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Designing smart, resilient cities for all

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Executive summary

RUGGEDISED aims to make an important contribution to improve the quality of life of citizens, reduce environmental impacts and to create a stimulating environment for sustainable economic development in districts in Rotterdam, Glasgow and Umeå. In the RUGGEDISED project three Lighthouse cities together had the ambition to deploy 32 innovative and integrated smart solutions in the cross-section of energy, transport and ICT (see Table 1).

Monitoring and evaluation (WP5) of the RUGGEDISED project assessed to which extent the ambitions of the project were met. The monitoring aimed to support all RUGGEDISED cities (not only the Lighthouse cities, but also fellow cities, Gdansk, Brno and Parma) in further deploying and scaling up smart solutions. It can also inspire other European cities who want to deploy such solutions. The monitoring consists of quantitative monitoring of the deployment of smart solutions (see deliverable D5.4). This deliverable analyses the alignment of the smart solutions in the Lighthouse cities with the city strategies, following a qualitative approach. Both the impact of the existing city strategies on the RUGGEDISED developments as well as the impact of RUGGEDISED on adapting and (re)formulation city strategies were studied. Deliverable D.5.5 provides an overview of the main monitoring insights. In order to assess the alignment of the smart solutions with the city strategies, the context in which the deployment took place as well as the various aspects that influenced the deployment of smart solutions in the Lighthouse cities Rotterdam, Glasgow and Umeå was studied. The insights are based on extensive interviews in the first half of 2022 with the primary stakeholders of the Lighthouse cities.

To support a structured description of the deployment processes, the monitoring was based on a monitoring framework as developed in task T5.1 which consists of:

- Operational factors in deployment of smart solutions
- Cooperation
- Planning
- Strategies
- Planning mechanisms
- Innovation capacity

It was found that the majority of the intended measures – 26 out of 32 smart solutions – were (partially) deployed. For each city the deployment of the smart solutions is described, followed by discussion of the deployment factors of the monitoring framework. Many changes took place in the implementation phase and the deployment processes were each affected by a variety of factors. The tables below summarize the main insights.

Table S1 Main deployment factors in Rotterdam

Deployment factors	Findings in Rotterdam
Operational factors in deployment of smart solutions	• Financial feasibility turned out to be an (unanticipated) barrier for deployment of the smart thermal grid. • Regulations, with regard to the concession and the PPP arrangements, led to deployment barriers and delays of several smart solutions. • The Smart Waste Management solution, the 3D city operation platform, smart grid solutions are considered the most successful measures and scaled up during the RUGGEDISED project.
Cooperation	• The cooperation between the RUGGEDISED project team and the area development team was hampered by incongruent timing. • Participating in RUGGEDISED has prioritised and accelerated the sustainability approach of several project partners (e.g. Ahoy Conference Centre and RET; public transport provider) and proved a springboard for several spinoffs. • The cooperation between the RUGGEDISED project team members (triple helix) was constructive.
Strategies	• RUGGEDISED was at the basis of a citywide Digital Program.

Planning mechanisms	• The area development in the Heart of South area resulted in complex spatial embedding of the deployed RUGGEDISED smart solutions.
Innovation capacity	• In general it was found challenging to find the right staff in the organizations with sufficient mandate and management support for deployment of innovative projects. • Close cooperation with knowledge institutes and universities supported knowledge exchange on innovations.

Table S2 Main deployment factors in Umeå

Deployment factors	Findings in Umeå
Operational factors in deployment of smart solutions	• Due to the proactive identification and handling of potential feasibility challenges, operational factors were hardly hampering deployment.
Cooperation	• Cooperation between the stakeholders – all public actors– involved in the RUGGEDISED project went well.
Strategies	• The RUGGEDISED Smart City Lighthouse status allowed Umeå to become part of influential national networks.
Planning mechanisms	• Umeå has an overarching policy plan, called the Comprehensive Plan, which steers all city developments from urban planning to energy and mobility.
Innovation capacity	• The most prominent innovation capacity is networking; demonstrated through influential and institutionalised networks. • Close cooperation with knowledge institutes and universities supports knowledge exchange for innovation.

Table S3 Main deployment factors in Glasgow

Deployment factors	Findings in Glasgow
Operational factors in deployment of smart solutions	• Financial challenges turned out to be an (unanticipated) barrier for deployment of several smart solutions. • Local arrangements and practicalities led to adjustments and delays.
Cooperation	• Strategic position of the project manager proved influential for the multi-level cooperation. • The RUGGEDISED project manager successfully coordinated with various stakeholders inside and outside the City Council such as developers, investors, citizens and businesses (e.g. via Sustainable Glasgow).
Strategies	• Sustainability is high on the city agenda (amongst others due to COP26), creating fertile ground for innovation projects like RUGGEDISED. • RUGGEDISED has had a strong influence on policy and strategy in Glasgow and is referenced in new policies and strategies.
Planning mechanisms	• RUGGEDISED is included as demonstrator in the climate plan and several RUGGEDISED measures are considered inspiring examples. • Glasgow is now working on an EV network strategy in its city region inspired by the pilots within RUGGEDISED (G6).
Innovation capacity	• The most prominent innovation capacity is leadership; demonstrated through a powerful councillor. • Close cooperation with knowledge institutes and universities supports knowledge exchange for innovation

The innovation processes in the Lighthouse cities were characterised by their own unique context and dynamics. Based on the most prominent similarities, the following overall conclusions were drawn:

- The most prominent **operational factors** were financial feasibility and regulation.

- **Cooperation** – both between stakeholders and within municipal organisations – is shaped by the people that are liaisons that build trust, support mutual understanding and who speak the same language.
- The RUGGEDISED project was positioned within the strategic context of the Lighthouses' city **strategies**. The RUGGEDISED project also contributed to city strategies through various policies, strategies and access to network and enforced the increasing attention for sustainability and climate in the cities.
- Alignment of innovations projects like RUGGEDISED with **planning mechanisms** is crucial; misalignment can affect the entire implementation process.
- The **innovation capacity** of the cities differs, and some great examples were found of the importance of leadership, organisational support and knowledge sharing.

This project contained many valuable insights and is particularly of interest for those cities who (continue) to deploy innovative measures in the context of the energy transition. It is hoped the following recommendations get to the heart of all civil servants that will (continue to) work on this transition:

- **Proactively manage the alignment with city strategies**

Innovation projects like RUGGEDISED should be well aligned with city strategies. Moreover, these innovation projects can also have a major impact on city strategies. This requires proactive management and advancements of the municipal innovation capacity (see below). In order to achieve this alignment, we recommend to:

- make an overview of all relevant city strategies (e.g. energy, mobility, ICT) and identify the objectives the project can contribute to and in what way (make lines of reasoning explicit).
- check periodically (e.g. bi-annually) if city objectives, strategies and the emphasis in the implementation of strategies give reason to update the alignment. Particularly when the city council changes or in case of major external events (like COVID or a financial crisis) it can be relevant to update the alignment.

- **Develop and professionalise the cities' overall innovation capacity to create fertile ground for innovations**

In the RUGGEDISED project, some great examples were found in the importance of leadership, organisational support and knowledge sharing. It is recommended to create awareness for the importance of innovation capacity and further develop and professionalise this capacity, building on each cities' unique strengths (such as close collaborations with knowledge institutes and universities) and exchange successful examples as inspiration.

For the respective five factors of innovation capacity the following suggestions are given to the municipal organisations:

- Leadership and ambitions of the city on innovation:
  - Organise support from political leaders as well as the administrative leaders by creating substantial internal communications about the project supported by liaisons.
- Organization that supports innovation:
  - Create networks consisting of people involved in formulating city strategies as well as people involved in innovation projects to bring learnings from projects to the strategic level and vice versa.
  - Create an organisation that supports innovation through enhancing the internal communication on both horizontal and vertical levels.
- Dealing with (new) data and knowledge:
  - Invest in creating a sustainable knowledge base in which lessons learned are being documented and shared. Ultimately, municipalities can create a learning strategy within the organization.
- Networking:
  - Establish long-term cooperation among key partners (triple helix) which increases trust and transparency.
- A learning organization:
  - Support a culture for innovation that rewards (or even expects) innovation and taking risks. This can be promoted via an awards system, regular publications about this or part of regular project reviews, etc. One way to organise this is through a mission-oriented learning program with dedicated funding aimed a joint learning and knowledge exchange.

- **Invest in preparation and proactive management of smart solutions to accelerate deployment**

The RUGGEDISED project has shown that the deployment processes of smart solutions were often characterised by an interplay of closely related factors, being operational factors, cooperation, planning mechanisms and strategies.

These factors can proactively be identified and anticipated for resulting in much less deployment barriers and accompanying delays. It is highly recommended at the start of complex innovation projects like RUGGEDISED to:

- Execute (more) extensive financial feasibility studies of smart solutions;
- Assess the involved stakeholders and their organisational readiness;
- Identify the relevant regulations and potential legal barriers;
- Identify the existing knowledge base and build on lessons learned in previous projects;
- Align the project goals with the relevant planning mechanisms and municipal strategies.

Furthermore, it is recommended to manage the deployment process proactively and in an integral way. As the context of innovation projects is per definition dynamic and complex, all activities listed above requires continuous updates and adjustments during the project execution.

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1 Introduction and reading guide

RUGGEDISED aims to make an important contribution to improve the quality of life of citizens, reduce environmental impacts and to create a stimulating environment for sustainable economic development in districts in Rotterdam, Glasgow and Umeå. The RUGGEDISED project introduces innovative, efficient, replicable, scalable and integrated solutions for smart cities and communities. The three Lighthouse cities together have the ambition to deploy 32 innovative and integrated smart solutions in the cross-section of energy, transport and ICT (see Table 1). At the start of the project, several quantitative and qualitative targets for the project were defined. Monitoring and evaluation were set up to track to which extent the project goals are met.

Table 1 Overview of smart solutions in the three Lighthouse cities

Rotterdam	Umeå	Glasgow
R1: Geothermal heat-cold storage and heat pumps R2: Thermal energy recovery from waste streams R3: Surface water heat-cold collection R4: Pavement heat-cold collector R5: DC grid, PV and storage for mobility R6: Smart charging parking lots R7: Optimising the E-bus fleet R8: Energy management R9: 3D City operations model R10: Long-range (LoRa) wireless network R11: Efficient and intelligent street lighting R12: High performance servers in homes R13: Smart waste management	U1: Smart City connection to 100% renewable energy U2: Smart peak power control of district heating U3: Geothermal heating/cooling storage U4a: Gamification – influence behavioural patterns U4b: Intelligent building control and end user involvement U5: Climate smart bus station U6: E-charging hub & charging infrastructure U7: Green parking pay-off for flexible parking U8: Smart City open-data decision platform U9: Demand-side management technology in a university campus	G1: Heat and cold exchange – connection of buildings to district heating network G2: EV-charging hub battery storage in car parks G3: TCB CHP surplus power storage in EV-charging hub battery storage G4: Optimisation of the integration of near-site RES G5: EV-Charging hub in city centre car park G6: Integrated EV charging functionality in intelligent LED streetlights G7: Smart open data decision platform & central management system G8: Implementation of demand-side management technology in street lighting G9: Implementation of demand-side management technology in domestic properties G10: Implementation of demand-side management technology in non-domestic properties

In general monitoring and evaluation supports:
- Obtaining decision information for the policy process and related investment decisions;
- Stimulating learning processes and knowledge exchange;
- Increasing transparency and communication with stakeholders;
- The accountability of the smart solutions.

The monitoring in the RUGGEDISED project comprises both quantitative as well as qualitative monitoring. While D.5.5 provides an overview of both quantitative and qualitative findings, this deliverable D5.6 describes the insights from the monitoring of the qualitative aspects that influences the deployment of smart solutions in the Lighthouse cities Rotterdam, Glasgow and Umeå and explains the alignment of smart solutions with city strategies. The reported insights in this deliverable were input for the final monitoring report (D5.5: Assessment of Lighthouse projects) that will contain an assessment of the deployed projects in the three Lighthouse cities (see section 1.1).

This deliverable 5.6 analyses the alignment of the smart solutions in the Lighthouse cities with the city strategies, following a qualitative approach. Both the impact of the existing city strategies on the RUGGEDISED developments as well as the impact of RUGGEDISED on adapting and (re)formulation city strategies were studied. In order to assess the alignment of the smart solutions with the city strategies and understand the findings, the context in which the deployment took place as was studied. The discussions in the Liaison Groups (in WP1) on the deployment of the smart solutions in the Lighthouse cities and the formulation of the lessons learned in work package 1, let to the understanding that the alignment with city strategies requires a wider perspective. First, is it needed to understand the deployment process, this provides the context for understanding the alignment. Next, the main deployment

factors – operational factors, cooperation, planning and innovation capacity are studied in addition to strategies and the related planning mechanisms – as these factors often interact and jointly influence the deployment of smart solutions in the Lighthouse cities Rotterdam, Glasgow and Umeå and are expected to provide insights for reflections, recommendations city strategies and lessons learned further deploying and scaling up smart solutions. It can also inspire other European cities who want to deploy such solutions.

This deliverable D5.6 describes:

- Which measures were deployed;
- In what way they were deployed;
- Which factors affected the deployment processes.

Hence, it can be seen as narratives that explain why, how and when deployment of smart solutions took place, while describing the unique context and dynamics of each Lighthouse city. The insights are based on extensive interviews in the last year of the project with the primary stakeholders of the Lighthouse cities.

1.1 Assessment of Lighthouse cities

In RUGGEDISED, Work Package 5 for Monitoring and Evaluation of the solutions was implemented. This section gives an overview of the various approaches to monitoring and evaluation and explains the scope of the related tasks and deliverables. The deployment of smart solutions in the RUGGEDISED project contribute to a wider transition. Hence, a long-term perspective on the monitoring of changes is required. To this end, the main objectives of work package 5 are laying down the requirements for monitoring and data collection, evaluating the demo-sites and solutions and providing project partners and stakeholders with meaningful results on the transformation of the districts into a low energy district with integrated infrastructure and sustainable mobility.

The foundation for this monitoring process was addressed during Tasks T5.1, T5.2 and the beginning of T5.3, which resulted in the deliverables D5.1 “Monitoring and Evaluation Manual”, D5.2 “Monitoring Templates”, and D.5.3. “Maintenance Plan”. The remainder of T.5.3. consisted of documenting all the changes occurring in the monitoring process and the elaboration of the deliverable D.5.4. “Monitoring documentation”. Following this report, the results of the overall monitoring and evaluation analysis, including quantitative and qualitative monitoring, social impact assessment and business model analysis, will be presented in more detail in the D.5.5 “Assessment of lighthouse projects”.

For the monitoring and evaluation of the RUGGEDISED project, several approaches to analyse the execution and impact of the project were foreseen. In complex projects and pilots such as the ones performed, it is fundamental to assess the impact of the activities from several perspectives. Besides the qualitative approach addressed in this deliverable, several other approaches were also developed, and are further detailed in D.5.5.:

- From a quantitative perspective, a comprehensive set of Key Performance Indicators (KPI) was prepared. Their calculation at the end of the project indicates the positive effects of the project in terms of reduction of Greenhouse Gas (GHG) emissions, and improved efficiency in the energy systems for most of the solutions that could be assessed.

- The implementation of these pilots also offered the opportunity to observe how new technologies and methods affect their environment. On these regards, the monitoring team also conducted a Business Model (BM) analysis, in which it was assessed to which extent the pilots were generating transformative approaches among local stakeholders that could lead to a paradigm shift in the energy production and consumption in cities. The results of this analysis on a selection of solutions indicates that the pilots did challenge the established operational model and confronted stakeholders – mostly city administrations and energy companies to collaborate more closely and explore new roles. While these changes were not sufficient to change the operation of their relations, they were useful to explore new models and identify ground rules useful for future initiatives.

- Beyond the actors involved in their implementation, new technologies operate within a context where they interact and affect other stakeholders, such as citizens, users of the technology, staff in the facilities, etc. The social impact of a selection of pilots on several groups of stakeholders was also assessed during the

monitoring phase. For the solutions analysed, the analysis showed that the expectations of users and citizens of the technology were moderately positive before the implementation of the project, and their opinion remained positive during their operation, indicating a minimal disruption in the lives of citizens. Also, that the communication efforts about the implementation of these solutions and their effects had positive influence in other actors that would consider investing themselves in more sustainable technologies.

Finally, an effort for documenting the monitoring process was also conducted during the project. The importance of documenting the monitoring process is of particular relevance in the case of a project that has been executed in particularly exceptional times such as RUGGEDISED, as it allows to track the effects of the different situations and contextualise the results of the analysis. For instance, the implementation of several solutions has been strongly affected by the effects of the Covid-19 pandemic, which started in early 2020 and has led to several lockdowns and operational challenges for all organisations in all the countries participating in the project. Later, the effects of the war in Ukraine, in February 2022, have also affected the execution of some solutions due to the increase of prices of materials and delays in supply chains. Understanding how these situations have affected the deployment of the different solutions, the installation of the monitoring devices, and the availability and reliability of data for comparisons is of key importance to understand the overall impacts of the project and contextualise the analysis.

1.2 Reading Guide

This report starts with a description of the monitoring approach. First the monitoring framework is presented followed by the description of the data collection (Chapter 2). In the following chapter (Chapter 3) the main insights on the innovation processes in the Lighthouse cities are discussed. Section 3.1 is dedicated to Rotterdam, section 3.2 to Umeå and section 3.3 to Glasgow. Each section on the Lighthouse cities follows the structure based on the monitoring framework presented in section 2.1:

- Operational factors in deployment of smart solutions
- Cooperation
- Strategies
- Planning mechanisms
- Innovation capacity

The report concludes with Chapter 4 that summarizes the main conclusions and recommendations from the monitoring of the innovation processes that took place in the Lighthouses in the past six years.

2 Monitoring approach

2.1 Monitoring Framework

The monitoring of the deployment of smart solutions in the Lighthouse cities Rotterdam, Glasgow and Umeå addresses the factors that affected the deployment processes of the smart solutions that were planned and not, partially or fully deployed. According to the Grant Agreement Task 5.6 "Impact Assessment" focuses on the evaluation of the overall impact of the technologies and processes deployed and on "how well the achievements of the demonstration projects are aligned with the cities' strategy". With the experience of the Liaison Groups (in WP1) that discussed the deployment of the smart solutions in the Lighthouse cities, and the formulation of the lessons learned in D1.1, D1.3, and D1.7, an extended framework for the monitoring of smart solutions was developed, see Figure 1. The content of this deliverable was attuned with the other deliverables Work Package 5 for Monitoring and Evaluation of the solutions (see 1.1 for more information). The framework focusses on several factors that are relevant for the deployment of the smart solutions in cities, which goes beyond the alignment with the cities' strategies yet help to understand the wider context of the alignment. The monitoring follows the developed framework that describes factors that can explain why the planned smart solutions were not/partially/fully deployed and how the smart solutions align with the strategic plans (strategic level) and the related planning mechanisms (tactical level) in the Lighthouse cities.

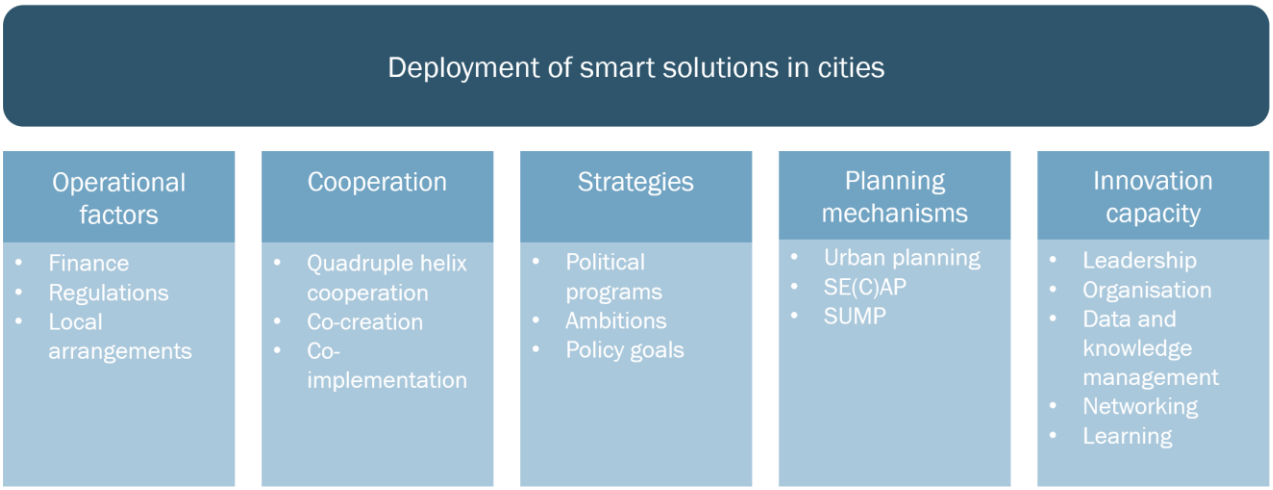

Figure 1: Monitoring Framework: factors relevant for the deployment of smart solutions in cities

Central in Figure 1 is the overall objective of the deployment of smart solutions by a city. Deployment can be affected by factors in five categories. First, **operational factors** have a direct influence on deployment. The city can support the deployment of the smart solutions, for instance on financing and regulations and laws. Also all kinds of local arrangements can play a role such as specific collaborations between stakeholders and the local prices of solutions. On the opposite, the lack of well-suited finance, regulations, or local arrangements can hamper or even obstruct the deployment of smart solutions.

Second, **cooperation** between the city and other actors as well as within the municipal organisation is necessary in the process of deploying the smart solutions (innovations). The actors of the innovation ecosystem in the city (from the quadruple helix: government, industries/businesses, knowledge institutes and citizens/civil society actors) should be involved to adapt the smart solutions to the local context (co-creation), to assess obstacles for deployment and to develop recommendations for removing these, and to support the deployment of the smart solutions in different ways (co-deployment).

Third, the deployment is related to the **strategies** of the city which is embedded in the political program of the City Council, and the ambitions and policy goals that have been established in the city's strategic plans. In order the understand the impact of city strategies in practice, it is also relevant how strategies are translated and embedded into the city **planning mechanisms** on the tactical level. Examples of the planning mechanisms of the city are the Urban Plan for a district or an area such as an overarching plan, the Sustainable Energy (Climate) Action Plan (SE(C)AP) for energy measures and the Sustainable Urban Mobility Plan (SUMP) for mobility measures. Hence, the

alignment of RUGGEDISED with city strategies concerns both strategies and planning mechanisms. The other factors of the monitoring framework might support a wider understanding of the context in which the deployment of smart solutions took place.

This deliverable focusses on the alignment of the smart solutions with all city strategies and related planning mechanisms relevant for RUGGEDISED, e.g. on energy, spatial planning, mobility, digitalisation etc. Through interviews the (potential) impact of the existing strategies and planning mechanisms on the RUGGEDISED developments as well as the impact of RUGGEDISED on adapting and (re)formulation city strategies and planning mechanisms was analysed. The findings in this deliverable concern examples of the interaction(s) between RUGGEDISED and the city strategies and are not exhaustive.

Finally, Figure 1 describes the **innovation capacity of the city** as an overarching factor for realising the smart solutions in the city: the capabilities or capacity that a city needs to possess in order to stimulate innovation[1]. Innovation capacity comprises several factors that indicate whether a local government has the skills, knowledge and capabilities to deploy innovations in the city:

1. Leadership and ambitions of the city on innovation
   This first factor concerns the ambitions on innovation in the city. For instance, are these ambitions articulated and taken up in policy documents? Has the city government taken leadership to support innovations in the city? etc.

2. Organization that supports innovation
   This factor describes how well the city's organization is able to foster innovations in the city. For instance, is innovative working rewarded in the internal procedures? Are bureaucratic procedures hampering innovation? Is the city able to work across silos? etc.

3. Dealing with (new) data and knowledge
   This factor is about the capability of the organization to deal with data in an open way, to select what data is needed, assessing the data sources that could provide the data, and to deal with its relevance for policy in an iterative way, but also for other users. Furthermore, this factor is about the capability to deal with relevant new knowledge; to acquire new knowledge and translate it into policies. It also deals with the capability of the city to broker knowledge between (internal and external) users and providers of information and knowledge.

4. Networking
   The fourth factor explaining the innovation capacity of a city is the capability to establish relevant networks with external stakeholders (for instance with industries, knowledge institutes, etc.) and to cooperate with these networks in such a way that innovation is fostered. Establishing public-private partnerships to foster innovations falls in this category.

5. A learning organization
   The last factor relevant for fostering innovation in the city is it's learning capacity. This factor is about organizational learning and adaptation. What mechanisms are in place to foster learning from pilots/project/programs? How are learnings scaled and embedded within the organization?

2.2 Data collection

[1] Tjokrodikromo, T. (2021) Innovation capacity of cities. Research in Amsterdam and Rotterdam (in Dutch). Erasmus University, Master thesis

To collect the data for the monitoring in the three RUGGEDISED Lighthouse cities (Glasgow, Rotterdam and Umeå) semi-structured interviews were conducted. Per city, two extensive interviews were conducted in the first half of 2022. Each interview was conducted with multiple representatives of the cities present. The interviewees were all part of the project teams, actively involved in the project in the respective cities and considered the primary stakeholders, e.g. project and program managers and advisors (see appendix A). One interview focussed primarily on the operational factors in the deployment process of each smart solution, helping to understand the context of the alignment with city strategies. The second interview focussed on cooperation, strategies and the related planning mechanisms and innovation capacity. The interviewees were asked to reflect on the alignment of RUGGEDISED with the city strategies and policy context as listed in the Grant agreement and, if relevant, mention also additional strategies. In this report the most impactful strategies and planning mechanisms are discussed. The interviews followed a structure as described in the interview guides which can be found in appendix B. The interviews were recorded and transcribed. The transcripts were factchecked with the interviewees and the concept version of this report was reviewed, amongst others, by the Lighthouse cities.

3 Understanding the innovation processes in the Lighthouse cities

3.1 Rotterdam

3.1.1 Introduction

Within RUGGEDISED, Rotterdam intended to deploy 13 smart solutions that are illustrated in Table 2. In Rotterdam the smart solutions can be categorized in three main groups. The smart thermal grid (R1-R4), the smart electric grid (R5-R8) and ICT on City level (R9-R13). These 13 solutions were all planned to be deployed in the Heart of South area which is a district in the South of Rotterdam. This area is known for its socio-economic issues, its young, multi-cultural community and its car-dominated infrastructure. The municipality aims for a redevelopment to transform the area into an attractive and safe place to stay. The municipality of Rotterdam embarked on a public-private partnership with two contractors, Ballast Nedam and Heijmans, for the redevelopment the Heart of South area. The RUGGEDISED solutions (R1-R13) are added to the development plans with a focus on maximum energy efficiency and CO_2 reduction.

Table 2 Smart Solutions Rotterdam

ROTTERDAM		Smart solutions	Status September 2022
Smart thermal grid	R1	Geothermal heat-cold storage and heat pumps	Deployed with adjustments
Smart thermal grid	R2	Thermal energy recovery from waste streams	Deployed with adjustments
Smart thermal grid	R3	Surface water heat-cold collection	Not deployed
Smart thermal grid	R4	Pavement heat-cold collector	Deployed with adjustments
Smart electric grid	R5	DC grid, PV and storage for mobility	16.000 m2 PV panels deployed, battery not deployed
Smart electric grid	R6	Smart charging parking lots	Not deployed, procurement won by non-RUGGEDISED partners
Smart electric grid	R7	Optimising the E-bus fleet	Deployed
Smart electric grid	R8	Energy management	Deployed with adjustments
ICT on City Level	R9	3D City operations platform	Development ongoing
ICT on City Level	R10	Long-Range (LoRa)wireless network	Not deployed
ICT on City level	R11	Efficient and intelligent street lighting	Not deployed
ICT on City level	R12	High performance servers in homes	Feasibility study done
ICT on City level	R13	Smart waste management	Deployed and scaled up

In this chapter first the deployment of each smart solution is described (see 3.1.2). Next, this chapter follows the structure based on the monitoring framework presented in section 2.1

- Operational factors in deployment of smart solutions
- Cooperation
- Strategies
- Planning mechanisms
- Innovation capacity

Table 3 summarises the main factors that influenced the deployment of the smart solutions, based on the qualitative monitoring.

Table 3 Main deployment factors Rotterdam

Deployment factors	Findings in Rotterdam
Operational factors in deployment of smart solutions	• Financial feasibility turned out to be an (unanticipated) barrier for deployment of the smart thermal grid.

	• Regulations, with regard to the concession and the PPP arrangements, led to deployment barriers and delays of several smart solutions. • The Smart Waste Management solution, the 3D city operation platform, smart grid solutions are considered the most successful measures and scaled up during the RUGGEDISED project.
Cooperation	• The cooperation between the RUGGEDISED project team and the area development team was hampered by incongruent timing. • Participating in RUGGEDISED has prioritised and accelerated the sustainability approach of several project partners (e.g. Ahoy Conference Centre and RET; public transport provider) and proved a springboard for several spinoffs. • The cooperation between the RUGGEDISED project team members (triple helix) was constructive.
Strategies	• RUGGEDISED was at the basis of a citywide Digital Program.
Planning mechanisms	• The area development in the Heart of South area resulted in complex spatial embedding of the deployed RUGGEDISED smart solutions.
Innovation capacity	• In general it was found challenging to find the right staff in the organizations with sufficient mandate and management support for deployment of innovative projects. • Close cooperation with knowledge institutes and universities supported knowledge exchange on innovations.

3.1.2 Deployment of smart solutions in Rotterdam

In this chapter the deployment of each smart solution is described. First the solutions regarding the smart thermal grid (R1-R4) are described (see section 3.1.2.1), followed by the smart electric grid solutions (R5-R8) (see section 3.1.2.2) and the ICT on City level solutions (R9-R13) (see section 3.1.2.33.1.2.2).

3.1.2.1 Smart thermal grid (R1-R4)

The first four solutions in Rotterdam are connected to the smart thermal grid developed in the in the Heart of South area around an event location, the Ahoy complex. R1 forms the basis and consists of heat pump systems and a Combined Heat and Power (CHP) system. R2, R3 and R4 are heat and cold sources that are connected to the smart thermal grid. The smart thermal grid has been realized, yet on a considerably smaller scale than originally planned. The original plan was to connect a swimming pool and an arts centre to the grid via a backbone passing under the main road to the Ahoy complex. This turned out to be unfeasible, both in terms of realisation and exploitation. The first obstacle was an operational factor. The development of the swimming pool progressed faster than the realisation of the smart grid. It turned out that there was no room left for cables and pipes making it technically impossible to install a system with a heat pump, whereas with proper planning this could have been avoided.

Secondly, the construction of the backbone via a passage under the main road proved to be a financial bottleneck. From an initial financial analysis, it became apparent that the energy exchange between the Ahoy complex and the swimming pool and arts centre would be limited, making the payback period of the backbone much longer than anticipated.

The second smart solution, energy recovery from waste streams (R2), was still in development during the interview period. Originally, the thermal energy recovery from waste streams was planned to be built in the municipal sewer system but due to technical reasons it was built in the sewer pumping station. There was serious delay in deployment of this measure due to changes in the implementing partner. When the original partner withdrew, it turned out to be difficult to find a new partner since it was difficult to close the business case for this solution. Since thermal energy recovery from waste streams was one of the key ideas of RUGGEDISED, the municipality considered it very important to test the concept and decided to build the system themselves. The investment was subsidized by the municipal energy transition budget. Another challenge was that the pumping station is relatively vulnerable part in the chain of the sewer system, therefore the project personnel needed to mitigate a lot of risks with the operational services. The asset owner of the pumping system was afraid that the energy from waste streams system would disrupt the

primary process of the pumping station. The project team managed to convince the operational staff and hence, this solution being deployed.

Smart solution R3 is surface water heat-cold collection and is not deployed due to miscalculations with purchase and selling prices of heat and opposition from within the municipal organization that the installation would compromise design quality (obstructing sightlines) of the area around the Ahoy complex. A re-location of the installation turned out to be so expensive that realisation was considered to be no longer feasible. The business case had a negative exploitation, also in the long term, with maintenance cost adding to the negative balance. The municipality decided not to deploy this (most unprofitable) solution.

Solution R4 is the pavement heat-cold collector. Initially the pavement heat-cold collector would be installed in the slope of the bus station and in the pathway between Ahoy complex and the station to keep the tiles frost-free. However, the tiles in the Ahoy square were too thick for this solution to work and will not be replaced anytime soon. The pavement heat-cold collector in the bus station could not be connected because the backbone in R1 was not realized. The solution is currently tested in another place, on a road behind the Ahoy complex, close to the technical room of Ahoy and the technical installation of the Combined Heat and Power system (R1).

The withdrawal of a project partner caused difficulties in the effectuation of R4. Because the road where the pavement heat-cold collector is being constructed falls within the contracts of a public-private partnership (PPP), the entire PPP had to agree with the development. The area director of the municipality did not want to reopen the PPP contracts, which meant that the pavement heat-cold collector had to be constructed using multiple private tender procedures. This tendering process took a long time because it was challenging to tender such an innovation. All the parties that had tendered for the contract withdrew because of the involved risks. COVID also caused delays and during this period there were changes in the tendering rules. Eventually, however, a party was found that could build the pavement heat-cold collector and this party has deployed the solution just before the end of the project.

A challenge for the entire smart thermal grid, smart solutions R1 to R4, was that the concession holder in the area where the development takes place is not a project partner. According to the concession, all new developments in the area are required to connect to the district heating system. This means that development is taking place in an area in which the RUGGEDISED partners are not allowed to install new connections to the smart thermal grid. Only existing connections or new-build developments that were announced before 2016 were allowed to deviate from the compulsory connection to the district heating system. The arts centre, theatre and conference centre were planned before 2016 and could all be connected to the smart thermal grid. The hotel and cinema in the area were not included in the original plan and therefore not allowed to connect to the smart thermal grid. In the end, the arts building, swimming pool and hotel got connected to the district heating system. The new conference centre, Ahoy and cinema are connected to the smart thermal grid.

3.1.2.2 Smart electric grid (R5-R8)

The fifth smart solution (R5), DC grid, PV and storage for mobility, is part of the smart electric grid. The original idea for R5 was to put Photovoltaic (PV) panels on the roofs of Ahoy, the arts centre, the bus station and the metro station and to store the transformed energy in a battery. A feasibility study showed that this was not an economic viable option. Leaving out the battery and optimising the direct use of the PV-electricity was a much better economic option. Moreover, the grid operator did not grant RUGGEDISED a pilot status. This means that it is legally not allowed to share generated electricity between buildings. Currently 16.000 m^2 of PV panels are installed and the generated energy is immediately used to charge electric buses. No battery was deployed because of the afore mentioned reasons.

The smart charging parking lots, R6, are not deployed in RUGGEDISED because the concession for electric charging stations in the entire city was won by another company than the project partner Eneco. Therefore, Eneco was not allowed to install their charging stations in any public areas. An alternative investigated was to install several charging stations on Ahoy premises but Ahoy did not see the added value for installing charging stations on their property and preferred their terrain to be free of obstacles for multi-functional use.

Smart solution R7, optimising the e-bus fleet, is deployed. The Erasmus University wrote a software package to optimise the RET bus routes and schedule in relation to charging. PhD research showed that there was no battery

necessary to charge the e-buses. The electricity from the PV panels is used immediately by adjusting the charging system of the buses, the buses now charge from 20% to 60% and not from 0% to 100%. The time schedule for the buses is adjusted accordingly.

Smart solution R8, energy management was downsized compared to the original plan. The original idea was that the energy management software Simaxx would allow to streamline the generation of renewable energy and make it possible to exchange energy in two directions between connected buildings. Furthermore, the software would enable data sharing between buildings for energy optimisation. Currently, energy management software Simaxx is used by Ahoy, the swimming pool and the arts centre as monitoring software. Data on energy use is displayed on an area dashboard.

3.1.2.3 ICT on city level (R9-R13)

The solution R9, 3D city operations platform, is in development. In RUGGEDISED, the municipality wanted to test the proof of concept of a 3D city operations platform that was developed in previous projects and apply it to several use cases. In RUGGEDISED a prototype for this 3D city operations platform was developed, however, the partners in RUGGEDISED did not agree on how to further develop a minimal viable product of the 3D city operations platform. Therefore, the development in RUGGEDISED was put on hold and the municipality chose to commence a new tender. Visually, the platform was completely delivered as planned. The platform combines and displays data, for example the data from the energy management system (R8). There are a variety of lessons learned on how to set up such a platform, what needs to be in it, and how to develop it technically. The next step is to also enable third parties to extract data.

The Long Range (LoRa) network (R10) has not been deployed in RUGGEDISED. The two test cases that were supposed to use LoRa, Efficient and Intelligent Street Lighting (R11) and Smart Waste Management (R13) did, in the end, not make use of the existing LoRa network due to another network that has replaced LoRa in the entire city. In the case of Smart Waste Management an additional issue was the lack of network connection with the sensors in the underground containers. The Smart Waste Management solution is deployed using another network (see R13).

Several of the efficient and intelligent lightning poles (R11) were deployed as a test. However, when the LoRa network was not used anymore, this solution was not further developed. The 3D city operations platform (R9) did not receive any data from the smart lighting poles. The smart lighting poles are monitored and data is sent to AIT to monitor their energy efficiency.

Solution, R12, concerns high performance servers in homes. Eneco cooperated with the company Nerdalizer on the feasibility study. The feasibility study was performed and with that the project objective was achieved. The feasibility study had a positive outcome. However, since this company went bankrupt and there turned out to be no other provider that could deliver the same service, the solution is not deployed in practice (which was never intended to be part of the RUGGEDISED project).

Finally, Smart Waste Management (R13) is a successfully deployed solution. The idea for this solution was already developed in previous projects and RUGGEDISED provided a test site. Smart Waste Management consists of installing sensors in the underground garbage containers. The data from the sensors is used to optimise the efficiency of the waste collection and to prevent full containers. The smart solution was tested in Heart of South area and was scaled up throughout the entire city of Rotterdam.

3.1.3 Operational factors in deployment of smart solutions in Rotterdam

All operational factors as listed in the monitoring framework (see section 2.1) had an impact on the deployment of the smart thermal grid. The most important factor was the financial feasibility, followed by regulation and a diverse set of factors resulting from local arrangements also played a role. There was a setback in the **financial** business case of the smart thermal grid as underground infrastructure proved much more expensive than expected. In addition, one smart solution of the smart thermal grid (R3) was not deployed because it proved financially infeasible. Regarding **regulations,** the most prominent operational factor was the concession for heat that was granted to an actor who was not part of the RUGGEDISED project. Regulations therefore restricted the number of buildings that Eneco could connect to the smart thermal grid. Several **local arrangements** led to practical barriers to realisation

(e.g. a building not being connected to the smart thermal grid due to a mismatch in planning of the construction and insufficient support of the operational department) and changes in the locations of deployment.

For the deployment of the smart electric grid the main factor of influence was regulation. Due to the lack of a pilot status and concession rules, smart solutions R5 and R6 needed adjustments. All energy saving measures were deployed without RUGGEDISED funding, but connecting these solution to a smart electric grid was not possible due to legislation. With regards to ICT on a city level the main constraints were related to local arrangements and practical issues with collaborating partners (e.g., a new tender, bankruptcy of a partner and insufficient network connection).

Several solutions of the RUGGEDISED project in Rotterdam resulted in spinoffs. The Smart Waste Management solution, the 3D city operation platform, smart grid solutions are all considered successful measures and scaled up during the RUGGEDISED project. As the Smart Waste Management pilot with the containers in the Heart of South area was very successful, the approach was rapidly deployed in the rest of the city. Based on the data from the sensors in the containers a dynamic collection route is created. This dynamic collection route led to significant savings in personnel, mobility movements and CO_2 emissions. Also the 3D city operation platform and smart grid solutions scaled up in terms of usage and other areas in which solutions are deployed.

3.1.4 Cooperation

In Rotterdam, the RUGGEDISED project team cooperated with the project team responsible for the area development of Heart of South. The cooperation was hampered by incongruent timing of the area development of Heart of South and the deployment of smart solutions in RUGGEDISED. Specifically, the timing of the deployment of the smart thermal grid (solution R1) was not well aligned with the planning process of the area development. The development of the swimming pool and the arts centre were already almost completed with the backbone not being installed. Hence, the different timelines have resulted in adjusted and delayed deployments.

Also, the cooperation between the two development teams was not well coordinated. The main reason was that the supposed linking pin, the contractor that was in the lead of the area development, withdrew as partner from the RUGGEDISED project. This contractor for the area development was the combination Ballast Nedam/Heijmans. They had great ambitions with regards to sustainability and wanted to experiment with the smart thermal grid and the smart electric grid. Therefore, they joined as a project partner in RUGGEDISED to incorporate the smart solutions in RUGGEDISED in the area development of Heart of South. However, due to changes in their organization, the contractor withdrew from RUGGEDISED. This caused a variety of challenges in the alignment of planning processes. Later in the project, this was improved by working in combined construction teams.

Another reflection is that the smart solutions, such as R1 and R2, were technically not mature enough for the collaborating parties. It turned out that the organizational readiness for deploying the smart solutions was rather low. Innovative solutions require cooperation with staff members that are willing to take a risk and test innovations. According to the RUGGEDISED project team, it is challenging to find these people within the operational departments of the municipality of Rotterdam. Furthermore, the team experienced a division between strategy and operations within the organisation that has hampered progress on realisation. At the strategic level ambitious plans and agreements were made and during the development of these, operational staff was not involved. This resulted in testing the feasibility of the plans and agreements in practice during the implementation phase. Some of the barriers in deployment could have been identified earlier if the operational staff was involved in the development phase.

For several smart solutions, the city cooperates with private companies and requires data on the solutions. The Simaxx data from Ahoy (R8) and the data from the waste containers (R13) are used in the 3D city operations platform (R9). One of the cooperation challenges is to determine the conditions under which the company delivers data to the platform and to ensure the municipality has access to this data. Even though there is an open data standard for these data, the municipality had to spend budget and effort each time they wanted to access the data. This struggle created awareness for the conditions under which the city prefers to cooperate with private companies in the future.

3.1.5 Strategies

There are three major strategic developments in Rotterdam that have influenced the RUGGEDISED project, the Rotterdam Energy Approach, the Rotterdam Climate Initiative and the Rifkin method. In 2009 the Rotterdam Energy Approach (REA) was developed. This method focuses on the utilization of residual streams and to assess that more explicitly. This vision is embedded in the strategy of RUGGEDISED. Thermal energy from waste streams (R2) is an example as it uses the residual energy from the system. Through the REA method, the city aims to achieve maximum energy efficiency. Hence, this strategy seems to have had the major impact on RUGGEDISED.

In addition, the RUGGEDISED project plan refers to the Rotterdam Climate Initiative. This climate initiative was established in 2008. Initially it was focused on climate mitigation, i.e., CO_2 reduction. Later, climate adaptation was added. After elections in Rotterdam in 2014, it turned out that sustainability was not a priority in the following years and the RCI came to a standstill. In 2018 the installation of the new the political board opened up new sustainability options, which is considered a more supportive context for deploying smart solutions.

Last, RUGGEDISED was the first pilot of the Next Economy roadmap, following the Rifkin method focussing on an area-based economy. Hence, the RUGGEDISED project had a demonstrative function. The Rotterdam-Den Haag metropolitan region is organising itself as a metropolitan area with the aim of making the best use of the major economic flows and models by allowing everyone to play to their strengths and strengthen each other.

In addition, it was found that the ambitions of the city council also impact the extend to which there is a fertile ground for innovation projects like RUGGEDISED. In Rotterdam, at the start of RUGGEDISED the solutions suited the city ambitions and its Smart City program. Yet, the implementation was sometimes complex as existing policies and regulations did not incorporate and reflect all of these ambitions, making implementation in practice at times challenging. In later years, when a new city council was installed, sustainability became a much more prominent policy objective in Rotterdam. This provided a more supportive project context for the deployment of smart solutions.

The RUGGEDISED project proved to be a springboard for several spin-offs within the municipality. Not only in terms of scaling up measures but also at the more strategic level. The most prominent example is the fact that RUGGEDISED was at the basis of a citywide Digital Program.

3.1.6 Planning mechanisms

At the start of the RUGGEDISED project the deployment of the district heating net was the primary focus of the municipality and other energy solutions were not addressed. The RUGGEDISED project team created room to look at more sustainable solutions. The project staff gained a better position in the organization and were increasingly given a place at the table when policy plans related to sustainability are discussed. In this way, they were able to provide input in new plans such as the energy system vision. The energy system vision discusses the decentralization of the energy supply, to make better use of local sources and local systems. Subsequently, a source strategy was created to stimulate the exploration and use of sustainable, local sources in the city. Exploration of new energy sources and technologies brought attention to the importance of acquiring an energy system strategy in the beginning of projects.

Along with the RUGGEDISED project plan, Rotterdam wrote a Sustainable Energy Action Plan (SEAP). For Smart City projects, it was a prerequisite to have a SEAP, but its further influence within the organization was considered modest.

3.1.7 Innovation capacity

The final aspect in the monitoring framework is the cities' innovation capacity which is described along the following five categories.

3.1.7.1 Leadership and ambitions of the city on innovation

In Rotterdam, the RUGGEDISED project team experienced sufficient political support from their mayor and since 2018, there was an alderman for Sustainability and Energy Transition. Both the mayor and the alderman supported

and backed the RUGGEDISED project team in their work. The RUGGEDISED project team did, however, feel that commitment and backing from their administrative leaders was less then they hoped for. Acquiring sufficient administrative leadership was found to be more challenging as the ownership for the project was not vested with a specific director.

Personnel changes in leadership positions have caused complications and delays in the deployment of smart solutions. For example, the lack of a linking pin between the RUGGEDISED project team and the area development team may have negatively influenced the decision not to alter an existing contract which altered and delayed the deployment of solution R4, the pavement heat-cold collector.

3.1.7.2 Organization that supports innovation

According to the RUGGEDISED project team in Rotterdam, negative publicity regarding procurement procedures led the municipality to become more reluctant in supporting innovative projects such as RUGGEDISED. In addition, the Court of Auditors recently reviewed the entire organization, and concluded in their critical report [2] that the municipality took too many risks and made ample mistakes. As a result, the municipality aims to identify and cover risks in advance as much as they can. The negative publicity and the report contributed to a more risk averse culture within the organization. The municipal staff felt little room to experiment and make mistakes. In addition, the municipal staff is evaluated on their specific tasks and roles which makes it difficult to think outside of these responsibilities and take a more integral approach.

The challenge with projects such as RUGGEDISED is to embed the project properly in the internal organization. In general it was found challenging to find the right staff in the organizations with sufficient mandate and management support for implementation of innovative projects. Due to the perceived lack of high-level sponsorship and insufficient stakeholder management, the organizational support for RUGGEDISED decreased over time. Communication between the various layers of the organization could have been more intense and ownership of tasks was not always clear.

3.1.7.3 Dealing with (new) data and knowledge

In Rotterdam, a knowledge- and quality management system is in place in the municipality. However, according to the RUGGEDISED project team it is rarely used in practice. The importance of knowledge sharing is strongly recognized in the organization, yet there are no consequences when it does not occur. According to the project team, the systems and tools are available, but there is little time and incentives to actually set up a knowledge database and disseminate lessons learned.

Moreover, the importance of workshops and other types of sessions in which experiences are shared is emphasized. It is recognized that reading a knowledge transfer document is not enough to properly train new employees. Sharing of knowledge takes place through, for example, lunch lectures where a variety of topics are discussed. That is the platform where people update each other on previous projects and lessons learned.

Lastly, there is a close collaboration with knowledge institutes (TNO) and universities in Rotterdam and Delft. The PhD research that led to the software for R7 is an important example of this. Moreover, the municipality is working together with the Erasmus University on the 3D City Operations Platform (R9). There is plenty of room for exchange and discussion between these organizations.

3.1.7.4 Networking

The municipality of Rotterdam is part of a variety of networks. There are all kinds of network organizations and, meetings where various parties can find each other. Networks cover the various fields of interest of the RUGGEDISED project, such as real estate, sustainability and energy transition. In addition, there are high-level covenants and partnership agreements between the municipality and private parties. The challenge remains to disseminate information from these networks to the right persons within the municipal organization and vice versa.

[2] Rekenkamer Rotterdam (2019). Publieke waarde in de knel. Samenvatting meta-analyse tien jaar rekenkameronderzoek over gemeentebestuur Rotterdam (in Dutch).

3.1.7.5 A learning organization

According to the RUGGEDISED project team in Rotterdam the municipality project teams do not structurally allocate time to reflect and evaluate projects. Moreover, the size of the organisation limits the capacity to embed lessons learned into existing processes. On an individual level the team members try to embed lessons learned in new projects. However, due to the multitude of departments and disciplines it is perceived as very difficult to get everyone on board and bring about cultural change.

Since the municipality is ISO-certified a number of Lloyd evaluations are executed annually. Next to the standard evaluation according to the ''Rotterdam Way of Working'', a number of projects are randomly selected for an obligatory Lloyd evaluation. During this evaluation the projects progress is assessed in order to see if the municipality still meets the quality mark. The impact of these evaluations is considered limited.

3.2 Umeå

3.2.1 Introduction

In Umeå the original plan was to deploy 9 smart solutions (U1-U9 see Table 4) in the Innovation District, in the east of the city. The Innovation District is also referred to as the University area. This area includes residential, academic and research facilities as well as a hospital and several recreational functions. The district is known for its young, student population and for its low car-dependency. The smart solutions in RUGGEDISED could be divided in four groups, being: smart thermal grid (U1-U3), energy efficiency interventions (U4), mobility solutions (U5-U7) and ICT on city level (U8-U9). In the end, Umeå has deployed 10 smart solutions with energy efficiency interventions (U4) separated into two separate solutions (U4A and U4B).

Table 4 Smart Solutions Umeå

UMEÅ		Smart solutions	Status September 2022
Smart thermal grid	U1	Smart City connection to 100% renewable energy	Deployed
Smart thermal grid	U2	Smart peak power control of district heating	Deployed
Smart thermal grid	U3	Geothermal heating/cooling storage	Deployment on hold
Energy efficiency interventions	U4A	Gamification – influence behavioural patterns	Deployed
Energy efficiency interventions	U4B	Intelligent building control and end user involvement	Deployed
Mobility solutions	U5	Climate smart bus station	Deployed with adjustments
Mobility solutions	U6	E-charging hub & charging infrastructure	Deployed
Mobility solutions	U7	Green parking pay-off for flexible parking	Business model developed
ICT on City Level	U8	Smart City open-data decision platform	Deployed
ICT on City Level	U9	Demand-side management technology in a university campus	Deployed, upscaling ongoing

In this chapter first the deployment of each smart solution is described (see 3.2.3). Next, this chapter follows the structure based on the monitoring framework presented in section 2.1:

- Operational factors in deployment of smart solutions
- Cooperation
- Strategies
- Planning mechanisms
- Innovation capacity

Table 5 summarises the main factors that influenced the deployment of the smart solutions, based on the qualitative monitoring.

Table 5 Main deployment factors Umeå

Deployment factors	Findings in Umeå
Operational factors in deployment of smart solutions	• Due to the proactive identification and handling of potential feasibility challenges, operational factors were hardly hampering deployment.
Cooperation	• Cooperation between the stakeholders – all public actors– involved in the RUGGEDISED project went well.
Strategies	• The RUGGEDISED Smart City Lighthouse status allowed Umeå to become part of influential national networks.

Planning mechanisms	• Umeå has an overarching policy plan, called the Comprehensive Plan, which steers all city developments from urban planning to energy and mobility.
Innovation capacity	• The most prominent innovation capacity is networking; demonstrated through influential and institutionalised networks. • Close cooperation with knowledge institutes and universities supports knowledge exchange for innovation.

3.2.2 Deployment of smart solutions in Umeå

In this chapter the deployment of each smart solution is described. First the solutions regarding the smart thermal grid (U1-U3) are described (see section 3.2.2.1), followed by the energy efficiency interventions (U4) (see section 3.2.2.2), the mobility solutions (U5-U7) (see section3.2.2.3) and the ICT on City level solutions (U8-U9) (see section 3.2.2.43.1.2.2).

3.2.2.1 Smart thermal grid (U1-U3)

In Umeå there are three smart solutions (U1, U2 and U3) that together make up the smart thermal grid. The first solution, Smart City connection to 100% renewable energy, concerns the business model development and is closely connected to U3, geothermal heat-cold exchange. The idea for these solutions was to find out how to make the most out of an asset from an integral perspective. Through extensive techno-economic analyses with a variety of scenarios and technologies it was calculated in which periods during the year it would be best to exploit what technology. The business model was developed, and the project objective is achieved. Based on that analyses it was decided to use a borehole storage for the district cooling system and to use the district cooling system to pre-heat the geothermal storage in order to get more heat during the wintertime from the storage. Umeå Energi has developed a pricing model and a match making software to trade energy on a daily basis in a local market. Currently the decision on further investment to connect this software to the actual boreholes (U3) is still pending.

The second smart solution, U2, is about peak load variation management and power control. This is software designed to shave heat peaks by regulating the indoor temperature. This solution is currently deployed in the Innovation District on campus buildings and in the hospital. Umeå Energi is looking into upscaling throughout the entire city. At the time, the function of the system is working well but to be able to evaluate the robustness of the system, further testing during a winter with more extreme colds is required.

3.2.2.2 Energy efficiency interventions (U4)

With solution U4A, gamification, Umeå Energi tried to nudge, promote and stimulate tenants of apartments in the Innovation District to get involved in energy related issues and challenges. The game is designed to increase attention and curiosity in energy saving issues and to get people intrinsically motivated to act, rather than stimulating them by paying or giving a gratification. The application was very expensive to build and to keep up to date. Of the tenants 13% participated in the pilot to test the application. It was found that the interest of users degraded over time. Hence, it proved challenging to keep users interested. As this solution was not effective and costly, it was decided to stop with it.

Solution U4B is aimed at intelligent building control and end user involvement. The main purpose of this solution is to save energy by installing an intelligent building control system called Lindinvent. This system is used to adjust and adapt the ventilation, heating, cooling and lightning. The system is now installed in 147 rooms in the Campus area. One of the challenges with this solution was that the regular maintenance staff were not properly trained to manage this smart system and needed additional training. Also, during COVID when people worked from home, the buildings were not in use so the system could not be tested. Currently the system is tested under normal conditions.

3.2.2.3 Mobility solutions (U5-U7)

Solution U5 is the Climate smart bus station. An innovation in the bus station was needed to decrease the heat loss during the boarding procedure of the buses in wintertime, which decreases battery power of the e-bus significantly. The original idea was to create a closed, pre-heated bus station. However, there were several technicalities, and for example safety issues that hampered this solution. Moreover, in the first years of the RUGGEDISED project it turned

out the heat loss problem was not that urgent anymore because of more efficient batteries and better insulation of the buses. The smart solution was adjusted to a completely open, well-designed bus station that was aimed to speed up the boarding process and where people can shelter during bad weather. The design is altered and used by one bus line. Evaluation to determine potential cost savings is challenging as it might take a series of adjusted stations to have a measurable effect of faster boarding on the entire bus route.

Solution U6, is the E-charging hub for electric cars, consisting of charging infrastructure, storage and exchange, and optimisation of the integration of renewable energy sources (RES) in the grid. In this solution Akademiska Hus has installed a solar powered charging infrastructure at the campus of Umeå and combined it with a storage battery. The purpose of this battery is to store the generated electricity in order to be able to charge electric cars. The deployment was delayed because the building on which it was intended to be installed was not being renovated. Therefore, Akademiska Hus decided to move the solution to another building suitable for this solution on the campus. Moreover, the solution got delayed due to the late delivery of the battery equipment. The solution is fully deployed, and the monitoring data is currently being delivered.

The last mobility solution is green parking pay-off for flexible parking (U7). This measure aims to reduce the amount of parking spaces for new developments, in this case private homes. Developers are stimulated to provide residents with less parking places and instead offer sustainable alternatives (e.g. facilitate biking). This resulted in a business model to test green parking pay-off for private housing. The plan was to test the business model on an apartment building that Akademiska Hus would build near the campus. The construction of this apartment building got delayed. When the building is completed, the municipality and Akademiska Hus will still test the business model.

3.2.2.4 ICT on City Level (U8-U9)

Solution U8, the Smart Open Data City Decision platform, is deployed. The main challenge was to find an adequate project manager from the IT-department within the municipality which took a few years. The municipality eventually did not build its own open data platform but bought a license from Open Data Soft. Together with Open Data Soft the municipality developed specific functions on the open data platform to put different kinds of datasets together and to create visualizations of the data. The platform is seen as a new city service visualising various types of city data on maps.

The last solution, U9, is an analysis tool for demand side management. The main objective is to decrease the heating of unused rooms of the University. A tool was set up by Umeå University in collaboration with Akademiska Hus to measure the use of the facilities in the campus area. The smart solution is successfully developed. It started with the installation of sensors in the buildings that measured occupancy, temperatures, carbon dioxide, noise, electricity pulses and heating in the radiators. There were some minor delays with measuring during COVID. The data was collected, and key indicators were formulated and integrated in the analysis tool. The key indicators are the occupation and use of various rooms in the University, the flow of people moving through the corridors, electricity use, heat supply and noise levels. The most used functionality is the utilization and use of the rooms combined with the time schedule data. This solution will be upscaled to all other campuses in Sweden where Akademiska Hus is the property owner.

3.2.3 Operational factors in deployment of smart solutions in Umeå

Regulations, one of the three main operational factors in the monitoring framework (see section 2.1), have not been influential in the deployment of the smart solutions in Umeå. According to the project staff, potential problems with regards to regulations were already covered before the start of the project by proactively identifying and handling potential feasibility challenges. **Financial** constraints played a role in the deployment of the smart thermal grid, specifically geothermal heating/cooling storage and exchange (U3). The boreholes are in operation, yet the hardware connection and software need further investment which is pending. For the energy efficiency interventions, mobility solutions and ICT on city level (U4-U9) several **local arrangements** and practicalities caused minor delays in deployment and monitoring (e.g. delays of (re)construction of buildings, late delivery of materials and COVID).

3.2.4 Cooperation

Cooperation between the stakeholders involved in the RUGGEDISED project in Umeå went well. A possible explanation is that the stakeholder that primarily cooperated are all public actors and hence, share similar goals,

governance, ways of working and culture. Examples are Umeå Energi, the sewerage company, the parking company and the housing company, all fully owned by the city government. These companies are steered by a political committee that includes the mayor, politicians and delegates of the municipal companies. These parties are the main actors to reach climate neutrality in Umeå and are working closely together towards this goal.

Within the RUGGEDISED project, the municipality of Umeå is working closely together with the other project partners Umeå Energi and Akademiska Hus for the deployment of the smart solutions. Especially Akademiska Hus has major climate ambitions and shows leadership and stimulates other stakeholders such as the city to take more action towards climate neutrality.

For the solution smart open data platform (U8) the municipality of Umeå cooperates with a private company for obtaining traffic data. This cooperation is perceived as challenging due to discussion on the conditions under which the company delivers data to the platform and the access the municipality has to this data. This created awareness for the conditions under which the city prefers to cooperate with private companies in the future.

3.2.5 Strategies

In Sweden there is a national innovation program called Viable Cities. This program initially only involved the major cities in Sweden. Due to Umeå's Smart City Lighthouse status in the RUGGEDISED project, Umeå (despite being a smaller town) was able to participate in this Viable Cities network. The RUGGEDISED project was crucial for the visibility of Umeå on a national level.

Via the Viable Cities network, Umeå was introduced to the Climate City 2030 contracts and signed this contract in December 2020, in which they set the ambition to become a climate neutral city by 2030. Through this strategic approach, the municipality managed to get the commitment of municipal companies to adjust their goals; from merely focusing on profit to investing in climate neutrality. The political committee of Umeå (that includes the mayor, politicians and delegates of public companies) plays an important role in shaping this ambition. In addition, in Sweden and specifically in Umeå, the overall rationale is also strongly focused on high sustainability ambitions. As a result, the municipal companies are compelled to quickly move forward as well.

The climate ambition and plans required a change in the organisation of the municipality. For example, there is a new overarching program for climate neutrality in the city, with a board for climate neutrality and political representation. The aim of this program is to embed climate neutrality in all fields of the city and to foster cooperation between the different departments within the municipality.

Innovation projects like RUGGEDISED have the advantage that they bring in subsidies that create more room for experimentation. Specifically, companies like Umeå Energi and Akademiska Hus have realised smart solutions in RUGGEDISED that they would normally would not have. Another advantage of innovation projects, as was the case for RUGGEDISED, is that it can raise the attention of decision makers and indirectly affect the strategies and plans.

3.2.6 Planning mechanisms

In Umeå the Comprehensive Plan 2018 is the most influential policy document. It is an overarching comprehensive plan steering all city developments from urban planning to planning of energy and mobility. For certain topics there are separate in-depth plans, all aligned with this comprehensive plan. For example, RUGGEDISED instigated Umeå to submit a SEAP, which they are currently updating, focussed on the ambition for climate neutrality. In addition, the municipality has developed a SUMP. The SUMP details the ‘five-kilometre’ city strategy, which aims to provide all important services for all citizens in Umeå within a maximum distance of five kilometres. The innovation projects that are deployed by Umeå are, by default, aligned with the Comprehensive Plan. This was also the case for RUGGEDISED. Hence, the Comprehensive Plan is leading to innovation projects like RUGGEDISED that need to operate within this context.

3.2.7 Innovation capacity

For the innovation capacity in Umeå the findings per category are described as follows.

3.2.7.1 Leadership and ambitions of the city on innovation

In Umeå the innovation department staff and specifically the RUGGEDISED project team, experienced a high level of support from their political and administrative leaders. The departments in the municipality have ample mandate for the required decision-making. There is strong mutual trust between administrative leaders and the staff (e.g. for problem solving by staff and support by the leaders).

Since the citizens in Umeå are environmentally aware, it is important for the political leaders to advocate climate ambitions. Overall, political leaders strongly support the project teams working on the climate neutral transition and are interested in innovation projects and open to acquire knowledge on this topic.

3.2.7.2 Organization that supports innovation

The organisational structure of the municipality of Umeå is characterised by silos sometimes hampering cooperation with other departments. For example, the RUGGEDISED project team is positioned in the innovation department with a focus on strategy and ideation. They are involved in the operationalisation of their ideas to limited extent. Departments are organized differently, and language and leadership vary. The openness for risk taking is higher in the strategic department than in the operational department. There is a need to better integrate the innovation projects in the day-to-day operations.

3.2.7.3 Dealing with (new) data and knowledge

Umeå is investing in training their employees to work in innovation projects. In the past, they had difficulty staffing innovation projects like RUGGEDISED. This was solved by hiring external staff for the duration of the project. However, this does not contribute to establishing a sustainable knowledge base within the city. A current training initiative teaches staff from different operational departments to lead innovation workshops and develop new ideas or ways of working.

Moreover, the municipality has a good connection with knowledge institutes. Umeå is part of an initiative of RISE, working on an innovation platform that is funded by the national government. Furthermore, there is a climate innovation platform in place in collaboration with the University of Umeå. This platform invites new actors to the Climate City 2030 contract. Also, in RUGGEDISED the municipality has been working together with the University of Umeå to exchange knowledge. For example, the demand side management analysis tool (U9) was developed together with the University.

3.2.7.4 Networking

In Umeå there is a tradition to work closely together with the actors in the city (i.e. the political committee, municipal companies, mayor, citizens, universities etc.). The city actors are organized in forums on different subjects. The political committee (also participating in the forums) are influential in city development as well as shaping the stakeholder discussions. There is a high level of trust among people and networking is considered relatively easy due to the modest size of the city and the networking culture.

3.2.7.5 A learning organization

Within the municipality, implementation of innovations is often evaluated and reflected on. The RUGGEDISED project team in Umeå indicates that the involved staff will incorporate the lessons learned in future projects. However, disseminating lessons learned throughout the organization is challenging. The project team indicates the following success factors for embedding for learning: cost effectiveness, publicity, public support and sufficient dialogue.

3.3 Glasgow

3.3.1 Introduction

With RUGGEDISED, Glasgow was planning to deploy 10 smart solutions (G1-G10 in Table 6) in their demonstration area. The demonstration area covers an area with mixed functionalities such as housing, academia and retail and challenges regarding ageing infrastructure, fuel poverty and air pollution. All except two smart solutions in Glasgow are connected to the smart electric grid (G2-G6 and G8-G10). G1 is the smart thermal grid. G7 relates to ICT on City level.

Table 6 Smart Solutions Glasgow

GLASGOW		Smart solutions	Status September 2022
Smart thermal grid	G1	Heat and cold exchange – connection of buildings to district heating network	Contractual models developed (without connecting heat networks)
Smart electric grid	G2	EV-charging hub battery storage in car parks	Deployed with adjustments
Smart electric grid	G3	TCB CHP surplus power storage in EV charging hub battery storage	Not deployed, financially infeasible
Smart electric grid	G4	Optimization of the integration of near-site RES (renewable energy sources)	Deployed with adjustments
Smart electric grid	G5	EV-charging hub in city centre car park	Deployed with adjustments
Smart electric grid	G6	Integrated EV-charging functionality in intelligent LED streetlights	Deployed
ICT on city level	G7	Smart open data decision platform & central management system	Deployed
Smart electric grid	G8	Implementation of demand-side management technology in street lighting	Deployed, monitoring pending
Smart electric grid	G9	Implementation of demand-side management technology in domestic properties	Deployed with adjustments
Smart electric grid	G10	Implementation of demand-side management technology in non-domestic properties	Deployment ongoing

In this chapter first the deployment of each smart solution is described. Next, this chapter follows the structure based on the monitoring framework presented in section 2.1

- Operational factors in deployment of smart solutions
- Cooperation
- Strategies
- Planning mechanisms
- Innovation capacity

Table 7 summarises the main factors that influenced the deployment of the smart solutions, based on the qualitative monitoring.

Table 7 Main deployment factors Glasgow

Deployment factors	Findings in Glasgow
Operational factors in deployment of smart solutions	• Financial challenges turned out to be an (unanticipated) barrier for deployment of several smart solutions. • Local arrangements and practicalities led to adjustments and delays.
Cooperation	• Strategic position of the project manager proved influential for the multi-level cooperation. • The RUGGEDISED project manager successfully coordinated with various stakeholders inside and outside the City Council such as developers, investors, citizens and businesses (e.g. via Sustainable Glasgow)
Strategies	• Sustainability is high on the city agenda (amongst others due to COP26), creating fertile ground for innovation projects like RUGGEDISED. • RUGGEDISED has had a strong influence on policy and strategy in Glasgow and is referenced in new policies and strategies
Planning mechanisms	• RUGGEDISED is included as demonstrator in the climate plan and several RUGGEDISED measures are considered inspiring examples. • Glasgow is now working on an EV network strategy in its city region inspired by the pilots within RUGGEDISED (G6).
Innovation capacity	• The most prominent innovation capacity is leadership; demonstrated through a powerful councillor. • Close cooperation with knowledge institutes and universities supports knowledge exchange for innovation.

3.3.2 Deployment of smart solutions in Glasgow

In this chapter the deployment of each smart solution is described. First the solutions regarding the smart thermal grid (G1) are described (see section 3.3.2.1), followed by the smart electric grid solutions (G2-G6 and G8-G10) (see section 3.3.2.2) and the ICT on City level solutions (G8) (see section 3.3.2.33.1.2.2).

3.3.2.1 Smart thermal grid (G1)

The first solution in Glasgow (G1) concerns the contractual model for the heat and cold exchange, being the connection of buildings to district heating network. The objective of G1 was to establish a contractual model that will facilitate the connection of district heating networks to customers outside the footprint of the original development. A contractual model was delivered, and the project objective is achieved. The contract is seen as basis that can be used in new projects. Since the city of Glasgow had hardly any knowledge or experience with selling and buying heat between organizations that are not utility companies, the development of the contractual model in partnership with the University of Strathclyde and Tennents Caledonian Brewery is considered an innovation. The next step, to use the contractual model in practice, was never intended to be part of the RUGGEDISED project. This is also not expected at the University campus as the financial business case turned out to be infeasible as already the required new (subsurface) pipe to connect the buildings turned out to be too expensive. Also, for the Tennents Caledonian Brewery, which was linked to solution G3, making the connection point to the power network turned out financially infeasible and adding a connection was not desired given the already high fault level of the power network. In both cases the distance to the electrical connection was too costly given the expected marginal gains. G3 was therefore not deployed.

3.3.2.2 Smart electric grid (G2-G6 and G8-G10)

The second smart solution, the EV-charging hub battery storage in car parks (G2) consists of PV panels that will generate electricity; the electricity is connected to the EV chargers and the battery storage unit. The battery is in place and installed and it is expected to be deployed in the summer of 2022. The deployment process was challenging, and the plan had to be adjusted multiple times due to unforeseen (external) events. Originally the PV array was planned to be installed on a canopy to avoid using parking spaces. However, due to Brexit the availability and price of steel and PV led to first downsizing the plan and later to remove the canopy which made it possible to install the intended capacity. Due to COVID the parking space could be used without revenue loss. Another

adjustment was that the PV array and the battery were entirely funded by the local public authority as it turned out that the European Commission would not cover the capital cost and new funding had to arranged.

The fourth solution is the optimisation of integration of near-site renewable energy sources (RES) (G4). This solution is closely related to the EV-charging hub battery storage in car parks (G2). Whereas G2 is specifically focused on the balancing mechanism of the battery, G4 is focused on the addition and integration of near-site renewable energy sources. The city of Glasgow had misunderstood the financial arrangements from the European Commission resulting in having to arrange capital funding from the city council, Transport Scotland and Scottish power. This funding was limited resulting in only having deployed PV and no other renewable energy sources. This lack of capital funding also influenced the deployment of solution G5, the innovative connection to renewables and storage. Less EV-chargers than originally planned were installed in the city centre car park.

The sixth solution, intelligent LED streetlights with integrated EV chargers, air pollution monitors and a wireless communication network (G6) is deployed. Intelligent streetlights with air pollution monitors and CO_2 sensors have been installed as well as the integrated EV chargers. Furthermore, the wireless communication network, Wi-Sun, is also up and running. The commissioning is in progress and aggregated data is being received via a third party. The main advantage of this solution is that the streetlights serve two purposes in an already crowded space. The operational challenge is that the streetlight columns need to be at the toe of the curb of the pavement and that the cut-out area within the street lighting column is very tight making it challenging to fit in the increased cable size. Therefore, the upscaling potential is limited. Yet it can provide a solution in areas where there is insufficient space for other chargers.

The last three smart solutions, deployment of demand-side management technology in street lighting, domestic properties and non-domestic properties (G8, G9 and G10) all follow the same approach but have three different characters. The demand-side management technology is ready to use but the data from the street lightning (G8) is still missing. In G9, for the domestic properties, the data comes from a battery in the concierge office of the housing block. Originally, the idea was to install the battery in the housing block itself, but due to fire regulations this was not permitted and therefore moved to the concierge office. Currently the Wheatley Group and Siemens are running trials on how to optimize the use of the battery in demand management situations. On the non-domestic side, G10, the demand-side management technology is being deployed in the City Chambers and this is still ongoing.

The deployment of solutions related to the smart electric grid delivered relevant lessons: the need to create room to manoeuvre in the implementation phase by a less specific formulation of the solution at the start (e.g., a renewable energy station for electric vehicles) to avoid early lock-ins.

3.3.2.3 ICT on City Level (G7)

The Smart Open Data Decision Platform, G7, is successfully deployed. However, the use of the platform is expected to be limited. Other companies, like ArcGIS, have caught up and developed more advanced platforms and tools that are competitive and are likely to be used by the municipality. It is going to be a challenge to demonstrate the specific benefits of this smart open data decision platform as opposed to other platforms. The main difference with competing companies is that the municipality does not have the capacity to constantly manage, update and maintain the operation of the platform.

3.3.3 Operational factors in deployment of smart solutions in Glasgow

Concerning the operational factors from the monitoring framework as discussed in section 2.1 the smart electric grid has come across quite some **financial** challenges. The construction of the pipelines (G1 and G3) proved financially infeasible and was therefore not deployed. Adding renewable energy sources other than PV was due to financial reasons not realised and less EV chargers were installed due to less capital funding than anticipated at the start of the project (G4 and G5). Moreover, the council encountered a variety of **local arrangements** and practicalities which influenced the deployment of the smart electric grid (e.g., Brexit, rapidly increasing material costs and positioning of the streetlights). In G9, fire **regulations** have led to adjustments of the original plan. With regards to ICT on City level (G7) the use of the platform is limited as other commercial platforms turn out to be competitive. Furthermore, managing, updating and operating the platform continuously turned out the be challenging for the city as they lack the capacity to do so. The operation factors led to many adjustments of the solutions and delays in the planning.

Due to the delays, some deployments are still ongoing, and outcomes cannot be evaluated yet. The operational factors also illustrate the need to create room to manoeuvre in the implementation phase by a less specific formulation of the solution at the start to avoid early lock-ins.

3.3.4 Cooperation

In Glasgow, the strategic position of the project manager proved influential for the multi-level cooperation within the city. The project manager was able to continuously connect between the project and the strategic policy developments in the municipal organisation (see 3.3.5), as he had a close relationship with both the designated director and politicians. The RUGGEDISED project team has been working together with them to shape the projects profile. Together they made sure that people understood what was going on within RUGGEDISED and to get positive press. The role of the project team was also crucial in this cooperation; to be a linking pin and actively promoting and connecting RUGGEDISED within the municipal organisation.

The project manager also has a management position, forming a direct link between strategy and operations. Everything related to sustainability, including the people, therefore falls under this responsibility. This supported the cooperation between the departments. The fair allocation of benefits, revenues, and information and a sense of shared responsibility between both departments was considered supportive as well.

The second important cooperation factor is the ability to work across silos, which was challenging given the siloed nature of the Glasgow municipal organisation. A primary team member was crucial for the cross-silo cooperation specifically needed for two smart solutions (G6 and G7). In case of the integration of the streetlights and EV chargers, different departments had to work together, but whenever there was an issue, all departments looked at each other to solve the problem. Having multidisciplinary knowledge and being capable of speaking the language of both departments, this person proved to be very important for the cooperation, connecting people with each other. In literature this role is labelled as a knowledge broker[3].

Last, the size of the project team was also an influential cooperation factor. At the beginning of the project, it was decided that two people from the municipality would be working full time on RUGGEDISED. Hence, the RUGGEDISED project team was rather small. During the project, one of the key persons left and a lot of knowledge was lost. Furthermore, this hampered the cooperation processes as responsibility regarding the project was poorly distributed. This turned out to be a gap that was difficult to bridge by a new team member. The cooperation factors illustrate that persons matter and can make a difference.

The RUGGEDISED project manager was also able to successfully coordinate with various different (local) stakeholders inside and outside the City Council such as developers, investors, citizens and businesses. Both within the context of the RUGGEDISED project with the Wheatley Group, Siemens, Tennents Caledonian Brewery and Scottish Power on the deployment of several smart solutions (G1, G3, G4 and G9) as well as in broader cooperation through Sustainable Glasgow and the COP26.

3.3.5 Strategies

At the strategic level, sustainability became one of the main priorities in Glasgow with the COP26. The idea is that everyone in the municipality, regardless of their daily tasks, should work on sustainability. Furthermore, a new role ''head of service sustainability'' was created because of COP26. The current ambition in Glasgow is to become a climate neutral city by 2030. The status of Glasgow as a Lighthouse city in the RUGGEDISED project provided the opportunity to promote the city and RUGGEDISED was then used as a reference to sell sustainability in general. According to the project manager in Glasgow, the RUGGEDISED project opened people's eyes within Glasgow and got discussions started, therefore most people within the municipality have a positive view on the project.

[3] Sheate, W. R., & Partidário, M. R. (2010). Strategic approaches and assessment techniques—Potential for knowledge brokerage towards sustainability. Environmental Impact Assessment Review, 30(4), 278-288.

3.3.6 Planning mechanisms

The sustainability ambition of Glasgow is embedded in the climate plan. The climate plan is the successor of the Sustainable Energy Action Plan (SEAP), which was called the Energy and Carbon Master Plan and ran from 2010 to 2020. The overarching target in that plan was to reduce the carbon emissions by 30% by 2020. By 2019, Glasgow had already reduced its CO_2 emissions by 41% and was considered very successful. The climate plan is an umbrella policy for everything related to sustainability. Underneath the overarching climate plan sits the circular economy plan and the green economy plan. These plans all tie into one and run until 2030. RUGGEDISED is a case study in the climate plan and serves as a demonstration project for sustainable innovations (i.e. the district heating business model, the PV's and the batteries). The city considers the RUGGEDISED examples as valuable input for future policy developments.

Specifically, Glasgow is now working on an EV network strategy in its city region. The pilots within RUGGEDISED with the smart streetlights and EV chargers from renewables and battery storage (G6) were very informative in this thinking and moving forward. At the moment, Glasgow has 300 EV chargers in the city and an increasing number of electric vehicles all over the city. Now the municipality is working together with the city region to think of a variety of different charging techniques and charging technologies and how to create a network.

The next step is to conduct a net zero feasibility study to find out what is technically needed to get to net zero by 2030. In order to ensure continuation after 2030, a new version of the climate plan will be developed by then. Overall, RUGGEDISED has helped influence the next cycle of development plans in Glasgow by making sure that certain lessons learned are included within new policy developments.

3.3.7 Innovation capacity

Lastly, the observations of the innovation capacity in Glasgow are described in the following section.

3.3.7.1 Leadership and ambitions of the city on innovation

Sustainable Glasgow is a network consisting of various actors that support the climate ambition in Glasgow. This network is an example of leadership, specifically by the chairman Councillor Aitkan. This network is chaired by political heads of the council and includes chief executives and directors of companies like Scottish Power, the NHS, the University of Glasgow, Strathclyde, the Wheatley Group and the Scottish Government. Sustaining this high-level network is challenging and requires resources and administrative support. However, due to the esteem and influence of the political leaders, all these partners now recognize the importance of the climate neutral ambition.

The same leader, Councillor Aitkan, was hugely active and influential in the run up to COP26, selling the virtues of COP26, committing Glasgow to be member of initiatives like the Carbon Neutral Cities Alliance. Furthermore, Glasgow is also a member of the C40. The C40 is a collection of megacities. Even though Glasgow is not a megacity they are almost an honorary member in the C40 because of the work that they do on sustainability, and megacities are looking at replication possibilities.

3.3.7.2 Organization that supports innovation

The municipality is striving to be innovative in terms of:

- policy development,
- relationship management,
- top down and bottom-up support,
- internal communication.

This latter point refers to communication going in all directions all the time, both vertically and horizontally. Therefore, an internal board was recently installed to funnel all ideas that are coming across the organization. The idea is to discuss all propositions in one place, to discuss how these ideas may have an impact on other people within the organization and to start identifying risks that come along. The goal is also to build a culture where it is encouraged to innovate and take risks and where it is easy to fail without ramifications. It is perceived by the project

staff as difficult to innovate in a public organization, when spending public money. However, they argue, it is nonetheless necessary to reach the climate ambitions.

The main challenge within the municipal organization is that the majority of the work is organised in siloes and has a high level of task specificity. Given the sustainability ambition of Glasgow, the municipality aims for a wider understanding of how sustainability impacts the daily work of their employees and vice versa.

Last, the stewardship of deployed solutions is challenging. Once a smart solution is installed, it also needs to be operated and maintained and it is often unclear which department takes that responsibility. The strategic department mainly works on designing innovation, projects and relationships and to move things to be more sustainable. After the deployment the ownership should be transferred to the operational department.

3.3.7.3 Dealing with (new) data and knowledge

In the last few years, the Glasgow City Council worked on strengthening their knowledge management system, by digitizing all their documents and putting them in a data record management system. By doing this knowledge and data is more easily accessible for everyone within the organization. According to the council staff, there is still room for improvement and to make sure that people actively make use of this system. Currently, knowledge is mostly shared via seminars and webinars, but it takes a long time before that reaches the entire organization and can influence policy.

One of the strengths in Glasgow with regards to innovation and knowledge transfer is the connection with academia. The municipality has access to a lot of knowledge through research and development funding and sharing of data with the three major universities in the city. In return, the municipality helps the universities by translating this knowledge into real life situations and provide them with feedback.

3.3.7.4 Networking

There are several networks in Glasgow relevant for innovation projects like RUGGEDISED, such as the Sustainable Glasgow network. The innovation capacity 'networking' refers to the ability to benefit from these networks by exchanging ideas, knowledge and funding between the network parties. The RUGGEDISED project manager successfully coordinated with various different stakeholders inside and outside the City Council such as developers, investors, citizens and businesses through these networks.

Citizens in Glasgow are mostly engaged through consultation. The public is often invited to react to certain plans and policies. The municipality is trialling different ways to get citizens more involved in co-creation processes. In relation to the climate ambitions, they are doing this through climate cafes, where groups of people represent organizations or themselves get the chance to speak about how certain initiatives impact them or what they need.

3.3.7.5 A learning organization

Learning within the municipal organization of Glasgow occurs in two ways. It is about internal optimization of how the organization operates on the one hand and there is knowledge sharing and continuous improvement within and among projects on the other hand. Optimization of how the organization operates occurs on a local level within council departments as well as on board level or chief executive level. Knowledge sharing and continuous improvement within and among projects occurs by evaluating and reviewing the projects. The city council is developing a project management office for sustainability to bundle and disseminate sustainability knowledge and best practices. Next to that, there is a department focussed on organizational improvements, for example, improvements on staff management, access to IT and office lay-out. This department manages the change process, including monitoring and evaluation.

4 Conclusions and recommendations

4.1 Conclusions

This report on monitoring of the RUGGEDISED project addresses the factors that affected the realisation processes of the smart solutions that were planned and not/partially/fully deployed. In this chapter the main conclusions are presented. The monitoring showed that the majority of the intended measures – 26 out of 32 smart solutions – were (partially) deployed. It is concluded that many changes took place in the implementation phase and that the deployment processes hardly ever followed the original project plans to the letter. The monitoring as described in this deliverable, helped to understand why changes were made. It can be seen as the narrative that explains why deployment took place in a certain way, with each Lighthouse city having its own unique context and dynamics. The complex deployment processes in the Lighthouse cities illustrate that adjustments are made frequently and are considered a common practice in the deployment processes of smart solutions. Given the inherent dynamics innovation projects like RUGGEDISED face, involving many project-related and external factors, a high degree of flexibility and adaptiveness seems required. The deployment processes of the smart solutions all concerned various aspects of the monitoring framework presented in this deliverable (see section 2.1): operational factors, cooperation, strategies and planning mechanisms. Conclusions are drawn on each of these four aspects as well as the concept 'innovation capacity' (see also section 2.1).

4.1.1 Operational factors

There were all sorts of changes made to the smart solutions during the implementation phase, ranging from the solutions itself (some solutions were adjusted and downsized), the definition of the solution, the area in which they are deployed, the planning of the deployment process (e.g. adjustments were needed in response to COVID and in response to changes in prices), the involved (public and private) actors who influenced the deployment processes with their actions, etc. During the deployment process various operational issues needed to be solved. The most prominent operational factors were financial feasibility and regulation. Operational factors proved barriers, that were sometimes successfully dealt with. Sometimes they also provided opportunities for acceleration of deployment and for scaling up of the solutions. The lack of financial feasibility proved to be a showstopper in Glasgow and Rotterdam for several solutions. Another example is the regulatory barriers such as a concession that hampered the further extension of the smart thermal grid in Rotterdam. In Umeå potential operational factors were proactively identified through feasibility studies (before and) at the start of the project and the operational factors were anticipated for. Hence, they experienced much less barriers and accompanying delays. In line with the Umeå experience of the importance of anticipating operational factors, it might not be a coincidence that the solution that was scaled up by Rotterdam, the smart waste management, was further developed than other solutions at the start of RUGGEDISED.

4.1.2 Cooperation

The second main conclusion is that an important factor for the deployment of smart solutions is *cooperation* between key actors. As illustrated in chapter 3, in every deployment process a variety of actors were involved. Only when the actions of key actors are aligned and directed towards the realisation of the intended solutions, the deployment moves forward and (can) result in the final realisation.

Cooperation first of all concerns the interaction between many different stakeholders such as various departments within the municipality, different layers of public authorities, private parties and knowledge institutes. In Glasgow the project manager successfully coordinated with various stakeholders inside and outside the City Council such as developers, investors, citizens and businesses. In Umeå, the RUGGEDISED project primarily consists of public actors making the alignment of interests towards common goals and cooperation easier. In Rotterdam, following the hands-on approach, the importance of management of the cooperation with the various stakeholders was underestimated, resulting in unforeseen barriers in the deployment process.

Cooperation within the municipal organisation of the cities is also an important aspect. In two out of three Lighthouse cities studied, it was found that the planning process is characterized by a predominantly sequential process where separate departments and different people are involved in each phase of the planning process (e.g. the strategic

planning phase followed by the operational implementation phase). Not only the transfer of work between the people in each phase is important (is there a common understanding of the goals, solutions and intended outcomes?); it was also found that the implementation phase is characterized by its own dynamics requiring iterations within this phase. For example, a steering board to facilitate consultation at the strategic level was lacking in Rotterdam. Therefore, it was much harder to keep the deployment aligned with the intended goals.

The most prominent conclusion is that cooperation is shaped by the people that have a mutual understanding of the goals of the solutions and speak the same language. Not surprisingly, it matters which individual people are involved; they can make or break it. The monitoring showed that personnel changes had major consequences, even completely changing the attitudes and commitments of organizations involved. The commitment and persuasiveness of individuals towards the project can make a tremendous difference as well as the required strategic connection and political support within the municipalities.

4.1.3 Strategies

The RUGGEDISED project was positioned within the strategic context of the Lighthouses' city strategies. All Lighthouse cities indicated that the RUGGEDISED solutions were aligned with the existing strategies. For example it was found that each city has its own Sustainable Energy strategy. In understanding the interaction between the city strategies and the RUGGEDISED project, it is important to note that policies and accompanying plans can significantly shift over time. For example, in Rotterdam the solutions suited the city ambitions and its Smart City program. Yet, the implementation was sometimes complex as existing policies and regulations did not incorporate and reflect all of these ambitions, making implementation in practice at times challenging. In later years, when a new city council was installed, sustainability became a much more prominent policy objective in Rotterdam. This provided a more supportive project context for the deployment of smart solutions. Also in Glasgow sustainability was placed higher and higher on the city agenda (amongst others due to COP26), creating fertile ground for innovation projects like RUGGEDISED. Furthermore, it was found that it can be challenging, even when strategies can seem very supportive, to align smart solutions if not all strategies are translated into concrete policies, plans or actions (see the recommendation on organization that supports innovation to overcome this challenge).

The RUGGEDISED project also contributed to city strategies through various policies, strategies and access to network and enforced the increasing attention for sustainability and climate in the cities. In Rotterdam, RUGGEDISED was at the basis of a citywide Digital Program. In Glasgow, had a strong influence on policy and strategy in Glasgow and is referenced in new policies and strategies. For Umeå the RUGGEDISED Smart City Lighthouse status allowed the municipality to become part of influential national networks. Note that a project like RUGGEDISED is modest in terms of the investments made in smart solutions compared to all other investments Lighthouse cities make. Therefore, the impact the project has, seems to depend on how the project is positioned and viewed within the city which is at least partly the outcome of a process explicitly aimed at making a strategic impact. For example, it seems that the strategic impact the project made in Glasgow was the outcome of a deliberate strategy of the projects ambassador who happened to be (more and more) strategic positioned and well connected to the city council resulting in 'positive press' and impact on the city strategies.

4.1.4 Planning mechanisms

The planning of RUGGEDISED was complex. First, each city aimed to deploy a set of smart solutions, with different timelines and having within each deployment their own planning dependencies linked to the actors involved. Secondly, there were many interactions with projects and planning processes outside RUGGEDISED, resulting in incongruent or even conflicting timings. The participants in the RUGGEDISED project were confronted with these planning challenges through learning by doing. As was true for the management of the cooperation between stakeholders, also the planning complexities were mostly underestimated at the start of the project (with Umeå as positive exception). The RUGGEDISED project demonstrated the importance of the planning process and how much timing of actions can matter for the entire deployment process. Preferably, the vision and plans of a project like RUGGEDISED should inspire the wider policy-making process and vice versa. However, this turned out too ambitious in practice. A possible explanation is that energy measures are traditionally treated as commodity in an area development and are as a result of this attitude planned in the last phases of a program or project. Given the fundamental nature and potential systems impacts (i.e., on other domains such as spatial planning, mobility, digitalization, etc.) of the smart solutions, it needs a 'by design' approach.

4.1.5 Innovation capacity

Innovation capacity is the set of competencies and conditions that supports innovation. Figure 2 shows the outcomes of a self-assessment on innovation capacity done by the Lighthouse cities as part of the interviews (see section 2.2). This concerns their own self-reported scores, hence the scores are not directly comparable across the cities. It should be seen as first indication and baseline measurement of how the Lighthouse cities assess their position in each of the innovation capacity's categories. In Table 8, the findings on innovation capacity are summarised for each city (the innovation capacity narratives per city can be found in sections 3.1.7, 3.2.7 and 3.3.7).

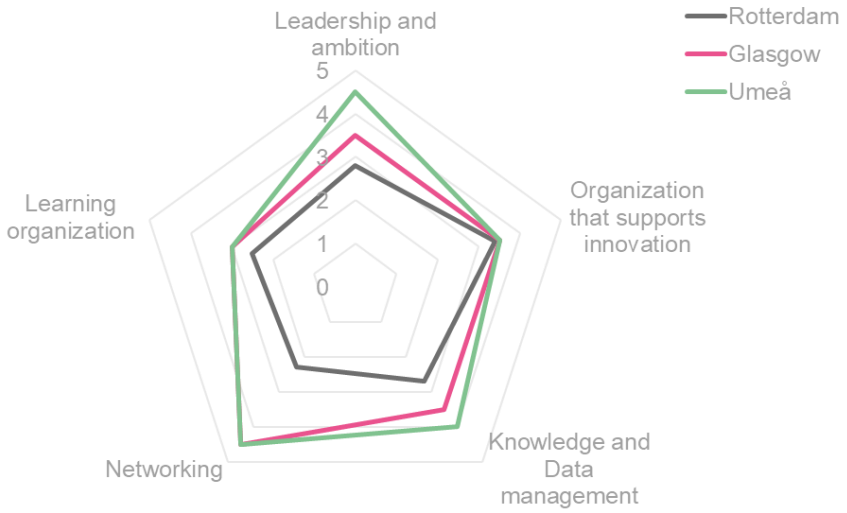

Figure 2: Self-assessment of innovation capacity in the Lighthouse cities

Table 8 Innovation capacity of Lighthouse cities

	Rotterdam	Umeå	Glasgow
Leadership and ambitions of the city on innovation	The project team had sufficient political support, yet they had difficulty to acquire sufficient administrative leadership. The project lacked an ambassador at the management level that took ownership.	In Umeå the project team experienced a high level of political and administrative support strengthened by strong mutual trust between administrative leaders and the staff.	In Glasgow the political support for sustainability is very high. Due to the influence of political leaders and COP26, a lot of stakeholders now recognize the importance of sustainability.
Organization that supports innovation	Organizational support for RUGGEDISED decreased over time due to insufficient internal coordination and unclear ownership of tasks and responsibilities.	The organizational structure of the municipality of Umeå is characterised by silos sometimes hampering cooperation with other departments. Specifically, better integration between the strategic and operational department is required.	The main challenge within the municipal organization is that the majority of the work is organized in siloes and has a high level of task specificity. However, the city council is experimenting with organizational structures to better integrate the work.

Dealing with (new) data and knowledge	The municipality of Rotterdam is regularly cooperating with knowledge institutes and universities for knowledge exchange. However, little time and incentive to internally disseminate new knowledge.	In Umeå the city has a close collaboration with knowledge institutes and universities. Moreover, the city is investing in creating a sustainable knowledge base among staff.	One of the strengths in Glasgow with regards to innovation and knowledge transfer is the connection with academia. The municipality has access to a lot of knowledge through research and development funding and sharing of data with the three major universities in the city.
Networking	The municipality of Rotterdam is part of a variety of networks. The challenge remains to disseminate information from these networks to the right persons within the municipal organization.	The most prominent innovation capacity in Umeå is networking; demonstrated through influential and institutionalised networks.	The RUGGEDISED project manager successfully coordinated with various different stakeholders inside and outside the City Council such as developers, investors, citizens and businesses.
A learning organization	Due to the size of the organization, the multitude of departments and disciplines the municipality of Rotterdam has difficulty becoming a learning organization.	Disseminating and embedding lessons learned throughout the organization is challenging. The project team indicates several success factors: cost effectiveness, publicity, public support and sufficient dialogue.	The city council is developing a project management office for sustainability to bundle and disseminate sustainability knowledge and best practices

4.2 Recommendations

Within the RUGGEDISED project, the Lighthouse cities aimed to deploy a large and diverse set of smart solutions. This project contained many valuable insights and is particularly of interest for those cities who (continue) to deploy innovative smart solutions in the context of the energy transition. It is hoped the following recommendations get to the heart of all civil servants that will (continue to) work on this transition.

- **Proactively manage the alignment with city strategies**

Innovation projects like RUGGEDISED should be well aligned with city strategies. Moreover, these innovation projects can also have a major impact on city strategies. This requires proactive management and advancements of the municipal innovation capacity (see below). In order to achieve this alignment, we recommend to:

- make an overview of all relevant city strategies (e.g. energy, mobility, ICT) and identify the objectives the project can contribute to and in what way (make lines of reasoning explicit).
- check periodically (e.g. bi-annually) if city objectives, strategies and the emphasis in the implementation of strategies give reason to update the alignment. Particularly when the city council changes or in case of major external events (like COVID or a financial crisis) it can be relevant to update the alignment.

- **Develop and professionalise the cities' overall innovation capacity to create fertile ground for innovations**

One of the key contributions of the RUGGEDISED project is the insights participants gained on how to deploy smart solutions. The challenge is to embed and disseminate these insights throughout the municipal organisation and even towards the wider innovation ecosystems. Some great examples were found of the importance of leadership, organisational support and knowledge sharing. As the RUGGEDISED project first introduced the innovation capacity concept, it is recommended to create awareness for the importance of innovation capacity and further develop and professionalise this capacity. Cities can start by building on their strengths (such as close collaborations with knowledge institutes and universities) and exchange successful examples as inspiration.

For the respective five factors of innovation capacity the following suggestions are given to the municipal organisations:

- Leadership and ambitions of the city on innovation:
  - Organise support from political leaders (e.g. Mayor, Alderman) as well as the administrative leaders (directors and heads of the involved departments) by creating substantial internal communications about the project as a way to inspire strategists and feed them with relevant project insights. This should be organised as a continuous process to ensure alignment with city strategies throughout the entire project supported by liaisons who speak the language of both worlds.
- Organization that supports innovation:
  - RUGGEDISED showed that in multilevel cooperation, from the working floor to the strategic level there is often a gap. To close this gap feedback loops need to be created between the strategic, tactical and operational level. Hence it is recommended to create networks consisting of people involved in formulating city strategies as well as people involved in innovation projects to bring learnings from projects to the strategic level and vice versa. By embedding the project within the organisation its impact beyond the project duration and scaling up smart solutions can be promoted.
  - To create an organisation that supports innovation the internal communication on both horizontal and vertical levels should be enhanced by working in an integral way. This supports working across silos and promotes policy coherence in all involved departments and projects. This requires the acknowledgement of the importance of liaisons (i.e. boundary spanners) and strong support of these people - possibly assign them to each department.
- Dealing with (new) data and knowledge:
  - In order to strengthen knowledge and data management the municipalities should invest in creating a sustainable knowledge base in which lessons learned are being documented and shared. Ultimately, municipalities can create a learning strategy within the organization.
- Networking:
  - To increase the impact of the various networks that the cities are active in, it seems promising to establish long-term cooperation among key partners (triple helix) which increases trust and transparency.

- A learning organization:

In the development towards a learning organisation it is important for municipalities to shift from a linear, sequential project-based way of working towards a more iterative and programme based approach.

  - Support a culture for innovation that rewards (or even expects) innovation and taking risks. This culture promotes room for innovation, flexibility in the deployment and adaptivity towards unforeseen events. This can be promoted via an awards system, regular publications about this or part of regular project reviews, etc.
  - One way to organise this is through a mission oriented learning program – centred around a specific mission or set of objectives (e.g. sustainability, climate, energy). The municipalities can organize such an overarching program with dedicated funding aimed a joint learning and knowledge exchange, for example focused on energy transition, linking all projects and the people involved across various departments and building a joint knowledge base.

- **Invest in preparation and proactive management of smart solutions to accelerate deployment**

The RUGGEDISED project has shown that the deployment processes of smart solutions were often characterised by an interplay of closely related factors, being operational factors, cooperation, planning mechanisms and strategies. These factors can proactively be identified and anticipated for resulting in much less deployment barriers and accompanying delays. It is highly recommended at the start of complex innovation projects like RUGGEDISED to:

- Execute (more) extensive financial feasibility studies of smart solutions;
- Assess the involved stakeholders and their organisational readiness;
- Identify the relevant regulations and potential legal barriers;
- Identify the existing knowledge base and build on lessons learned in previous projects;
- Align the project goals with the relevant planning mechanisms and municipal strategies.

Furthermore, it is recommended to manage the deployment process proactively and in an integral way. As the context of innovation projects is per definition dynamic and complex, all activities listed above requires continuous updates and adjustments during the project execution.

Appendix A: List of interviewees

Lighthouse city	Name	Organisation	Date
Rotterdam	Katelien van den Berge	Municipality of Rotterdam	07 – 03 – 2022 24 – 05 – 2022
Rotterdam	Roland van Rooyen	Municipality of Rotterdam	07 – 03 – 2022 23 – 03 – 2022 24 – 05 – 2022
Rotterdam	Roland van der Heijden	Municipality of Rotterdam	23 – 03 – 2022
Rotterdam	Martin Blaas	Municipality of Rotterdam	24 – 05 – 2022
Rotterdam	Machiel Karels	Buroloo	24 – 05 – 2022 28 – 05 – 2022
Umeå	Carina Aschan	Umeå City	25 – 04 – 2022
Umeå	Sara Ghahani	Akademiska Hus	25 – 04 – 2022
Umeå	Jörgen Carlsson	Umeå Energi	25 – 04 – 2022
Umeå	Lisa Redin	Umeå University	25 – 04 – 2022
Glasgow	Gavin Slater	Glasgow City Council	10 – 05 – 2022 09 – 06 – 2022
Glasgow	Stafford Motteram	Glasgow City Council	10 – 05 – 2022

Appendix B: Set up of interview protocol for monitoring and innovation capacity

Through partially structured interviews (see section 2.2 for more information on the data collection and Appendix A for an overview of interviewees) we are going to talk to each Lighthouse city to understand:

1. **Which** solutions have actually been deployed and which not?
2. **Why** some solutions were deployed and why other not, or have been changed, or have been delayed. The reasons could lay behind one of multiple of these aspects that will be investigated during the conversations with the cities:
    a. **technological** challenges / characteristics
    b. link with the **strategic** levels in the city (political programmes, ambitions, …)
    c. link with the **tactical** level of planning and deployment of the solutions and their embeddedness in the local urban / energy plans
    d. link with the **operational** level in relation to financing, regulations, local arrangements, etc.
3. The **innovation capacity** of the city. Here we will look at the ambition of the city on innovation, its organization, the capacity of dealing with data and knowledge, the cooperation and network structure and organisation, the learning capabilities and processes within the organization.

Below an elaboration of the interview topics into specific interview questions is given. This concerns the interview protocol which supported a semi-structured approach to all interviews.

Deployment of smart city measures

Technologies

- Can you give us an update on which of the technologies (mentioned in the tables above) have actually been deployed, which not, which have delay and which ones have changed?
- What is the main reason why certain solutions where deployed and others not or have been delayed/changed?
- To what extent was the technology and its (un)successful deployment dependent on
    - Existing or new infrastructure
    - Access to financing instruments
    - Costs versus benefits
    - Regulations
    - Other
        - Share of investments among partners and covered by grant
        - Share of risk among partners
- To what extent have (innovative) cost/revenue/risk divisions between partners been used to deploy and exploit smart solutions?
    - Were cross-sectoral opportunities investigated especially in relation to financing? (Connection with question 6, on other sector's policies)
- Have business models been developed?
    - When in the process and with whom?
    - Was it aligned with the higher levels plans and did it receive political support?

Strategic and planning aspects

Strategies (strategic level)

- Did you receive political commitment at high level in the city council when the project started?
    - By whom? Were there also other relevant political stakeholders committed?
    - How did they support the project development and implementation?
    - Did the political commitment support and back up the project when issues or barriers were encountered? If so, how? If not, why?
- Was the project integrated into other sector's policies in order to achieve strategic city targets (industry, energy, building, mobility, public procurement,)? To what extent? And why?
- Was the project aligned, and in which way, with the ambitions of the city council on climate change, sustainability, such as (examples, not exhaustive):
    - In Rotterdam: Energy vision, city council strategy 2016 and 2019
    - In Glasgow: Glasgow strategic Plan 2017 – 2022, City development Plan & City Development Plan 2, Glasgow Housing Strategy,
    - In Umea: Comprehensive Plan
- Was there a shared vision?
    - Was that co-developed by all the stakeholders or only by some?
    - Was the shared vision aligned with the plans at higher level?

Planning (tactical level)

- What is the horizon of the current planning programmes?
    - Are they connected with the SECAP (sustainable energy and climate action plan) – SUMP (sustainable urban mobility plan) or other plans?
    - Are these plans assessed against higher level objective plans? If so, to which extent?
    - Where these plans updated or revised during the duration of the project? Or were other additional plans published in this period?
- Were the solutions deployed in the RUGGEDISED project integrated into the urban (or others) plans of the city?
    - If so, how? If not, why?
    - Did the fact it was/was not had an impact on how many solutions were at the end deployed?
- Are the plans going to be updated with the technologies deployed and lesson learned from RUGGEDISED? If yes, when where and how? If not, why?
- Have special permits or deviations to the law or urban plans used to facilitate the deployment of the solutions?

Innovation capacity and operations

Leadership

- Can you tell us whether there is a clear innovation strategy in the city?
- To what extent did you receive political commitment?
- To what extent did public leaders (in the administrative unit) inspire and support the project?

Organisation

- How many city departments and personnel were involved in the project?
    - Was that enough?
    - To which level of the organization did they belong to (operational, tactical, strategic)?
- To what extent have the strategic, tactical, and operational levels collaborated in deploying the smart solutions and support the goals of the project?
- Did you adjust your administrative organization to achieve the goals of the project and deploy the smart solutions?
    - If so, how? Was it successful? If not, why?
    - What would you do differently the next time?
- To what extent were roles and responsibilities clearly demarcated?
- To what extent was experimentation with innovative methods/materials/technologies and taking risks encouraged?
- Were there sufficient resources for innovation?
    - What resources are needed?

Knowledge management

- To what extent did the team have the right expertise for implementation of the project?
    - Did you have to bring external people into your organization as experts in specific domains?
    - If so, which kind of knowledge was missing? How soon was the knowledge gap identified?
    - How do you acquire new knowledge in the organisation? Are there clear structures for that?
- To what extent is knowledge exchanged within networks?
- How is knowledge being collected and disseminated in the organisation?

Network

- To what extent were local stakeholders (quadruple helix of cooperation: industry, civil society, academia, government) aware of the project and of its positive impact?
- Were they involved in the process? If so, who was involved, when and how?
    - Did they have a specific role and/or responsibility?
    - Did they perceive to feel enough involved in the project and in the decision-making process?
    - Was the objective of the cooperation clear?
    - Was a partnership agreement made? With all stakeholders or only with some?
- How many interactions with the stakeholders did you have? What was the set up (event, co-creation session, site visit, official assembly, ...)?

Learning

- How would you describe the attitude of the workforce towards innovation and change?
- Are innovative ideas and their implementation being evaluated? If so, how?
- Is it ensured that the lessons learned from a project are embedded in the organisation? How do you do that?