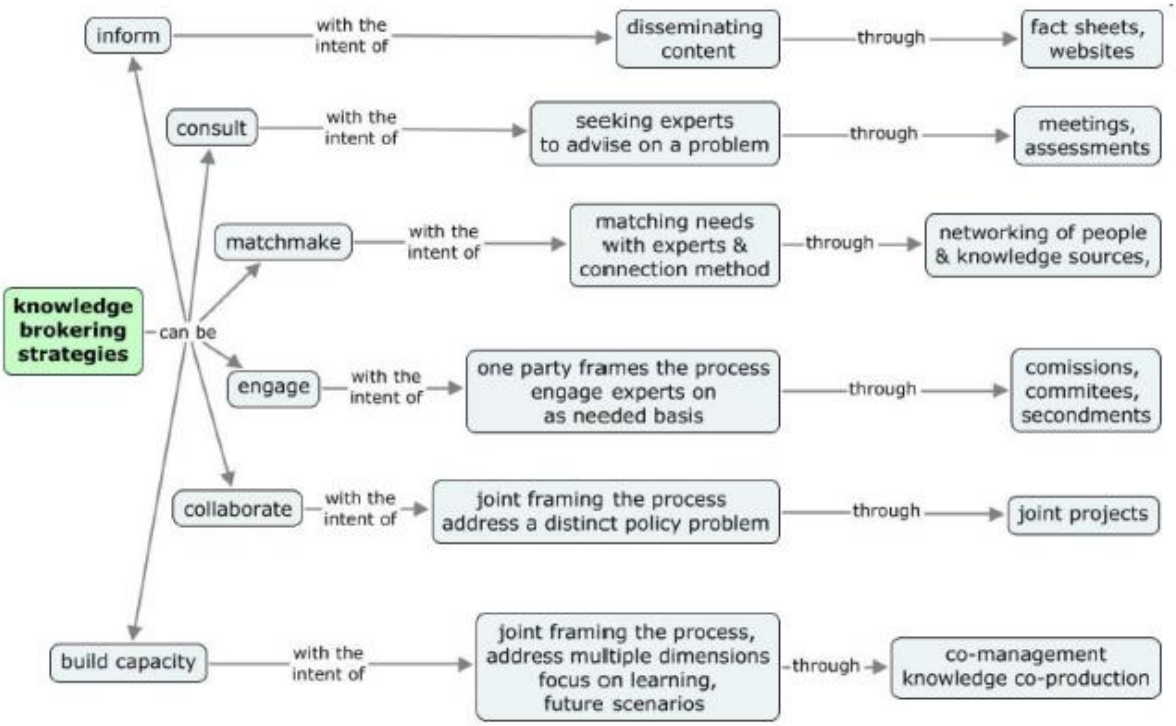

Figure 1: Knowledge brokering strategies (Magnuszweski et al., 2010)

2.1 Urban Data Platforms (8th Liaison Group meeting in Amsterdam 6 May 2019)

Types of knowledge

During the morning session of this Liaison Group meeting the participants discussed three topics related to Urban Data Platforms: data governance, business models and privacy. Each topic was introduced in a practical way by one of the Lighthouses and afterwards reflected upon by the knowledge institutes (TNO and Erasmus University) from a theoretical perspective. With this combination of practical and theoretical knowledge, and by highlighting different approaches towards Urban Data Platforms, we wanted to trigger the creativity that we needed for the afternoon break-out sessions. The morning session was mainly filled with presentations and explicit knowledge sharing.

Spanning boundaries and brokering knowledge

Especially the presentations on both governance and business models triggered the discussion on two fundamentally different perspectives on designing Urban Data Platforms. The discussion started with a metaphor from a famous essay about open source codes: the Cathedral and the Bazaar[2]. The essay contrasts two different free software development models:

> "The Cathedral model, in which source code is available with each software release, but code developed between releases is restricted to an exclusive group of software developers. The Bazaar model, in which the code is developed over the Internet in view of the public.
> The essay's central thesis is Raymond's proposition that "given enough eyeballs, all bugs are shallow": the more widely available the source code is for public testing, scrutiny, and experimentation, the more rapidly all forms of bugs will be discovered. In contrast, Raymond claims that an inordinate amount of time and energy must be spent hunting for bugs in the Cathedral model, since the working version of the code is available only to a few developers"[3]

[2] Eric S. Raymond (1999) The Cathedral & the Bazaar, O'Reilly Media.

[3] https://en.wikipedia.org/wiki/The_Cathedral_and_the_Bazaar (accessed 24-07-2019)

The Cathedral shows a more central structure/model, but leaves less room for free participation. The Bazaar, like any open source, is built by communities, with lots of liberty to participate and be creative. We need to reflect on the fact that cities can create their urban data platforms using both models at the same time: a central structure and at the same time building up from the bottom. In the discussion some mention that cathedrals are built for ages and bazaars for a shorter period of time. Bazaars are more dynamic. In terms of urban data platforms, government may focus on the cathedral model to facilitate bazaar models. The evident risk is that people may not like or need prescribed structures. You need software developers, end-users and investors to be involved (co-creation). However, this also bears the risk of setting up incredible complex processes.

Knowledge brokerage strategies
During this morning sessions the knowledge brokerage strategies we used were mainly 'informing' and 'matchmaking'. The exchange of practical examples from different cities (governance was led by Umea, business models was led by Rotterdam, and privacy was led by Glasgow) helped the participants to understand each other's approaches towards the design and development of Urban Data Platforms. Furthermore, by making the connection between theoretical perspectives and practical examples we aimed to set up a matchmaking process. This worked out well, especially in the case of business models. The close connection to the value case canvas, which was also used in the afternoon session, helped the participants to learn to speak each other's language.

2.2 Urban Data Platforms, value cases (8th Liaison Group meeting in Amsterdam 6 May 2019)

Types of knowledge
The break-out sessions on potential value cases of Urban Data Platforms and the role of government in developing, designing and maintaining the platform led to fundamental reflections on the public interest of an Urban Data Platform and the public interest of data gathering. The way these break-out sessions were set up (build a value canvas for a public Urban Data Platform and for a private Urban Data Platform) activated the discussion on implicit assumption on the role of government. It generated a discussion between participants with a more neo-liberal view on the role of government and participants believing in a more community-driven approach. It led to the conclusion that, within the design, development and maintenance of Urban Data Platforms, there are many 'services'. It should be carefully thought through which services can be privately driven, and which services should be placed in the public domain.

Spanning boundaries and brokering knowledge
The business model canvas exercises show that platforms don't work just by themselves. There is a whole set of functions that make the platform work. In the session it's the goal to fill in the canvas. It's about what are you doing, for who, what are the functions?

The discussion centred around the following statements:
1. Governments should show leadership in UDP developments;
2. Governments should take ownership of UDPs;
3. UPDs are best left to the market: government's role is to facilitate;
4. UDPs are vital public infrastructure.

Knowledge brokerage strategies
Collaboratively defining the value case of Urban Data Platforms aims to pursue the knowledge brokerage strategy of 'collaboration'. Although building such a value case is a theoretical exercise, it aims to create a 'joint project'. Collaboration, as a strategy, goes beyond the informing each other and exchanging lessons learned. It stimulates to seek for parallels and to overcome different opinions.

Mission Statement for Urban Data Platform: Create public and private value thru Ecosystem Matchmaking

<table>
<tr>
<td rowspan="3"><u>Partners</u>

Investor / Owner

Governor vs Manager

Technology / (Social) Media Partner

Subcontractor</td>
<td><u>Platform Activities</u>

Tools & svcs, Matching, Audience building, Rules and standards</td>
<td rowspan="3"><u>Value Proposition</u>

“Place” for innovation, participation, collaboration, and public and private value creation</td>
<td><u>Leading Public Values</u>

Driving purpose of the platform</td>
<td rowspan="3"><u>Customers, Users & Participants</u>

Citizens, Communities, Companies, Start-ups, Developers, Data providers, Government, NGOs</td>
</tr>
<tr>
<td><u>Platform Data Assets</u>

Data-acquisition, data gathering, visualisation, exploitation/mining</td>
<td><u>Scope and Reach</u>

Open-closed, Local-global, Interoperability Access</td>
</tr>
<tr>
<td><u>Key Infrastructure & Resources</u>

Digital, Physical, Monetary, People, IP, Brand</td>
</tr>
<tr>
<td colspan="3"><u>Financial Cost</u>
E.g. investments, run costs</td>
<td colspan="2"><u>Financial Benefit</u>
E.g. ROI, revenue streams</td>
</tr>
<tr>
<td colspan="3"><u>Social Cost</u>
E.g. privacy, security, freedom</td>
<td colspan="2"><u>Social Benefit</u>
E.g. democratic participation, growth</td>
</tr>
<tr>
<td colspan="3"><u>Environmental Cost</u>
E.g. carbon footprint platform ecosystem</td>
<td colspan="2"><u>Environmental Benefit</u>
E.g. sustainable innovation</td>
</tr>
</table>

Figure 2: Mission statement for Urban Data Platform

2.3 Energy Management and Urban Data Platforms (8th Liaison Group meeting in Amsterdam 6 May 2019)

Types of knowledge

The break-out sessions on Energy Management revealed that the cities differ in their approaches towards sharing data and how they deal with privacy issues. Exchanging different approaches for gaining trust of inhabitants and partners to share data for energy management purposes led to a fundamental reflection on the way some of the Lighthouses (especially Rotterdam) are currently dealing with this issue.

Spanning boundaries and brokering knowledge

The discussion between Rotterdam and Umea highlighted the various differences between the city’s approaches. Some examples are:

- In Umea, the energy companies are government owned, so they have an entirely different collaboration with the companies than in Rotterdam, where all companies are privately owned.
- In Umea, house owners can see their neighbours’ energy bills and compare them with each other. This can work as an incentive to save energy and lower the energy bill. But this only counts for private house owners and not for rental properties. Their energy use is calculated within the rent, so they don’t have the incentive to change their energy consumption. In the Netherlands it’s not possible to get energy data per household. Some houses do have a ‘smart meter’ with which people can exchange their data to get insights in their energy use. But the dashboard of the smart meter can only show the insights from yesterday, and a lot of people rather want real time data. Also, yesterday’s insights do not incentivise changing energy consumption patterns.

Both cities have a hard time changing the behaviour of people to save energy. This could be an interesting aspect to work on. An option that was mentioned to do so is gamification.

The discussion between Rotterdam and Glasgow centred on the different approaches that the cities used to connect energy data and energy systems from various users (demand and supply) within the area and integrate them into an energy management system. For that to succeed, support and trust are necessary prerequisites. Glasgow spent a lot of time in setting up the dialogue between area partners to develop trust and get insight in the hurdles to overcome. Moreover, they discussed various incentives to exchange energy data. Rotterdam focusses on getting the technical ICT system in place. The city first aims to start small

(connecting two or three buildings) and upscale in a later phase, once the systems has proven its effectiveness and trustworthiness.

Knowledge brokerage strategies
The sessions on Energy Management mainly focussed on 'informing' each other on the approaches taken and 'consulting' each other on the best way to deal with issues of privacy and trust.

2.4 Collaborative design of Smart City Guides (9th Liaison Group meeting in Rotterdam 11 November 2019)

The participants of the Liaison Group meeting in Rotterdam (the first day of the of the two-day event) discussed and filled the upcoming deliverables of WP1 that focus on smart city guidance for implementation and upscaling. After three years of implementation and learning, TNO prepared preliminary tables of contents for these three deliverables (D1.5 together with University of Strathclyde), D1.6 (together with city of Rotterdam and D1.8). The purpose was to synthesize the learned lessons into smart city guides for the RUGGEDISED Fellow Cities and other EU cities. "Can we, based on our collaborative lessons learned in RUGGEDISED, advise other cities on how to become a smart city?". The guidance and tools should become a stepping stone for other cities. Interesting element of this Liaison Group meeting was that the Fellow Cities were also present and actively reflected on the information that they need from the smart city guides.

Types of knowledge
The knowledge that was exchanged focused primarily on explicit knowledge, both high-level observations and detailed illustrations of good and bad practices. Due to the fact that the tables of content of the deliverables covered many aspects of smart city infrastructure planning (D1.6), Urban Data Platforms (D1.6) and smart city governance, (D1.8), the participants focused on a system-level of smart city innovation. This led to critical insights in how these guides should be organized, presented, how they can be used and why they were made in the first place. The first day of the final Liaison Group meeting clearly showed second order learning of the participants as both the level of reasoning and the system itself were critically reviewed. The observation that the three cities have fundamentally different starting points (Umea is community-driven, Glasgow is market-driven, and Rotterdam has a mix of drivers) contributed to the fundamental reflections on the system level.

Spanning boundaries and brokering knowledge
The transition towards smart cities requires radical (game changing) innovation and a thorough reassessment of roles, structures, potential collaborations and enabling factors. As the setup of this meeting aimed to enrich the tables of content of the upcoming deliverables, the discussions centred around the illustration of good and best practices that can be included in the upcoming smart city guides. Collaboratively building smart city guides is a very targeted way to exchange lessons learned and define mutual learnings. Cities tried to build a collaborative synthesis themselves.

Knowledge brokerage strategies
The following knowledge brokering instruments were used during the Liaison Group meeting: (1) collaborate; and (2) build capacity. During the collaboration the participants came together to jointly frame and assess the overarching process and problems with the intention to creating helpful, hands-on tools and guides for other cities (and its governing people) that want to move towards smart cities. The following guidelines and instructions were presented by TNO to the participants for the assessment of the tables of contents of the guides and tools:

- The guides and tools should primarily serve upscaling and replication purposes (and are not meant to be monitoring documents), they should help other cities reflect on fundamental choices and do's and don'ts;
- They should also include illustrative examples from the RUGGEDISED cities and lessons learned from the RUGGEDISED project as a whole.

By collaboratively building a line of reasoning this Liaison Group meeting aimed to create a joint ownership of the knowledge production process. The evaluation after the session showed that participants really liked the overarching and holistic view on the implementation process so far.

2.5 GO2Zero serious game (9th Liaison Group meeting in Rotterdam 11 November 2019)

During the second day of the final Liaison Group meeting in Rotterdam, the participants were invited to play a serious game focused on a local energy transition process in a fictional urban district; the GO2zero simulation game. The game was developed by TU Delft in the context of the H2020 project CityZen. Two facilitators from TU Delft prepared and supervised the game during the Liaison Group meeting in Rotterdam. The game simulates a (small part of a) low-density suburban neighbourhood, with terraced houses, semi-detached houses and low-rise apartment buildings simulating a very frequently occurring neighbourhood in a European city (Bekebrede, van Bueren & Wenzler, 2018). The goal of the GO2zero game is to reduce CO_2 emissions in the district to zero and to reduce the neighbourhood's energy consumption by 50% with the additional requirement that all the energy is produced locally. The following stakeholder-categories are present in the game: building owners and users, energy generation and distribution-related actors, governmental and non-governmental actors and highly interconnected stakeholders. The following parties are present: tenants and home-owners, the municipality, the electricity grid operator, two technology contractors active in the field of heating, ventilation, and air conditioning (HVAC), a housing corporation, and a local energy company (Bekebrede, van Bueren & Wenzler, 2018).

Types of knowledge
The aim of playing the game during the Liaison Group meeting was to aspire implicit knowledge development, focused on (high-level) system-level thinking, simultaneously addressing causal relations and experiences. Also, the game stimulated to ask critical and existential questions regarding the stakeholders, their traditional roles, who should be in the lead and should the transition be driven from bottom-up or top-down initiatives.

Bekebrede, van Bueren & Wenzler (2018) advocate that serious gaming can be used as a useful support tool due to the complex nature of the energy transition, especially in combination urban development. Fundamental thinking, disruptive transition reasoning and critically reviewing current scenarios and future goals were the goal of participating in the serious game. The simulation game GO2zero intends to achieve learning goals at two levels: participants learn of the complexity and opportunities for action to further the local energy transition; also researchers can learn from the game regarding real-life complexity of relationships, possible actions, and their consequences reflected in a game.

Spanning boundaries and brokering knowledge
The game was included in the Liaison Group meeting because it encourages a re-evaluation of the system as we know it: the roles of the different stakeholders and how carbon reduction goals can be achieved. Brokering knowledge occurred in an interactive manner, where participants were both focused on their goal and the protection of their interests as well as a more high-level and disruptive, fundamental reflection. A discussion on lessons learned at the end of the game aimed to transfer and further challenge the workings of the current system and how to progress towards a carbon neutral built environment.

The creators of the GO2zero game purposely included very little guidance for the game and made sure that no straightforward strategy was visible. This to reflect and simulate the complex real-world situation. The participants are explicitly invited to think of a strategy, which they can reflect upon and revise after each round (Bekebrede van Bueren & Wenzler, 2018). To reflect and mirror the current energy system, there is not one straightforward strategy towards replacing the energy system with alternative sources and technologies. It also features diverging interests and dysfunctional combinations of technologies, resources, grid-aspects and energy saving measures.

Knowledge brokerage strategies
The knowledge brokerage strategy that was pursued during the game was to explicitly build capacity among the participants, thereby addressing multiple dimensions of the complexity of the decarbonisation challenge. The game explicitly ends with a debrief to discuss what went well, how the transition took shape, which actors were lagging, which actors were taking the lead and which combinations of solutions, collaborations worked and in which order. Simultaneously stimulating second order learning. Participants should ask themselves and each other critical and fundamental questions.

Lessons Learned from the debriefing

The game and the two goals (a 50% energy reduction and zero carbon emissions) were achieved after 5 rounds of playing the game. No upfront strategy was determined by the participants of the game. Some other aspects were striking regarding the course of the game:

- In the beginning (first two rounds) there was almost no cooperation between partners. This changed over the course of the game and got intensified by the network operator who realised how important it is to have good information in order to plan the grid. To obtain this information he needed good cooperation with all parties. To some extent, cooperation was also established between the house tenants. They collaboratively invested in energy efficiency and generation measures, where the corporation lacked initiative to do so.
- Overall, bottom-up initiatives dominated the game. The participants that represented the home-owners were truly ideal occupants and acted as frontrunners regarding energy saving measures. Ideal home-owners and tenants dominated the game, who were driven to invest in dwelling sustainability and even had the measures to do so, this is not realistic.
- Moreover there was little initiative from the green energy company and no effort to combine investments. Very much like *trias energetica,* tenants and home-owners started with energy efficiency, followed by local generation measures.
- Cooperation turned out to be very complicated. Even though we had a group that knows how important it is to collaborate. This reflects the complexity of the game as well as the current status in most European cities.
- Large disruptive investments came in late. The first three rounds were dominated by small investments related to the dwellings' energy efficiency. A lack of strategy and financial resources withheld the utility company from big investments in the beginning.
- There were many discussions on the way to go and possible solutions by the players. However, during those discussions there was always a critical and strong (public?) party missing. This led to many ideas never materializing. The importance of having the right players at the table at the right moment was emphasized by this observation.
- The network operator emphasized the importance of information in order to timely develop the grid and to facilitate the initiatives pertaining the local green energy generation. Without this information the network operator was always lacking behind in planning. It was forced to be reactive, which led to a rushed planning and sub-optimal situations. The municipality also clearly lacked information on the investing capacity and preferences of the citizens and housing corporations. This led to subsidy measures which were not always effective (shared subsidy in sun and e.g. heat pumps would tackle both electricity and heat challenge) or efficient (too much subsidies leading to overinvestment in solar PVs).
- During the game more investments were done than needed, although even after the last round, thermal energy supply and storage was possibly not sufficient to cover fluctuations with sunlight and demand.

3. Discussion on Innovation and Implementation Framework

Chapter three analyses the implementation status of the RUGGEDISED smart solutions. The Implementation Reports, developed by the Lighthouses (D2.6, D3.4 and D4.6) provide useful insights in the implementation processes of the smart solutions. This chapter views the insights from the implementation reports in the perspective of the RUGGEDISED Overarching Innovation and Implementation Framework. The chapter first elaborates on the framework (section 3.1) and then discusses the various groups of smart solutions (section 3.2). The discussion focusses on the extent to which the smart solutions have succeed in achieving the levels of embeddedness, interconnectedness and upscaling (as defined in the framework).

3.1 Updated scientific and contextual background Overarching Innovation and Implementation Framework

The European Commission uses the following definition of a smart city:

"A smart city is a place where traditional networks and services are made more efficient with the use of digital and telecommunication technologies for the benefit of its inhabitants and business. A smart city goes beyond the use of information and communication technologies (ICT) for better resource use and less emissions. It means smarter urban transport networks, upgraded water supply and waste disposal facilities and more efficient ways to light and heat buildings. It also means a more interactive and responsive city administration, safer public spaces and meeting the needs of an ageing population." – European Commission (n.d.)

Key to a smart city is the system perspective. That is what makes smart city projects different from traditional urban development and urban maintenance projects. The development and implementation of smart solutions, in essence, should be well-embedded in the (existing) urban system, and well-connected to other projects and locations.

Smart city development is essentially a multi-disciplinary endeavor rather than simply offering a technological fix for urban challenges and requires the integration of physical, digital and human systems in the built environment (Caird & Hallett, 2019). Carvalho (2015) argues that the diffusion of smart city technologies and solutions in society resemble socio-technical transitions. Technological transitions are a change from one socio-technical configuration to another, involving substitution of technology, but also changes in other elements, such as policy frameworks and economic conditions (Geels, 2011). These technological transitions are about more than just technology, they entail a socio-technical transition (Geels, 2002; Geels, 2011). Smart city solutions require experimentation gardens or so-called arenas for strategic niche management (Carvalho, 2015). The niches are protected from market selection and they act as 'incubation rooms' for radical innovations or novelties (Geels, 2002). Radically new technologies need protection, because they are expensive and still have low technical performance.

The RUGGEDISED Overarching Innovation and Implementation framework was developed and published early 2017 (RUGGEDISED D1.2). The framework is an analytical tool that helps city planners and smart city practitioners to assess the enhancers and suppressors in the implementation process of their smart solution(s) (RUGGEDISED, 2017). Based on 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/or replication within or even across organisations 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.

Deliverable D1.2 stated the following: "The framework distinguishes between six steps of realisation that are relevant for the impact of smart city solutions on different levels. These steps of realisation start with a 'simple' and isolated realisation of a smart solution in a city. The next step is that a smart solution will produce real output if it is well-embedded in the existing urban context. Multiple smart solutions may then successfully produce outcome if they are well connected and collaboratively work in an efficient manner. Outcome at the city level will be reached if smart solutions go beyond being 'pilot' projects and are successfully up scaled within the same city. Together they constitute a smart urban structure. Real impact

of the RUGGEDISED project, in terms of the replication of smart solutions, is reached if smart solutions are successfully replicated in the RUGGEDISED follower cities. The spin-off of RUGGEDISED is realised when other EU-cities take up the lessons learned and smart solutions." – RUGGEDISED, 2017.

Level of impact 1: Realisation and output of a smart solution
The first level of impact of a single smart solution is its successful implementation and delivering its output. However, such implementation sometimes occurs in an isolated manner. That is why successful realisation does not automatically will produce the intended output. In order to produce real output a smart solution should be used by its stakeholders in the longer term and in a sustainable way. Embeddedness, thereby considering contextual, physical, social, economic and institutional aspects and factors, in the existing urban innovation ecosystem is of great importance to guarantee awareness and acceptance (RUGGEDISED, 2017).

Level of impact 2: Embedded outcomes of multiple smart solutions
Several smart solutions in an area are interlinked. Establishing these linkages and effectively exploit them is a challenging task but will ultimately result in smart districts. Smart city development is about integrating infrastructures, communicating systems, connectivity and data exchange. Collaborative business cases, interoperability and openness are important prerequisites to successfully connect different smart solutions (RUGGEDISED, 2017).

Level of impact 3: Upscaling and replication
If implementation experiences and knowledge of smart solutions are transferred to other parts of the city, this ideally leads to a city-wide smartness (thus within a city). Such upscaling leads to reaching smart city ambitions, however it requires well implemented and successful smart solutions in earlier stages, ongoing innovation and maturity of business cases. The main difference between upscaling and replicability is that the smart solutions will be implemented and embedded in totally different social, economic and institutional contexts (in other cities). In order to ensure replicability - the smart solutions should be really robust and flexible (RUGGEDISED, 2017).

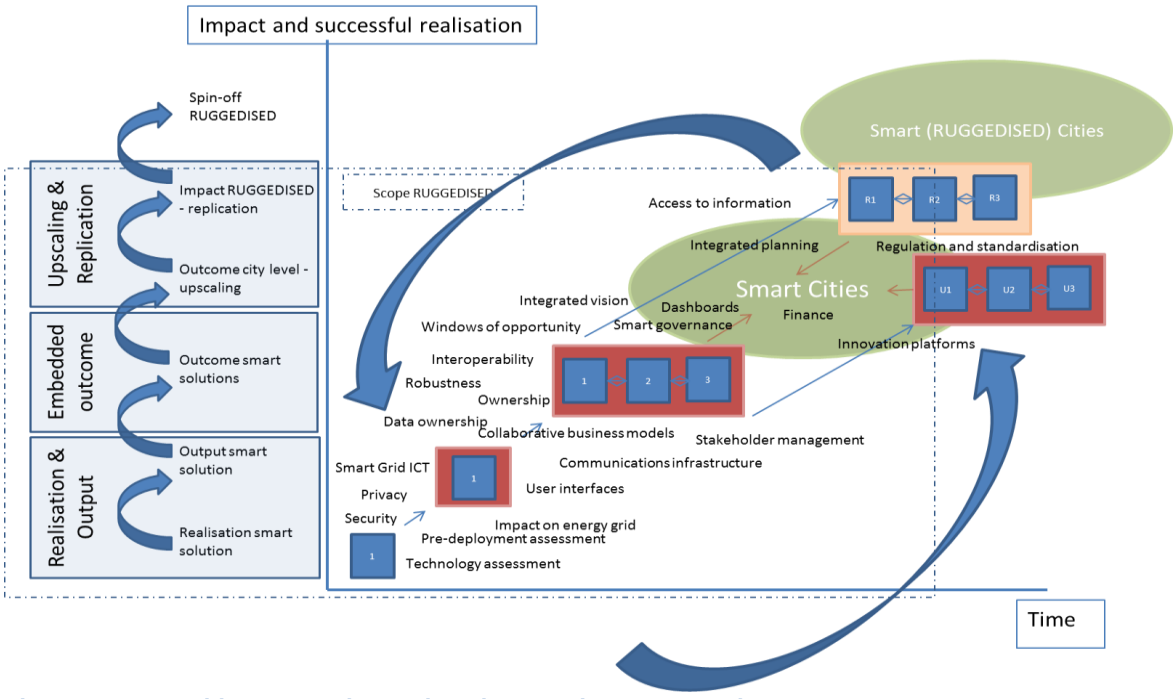

Figure 3: Overarching Innovation and Implementation Framework

Figure 3 shows the implementation hurdles that the RUGGEDISED Lighthouses have collaboratively defined to reach the level of successful upscaling and replication.

3.2 Current status across (and between) lighthouse cities

The following smart solutions are introduced by their RUGGEDISED numbering; for Rotterdam these are R1 – R13, for Umea those are U1 – U8 and for Glasgow they are G1 – G10.

3.2.1. Energy Thermal Grids & heat-cold storage / exchange

Update Rotterdam: Rotterdam implemented the smart heat grid using **(R1)** geothermal heat-cold storage in combination with electric heat pumps. This solution is currently in working order (as of October 2019). As a result of this, it is now possible for the event centre Ahoy to not use natural gas anymore for heating and cooling. The idea is to connect other buildings e.g. the cinema, hotel and hospital to this grid, as well as a variety of other energy sources will be connected. Due to the diversity of functions of the connected buildings and energy sources, peak demand at different times therefore requires a lower total base load. Other energy sources will be connected, however, are still in development, such as **R2**: thermal energy derived from waste streams. **R3**, surface water heat-cold collection, turned out to be not economically feasible and was therefore terminated, alternatives would not lead to a net CO_2 reduction and are not further explored. **R4**, a pavement heat-cold collector, turned out to be unfeasible due to the large distance between the bus station and the thermal smart grid. The pavement heat collector (ca. 400m2) will be relocated to the back of the complex. This is a less visible location, but the realisation can be combined with the re-paving of an existing asphalt road. Further benefits are the short distance to the heat pumps of the Thermal Smart Grid, cutting down infrastructure and pump energy costs.

Update Umea: U1 on climate smart business models focused on 100% renewable energy supply and **U3** geothermal heating/cooling storage are connected. The in-depth energy analyses combined with business model innovation have given a holistic view of the complex business landscape of energy supply systems – local and distributed – and it has given the project both the opportunity to pinpoint the bottlenecks and find ways of mitigating them. The team is connecting the solutions on a holistic level in order to find the value proposition, which promotes the synergies between the solutions. The solutions U1 and U3 are innovations based on the existing energy systems of district heating and cooling, heat pumps and geothermal storages. By integrating software with traditional energy systems, the solutions may be able to help reducing the climate impact of the energy systems. **U2** is a peak load management system, which is currently up and running. The smart peak power control on a small number of buildings in Umeå. The ones included in RUGGEDISED are a health centre and an office building. The health centre is used almost constantly and the office only during daytime. Alongside these buildings, apartment blocks were added to increase the peak load shaving capacity of the tests. It all works fine and is easily scaled up if needed. Discussions are currently being held with project partners on potential upscaling of the technology. The peak load management system connects with district heating, thereby even considering the geophysical aspects of its surroundings thus truly embracing its position as solution in an urban area. The use of weather forecasts in combination with heat buffering in building constructions, along with peak power controls, is smart.

Update Glasgow: Smart Solution **G1** was completed in August 2018. The development of smart solution G1 led to the creation of a contractual model for implementation, which is agreed by all stakeholders to be an accomplished piece of work, that will enable more informed contract negotiations between generators and consumers of heat and facilitate easier establishment of heat connections in the future. Immediate implementation beyond the aimed achievements in RUGGEDISED, was unfortunately hindered due to issues outside the control of the actors involved in this Smart Solution activity. The physical district heating connections (and thus linking between smart solutions) between the University of Strathclyde and Glasgow City Council City Chambers, and between Tennents Brewery and the Drygate housing will not proceed as expected. During the planning phase, the former has been hit with very high connection costs that make the provision of heat from the University to the Chambers uneconomical. This is largely due the very congested infrastructure underneath the roads in the city centre creating multiple routing issues for the pipe network. The latter was impacted by a constrained power network which, in the area of the brewery, was close to its fault level limit and, due to this, could not connect a CHP of the size required by the brewery. An alternative connection point was offered but, due to the distance away from the point of generation, it added £2M to the cost of the project and made this uneconomical. Neither of these issues were foreseen in the design stages of RUGGEDISED. In search for alternative applications of the contractual collaboration agreement, a new source of heat is being explored for Tennents Brewery. The RUGGEDISED team in Glasgow has been involved in the development of this project and is working to have the model contract utilised in the contract negotiations should the project be successful. The University of Strathclyde have also developed a district heating modelling tool with the capability to

verify the effectiveness of the district heating connections for Glasgow City Council and the Wheatley Group. This tool has been added to the Energy Systems Performance building simulation platform. The tool can be accessed at gwww.esru.strath.ac.uk/ Programs/ESP-r.htm for other cities wishing to explore the district heating potential in their own cities.

Glasgow has an aspiration to promote more district heating throughout the city. To date, the district heating installed has failed to grow beyond its original boundary. Smart solution **G1** provides a means by which discussions around new connections can be facilitated and brings potential customers and generators into a discussion from an informed position. During the life of RUGGEDISED, Glasgow City Council has produced a Local Heat and Energy Efficiency Strategy that designates several zones in the city where district heating will be pushed. G1 and D4.1 will play an important part in the growth of district heating in these zones.

Smart heat solutions show the crucial importance of a sound system analysis and extensive trust (or clear contractual guidelines) between exchanging partners. Umea built this trust with a theoretical exercise in which potential exchange scenario's and business models were tested. Glasgow achieved transparency for future projects through developing clear contractual guidelines. Moreover, connecting various heat sources turns out complicated, largely due to high costs of the connecting infrastructure (see the example of Rotterdam). Relocation of the smart solution might be a solution, which can be read as a plea to carefully design grids and smart solutions at the starting phase of a project.

3.2.2. Smart EV Charging and e-mobility

Update Rotterdam: Within **R5**, Rotterdam is installing PV panels that directly feet the fast charging system of the bus station. For the RACC and the hall of Ahoy a comment must be made. An ongoing study is executed to investigate whether the proposed solar panels can in one way, or another amplify the volume of the inside program. If that is the case, the solar panels cannot be placed on the roof. Today it is clear that the solar panels are increasing the noise resonation. Therefore, the investigation is now focusing on how these solar panels can be placed under a different angle to lessen the effect. Since the Ahoy centre is next to a residential area, the regulations for extra noise are very strict. A technical and financial feasibility study for the battery was ordered by the municipality and conducted by Eneco in co-creation with the network operator (DSO) STEDIN, RET, EUR and the municipality. The feasibility study showed no potential for peak shaving with a local battery in combination with a small new net connection, versus a big new connection to the main net ring. However, the follow-up study showed this: connecting the solar panels with a DC cable directly to the fast charging system of the new E-buses (in combination with the small new net connection) is the preferred option (business case wise). Because of this, the new big connection to the main net could be avoided. This means increased new electricity demand from the main power station will be avoided.

R6, smart charging parking lots are still in development, negotiations are ongoing. In early 2017 the concession to place electric charging stations in the city of Rotterdam was won by the energy company Engie, therefore Eneco is not in the position to place two-way charging stations in the public domain of the city and thus also in the Heart of South area. In January 2019 Eneco looked at the possibility of installing 25 charging stations on the Ahoy premises. It was not possible to place the charging stations in the parking area, because Ahoy is using the area as a festival terrain as well. The terrain must be free of obstacles at those times.

R7, optimising the RET E-bus fleet, has resulted in two types of models. First, we developed a simulation model that can evaluate different charging strategies. A charging strategy specifies where, when, and for how long each bus can charge. Common-sense strategies include first-come-first-serve, where a bus charges whenever it has time to charge and a charger is available and lowest-SOC-highest priority. In this last strategy, a bus with a lower SOC can take the charger from a bus with a higher SOC. By adding delay-data to the simulation, we can evaluate the impact of delay on the feasibility of the schedules. Second, we developed an optimization model that could find the optimal charging schedule with respect to some objective. We included two objectives: 1) minimize the number of charging activities, 2) minimize the charging cost. The first one aims at finding a robust schedule, as having fewer charging events reduces the risk of missing an event as a result of a short delay. The second objective tries to align the charging events by charging more at cheaper, off-peak hours. Originally, RET was planning to start with six E-buses, but the electrification of buses will be implemented at a faster pace than was foreseen. In Q1 2018 RET put out a tender for 55 buses and the realisation of both overnight charging equipment (at the depot) and opportunity charging points

(at bus lines stop end). The charging stations will be especially designed for the massive and quick charging of city operating E-buses.

Update Umea: U5, the climate-smart bus station. The climate-smart bus station is a new type of bus stop is expected with its innovative design - where technology, people and the environment interact with each other to reduce the city´s environmental impact and its carbon dioxide emission - to act as a symbol for the Smart University District. The bus stop is served by both electric and fossil fuel buses. The climate-smart bus station is implemented and in service. Procurement was carried out as a design-and-build contract. With its futuristic and unique design, the bus station establishes public transport as a modern mode of transport in the smart city. The design can potentially give passengers the opportunity to 'rest and reflect' while waiting for the bus. The design can also contribute to reduced boarding time and a reduction in CO2 emissions. The designers had to turn the feeling of "wasted waiting time" into "finding time to be, to reflect, to feel and to transform". The challenge was to create a space that felt protected, but that could not be totally enclosed because of the different bus types (electric and fossil fuel) have the doors located in different places.
Innovations include: Hanging pods to create a micro-climate for the passengers, which can be turned in any direction by the wind or by choice from the traveller. The pods are placed in such a way so that the bus station, if necessary, can be ploughed with a snowplough. The meditative light- and soundscape connects to the real-time GPS-system for the buses. The GPS-system updates data every five seconds. Each bus route has its own colour and sound, and data for the incoming buses are displayed on a screen in the bus routes' own separate colours. The light and sound makes the station more accessible for citizens with a visual impairment or hearing loss. Children who cannot read can learn the colour and sound of their bus A separation of the waiting- and boarding zone to promote faster boarding, made possible.
U6, the E-charging hub & charging infrastructure. Akademiska Hus will test a charging hub for e-vehicles serving e-bikes, e-cars, and carshare. As e-vehicle charging adds strain to the power system, different batteries and storage solutions within this solution as well as a smart power control management-system, including a dynamic payment system for the charging, will be tested. Integration of small-scale photovoltaic (PV) installation within the overall system and how the battery storage can be upscaled will also be explored. The overall aim for the e-charging hub is to develop it in into an "Energy-hub". VCC will also install a charging hub for e-vehicles in front of the hospital in Umeå. Expected impact: The main aim of this solution is to find a smarter energy system solution with lower climate impact by integrating grid owners and involving end users to reach the objectives of a climate neutral energy system. This smart solution will provide smart energy to recharge electric vehicles from renewable energy sources. By installing PV plants along with energy storage, advanced monitoring and governing systems, and charging points for electric vehicles within the innovation area, good results will be gained in terms of reducing building energy use, as well as systemic effects such as decreasing peak loads. One goal is to be able to draw scalable conclusions. With the experience from the charging hub, the aim is to be able to make assessments of the size of the battery plant that is optimal for different types of properties. The idea is to be able to draw conclusions on how use-patterns and loads affect the need for battery storage. The EV-chargers built at the hospital entrance focuses on taxis, where the main goal is to see if, by giving them the possibility to charge while waiting for patients, whether taxi companies could be encouraged to invest in e-vehicles. Long term, this would lead to an improvement around the hospital with less noise from cars in the area, and better air quality. The installation of the system began in the summer of 2019 and is complete. After finalising the installation, the system is operational.
U7, the smart business model for flexible parking. To help manage air quality in the centre of Umeå, the local authority has decided that no new workplace parking places shall be built in the central urban area. Property developers are therefore offered the possibility of alternative pay-off schemes for parking places through Umeå Parking, the municipal parking company, when they get planning permission. In order to enable more sustainable travel to and from the building, property developers are offered the possibility of a reduced fee on the cost of the parking pay-off fee through the business model called "Green Parking Pay-off". In this case, the developer signs an agreement with Upab in which they agree to implement measures to support sustainable travel for the users of the building. This new model allows the property owner to take responsibility for employee travel to and from the property in other ways than merely offering car parking according to the car parking standard. The property owners receive a reduced parking standard if they undertake to pay a fee to a mobility management fund, connect the property to car sharing and arrange heated bicycle parking areas with changing rooms for employees that commute by bike. Property owners thus get a reduced parking standard, more attractive facilities, participate in a

better urban environment and strengthen their brand. Upab undertakes to reduce the car parking standard for the property, provide resources within mobility management on behalf of the property owner, produce a green travel plan and a communication plan for the property and arrange parking solutions for employees outside the city centre. The business model was completed by May 2018. The municipality board agreed on the terms and criteria that the property owners have to fulfil in order to get the reduction on the parking space standards. The business model is now part of the overall "offer" and part of the comprehensive plan. This means that all property owners in Umeå that fulfil the criteria may now choose to benefit from the possibilities of the green parking pay-off.

Update Glasgow. G2: Deployment of a suitable battery storage, The Electrical Energy Storage (EES) proposed for implementation within the Duke Street car park has been subject to consideration of the physical and electrical requirements of the location with respect to its proposed future role as an e-mobility hub. This would see the car park being used for greater EV charging for both private and taxi use, and also to support EV owners who do not have parking spaces due to the built up nature of the city. The implementation part of a larger vision for Glasgow as a low, or even zero, emission zone with the majority of vehicles being parked outside the central zone and pedestrian or e-vehicle transport being used within this area. Emerging energy markets, which are as yet only being considered, will drive such e-mobility hubs and the planned EES has been scaled to permit engagement in these markets. The implementation of the battery under RUGGEDISED will allow learning and a hierarchy of control which will allow for dynamic responses to CO2 reductions, fuel poverty alleviation and economic benefit which will all be governed by Glasgow City Council. Due to the innovative combination of the technology, a business model for replication and upscaling of this solution, which considers future energy markets, is to be established post installation, as there is the requirement to understand integration points and where best value can be gained. At this stage, the EES is still at the procurement stage, in addition, the types of energy market in to which the system could be trading do not yet exist, but potentially through the operational phase of the project these can start to be recognised. Following an extensive procurement exercise, which was challenging due to the innovative requirements and technical specification, a Glasgow based company called Campbell and Kennedy were appointed to install both the EES and the solar canopy by October 2019. However, this company formally ceased trading in June 2019, leaving the future of this solution unknown. Legal processes have now been undertaken to formally remove Campbell and Kennedy from the project. It is hoped that this smart solution will still be delivered in the future.

G3: Tennets Caledonian Brewery (TCB) CHP surplus power storage in EV Charging hub battery storage. Tennents Caledonian Brewery were unable to install a new CHP due to the fault level limit, which ultimately impacted this smart solution in progressing as it was initially intended. Because of this, the decision was made to examine power transfer from the large scale battery to the smaller domestic battery that is due to be installed in the Drygate flats as a fuel poverty alleviation measure. Project partners SPEN investigated the mechanisms for managing the potential power transfer in a way that could potentially reduce costs to the domestic residents, however, the UK network regulations make discount transfer possible but the cost would be socialised across all customers. Therefore, this is not a viable option. In tandem, work was undertaken to investigate the potential for a Power Purchase Agreement to be established with a not-for-profit energy company, OurPower. Unfortunately, they ceased trading in 2019. No alternative currently exists and this smart solution will not be progressing at this stage.

G4: the optimization of the integration of near-site RES, This solution set out to install a 200kW solar canopy on the roof of a multi-story car park. The power generated by the PV array would be fed directly to either the building, to support its electrical load, and energy storage system, to allow for storage of the energy for use at a later time, or directly to electric vehicle chargers, ensuring that the electric vehicles in the city were as renewably powered as possible. Initial work on Smart Solution G2 - EV-charging hub battery storage involved extensive modelling by project partners at the Energy Systems Research Unit (ESRU) based at the University of Strathclyde. The outcome of the modelling work shaped the development and potential deployment of the renewables deployed at Duke Street car park. The modelling for the Vertical Axis Wind Turbines (VAWT) found that whilst wind turbines have value in an urban environment, deploying them at Duke Street car park in parallel with a solar canopy, would lead to extensive shadowing of the canopy, and a reduction in overall power output, therefore the decision was taken not to deploy the turbines. The solar PV canopy was also extensively modelled by the ESRU and it was found that it would support the installation of electric vehicle charge units and building operations whilst having no negative impact on revenue generation from parking and additionally will also provide shelter from the elements to car park users. This modelling report formed the basis of the procurement documents for delivery of the Solar PV canopy. Considerable work was undertaken, detailing the structural design and integration points, solar PV specifications, and connection to the

energy storage solution. Unfortunately, during delivery of this solution, the contractor went bankrupt and works of the installation have stalled. Work is currently underway to source an alternative delivery partner.
G5, the EV Charging hub in city centre car park, This smart solution looks at utilising a number of the car parking spaces in the multi-story car park to install electric vehicle (EV) charging points, increasing the number from four fast chargers and one rapid to 12 fast chargers and five rapids. The challenge is to develop the business case for concentrated deployment of EV chargers, alongside the connection of those chargers to renewable technologies and battery storage. The charge point installation at Duke Street car park is expected to support current EV drivers in the city as well as promoting other car users to switch to electric, facilitating Scotland's phase out of new petrol and diesel cars by 2032. The charging infrastructure is funded by Transport Scotland with the innovative connection to renewables and storage funded by H2020. Two 50kW charging units have been installed in the car park with funding from project partners Transport Scotland as part of the overall funding package for Glasgow City Council. These have the ability to charge four EV's. The chargers were initially anticipated to be installed at the front entrance of the car park, adjacent to the energy storage system installation as this was expected to reduce costs by reducing cable length. Duke Street car park was designed with a channel on certain elevations for the installation of infrastructure, however due to the one-metre-deep earthing requirements of the chargers, the installations had to be repositioned towards the rear of the car park where a gravel channel exists to allow for installations such as these. Due to the combination of technology to be installed, investigation works found that the electricity supply to the car park was insufficient, therefore the other chargers will be installed at the start of 2020 after upgrade works have been done to the neighbouring substation which are currently underway.
G6: intelligent LED street lights with integrated EV charging. With approximately 70% of Glasgow households residing in flats, access to charging infrastructure can be challenging. This is both technical challenge and business case related. The intelligent street lighting with integrated electric vehicle (EV) charge points will serve as a test for the city where the street lights still remain on the toe of the pavement, therefore allowing charging infrastructure to be installed whilst minimising the impact on pedestrians and ensuring street furniture is kept to a minimum. The charging units installed will be between 3.5 – 7kW as the expectation is that the use will be for businesses or domestic users with long duration parking requirements. The integration of EV charging into the street lighting column will be funded by Transport Scotland and the street lighting will be funded through European Regional Development funding. The design of the integration and the selection of the solution is now complete. One of the main issues with this solution has been the inclusion of the required cable sizes (16mm and 25mm) inside the lighting column, where there is not an abundance of free space. Furthermore, changes to the supply pillar earthing arrangement are required. The design of these elements is close to completion. The EV charging infrastructure that is to be integrated into the lighting column will be supplied by a company called Swarco. These units have now been procured. Due to the nature of the cabling requirements, the columns need to be replaced and are due to be installed before the end of October, along with the integrated chargers. Over 300 intelligent LED street lights have been installed within the project district, the columns with integrated EV charging will be the last to be done. Work is also ongoing with the Glasgow City Council air quality team to identify the best sensors and locations for deployment within the project district.

The smart solutions described under the heading EV-charging and e-mobility are typical system solutions in which the urban mobility configuration, mobility mix and the electricity infrastructure are closely interlinked. It is therefore not surprising that implementation hurdles appear at this system level and the level of embedding the smart solution in the current urban (mobility and energy) infrastructure. Some observations are worth mentioning:

- The embeddedness of EV charging stations (fast and slow, uni- and bidirectional), near-side RES, CHP applications etc. require a robust electricity grid. If the applications do not fit the 'free space' in the grid, this has potential drawbacks on the design of the smart solution. Either the electricity grid should be upgraded, or the geographical location of the smart solutions should be changed. There is a need for detailed knowledge on how various sources of RES, distribution, demand, and flex options such as batteries, interconnect. Models should be able to calculate robust sizes and locations of such chain of smart solutions, under various parameters. For instance, also considering situations we saw in Rotterdam, where the number of e-busses increased significantly and faster than expected.
- Another system aspect are judicial boundaries, as could be seen in Rotterdam. The EV charging poles were already procured to another city-partner, covering the entire city of Rotterdam. Such a system does not allow for area-specific innovative systems, as was foreseen in RUGGEDISED.

- Also, various implementation hurdles come to the fore at the operational level. The example from Glasgow on the required cable size and the free space inside the existing lighting column is illustrative in that sense. Another example is the fact that solar PV panels on the roof increase the noise that comes from the Ahoy building in Rotterdam. Umea had to deal with the fact that electric busses and conventional busses have different door locations. In designing a bus stop, this is a problem. These operational hurdles seem to be unavoidable. The questions is, how do you deal with it? Do you expect the unexpected? And is the process robust enough to adapt to changes?
- What is prominent here as well, is that innovation partners sometimes go bankrupt or stop their services. Within the field of smart cities, of course, there are lots op pioneers. Some succeed, others fail.

3.2.3. Energy (demand side management)

Update Rotterdam. **R8**. Energy Management. After the second amendment, Ahoy and Eneco gave Simaxx the task to implement the energy- and building software of Simaxx at Ahoy. The goal is to have Simaxx software implemented at all buildings in the area. Prior to this Eneco gave Simaxx the assignment to make a dashboard at area level in which all buildings (and their building data) with Simaxx software will be visualised. The Simaxx software at building level can visualize and optimize the energy usage, comfort level and operations of the HVAC installations. The expected impact is a yearly CO2 reduction of 1.118 ton with the proposed smart solution. This implementation is still work in progress. Ahoy will be the first building ordering and using this software. The creation of the innovative dashboard is still work in progress. A first version is expected after the summer of 2019. Eneco gave Simaxx the assignment by Eneco to enable the exchange of energy data from the master meter of a building to the City data hub and / or City 3D Model.
R11. Efficient and intelligent street lighting. Besides the energy management system and the 3-D model, one of the other aspects of the project was the introduction and unrolling of the KPN-LoRa network. The LoRa network ensures that Wifi or, nowadays still expensive, 4G are not required. The LoRa-network will make dozens of applications possible. The network is meant for equipment which does not constantly need its own internet connection.
The expected impact is a yearly CO2 reduction of 104 ton with the proposed smart solution. The Smart Street lighting poles are installed in October 2019. Six poles are being placed as a test case between the swimming pool and the bus station. The rest of the poles can only be placed when the public area designs will be executed in the whole area, which will be at the end of 2021. The Six test poles are equipped with a tele-management system and LED lights. From a distance they can be controlled, monitored and give insight in their energy use. The energy use data can be fed into the 3D model of the digital twin to provide insight in their performance.
R13. Smart waste management. In Rotterdam there are approximately 6,500 underground waste containers. There was always "static collection", meaning a permanent deployment of people and equipment. The waste was collected at fixed scheduled times via fixed routes. In the first two years all the textile-, paper- and glass-waste containers in the Heart of South area are equipped with a smart sensor. The so-called 'filling degree meter' in the waste container measures every hour how full the container is. Based on this information, the system determines when the container can best be emptied. The routes for the drivers are automatically generated, based on the collected data, a so called 'dynamic route planning'. All drivers are equipped with a tablet/navigation system, which show them the ideal route to collect the waste With the sensors in the containers, the city of Rotterdam contributes to a more efficient management of the waste containers and a better service to the people of Rotterdam. Data is collected to find out the savings in driven kilometres and thus CO^2 savings. It seems that the goals of the project (25% savings in kilometres and 20% in CO^2) will be met. The first results were very positive: the number of days necessary for waste collection was reduced. The moment the waste is collected the containers are approximately 75% filled.

Update Umea. U4A: Gamification. Often when trying to optimise energy use, the general approach has focused around the supply chains and buildings. This solution is different and aims rather to involve the tenants to achieve a more sustainable behaviour towards energy usage and other parts of their day-to-day lives. The idea is to use gamification methods to encourage tenants to alter their habits and behaviour. Through an App produced as part of the RUGGEDISED project, participants will be provided with information designed to inspire them to rethink their behaviour, this includes: providing challenges to encourage them toward particular actions; enabling continuous feedback to provide results of their actions; and holding group events to engage a larger number of participants generating a bigger combined effect and a sense of accomplishment within the community. A mock-up was constructed at the end of 2018 and tested on external users. Results from this initial test were fed into the

construction of the prototype as baseline requirements. The prototype was built and tested on a group of users during the summer months of 2019. Feedback and findings resulting from the test are currently being compiled and analysed. The development of the full application is in progress and is intended to include corrections and feature requests based on the prototype testing. Requirements of the consumption data extraction has been completed and the initial data compilation for the baseline is in progress. **U4B** Intelligent building control. Akademiska Hus AB, which owns and operates the university and college buildings for the Swedish State, will install automatic smart control equipment to control air flow, room climate and presence-activated lighting in 130 offices at the University area in Umeå. The solution is a major energy project in one of the large lab houses, the Physiology House, with includes both offices and laboratories and where ventilation is in operation 24 hours a day. The offices will be connected to a monitoring system where settings can be managed and the status reported and stored. The idea is that the air flow and lighting adjusts depending on the degree of occupancy – both current and expected – in the rooms. The occupancy-rate will be decisive for the total cooling effect and the heating power needed to maintain the desired climate. For the moment the installation of the system is going on. Sound absorbing ceilings have been installed with the purpose of reducing the noise from the installations. The installation of the solution was ongoing until October 2019 when the final inspection was held.

U9: The Demand Side Management system, logs sensor data from different sources and aggregates it into one platform. The collected data will be used as the baseline when setting up a new kind of analysis tool in which the building' status will be analysed and visualised. Results from this research will improve the tool in that case, for example, showing the optimal indoor climate, unnecessary energy use or true usage of the bookable rooms. The research will also contribute to improving the measurement method by studying the accuracy in the sensor when logging. While the solution will affect the buildings in terms of better managing energy use, people using the buildings are unlikely to notice a difference expect when visiting facility services. For planners, operating personnel as well as energy operating technicians the project will make difference. Currently, 1000 sensors installed in one of our university buildings. 500 sensors are installed within the Demand Side Management solution and 500 of them were already installed, through the building's smart heating and ventilation devices. With an integrated time-scheduling component, the Demand Side Management system brings together the output from all these sensors, as well as from a weather station.

Update Glasgow. **G8:** Implementation of demand-side management technology in street lighting. RUGGEDISED will seek to understand how Demand Side Response (DSR) can be cost effectively delivered from new low energy street lighting, particularly that managed as an system. This will depend upon simple, standardised communications connectivity. RUGGEDISED should inform on the level of DSR achievable from such systems. Street lighting is ubiquitous in most cities and with the wholesale switch to energy efficient LED luminaires in full swing a number of benefits can be quickly achieved. However, the lower energy requirements in LED luminaries also reduce the benefits of DSR since there is a smaller amount of available, spare, energy to work with, so the innovation in RUGGEDISED will be to investigate what level of DSR can be achieved using the simplest, most replicable and straightforward approach possible. It is also anticipated that the overall carbon reduction from the installation of the intelligent street LED lighting will be around 60%. The new intelligent street lighting is in place and Central Management System is being trialled. An IoT Edge Router has also been installed which allows the internal network to communicate with the wider internet for enabling IoT capabilities in the future. This smart solution is now in the monitoring and verification phase. The wireless communications network has been installed and allows for transfer of data through the city and to the data based decision platform.

G9: implementation of demand-side management technology in domestic properties This is a new area that RUGGEDISED will investigate and will have wide ranging impacts and learnings, domestic properties being occupied by individuals will need careful implementation if any interventions are not to either cause disturbance to these or simply be overridden through local control or usage patterns. It will also be interesting to understand how the Demand Side Response availability of these properties aligns with or complements that of the non-domestic properties and other assets in the system. The opportunity to model energy transfer between battery systems and perhaps differential price modelling are other areas of innovation in RUGGEDISED. It is hoped that the deployment of a domestic battery storage solution will be able to facilitate a study in to the alleviation of fuel poverty. There has been many unforeseen issues with the domestic battery procurement due to the size, location of the storage room to house the battery and fire suppression systems. The first company procured could not deliver the system with the fire safety guarantee, therefore the contract was terminated and another company procured. The location of this battery has been changed due to issues with asbestos, electricals, and fire detection and will now be housed within

the concierge office serving the Drygate flats. The installed system is in place by October 2019 and will have a 45kWh capacity and 9.9kW charge/discharge rate. On completion of this, the system will be connected to the CMS and Grid Interface Controller provided by Siemens.
G10: Implementation of demand-side management technology in non-domestic properties examines how non-domestic buildings can be used in a demand-side management context to be part of a 'smart grid'. From a technical perspective, the communications will be via the Intelligent Street Lights mesh radio network using an IoT Edge Router device. This will communicate with the existing Building Management System (BMS) controller within each building and relay signals to/from the Demand Side Management controller (DSMc) when seeking to perform a demand-side instruction. The BMS will always be in control of the connected building loads and when an instruction is received from the DSMc, local environmental setups will be assessed before any loads are curtailed. If the BMS is able to shed load, a positive response will be provided back to the DSMs. If it is not possible to shed load, a negative response will be sent. The RUGGEDISED partner Siemens have the IoT Edge Routers and are working with the ISL network providers - Itron - to configure them for communication across the network. Site visits are planned to confirm that the IoT Edge Router can communicate with the BMS (via the 'eMic' device installed as part of a previous project), but as the configuration has not been changed it is expected to work without any modifications required.
The modifications to the non-domestic building BMS interfaces will be performed in conjunction with deployment of the DSMc platform.

The demand side management smart solutions in RUGGEDISED are well on track. Some interesting observations with regard to the implementation factors are worth mentioning:

- Potential hurdles to implement demand-side management are sometimes very 'operational' in nature (i.e. the size of the battery storage in Glasgow and the alternative baseline numbers for the business case of intelligent streetlights. Also, the extent to which demand side management relies on behavioural change in Umea, and the timeline of designing the public space in Rotterdam).
- The real complexity is in bundling and using data from various users and building owners. Most smart solutions in RUGGEDISED show the success of single functioning solutions. Upscaling the energy management systems to entire areas (and connected buildings) will provide additional complexities in terms of privacy, trust and data quality.

3.2.4. ICT and management of data

Update Rotterdam. R9: The development of the 3D city operations platform is an iterative process of learning by understanding and learning by doing. Learning by understanding takes shape through several studies done, learning through looking at others and talking to experts. The main research question is how to organize the governance of the platform, and which role the municipality of Rotterdam has in this. The first proof of concept (PoC) was conducted in 2017. The goal was to prove that the municipal vision on the meaning and form of the platform is technically possible. In the second proof of concept (2018) the information need was the central aspect. The platform is technically possible, but is it still flexible enough to give answers to real questions? And which functional components are needed on the platform? In this second PoC we therefore disclosed (real time) data regarding traffic mobility, public transport and opened bridges. We also tested the usefulness of several open data standards.
R10, Besides the energy management system and the 3-D model, one of the other aspects of the project was the introduction and unrolling of the KPN-LoRa network. The LoRa network ensures that Wifi or, nowadays still expensive, 4G are not required. The LoRa-network will make dozens of applications possible. The network is meant for equipment which does not constantly need its own internet connection. The LoRa network is implemented at the HoS area. The two testcases which were supposed to use LoRa, are not using LoRa in the end. The LoRa solution was implemented in the beginning of the Ruggedised project but caught by the law of the inhibiting lead. The two solutions 'efficient and intelligent street lighting and 'Smart Waste Management' did, in the end, not to make use of the existing LoRa network.
R12, A feasibility study was conducted by Eneco and the start-up Nerdalize (partially owned by Eneco) to explore whether high performance servers in residential buildings (built by Ballast Nedam), could provide highly distributed computing power (computing facilities, data centres) while, at the same time heating homes for free and drastically reducing overall CO2-emissions. The results of this innovative proposition were promising and Ballast Nedam and the municipality were enthusiastic, but unfortunately Nerdalize had declared bankrupt due to a lack of sales growth and the necessary additional funding in final quarter of 2018.

Update Umea. U8, The smart city open data decision platform, aims to provide real-time visualisation as well as static data to show the impact of smart city interventions. It will also provide a way to quickly access and combine different data sets to examine results, and as such to enhance the possibility of quickly making well-founded decisions for the council as well as for citizens. Bringing together different data sets as part of one platform, enables a more uniform approach towards decision-making and the potential for a real impact on an improved quality of life. Since Umeå realised that neither the resources nor the time was available to build an open-data decision platform from scratch it was decided that one would be purchased to use as the foundation for it. The first step was to examine what could be found on the market today. Initial research found that none of the products delivered the 'whole package', so a procurement process was opened with a list of requirements. A mistake in the procurement process was that some requirements we considered as selfevident e.g. an open data platform should not require registration in order to view the data. In hindsight, clearer requirements would have saved time spent on discussions with vendors who were unclear why they were rejected. In some cases, sharing HOW met requirements were verified more clearly would also have been beneficial. The real challenge is to collect sufficient data on the platform, to convince stakeholders of the value of publishing and sharing data as open data. This is much easier with a portal which has a visually attractive user interface, so that contributors can see the data, and understand that the combination of different data set could be interesting.

Update Glasgow. G7. The data based decision platform will pull together existing open data sets, along with the data generated from the project district to create a dashboard that allows users to analyse and present the data in a meaningful way without the need of data analysts. The idea behind the system is to allow individual users to customise their own dashboard, which will allow them to view all of the chosen data sets at once in order to ensure the most efficient use of time, planning and resource across the city. The data generated by the project will also be used to evaluate opportunities for new business models in relation to things such as energy storage and sharing, and EV charging for electric taxi's, as well as generating unforeseen business cases. The DBDP is also able to cross reference datasets, including those from our project partners in Glasgow and across Europe, and create bespoke visualisations that will inform the creation of business models. The development of the DBDP is now complete. This particular Smart Solution has attracted a lot of attention and has already generated a number of potential use cases that will be additional to the upscaled deployment of the solutions delivered in the project. The DBDP can, via API's, ingest data created by the project, as well as existing open datasets that will have the potential to better inform strategic and, potentially, operational decision making. A data sharing agreement has been negotiated between Scottish Power Energy Networks (SPEN) and Transport Scotland (TN), thus allowing the former to fully understand the use of EV charges by vehicle type and frequency, and the latter to know how the network is coping with the growing charging infrastructure. The data generated, and the outputs created from the combination of data, is already playing an important part in shaping partners approach to Electric Vehicle charging in the city and it informs Glasgow City Council's strategy for transforming vacant and derelict land sites into Electric Vehicle charging hubs. This smart solution spans across all of the other data generating smart solutions. Data will be pulled from the other solutions via the wireless communications network (WISUN) installed on the intelligent street lights to be analysed using the data based decision platform.

The approaches taken by the Lighthouses in designing and developing an Urban Data Platform are completely different (see also deliverable 1.6 'Guide on Urban Data Platforms'). It becomes clear that developing an urban data platform takes a lot of time and effort. Moreover, a clear vision on the aim and its functions is crucial. Not only in those cases in which the design and building of the UDP is sourced out (Umea), but also in those cases in which it is done in-house (Rotterdam). *Learning by doing* requires a continuous reflection on: 'am I doing the right thing and does it still serve my aims?'

Urban Data Platforms have the potential to connect smart solutions with each other and to form the necessary basis on which city partners can build new integrated services. Apart from the ability to connect data set with each other, visualisation seems to be the key in showing partners the benefits of data sharing. Sharing data, as we explicitly see in the case of Glasgow, requires detailed contracts or agreements.

The case of Rotterdam also shows that ICT infrastructure, such as the LoRa network, needs to be embedded in the existing urban infrastructure. It competes with alternatives. Whether for some applications it is already out-dated or for some applications perhaps still too advanced, such ICT infrastructure provision should be carefully thought through in terms of its value chain. Who is going to supply data to it, and who is going to use its functionality?

As for the Nerdaliser, we have seen it with other innovation partners. Innovation inherently implies taking risk. Bankruptcy is an unexpected event that can happen.

3.3 Utilization of the Overarching Implementation and Innovation Framework

The Overarching Implementation and Innovation Framework was collaboratively built with the RUGGEDISED partners to discuss – and keep track of – important implementation factors that would influence successful implementation of smart solutions. Apart from these factors, the framework showed three levels of successful implementation: (1) realisation and output, (2) embedded outcomes, and (3) upscaling and replication. Determining feature here is the way in which the Lighthouses and their partners succeed in embedding smart solutions in the existing urban configuration (also in terms of governance and organisation) and the extent to which connections between smart solutions can successfully be made. The idea is that smart city projects are different from traditional urban development projects in the sense that the connection to other projects and existing infrastructure is intensified. This section synthesises the lessons learned and reflects on the robustness of the ideas behind the overarching framework.

Development project versus innovation program
Projects, such as RUGGEDISED, are no traditional urban development projects. Traditional development projects are planned in very much detail. Implementation means following linear phases (initiation, exploration, preparation, implementation, evaluation etc). Framing projects this way, results in a significant focus on risks, deviation from a predetermined time schedules, and steering on the business case of the project itself. RUGGEDISED, and smart city projects in general, require a different mind-set. The mind-set of collaboratively shaping an *Innovation Program.* This is for the following reason:

- There is still some fundamental uncertainty on the functioning and success of the smart solutions. That means that during the implementation phase of the innovative solutions, inherently, partners will face unexpected events. In a project management frame, such unexpected events mean *risk.* While trying to see this in the frame of an innovation program, unexpected events are learnings and points in time where fundamental transitions can take place. As was seen, for instance with the Smart Thermal Grid in Rotterdam, unexpected events were caused by the fact that such an innovative project does not fit existing regulatory and contractual frameworks. Unexpected events are key windows of opportunity to really fundamentally change existing institutional settings. Challenge in innovation programs is: how can we, in the timeframe of the project, embark upon the process of fundamental institutional changes, instead of reshaping/readjusting the smart solutions to fit the current regulatory frameworks and finish the project in time? A persistent focus on project management does not allow partners to learn and to fully exploit the innovation potential of the projects they are working on. Innovation programs are meant to experiment, show, learn and upscale/replicate. If such an innovation approach grows with all regional partners, the full innovation opportunity of projects such as RUGGEDISED can be exploited.

The importance of a joint and binding vision
To avoid the pitfall of a traditional project management approach towards innovation projects, it is key to develop a strategic vision at the start of the project, together with the innovation partners. An overarching strategic vision will improve the coordination and collaboration between departments and partners in the city. Such a process allows partners to gain trust, get to know each other's interests and aims, an reflect on the question whether crucial partners (or expertise) is missing in the consortium. One of the main mistakes we have seen is that at the start there was too little time for reflection, whilst innovation takes time and reflection leads to learning. Questions that should have been asked are: "what are we doing collaboratively? And are we doing the right things?" In RUGGEDISED we have seen that especially Umea, and the Fellow Cities took the time to collaboratively create such a vision. Umea is a special case in the sense that a theoretical innovative business case design was built in in one of the smart solutions (U1). By putting much effort in developing an area-wide business case for a sustainable area, partners got to know each other's interests and stakes. Transparently discussing models to exchange and divide costs and benefits allowed partners to gain trust for the implementation phase.

Strategic positioning of the program within the organisation
The positioning of the RUGGEDISED project team within the municipal organisation, and the positioning of the partners within their specific organisation, is of crucial importance. In the RUGGEDISED consortium,

this positioning differs across the three cities. In Rotterdam, the project team is positioned in the 'engineering department' of the city administration, in Umea the team is positioned in the 'strategic urban development department', in Glasgow the team is part of the 'sustainability department'. The position within the municipal organisation not only affects the ease with which the team can align with other departments, it also influences the access to the decision-making - and political levels in order to secure political back-up. Moreover, our experience is that the positioning within the organisation also impacts whether people are 'allowed' to shift focus from a project management approach towards an innovation program approach. This has something to do with the mandate they have to address malfunctioning regulatory frameworks and the time they have for reflection, learning and making mistakes.

Another aspect regarding the strategic positioning of the project is its 'function' in ongoing projects. In RUGGEDISED we can see many different approaches on this issue. A helpful illustration is the development of the 3D city model in Rotterdam (R6). The development of the Urban Data Platform was not started in (and because of) RUGGEDISED. The aim of Rotterdam is to bring the Urban Data Platform development one proof of concept further within the timeframe of RUGGEDISED, and use other smart solutions within the project as necessary use cases to do so. Also, after RUGGEDISED another proof of concept will follow. Glasgow is also building on experiences from earlier projects and explicitly dealing with the lessons learned from projects that have been started earlier. The aim of RUGGEDISED is to push these projects further. The risk of starting from scratch and aiming to fully finish in the timeframe of just one project (RUGGEDISED = 5 years) is that cities rush through the required phases of an innovation program: vision, trust, learning, embedding, upscaling etc. We have seen that it works better if the opportunity of having a project such as RUGGEDISED is used to proceed dedicated steps in your innovation journey. The example from Umea in collaboratively having the time to develop an area-wide business model for sustainable energy, is exemplary in that sense. Dedicated use of a project such as RUGGEDISED also has its drawbacks. In Rotterdam we have seen that the framing as add-on to an existing urban development PPP in the Hearth-of-South Area also complicated the project. The timeframes and contracts of the PPP proofed much more inflexible than originally perceived and did not very easily allow for an 'add-on'.

Cooperation

Culture is a really important aspect in successfully building trust and allowing the opportunity for mutual gains; these things take time and were built over the course of the first Liaison Group meetings. The RUGGEDISED lighthouses deal with three completely different cultures. Umea is community based. The local government is very strong. A lot of the challenges and issues are perceived to be in the public interest. Moreover, the regional innovation partners, although some more economically driven than the others, are publicly owned. This adds up to the frame of innovation and a sustainable city to be in the public interest. It seems to be a crucial success factor in building trust and aligning partners. Glasgow, on the other hand is strongly market based. The example from the multi-storey car park is illustrative in that sense. Within RUGGEDISED, Glasgow aims to show the opportunity to use a multi-storey car park as urban battery. The upscaling of such a solution requires a very specific approach, since most car parks in Glasgow are privately owned. To show the upscaling potential of the urban battery solutions, a rather simple and positive business case becomes more important. Private car park owners only adopt solutions that are technically proven and economically viable. Government has the role of front-runner. Rotterdam is somewhere in between the spectrum of public and private incentives. With its connection to the Hearth-of-South PPP redevelopment, the local government has both an economic, as well as an innovation incentive in RUGGEDISED. This is also true for the partners. Eneco and RET are private partners, though partly publicly owned or funded. Only KPN and Ballast Nedam are private partners. Experience shows that a mix of public and private partners (and also a mix of incentives within the municipality itself) requires more time to strategically discuss common goals. If particular interests become clear during the process of implementation, cooperation may be complicated.

Vertical alignment

All RUGGEDISED lighthouses explicitly show the importance of 'vertical alignment'. Vertical alignment means the establishment of a smooth connection between people in strategic policy making and decision departments and people in operational departments. Implementation hurdles are often very operational: size of batteries, capacity of roof to bear solar PV, subsurface cable complexities, differences in EV charging software, existing contracts etc. However, in order to overcome these challenges, the strategic policy level needs to deal with them as well: do we want to change contracts in order to exploit the innovation potential? Do we want to additionally invest here as 'learning money' etc.? The other way around: if smart city projects

have been designed by people in strategic policy departments, very often they lacked the operational 'system' information. Both Rotterdam and Glasgow said they would really benefit from setting up an 'innovation training' for their financial/accountancy/legal departments. Probably these colleagues would say the same: to set up a 'contract training' for their colleagues that deal with innovation projects. Umea explicitly stated that if the operational colleagues would have been part of the RUGGEDISED proposal writing, the suggested smart solutions would have been differently designed.

Moreover, not only in terms of smoothening the process of implementation, but also in terms of learning, the connection between operational levels and strategic levels needs to be intensified. During the implementation of smart solutions many implementation hurdles and unexpected events show up. To exploit the innovation potential and transformative power of these solutions and unexpected event, at all levels lessons should be learned.

Embeddedness
The overarching framework underlined the importance of a pre-deployment assessment in order to carefully embed the smart solutions in the existing urban infrastructures. Each Lighthouse has struggled with this issue, especially regarding the capacity of electric grids to accommodate new solutions (Glasgow), the connection between the smart thermal grid and the existing heat infrastructure (Rotterdam) and the location of EV charging polls (Umea). We saw that, especially regarding EV infrastructure, the connection between mobility and electricity requires a systems approach. Detailed information and knowledge on the functioning and capacity of different systems/grids is necessary before making any further (strategic) plans. Embeddedness also relates to the use of new infrastructure. In Rotterdam, for instance, the LoRa-network has been installed, but is not being used at the moment. Smart grid use cases in the area chose to use other networks to connect to each other. This point stresses the importance of infrastructure provision in close cooperation with future users. End-user involvement got more attention in Glasgow and Umea .Those Lighthouses had intensive trajectories in place with the end-users and maintenance staff of smart devices that were installed in buildings and offices. Embeddedness, and the example of the LoRa-network pose the question of whether innovations should designed and implemented in a demand driven or supply driven way. Both approached are possible, we see in RUGGEDISED. Especially the Urban Data Platform in Rotterdam has a strong focus on supply driven innovation. Without having too many use cases at this moment, and a clear idea of the value cases, the future vision of the establishment of a digital twin in Rotterdam remain intact.

Flexibility
Smart city solutions are inherently connected to each other and very often have an infrastructure system perspective. This means that project boundaries are fuzzy. A public transport mobility system does not match the optimisation boundaries of an energy system, and does not match the cadastral urban planning system etc. Moreover, innovation in techniques (such as batteries or fast EV chargers) change the boundaries of specific systems continuously. For instance, energy systems become more locally oriented due to neighbourhood batteries. Mobility systems can become more regionally oriented if fast bus chargers become cheaper and better. Also, smart thermal heat grids can be better balanced if an unforeseen adjacent building is connected. Innovation programs need to reflect on their project boundaries continuously. This is a difficult task. Flexibility is often perceived as a risk. Moreover, clarity may also be necessary in order to make progress. On the other hand, flexibility should not be ruled out. Partners need to make clear process arrangements on how to deal with flexibility. Here it links closely to vertical integration. We have seen in the Lighthouses that unexpected events that require flexibility are dealt with at the operational level (for instance the redesign of the smart thermal heat grid in Rotterdam), while a flexible solution at the strategic (contractual level) should perhaps have stimulated the innovation more.

A systemic approach should also be translated to the municipal organisation. Dealing with urban systems requires an interdisciplinary and integrated approach towards city development, which may have its consequences for how cities are organised at this moment. Very often they still rely on a departmental organisation that hampers the integrated view. Interdisciplinarity and integrated planning are still profound challenges.

Ensure the success of the project beyond its life span
RUGGEDISED provides Lighthouses and their regional partners with the opportunity to create a long-lasting cooperation that resembles the key characteristics of a Living Lab or innovative cooperation: geographical

embeddedness, experimentation and learning, participation and user involvement, leadership and ownership, and evaluation and refinement. The sustainability of such a cooperation itself is an important issue, as it should sustain the cooperation of the actors, the maintenance of the lessons learned, potential upscaling of successful smart solutions, and a collaborative effort to develop new solutions. However, the sustainability of the results of Living Labs is a known challenge. Therefore, it is interesting to see whether the local RUGGEDISED consortia can be provided with a (organisation and financing) model to sustain the innovation cooperation beyond the lifetime of the project, which fits to the recommendations of an European report on Living Labs. To this aim, the RUGGEDISED consortia may be inspired by the organisation and financing models of Open R&I Innovation PPPs. Public Private Partnerships for Open Research and Innovation refer to the collaboration between governments ((supra)national / regional / local), knowledge institutes, and private actors (firms) with the aim to address scientific, technological or innovation objectives, to contribute to “the public interest” and “societal challenges”.

As originally mentioned in D1.2 the framework provides a clear definition and operationalisation of (solutions to implement in) smart cities. It addresses the technical, socio-economic and contextual factors that influence (enhance or suppress) local innovation and the implementation of smart solutions in the lighthouse cities. We have seen in RUGGEDISED that a smooth process linking operational and strategic level, and linking project implementation to program learning is hard to establish. The framework addresses the aspects of interconnectivity and promotes knowledge brokerage within and between relevant organisations, organisational levels and departments. It promotes cross-city learning as it encourages its users to think of interconnectivity, upscaling and replication aspects during the first phases of a project.

4. Journey cross-city learning lighthouse cities

This final section reflects on the lessons learned of three years of Liaison Group meetings in RUGGEDISED. In contrast to section 3 of this deliverable in which we reflected on the lessons learned regarding the implementation of smart solutions, this section 4 presents the lessons learned regarding our own observations on the **process and methodology** of cross-city learning in the Liaison Group meetings, the general advance of urban innovation capacity in the Lighthouses and the capacity to address systemic innovation issues.

In November 2016 Rotterdam, Umea and Glasgow started their RUGGEDISED journey to implement their smart city innovations, in close cooperation with their private partners and connected knowledge institutes. At that time, the Lighthouses had divers starting points, different ambitions and, most importantly, were embedded in completely different cultural contexts. Sweden (Umea) is, to a large extent, publicly oriented and community-based. The United Kingdom, on the other hand, has a clear and strong division between the public realm and private partners. The Netherlands, is somewhere in between. This diversity is not only reflected in the local consortium partners (i.e. in Umea most of the partners are publicly owned) it also shapes the way in which local collaborations grow. Also, it determines the perception of the role of local government (what is the public interest?) in innovation projects.

In this context, the challenge posed to the Lighthouses, accompanied by their knowledge partners (TNO for Rotterdam, RISE for Umea and the University of Strathclyde for Glasgow) and lead by WP 1 (TNO), was to exchange lessons learned, articulate knowledge gaps, share practices and collaboratively build new ways to improve the implementation process and increase their innovation capacity. Between November 2016 and November 2019 in total 8 'Liaison Group meetings'[4] took place in which civil servants from the three Lighthouses and their local consortium partners physically met to engage with each other and dig into pressing topics and reflections.

From the start, the Liaison Group meetings were intended to be 'demand-driven'. The idea was that the Lighthouses would be in the lead to bring forward the topics that they would like to discuss and the people that they would like to attend the meetings. With this set-up, TNO hoped to create a safe space to discuss not only successes, but also hurdles and struggles that would undoubtedly occur during such innovative projects. By handing over the responsibility to invite their local partners to the meetings, they could deliberatively choose for themselves for which partners it would make sense to attend. Most of the times, the three Lighthouses chose to attend the Liaison Group meetings with their collaborating consortium partners, as to make sure to exchange lessons in more practical and operational detail.

A system perspective on hardware-software-orgware
Originally, we set up three Liaison Groups: 'Hardware' (with a focus on energy and mobility physical infrastructure topics), 'Software' (with a focus on ICT aspects, such as energy management, urban data platforms and data gathering), and 'Orgware' (with a focus on the organisational and governance aspects). Both the second and third meeting (Delft and Glasgow), we gathered plenary, as well as in the separate thematic Liaison Groups. However, soon the participants discovered that the smart solutions that they were implementing – and the implementation hurdles they came across – where mostly systemic in nature. Infrastructure complexities, such as the thermal heat grid in Rotterdam, had close linkages with governance arrangements, contracts and finance. Decisions on technical EV charging systems in Glasgow – and Scotland – also depended on national laws and regulations. Smart solutions are about making 'connections' and embedding technology in existing urban systems and existing ways of working. The division between hardware, software and orgware soon faded out after the second meeting. We realised it would be better to combine the different expertises and discuss the various topics in a holistic and systemic way.

[4] 1st LG meeting (Rotterdam, November 2016), 2nd LG meeting (Delft, January 2017), 3rd LG meeting (Glasgow, June 2017), 4th LG meeting (Amsterdam, November 2017), 5th LG meeting (Leiden, February 2018), 6th LG meeting (Umea, March 2018), 7th LG meeting (Gdansk, September 2018), 8th LG meeting (Amsterdam, May 2019), 9th LG meeting (Rotterdam, November, 2019)

The added value of bringing the system perspective of a city into the Liaison Group meetings was to better learn each other's 'language' and 'interests' The extensive discussion on the Smart Thermal Heat grid, during the 4th session in Amsterdam, shed light on the interconnection between social, economic and technological elements of what had been perceived as primarily technical. Looking back, after three years of Liaison Group meetings and discussions, the interconnectedness between hardware, software and orgware could have been made more explicit and, above all, practical. With the collaborative effort to design a systemic framework on smart city development (in the 2nd Liaison Group meeting already, resulting in D1.2) the participants tried to understand that developing smart solutions in an isolated way, does not result in a smart city. Moreover, with an introductory presentation (at the start of the 6th Liaison Group in Umea) digging into the system- and transition perspectives on smart solution implementation, TNO tried to re-emphasise the importance of a system perspective. However, we may conclude that such exercises, which stay at a rather theoretical level, are hard to translate into everyday practice. The Liaision Groups meetings, in that sense, should be seen as having served two aims: first, to plant seeds for fundamental reflection and second, to provide the Lighthouses with hands-on information. The 5th meeting in Leiden especially succeeded in providing these hands-on information, regarding EV charging infrastructure decisions.

Timing
During the course of the project we experimented with several set-ups and timings of the Liaison Group meetings. In order to keep the travel and locational costs as low as possible, some of the Liaison Group meetings where adjacent to, or incorporated in the RUGGEDISED General Assemblies (Glasgow, Umea and Gdansk). Other meetings were organised as stand-alone workshops (Delft, Amsterdam (2 times), Leiden and Rotterdam). Our observation is that knowledge exchange and collaborative knowledge building are highly intensive activities, which require concentration and discipline of participants, as well as facilitators. The sessions that were organised in connection to the General Assemblies turned out to be less effective. Although, in general, more people (and valuable expertise) participated in these meetings, it was harder to keep focus and discipline. Such intensive efforts require dedicated timeslots and programmes. The stand-alone meetings differed in duration (1 or 2-days). Intensive 1-day sessions (such as in Leiden and Amsterdam) turned out to be most valuable.

The characteristics of the themes that have been discussed
Over the years many implementation factors (enhancers and suppressors) have been discussed and reviewed (see also section 3 of this deliverable). In general, we may conclude that both very strategical/fundamental and detailed/operational/technical topics were subject to the meetings. This is partly because TNO aimed to program both levels, however, it is mainly due to a direct reply to the requests of the participants themselves.

In the first Liaison Group meeting, during the RUUGEDISED kick-off we tried to cluster the smart solutions and define the links between them.

In the second Liaison Group, it started off with a collaborative effort to strategically reflect on the questions: what is a smart city? And what do we already know about the factors that can potentially influence the process of implementing smart solutions? Moreover, the participants discussed the very practical needs (i.e. a request to review the business case of a smart solution in Glasgow and the need for ideas of a collaborative use case for the Urban Data Platforms). Moreover, this Liaison Group meeting was used to further set the agenda for the upcoming period.

The third Liaison Group meeting built on these practical needs (the battery EV and battery business case in Glasgow, and the relationship between existing heat-infrastructure and the planned smart heat-cold grid in Rotterdam). Together with the other research institutes (University of Strathclyde, RISE and Erasmus University) we tried to embed these practical questions in some theoretical notions. This way we emphasized the generic and strategic character of the practical and contextualized questions that were addressed by the Lighthouses.

The fourth Liaison Group meeting elaborated further on the pressing heat grid discussion in Rotterdam. Moreover, we discussed contributions by various local stakeholders 'outside' the Liaison Group by ways of a movie that they sent in. In this movie, they reflected on the main challenges they had. Discussing these challenges triggered a fundamental reflection and fundamental strategic questions. We discussed the pressing issues of the Rotterdam thermal heat grid and EV charging infrastructure. The Rotterdam

case was carefully prepared by the city of Rotterdam, including reflective questions that led to a fundamental discussion on the role of government in heat infrastructure.

The fifth Liaison Group meeting was targeted at technical and governance considerations regarding EV-charging infrastructure. The (additional) meeting was explicitly requested for by Glasgow, as a follow-up on the third Liaison Group meeting. Together with Glasgow, TNO prepared in-depth discussion points and questions for Umea, Rotterdam and also three external Dutch stakeholders (grid operator, the Dutch national EV knowledge center and an EV consultant). The combination of the detailed technical discussions and the strategic policy reflections worked very well. The success of this meeting laid in a very good preparation, dedicated external knowledge and well-defined knowledge gaps by the city of Glasgow. We made sure that from each Lighthouse expertise on the grid, technical EV-charging knowledge and policy knowledge was present in the meeting. People could have a profound dialogue with their 'equals'.

The sixth Liaison Group meeting took place during the General Assembly in Umea. We explicitly asked the Lighthouses to answer the question: what would you have done differently, having the knowledge and expertise you have now? This question was meant to stimulate second order learning, or profound reflection on 'are we doing the right things'?. Interesting outcome of this session is that both Umea and Rotterdam indeed fundamentally reflected on the pros and cons of the setup of their project and local cooperation. At first sight, our intention to stimulate such reflections worked. However, we did not have enough time to continue the dialogue afterwards.

During the seventh meeting we first touched upon the aspect of innovation platforms (together with WP 6). We had a first discussion on the development of innovation platforms, their different set-ups and goals. The discussion had a strategic character and served the aim to get to know the arguments behind the choices that had been by the Lighthouses in designing their particular platforms. The meeting took place during the General Assembly and was held plenary. Detailed and elaborated discussions on the considerations behind the differences between the Lighthouses was taken over by WP 6, after the meeting (and reported in D1.4).

The eighth Liaison Group meeting again was an intensive 1-day session in Amsterdam. Upon request of the Lighthouses we discussed two topics: energy management and Urban Data Platforms. To introduce the implementation hurdles, we started with a theoretical reflection on 'governance in transition', 'UDP business models' and 'privacy'. With such a theoretical reflection we aimed to structure the practical discussions that would follow in the afternoon. It was hoped for that such presentations provide the participants with a shared 'anchor' or language. It also helps to put detailed discussions to a more strategic level. This set-up worked, especially regarding the role of government in the value case of Urban Data Platforms were some fundamental discussions reflected on the theoretical framework.

The final Liaison Group meeting consisted of two days (see also section 2 of this deliverable). During the first day we collaboratively detailed the table of contents and line of reasoning of the guidance documents that will be the synthesized output of the Liaison Group learnings (D1.5, D1.6 and D1.8). Such a collaborative effort to develop something can be seen as a specific knowledge brokerage strategy in which participants seek how their contextualized experiences match the experiences and learnings of the other cities. Overall this effort was perceived as very useful and structuring. On the second day of the meeting the participants played a serious game. The game aimed to collaboratively decarbonize a specific neighborhood. The lesson that the game wanted to bring forward was: it is important to have a vision, clear centralized coordination and good cooperation between various interests. Afterwards, we observed that the fact that the partners succeeded in 'winning' the game did not let to such fundamental reflections and insights.

Exchanging lessons learned - explicitly seek and define both context-specific and generic factors in determining the success

As already discussed in this deliverable, the specific contexts and cultures in the three Lighthouses are completely different. That makes it difficult to exchange lessons learned, because a lot of the successes and hurdles are specific for the different contexts. However, this should not be a reason to not learn from each other. As facilitators we continuously tried to let the participants reflect on the context specific factors of their stories and examples. This helped participants to better understand and value their own situation.

Looking at challenges from a different perspective also allows to fundamentally reflect on their own context that is often taken for granted. It stimulates second order learning. We did find this in particular regarding the role the government has in society. During one of the Liaison Group meetings Rotterdam even mentioned to bring the heat infrastructure even further in the public domain (as is the case in Umea). Also, we found that discussions on techniques and software choices are less sensitive to contextualized challenges. The Liaison Group meeting on EV charging was very well received by all Lighthouses. The technical component was relevant to all contexts.

Complexity of connecting fundamental reflections to everyday practice
A key issue to address in cross-city learning is the relevance of fundamental reflections for everyday practice. The Lighthouses are involved in complicated projects that require a lot of time, effort and concentration. The Liaison Group participants wanted to be fostered during the meetings. They needed inspiration and solutions to the challenges they were readily dealing with. Their expectations sometimes conflicted with the fundamental reflections we tried to provide in the Liaison Group meeting. Shifting focus from: “are we doing things right?” towards “are we doing the right things?”. Fundamental reflections enrich the implementation process, however not right away. It was a challenge to connect fundamental reflections to everyday practice, challenging for both the facilitators as well as the participants. Fundamental reflections aim to get past ‘political sensitivities’ and discuss fundamental content. This point refers to the earlier reflections on the difference between the perception of a smart city project as an urban development project or an innovation program. Innovation programs inherently deal with political sensitivities, because you are challenging things you have always done a particular way.

Difficulties to articulate knowledge gaps/questions
One of the aims of the Liaison Group meetings was to collaboratively build knowledge and define knowledge gaps. This point once and again proofed very difficult. To know what you do not know is a challenging task. The Liaison Groups and the knowledge partners provided the Lighthouses with a lot of information, in particular on EV charging choices to be made (Glasgow), heat grid governance and business cases (Rotterdam) and innovation labs (Rotterdam). We observed that it really helped here to put a lot of time in preparing the sessions and articulating the knowledge questions, together with the Lighthouses. Moreover, the ‘matchmaker’ session during the Liaison Group meeting in Umea also provided the participants with direct contacts and an overview of the expertise available in the consortium. However, we must conclude that the ambition to be a clearing house and knowledge broker is harder to meet than expected before. This is partly due to the point mentioned on connecting fundamental reflections to everyday practice and the variety of specific and local contexts. The University of Strathclyde did a lot of work for Glasgow, Rise for Umea and TNO for Rotterdam. However, we did not have the time to translate this specific knowledge to a generic level and make it open for the other cities. One of the reasons is that the demand-driven agenda setting prioritised other issues over these specific knowledge development. However, we tried to bring in as much expertise as possible from the knowledge institutes (University of Strathclyde, Erasmus University, RISE, AIT and TNO). Our experience is that, in this regard, it helps best to carefully discuss the issues that Lighthouse cities want to bring into the sessions well in advance. Knowledge institutes can help to articulate knowledge questions and coordinate that the necessary expertise is at the table, the moment issues are being discussed among Lighthouses. This way the Liaison Groups can apply a matchmaking strategy and put both external participants as well as the Lighthouses themselves in the position to inform and advice policy makers in a targeted way.

Importance of well-prepared sessions
We may conclude that preparation is everything. Several observations are worth mentioning here.
Knowledge exchange and collaborative knowledge building works best if ‘someone’ or ‘something’ is the owner and responsible for questioning and detailing what is being said in the discussions:

- Someone. We carefully prepared the sessions with the Lighthouses and discussed with them their knowledge questions and particular cases they want to be part of the discussion. We felt that a clear goal of (one of) the Lighthouses was important to really sharpen the discussions.
- Something. Sessions worked also very well in those cases were the participants had to collaboratively build something or contribute to something. The collaborative effort to build the Overarching Innovation and Implementation framework, the Urban Data Platform value canvas, the GO2Zero serious game. All these aspects can be seen as boundary spanning objects that were able to span the boundaries between participants, contexts, and let them collaboratively design something.

Towards a synthesis. Towards second order learning across the lighthouse cities: future steps
Cross-city learning requires a continuous process of 1) decontextualization (generalisation)-contextualisation; 2) connecting fundamental reflections to everyday practice (zooming in-zooming out) and 3) increasing the innovation capacity of yourself and your organisation. The Liaison Groups, both participants and facilitators made significant progress on these challenges. However, we do see a tendency towards framing smart city projects as mere urban development projects. Such a framing hampers the focus and concentration to fundamentally reflect and generalise lessons learned for upscaling purposes. A framing as innovation programs would benefit the growth of innovation capacity and also the expertise to translate lessons learned within the own organisations. Moreover, and perhaps more important, it allows Lighthouses and their partners to recognise the values of the lessons that they learn during the course of the project. Illustrative in that sense is the recent request to us of the Urban Data Platform lead in Rotterdam, to help him capture the lessons learned with his entire team (also outside RUGGEIDSED). Such a request shows the growing awareness that lessons learned during innovation trajectories are really helpful and valuable for future projects. Programs such as RUGGEDISED should be regarded also as starting points of new innovations in the cities.

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6. Appendix List

1. Minutes of the Liaison Group meeting in Amsterdam (6 May 2019)
2. Minutes of the Liaison Group meeting in Rotterdam (11 & 12 November 2019)

Appendix 1 – Minutes Liaison Group meeting Amsterdam

RUGGEDISED
Minutes Liaison Group Meeting

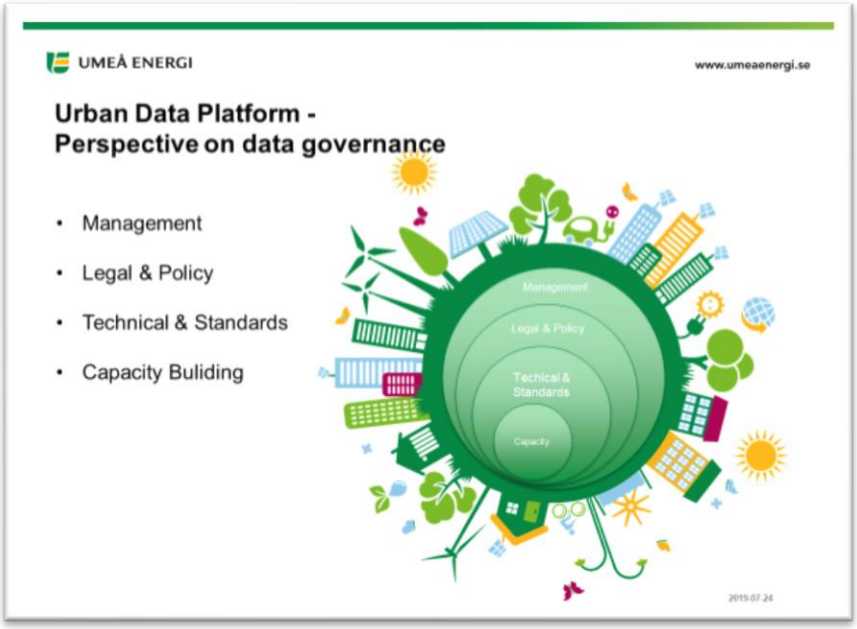
Amsterdam – 6 May 2019

1. Program


Designing smart, resilient cities for all
RUGGEDISED
Welcome and Introduction
09.00 – 09.15 Plenary start
09.15 – 10.05 Presentations about Governance & Plenary Discussion
10.05 – 10.20 Coffee Break
10.20 – 11.10 Presentations about Business Models & Plenary Discussion
11.10 – 12.00 Presentations about Privacy & Plenary Discussion
12.00 – 13.00 Lunch Break
13.00 – 14.30 Breakout Sessions
- Energy Management System in relation to the UDP
- Business Model Canvas
15.30 – 15.45 Coffee Break
15.45 – 16.30 Continuing of the Breakout Sessions
16.30 – 17.00 Wrap-up and Reflections

2. Presentations about Governance & Plenary discussion

Magnus Torrkulla from Umea Energi starts his presentation by defining data governance in the context of urban data platforms: "the interplay of rules, standards, tools, principles, processes and decisions that influence which urban data is considered opened up (closed or partial open), how it's done and by whom". Magnus elaborates on four crucial perspectives that should be taken into account when developing and exploiting an urban data platform (see inserted slide from the presentation).



Alexander Woestenburg (TNO) brings in the citizen perspective on data governance and data ownership. His presentation is shaped around the following table, drawn from an article written by Igor Calzada from the University of Strathclyde.[5]

Citizen Participation in the Technopolitics of Data	Collection	Analysis	Storage	Reuse	Ownership
High participation	Subjects own or control devices; data collection can be customized	Raw data accessible; subjects can conduct their own analyses	Data stored on local devices	Individuals control reuse	Individuals own their data and customize their data policy
Low participation	Subjects aware of devices; data collection can be avoided	Subjects can see visualizations or analysis of their data	Data in cloud storage with options for deletion	Reuse is restricted to aggregated forms	Data collectors use contracts to obtain citizens' consent over their own data
Little to no participation	Subjects unaware of devices; data collection cannot be avoided	Subjects are evaluated or categorized without their knowledge	Data in cloud storage with no option for deletion	Data collectors share or sell data	Data collectors own citizens' data

Data governance is also about reflecting on the role that citizens have as data consumers and data providers. Central question here is: how can urban data platforms better facilitate policy making for a better living environment? And: should citizens become more active in decision making and to what extent can this be facilitated by data and urban data platforms? Alexander shows in his presentation the various changing perspectives that are needed to provide citizens with a greater role.

Discussion

[5] Calzada, I. (2018). (Smart) Citizens from Data Providers to Decision-Makers? The Case Study of Barcelona. *Sustainability*, *10*(9), 3252.

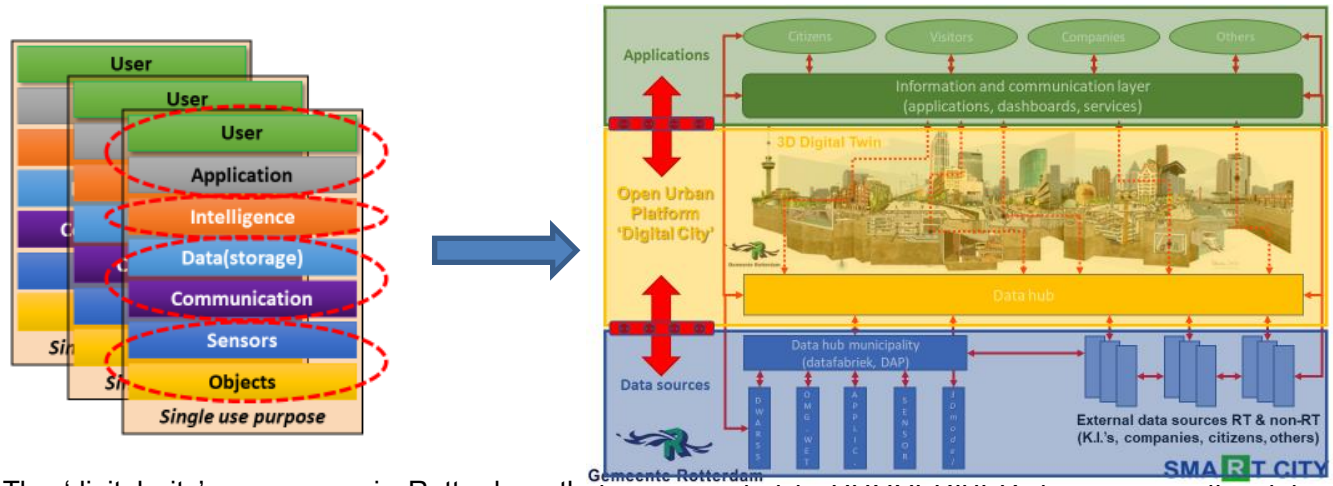
The discussion starts with a metaphor from a famous essay about open source codes: the Cathedral and the Bazaar[6]. The essay contrasts two different free software development models:

> *"The Cathedral model, in which source code is available with each software release, but code developed between releases is restricted to an exclusive group of software developers. The Bazaar model, in which the code is developed over the Internet in view of the public.*
> *The essay's central thesis is Raymond's proposition that "given enough eyeballs, all bugs are shallow": the more widely available the source code is for public testing, scrutiny, and experimentation, the more rapidly all forms of bugs will be discovered. In contrast, Raymond claims that an inordinate amount of time and energy must be spent hunting for bugs in the Cathedral model, since the working version of the code is available only to a few developers"*[7]

The Cathedral shows a more central structure/model, but leaves less room for free participation. The Bazaar, like any open source, is built by communities, with lots of liberty to participate and be creative. We need to reflect on the fact that cities can create their urban data platforms using both models at the same time: a central structure and at the same time building up from the bottom. In the discussion some mention that cathedrals are built for ages and bazaars for a shorter period of time. Bazaars are more dynamic. In terms of urban data platforms, government may focus on the cathedral model to facilitate bazaar models. The evident risk is that people may not like or need prescribed structures. You need software developers, end-users and investors to be involved (co-creation). However, this also bears the risk of setting up incredible complex processes.

3. Presentations about Business Models & Plenary discussion

Roland van der Heijden (City of Rotterdam) presents the current status of the Urban Data Platform development in Rotterdam. In Rotterdam currently around 350 smart initiatives take place. However, this many smart initiatives "doesn't automatically make Rotterdam a smart city". Every initiative has his own siloed and layered approach of: object, sensor, communication, data storage, intelligence, application and user. Many initiatives are not even connected with each other. The fact that they are being developed in siloes causes several problems, such as: 1) vendor lock-ins (companies have their own applications and sensors), 2) no communication between the silos, 3) multiple infrastructures by each company, 4) exploding data management, 5) suboptimal benefits and higher costs (no efficiency), 6) no re-use of data from earlier projects, and 7) data collection and application development cannot be separated.



The 'digital city' programme in Rotterdam, that is connected to RUGGEDISED, focusses on the data marketplace and data storage layer to connect the data with the applications. Open data standards make it possible to let the data flow. Companies need to know on what type of data they can built their application. However, open data standards have their influences on traditional business cases and lead to many questions. *"Do we want a business case on the whole set of functions, or on single functions (data storage,*

[6] Eric S. Raymond (1999) The Cathedral & the Bazaar, O'Reilly Media.

[7] https://en.wikipedia.org/wiki/The_Cathedral_and_the_Bazaar (accessed 24-07-2019)

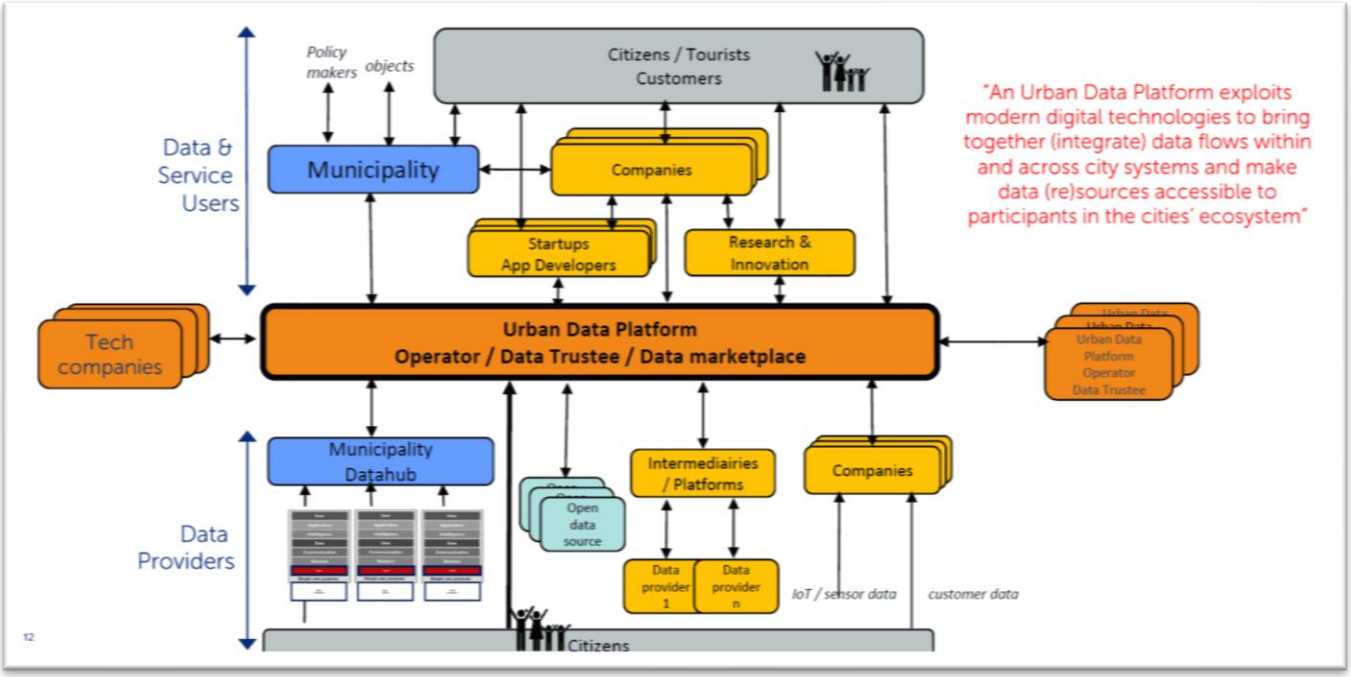
geo functionality, etc). And if we have a business case on the whole set should it be a positive business case on the platform? Or do the transactions within the platform serve as a business case?"

Rotterdam would like to work towards a shared business - or value case. If a platform generates societal benefits, those should also be included in the business case. The municipality is not willing to put in money every year to keep the platform a live – especially when the benefits are lower than the costs.
There are three ways to achieve a positive business case
1) smaller business cases (for example only on the collection of data), or
2) adding up all business cases to keep the whole platform alive.
3) the platform itself creates new data – can be part of the business case.
Challenging is the fact that investors often do not agree with Return on Investment periods of appr. 10 years. However, according to Roland, that's the period the municipality is aiming for.

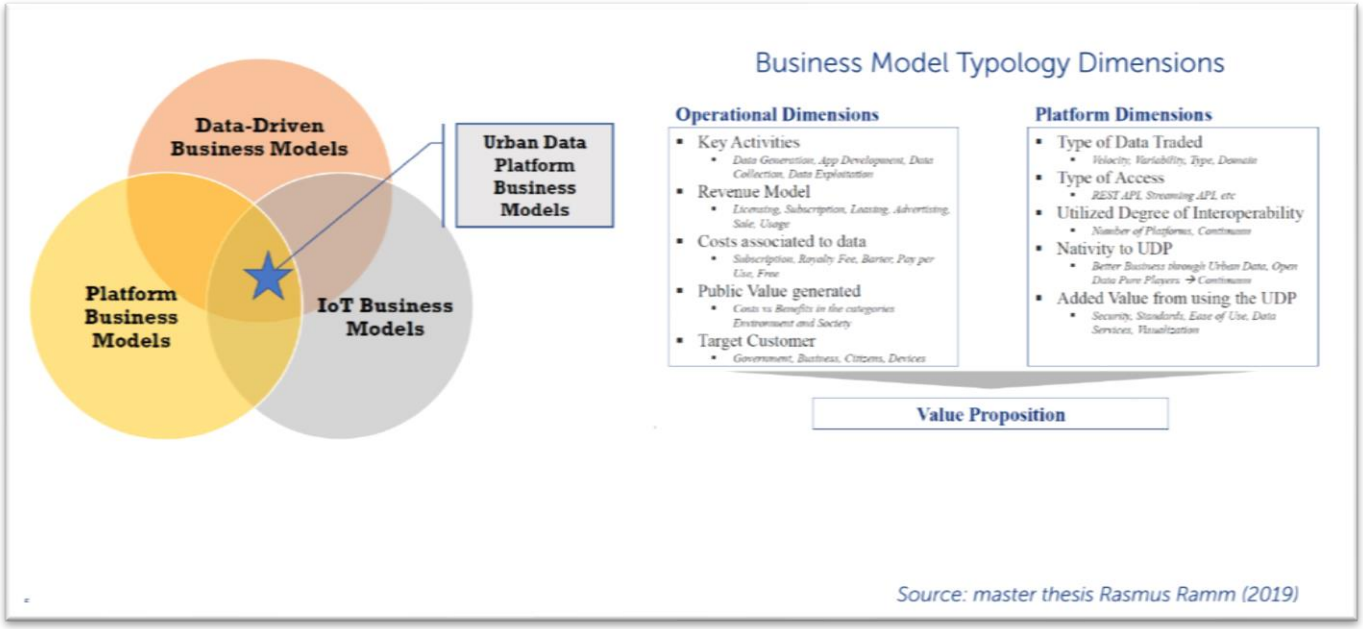
A shared business case / value case is often established cooperation with companies. Potential hurdles to achieve such cooperation are the current procurement rules (private parties that have invested in the development phase of the Urban Data Platform can be disclosed of the procurement phase for the operational development.

Marcel van Oosterhout (Erasmus University) presents his statement that data are the 'lifeblood' of a smart cities. There are different types of data available (public, private, etc.) with different formats and of different quality, so it is difficult to process these data in one platform.
In his research on Urban Data Platforms, Marcel sees the smart city applications are developed in different 'verticals' (a vertical row from object to user per smart initiative). Municipalities are now working on the improvement of their data hubs to improve the integration of different data flows. After this, it is possible to involve other stakeholders and data sets, to create an urban data platform. Interoperability is important to do this.

To create an urban data platform ecosystem, it is important to take some considerations into account: open platform, open source code, open data standards, and open data.



Different types of business models start to merge: platform BM, data driven BM, and IOT BM, there is also some overlap where we think that the urban data platform can create some value.



Urban data platforms can facilitate the scaling of business models. Upscaling can happen in three ways: 1) geographical expansion, replication (within cities / to other cities), 2) functional upscaling (adding new data sets), and 3) demand aggregation (different cities team up, share their data platforms).

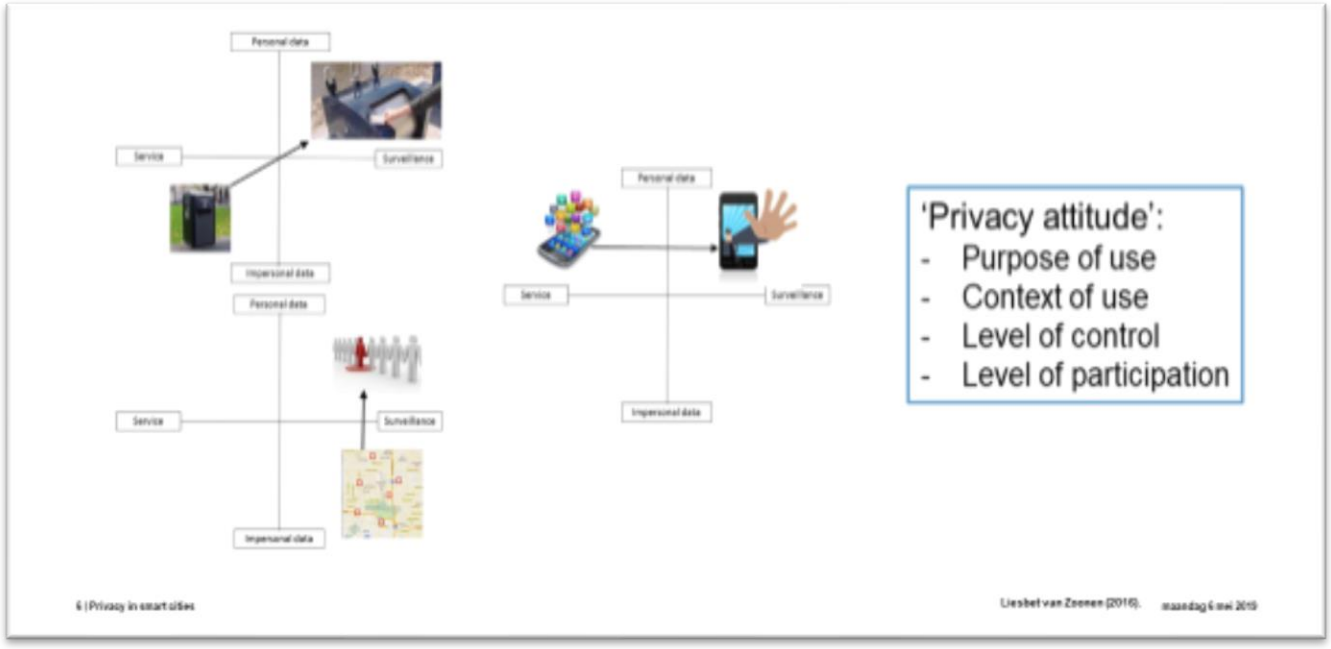
Currently, Marcel sees three types of business models / governance models for Urban Data Platforms:

1. The municipality as an operator of the platform.
2. The data providers of the UDP -> value from the data that you deliver.
3. UDP is used as a BM (generate data itself).

4. Presentations about Privacy & Plenary discussion

Marc van Lieshout (TNO) starts his presentation by mentioning that urban data platforms use a lot of personal data. These data have so much value that privacy needs to be guaranteed. How do you do this?

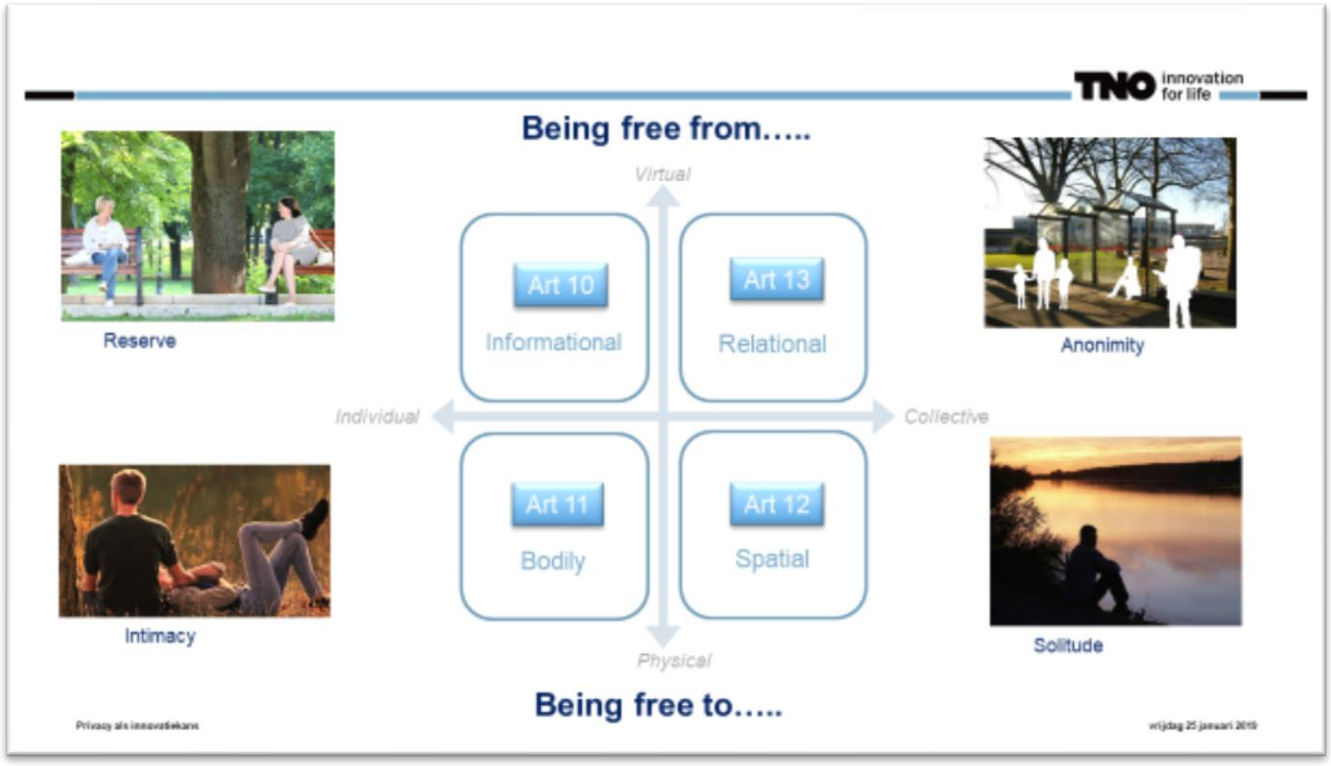
Marc builds on work of Liesbet van Zoonen (researcher at the Erasmus University) in the field of smart cities.



Smart solutions can be plotted on the axes of impersonal → personal data and service → surveillance. Where most smart initiatives start with using impersonal data to generate services, they can easily switch to use personal data for surveillance purposes. An example is crowd monitoring. Is it use anonymously for crowd control, or is it used to know where individual people are? There is public value in smart cities, but is has also a counter value. Why is this relevant? Because the legal frame for surveillance is different from the public smart service perspective.

Marc shows four privacy spheres on which ICT has an impact:

1. Solitude: simply by themselves.
2. Intimacy: family sphere.
3. Reserved: working sphere with a role.
4. Anonymity: not known by other persons (almost hard to reach).



The example shows that privacy is imbedded in four separated articles in the Dutch constitutional law.

The General Data Protection Regulation (GDRP) focusses on legal grounds. The protection of personal data is a balance, because fundamental rights are not absolute rights. The advice is to only use the data that are absolutely necessary for the use (or purpose). In this way, the risk is low (as long as you can identify the use) and you are allowed to do more with the data then when the risks are higher.

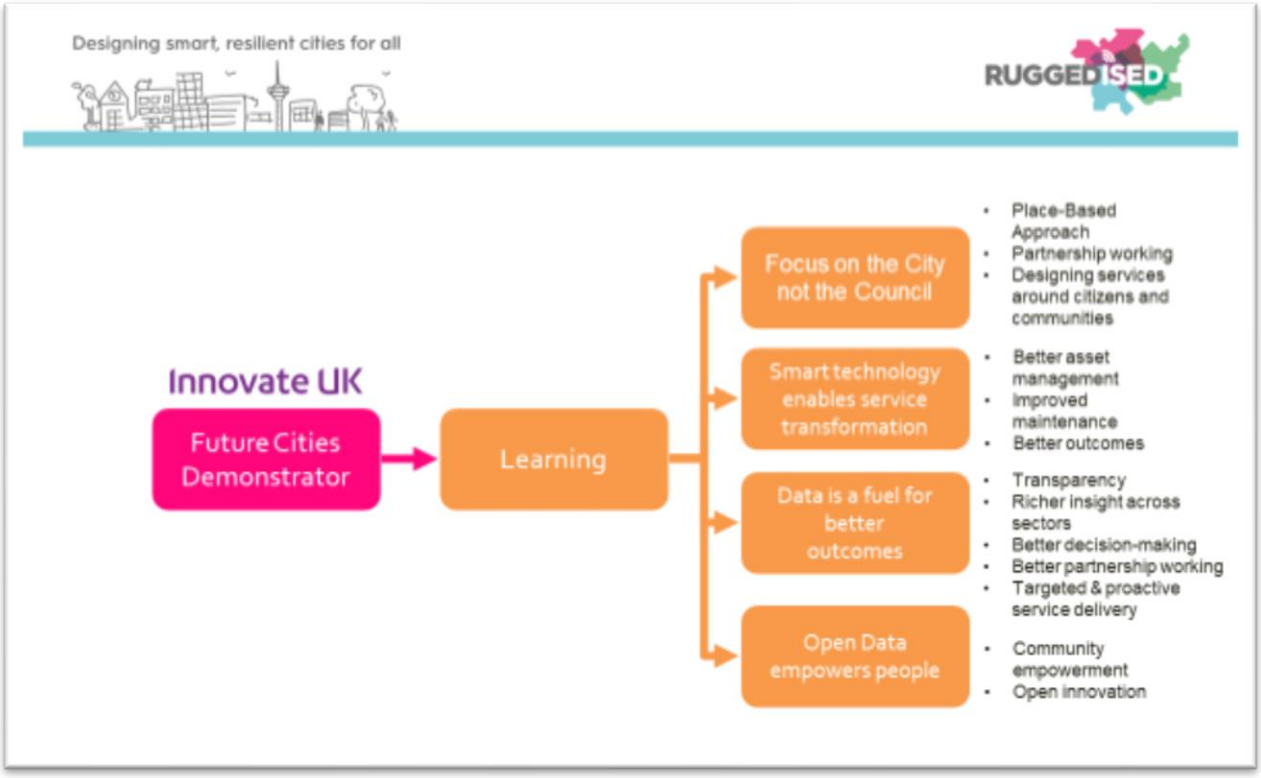
The GDRP only states the conditions to use data. If you take these conditions into account, you can work Taking privacy with us into the innovations within smart cities is a challenge. Because it's about consent (acceptation from people to use the data) and public interest (why you use it). If there is a clear public interest, you don't need consent. However, you need to always inform people.

TNO developed a 'Privacy by Design' approach; respect 4U. There are seven relevant domains which should be taken into account to have privacy and innovation

Conclusions:

- Data is mostly from persons (personal data).
- Including citizens is relevant (participation, control).
- Legal frame is there, enables all kind of operations (allows you the things that you want to do).
- Take privacy into account in the design process.

Gavin Slater (city of Glasgow) presents the journey that he and his colleagues made to become a smart city. This started with "Innovate UK" in 2015 with a future cities demonstrator. This demonstrator has three components: Glasgow Operations Centre, Open Glasgow, and City Demonstrator projects.



With this demonstrator, people faired that Glasgow would become one of the most observed cities in Europe. The media posted messages about "big brother is watching you".

Within the smart initiatives that were implemented in Glasgow, they came across several privacy issues. For example, visualisation of the energy use in the city based on real data. A lot of people didn't want to share their energy data. To solve this issue, they sought advice from the information commissioner, and he came up with the Privacy Impact Assessment. This assessment looks at the background, information flows, risk assessment and privacy solutions. They received a long list with every risk, and for every risk they had to find a solution. Therefore, they needed to look at the information that they collected, how they stored it and how they were going to use it. But also, how they were going to protect it. What they learned from this is that one single aspect cannot be seen as a privacy risk, but a combination of different aspects/sets can be a risk.

Gavin continues with the 8 data principles from GDPR. This has been a useful help in their journey. But Gavin states that you have to look at the privacy impacts as well. The privacy impact assessments is one

of the first things that you have to look at. The sooner this is finished, the easier it gets to design your technical implications.

5. Break-out sessions on business models

Some background
The background of this sessions lies in a paper that has been written by the Erasmus University[8]. The storyline of this paper reflects that smart cities in itself cannot scale, but urban data platforms can. So, if platforms and cities are combined, they become scalable. Urban data platforms are therefore vital infrastructures for governments to survive in the future. But there is a lot of discussion about platforms, about what they are and how they scale.

The business model canvas shows that platforms don't work just by themselves. There is a whole set of functions that make the platform work. In the session it's the goal to fill in the canvas. It's about what are you doing, for who, what are the functions?

Discussion
What is your position on the following statements?

1. Governments should show leadership in UDP developments;
2. Governments should take ownership of UDPs;
3. UPDs are best left to the market: government's role is to facilitate;
4. UDPs are vital public infrastructure.

A small discussion starts after the last statement. The opinions about the need for a UDP differ. Someone says that it's possible to survive without this. But someone else notes that when the government collects data, they need to make it public. With this process they help start-ups. Another person states that it's important to create attractive cities. The value proposition of an UDP is not to create a community, but to achieve a goal (for example, reducing climate change). Through an UDP more stakeholders can be involved and as a result, the costs can be lowered. Someone else notices that UDPs help to efficiently maintain the city. For example, if a light is broken, people can let the government know that through an app.

Then the discussion develops towards the role of the government in the development of an UDP. Someone says that the government should take the lead, because they need to secure the citizen perspective. They need to take the lead as a director together with private partners. Another person says that it's possible to play a small role as a city (facilitate), but you still need to deal with the issues around data. But not being a part of this is not an option. Someone else says that government has the responsibility to make sure that they are experts in the field as well.

[8] Sheombar, H., Oosterhout, van, M., Larsen, C.P., Kotterink, B., & Dittrich. (2019). *Urban Data Platforms: why local governments should take the lead.* Erasmus University Rotterdam.

Wrap up

Mission Statement for Urban Data Platform: Create public and private value thru Ecosystem Matchmaking

<table>
<tr><td rowspan="3"><u>Partners</u>

Investor / Owner

Governor vs Manager

Technology / (Social) Media Partner

Subcontractor</td><td><u>Platform Activities</u>

Tools & svcs, Matching, Audience building, Rules and standards</td><td rowspan="3"><u>Value Proposition</u>

“Place” for innovation, participation, collaboration, and public and private value creation</td><td><u>Leading Public Values</u>

Driving purpose of the platform</td><td rowspan="3"><u>Customers, Users & Participants</u>

Citizens, Communities, Companies, Start-ups, Developers, Data providers, Government, NGOs</td></tr>
<tr><td><u>Platform Data Assets</u>

Data-acquisition, data gathering, visualisation, exploitation/mining</td><td rowspan="2"><u>Scope and Reach</u>

Open-closed, Local-global, Interoperability Access</td></tr>
<tr><td><u>Key Infrastructure & Resources</u>

Digital, Physical, Monetary, People, IP, Brand</td></tr>
<tr><td colspan="3"><u>Financial Cost</u>
E.g. investments, run costs</td><td colspan="2"><u>Financial Benefit</u>
E.g. ROI, revenue streams</td></tr>
<tr><td colspan="3"><u>Social Cost</u>
E.g. privacy, security, freedom</td><td colspan="2"><u>Social Benefit</u>
E.g. democratic participation, growth</td></tr>
<tr><td colspan="3"><u>Environmental Cost</u>
E.g. carbon footprint platform ecosystem</td><td colspan="2"><u>Environmental Benefit</u>
E.g. sustainable innovation</td></tr>
</table>

Since the government perspective is written out above, only the wrap-up of the company perspective will be mentioned here. They choose to use the headline: ‘a smart city for a better living’. They mention that a more efficient city (safer, cleaner, happier) is important.

With the gains from the UDP (cost saving, less unemployed) investing in innovation becomes possible. But how do you finance that? They think of a joint finance between governments and companies. Companies need to help with the development of a platform (analytics and solutions), but there should be a shared risk and benefit. Companies benefit from more use cases that can be built on the platform, but the companies and government should work in cocreation on those use cases. Some of the use cases can influences the financial, social and environmental layers. There are a lot of social benefits named in the canvas, but it’s hard to make a business case out of social benefits. So, governments need to invest in these benefit.

The participants mention that a 10 year return on investment is too long for most investors. So, in the beginning the budgets for the municipality will be the highest. Also, high level sponsors (management of the city and companies) that believe in this UDP are needed. They are the ones that help you going when things got struck. Conclusion; start with quick gains and look at shared wins and benefits.

6. BREAK-OUT SESSIONS ON ENERGY MANAGEMENT SYSTEMS

The two break-out sessions started with the different cities explaining their energy management system, where they stand and what they want to achieve with this.

The discussion between Rotterdam and Umea highlighted the various differences between the city’s approaches. Some examples are:

- In Umea, the energy companies are government owned, so they have an entirely different collaboration with the companies then in Rotterdam, where all companies are privately owned.
- In Umea, house owners can see their neighbours energy bills and compare them with each other. This can work as an incentive to save energy and lower the energy bill. But this only counts for private house owners and not for rental properties. Their energy use is calculated within the rent, so they don’t have the incentive to change their energy consumption. In the Netherlands it’s not

possible to get the energy data per household. Some houses do have a ‘smart meter’ with which people can exchange their data to get insights in their energy use. But the dashboard of the smart meter can only show the insights from yesterday, and a lot of people rather want real time data. Also, yesterday’s insights do not incentive changing energy consumption patterns.

Both cities have a hard time changing the behaviour of people to save energy. This could be an interesting aspect to work on (together with TNO). An option that was mentioned to do so is gamification.

The discussion between Rotterdam and Glasgow centred on the different approaches that the cities used to connect energy data and energy systems from various users (demand and supply) within the area and integrate them into an energy management system. For that to succeed, support and trust are necessary prerequisites. Glasgow spent a lot of time in setting up the dialogue between area partners to develop trust and get insight in the hurdles to overcome. Moreover, they discussed various incentives to exchange energy data. Rotterdam focusses on getting the technical ICT system in place. The city first aims to start small (connecting two or three buildings) and upscale in a later phase, once the systems has proven its effectiveness and trustworthiness.

List of participants

Name	Affiliation
Katelien van den Berge	City of Rotterdam
Roland van der Heijden	City of Rotterdam
Machiel Karels	City of Rotterdam
Roland van Rooyen	City of Rotterdam
Albert Engels	City of Rotterdam
Marcel van Oosterhout	Erasmus University / RSM
Haydee Sheombar	Erasmus University / RSM
Rutger Borst	KPN
Jasper Feuth	Eneco
Rick Klooster	Future Insight
Wilfred van der Plas	Simaxx
Carina Aschan	City of Umea
Maria Söderlind	City of Umea
Kristofer Linder	VLC
Jorgen Carlsson	Umea Energi
Gavin Slater	Glasgow City Council
Christine Downie	Glasgow City Council
Adriaan Slob	TNO
Nikki van der Nat	TNO
Marc van Lieshout	TNO
Bas Kotterink	TNO
Alexander Woestenburg	TNO

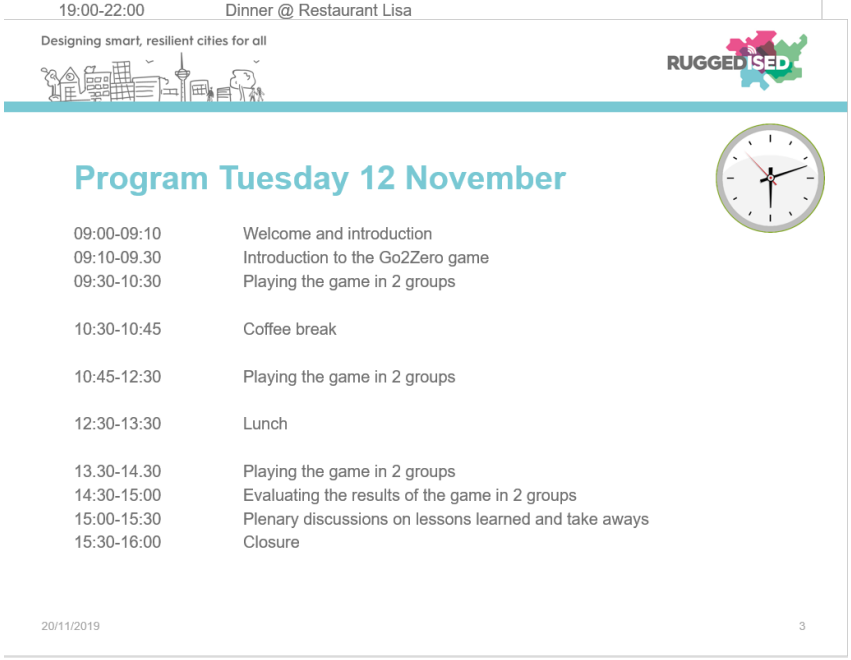
Appendix 2 – Minutes Liaison Group meeting Rotterdam

RUGGEDISED
Minutes Liaison Group Meeting

Rotterdam – 11 & 12 November 2019

1. Program

The final liaison group meeting took place 11 & 12 november in the Ahoy Conference Centre in Rotterdam, the Netherlands; one of the lighthouse cities. The two-day event was focused on the lessons learned during Ruggedised; how to incorporate these in other cities and reach a consensus on the table of contents of D1.5 & D1.6 & D1.8.



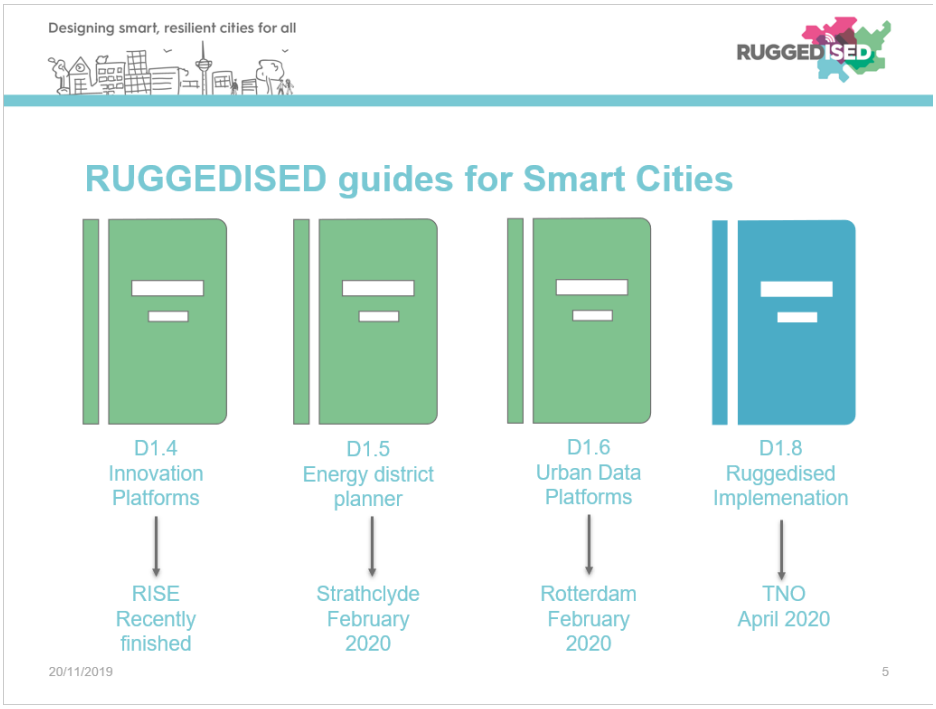
2. Introduction to event

Alexander Woestenburg (TNO): Deliverables of WP1;

Three-year history of exchanging lessons learned and what is happening in the three light house cities. The next step now is to synthesise these lessons learned to a smart cities guide; it should give a flavor of what was learned in the liaison groups so far.

Deliverable 1.4 was recently finished (the deliverable on how to set up and run an innovation platform in the city). The guides should be short and mainly serve the upscaling and replication purposes. They are not meant to be monitoring documents, but to help other cities to reflect on fundamental choices; in other words the most important do's and don'ts. The different deliverables and tables of content for the reports were discussed; first during plenary pitches and consequently also during the carousel-round which goes more into depth. Plenary and parallel sessions on:

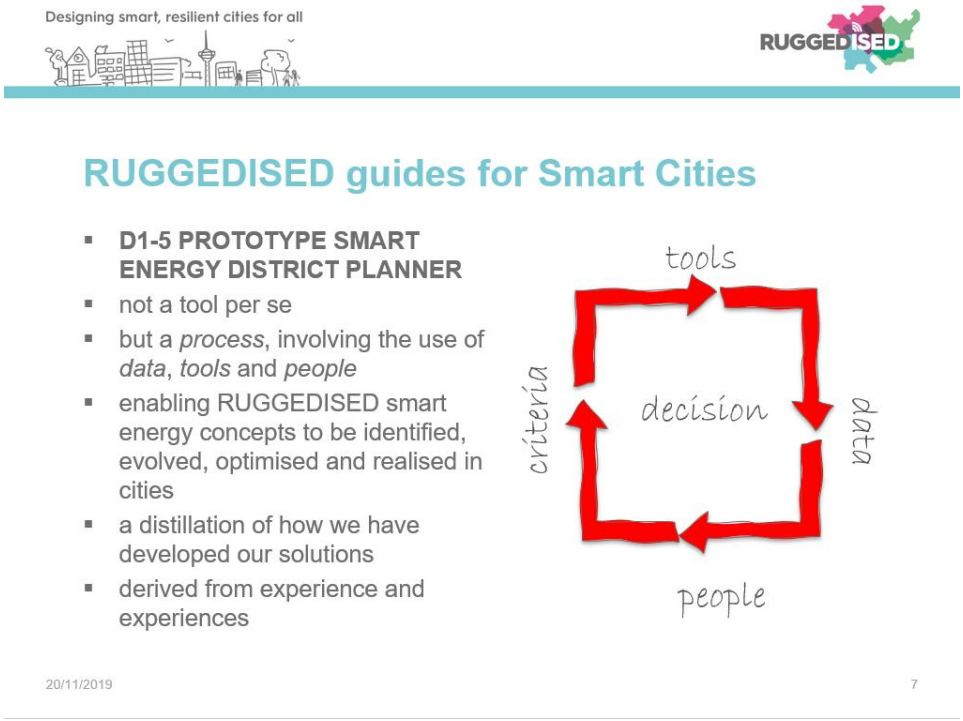
- What lessons learned should be included and highlighted in the guides
- Structure and line of reasoning of the guides
- Optimization of the usage of and linkages between the guides
- Contributions and task division for the upcoming months



3. Plenary pitches

Deliverable 1.5: prototype smart energy district planner

Nicholas Kelly (University of Strathclyde); The Smart energy district planner is not a tool per se, but a process involving the use of data, tools and people! The Ruggedised smart energy concepts need to be identified, evolved, optimized and realized in cities.



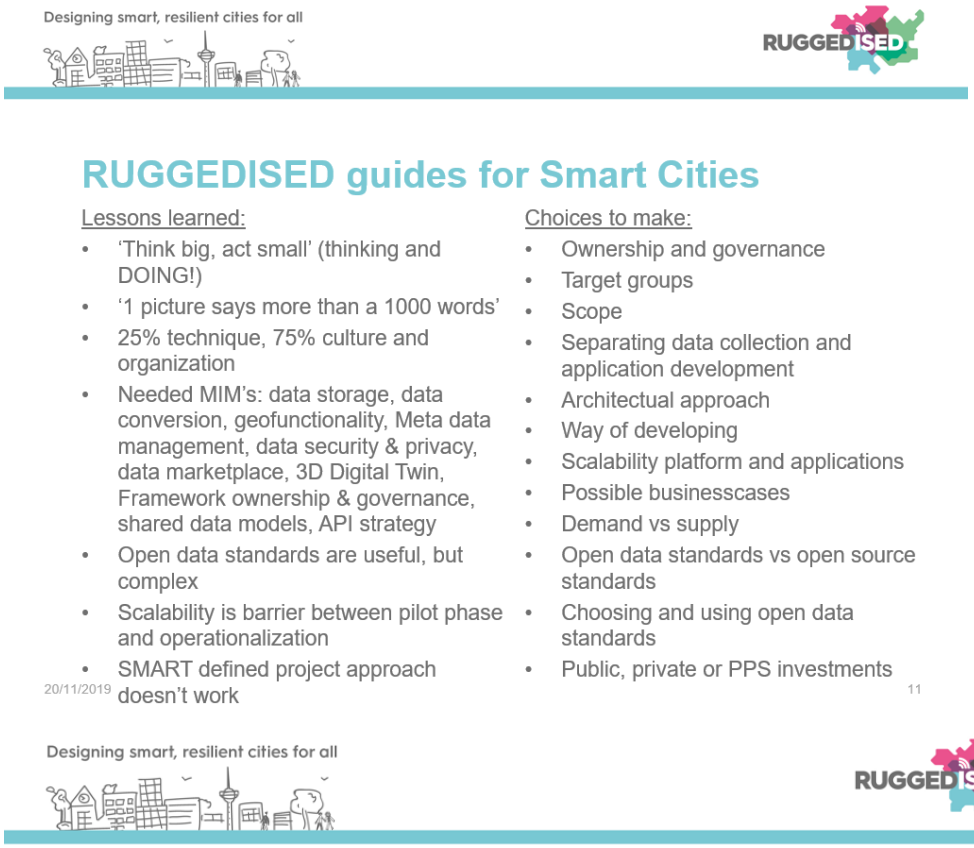
What is critical is the decision points; thereby focusing on four key elements:
→ what are you judging against?
→ What are the criteria?
→ Tools
→ People that need to be in place

This can be found out by doing illustrative case studies and consequently looking for common aspects. The following questions should be asked:

Criteria have commonality or are they completely different?
→ What data do we need to activate the decision?
→ What tools do we have that can help and support us?
→ What people are required to make a robust decision?

Deliverable 1.6: guidance on smart city design and decision platform

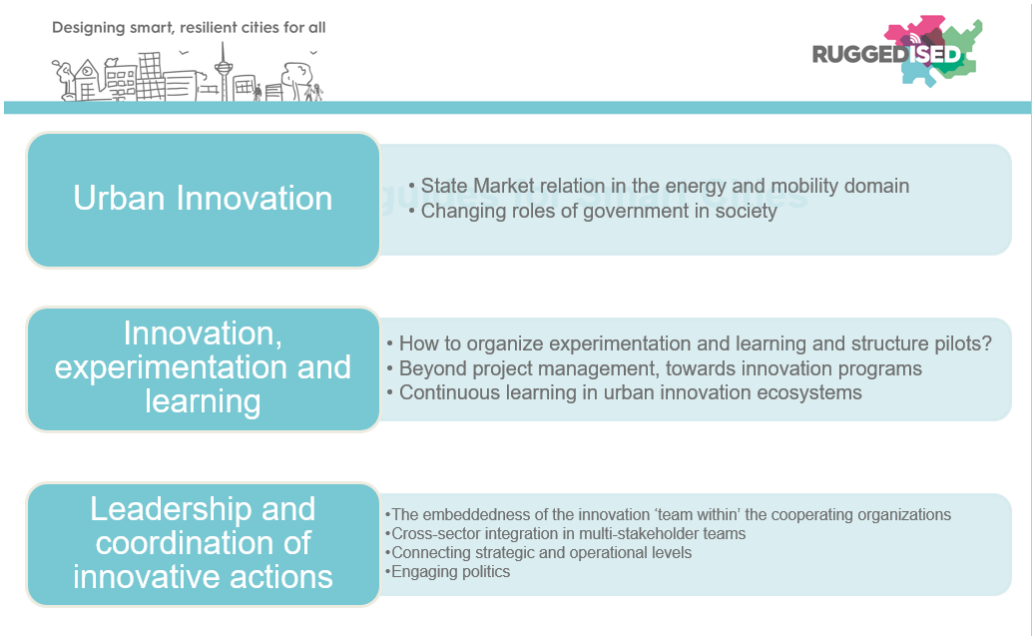
Roland van der Heijden (City of Rotterdam): “There should be a delicate balance between exploring and communication. Furthermore, scaling is something you need to take into account as soon as possible. Business cases need to come from the platforms. A demand-driven organization (as municipality) should thus consider the following; open data standards vs open source standards.”

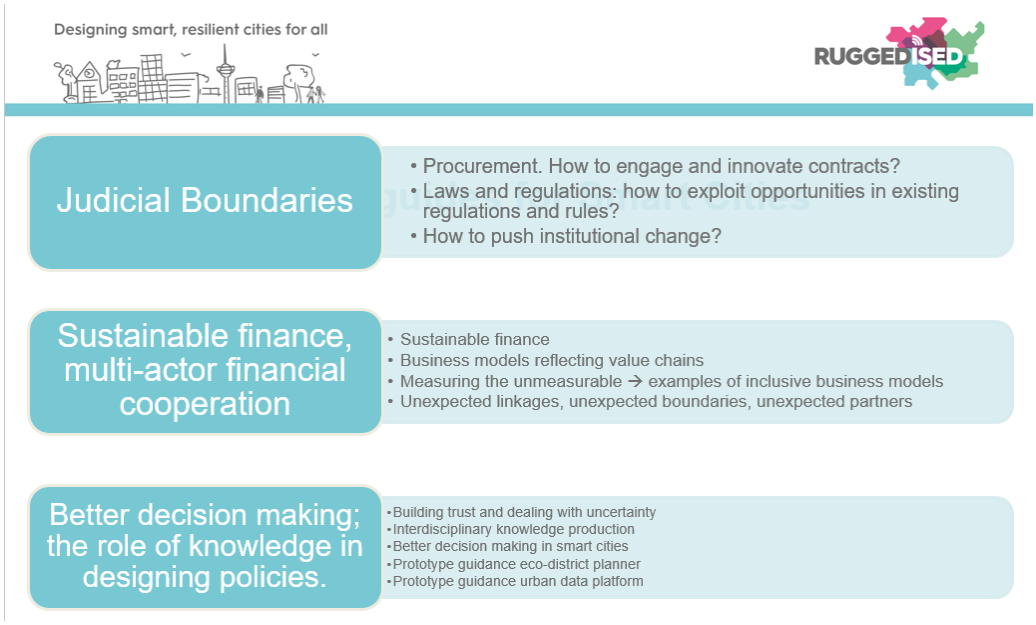


Deliverable 1.8 Guide on ruggedised implementation

Alexander Woestenburg (TNO): Deliverable 1.8, the Guide on Ruggedised Implemenation is the overarching document, as it also including linkages to the other guides. The focus in this report is on the governance issues and topics that are not yet covered in other guides. Lots of communalities between urban data platforms and energy systems. When considering the decarbonization of your city do you then perhaps need to change roles? Do you need to rethink you role? How do you innovate, how do you experiment and learn and structure the experimentation that you are doing in your city? The second topic

is continuous learning; The third one is how do you cross-sectors within your city? How do you align mobility and urban energy planning department? Where is your innovation-team embedded in the organization?





Day 2: Serious game: go2zero

Go2Zero is a serious (role playing) game including the roles of various decision-makers in the energy systems e.g. local governments, construction companies, network operators, energy utility companies, financial institutions and citizens. The aim of the game is to collectively make the transition towards a carbon neutral energy system, whereby the players encounter the impact of individual decisions and different strategies. The game is developed by the TU Delft in the context of the H2020 project CityZen.

The game and the two goals (a 50% energy reduction and zero carbon emissions) were achieved after 5 rounds of playing the game. No upfront strategy was determined by the participants of the game. Some other aspects were striking regarding the course of the game:

- In the beginning (first two rounds) there was almost no cooperation between partners. This changed over the course of the game and got intensified by the network operator who realised how important it is to have good information in order to plan the grid and that this information is only possible via good cooperation with all parties. To some extent, cooperation was also established between the house tenants to collaboratively invest in energy efficiency and generation measures where the corporation lacked initiative to do so.
- Overall, bottom-up initiatives dominated the game. The participants that represented the home-owners were truly ideal occupants and acted as frontrunners regarding energy saving measures. Ideal home-owners and tenants dominated the game, who were driven to invest in dwelling sustainability and even had the measures to do so, this is not realistic.
- Moreover there was little initiative from the green energy company and no effort to combine efforts by the tenants and house owners. Very much like *trias energetica* tenants and home-owners started with energy efficiency, then with local generation.
- Cooperation turned out to be very complicated. Even though we had a group that knows how important it is to collaborate. This reflects the complexity of the game as well as the current status in European cities.
- Large disruptive investments came in late. The first three rounds were dominated by small investments related to the dwelling's energy efficiency. A lack of strategy and financial resources withheld the utility company from big investments in the beginning.
- Many discussions on the way to go and possible solutions by the players, but during those discussion there was always a critical and strong (public?) party missing. This led to many ideas never materializing. The importance of having the right players at the table at the right moment is emphasized by this observation.
- The network operator emphasized the importance of information in order to timely develop the grid in order to facilitate the initiatives pertaining the local green energy generation. Without this information the network operator is always lacking behind in planning and must be reactive and rush planning leading to sub-optimal situations. The municipality also clearly lacked information on the investing capacity and preferences of the citizens and housing corporations leading to subsidy measures which were not always effective (shared subsidy in sun and e.g. heat pumps would tackle both electricity and heat challenge) or efficient (too much subsidies leading to overinvestment in solar PVs).
- During the game more investments were done than needed, although even after the last round, thermal energy supply and storage was possibly not sufficient to cover for fluctuations with sunlight and demand.

11 November 2019

Name	Affiliation
Klaus Kubeczko	AIT
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Christine Downie	City of Glasgow
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Jorgen Carlsson	Umea Energi
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12 November 2019

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