RUGGEDISED
Designing smart, resilient cities for all

EUROPEAN COMMISSION
Horizon 2020
H2020-SCC-2016
GA No. 731198

Deliverable No.	RUGGEDISED D5.7	
Deliverable Title	Monitoring report on measures to maximise the impact	
Dissemination level	Public	
Lead participant	ISINNOVA	
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Status		Final

H2020-SCC-2016 – Grant Agreement number 731198 - RUGGEDISED

Acknowledgement:

The author(s) would like to thank the partners in the project for their valuable comments on previous drafts and for performing the review.

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Disclaimer:
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731198. The sole responsibility for the content of this document lies with the Ruggedised project and does not necessarily reflect the opinion of the European Union.

Executive summary

The RUGGEDISED project strategy focused on four different steps that started separately but were then carried out in parallel throughout most of the project lifetime (Figure 1).
The implementation of the smart solutions, data collection/mapping as well as partial analysis and validation of these took place in Step 1; upscaled deployment of smart city solutions was carried out in Step 2; replication activities in Step 3 and the dissemination and communication activities in Step 4.
The actions to maximise impact were arranged along a cascade with growing impact and growing market uptake.
This report provides an assessment of the effectiveness of the measures put forward to maximize the impact of the project, thus looking beyond the actual impacts borne by the smart solutions in the Lighthouse Cities.
The focus is primarily on the effects of the sustaining actions delivered by WP1, WP6, WP7, WP8 and WP9, which relate to knowledge advancement, replication of smart solutions in the Fellow Cities, and the more general uptake of the smart solutions implemented by the project in the rest of the EU.
In the following chapters, the work carried out in each WP will be analysed, drawing attention to all those activities that contributed to maximizing the impact of the project.
In particular:

- Chapter 1 focusses on the activities of Cross-city Implementation and Innovation in the Lighthouse Cities carried out under the guidance of WP1.
- Chapter 2 reports the activities related to the upscaling of smart city solutions and how the work carried out in WP6 has contributed to maximise the impact.
- Chapter 3 centres on the impact of replication activities in the three Fellow Cities. In particular, a final assessment is provided on the cooperation level gained by each city governing group as well as on the capacity and knowledge achieved thanks to the activities carried out in WP7. Moreover, the methodology and results of the Replication Assessment are provided within this chapter.
- Chapter 4 focusses on how all the other networks and market actors benefitted from the work of RUGGEDISED, thanks to the work carried out in WP8 and WP9.
- Chapter 5 picks up the salient points touched upon in the previous chapters, focusing on the contribution of the various WPs to maximizing the impacts of RUGGEDISED.

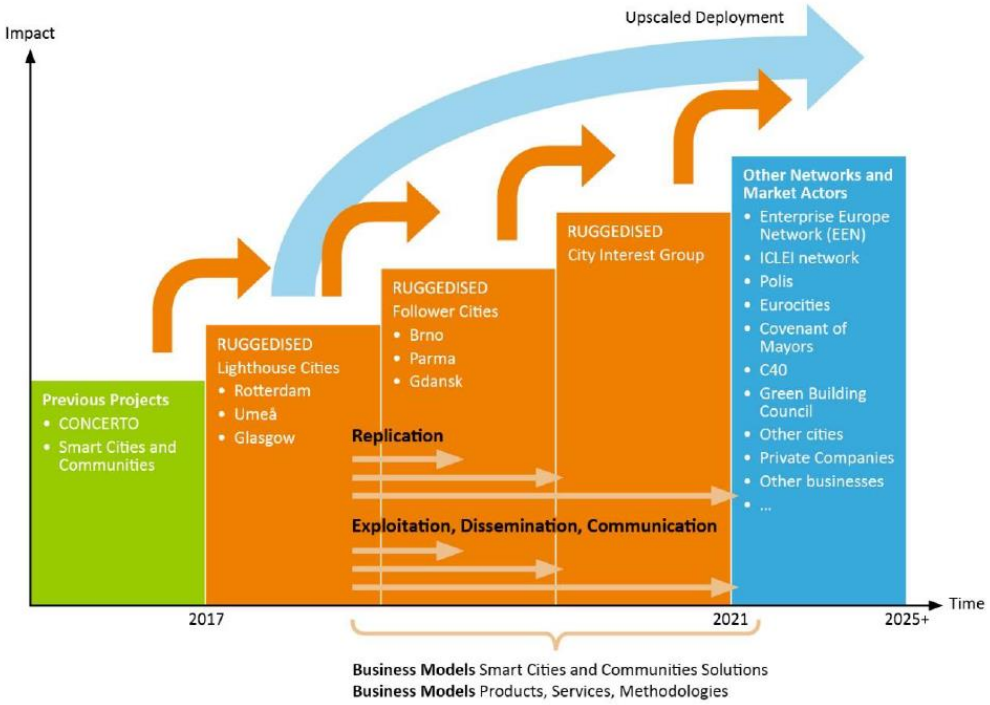

Figure 1: Overview of RUGGEDISED Impact

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1. Effectiveness of measures put forward in WP1 - "Cross-city Implementation and Innovation in the Lighthouses"

The overall objective of WP1 is to **guide**, **coordinate** and **facilitate the implementation** of smart solutions in the three Lighthouse Cities, and to **support** the Lighthouse Cities **with knowledge and processes to maximize the impact of the measures**. To reach this objective, a process was set up to facilitate learning across the three Lighthouse Cities by exchanging experiences, discussing challenges and by delivering targeted knowledge support from the local partners (TNO for Rotterdam, RISE for Umeå, and the University of Strathclyde for Glasgow). With this objective in mind, the coherency of the implementation of smart solutions has been secured and lessons learned have been extracted and condensed in an easy-to-use manner for Fellow Cities and for other EU-cities, **thereby maximising the project's impact.**

The Liaison Groups play a central role in this cross-city learning process. In the first three years of RUGGEDISED (i.e. from 2016 – 2019), the Liaison Groups met at least twice a year. This peer-to-peer learning enriched the design of smart solutions and improved their implementation processes. The function of the Liaison Groups was not only on a practical level but also on a more fundamental level of capacity building to deal with complexity of urban innovation processes. Furthermore**, the lessons taken from the cross-city learning facilitate replication and upscaling of the solutions in the Fellow Cities (Brno, Gdańsk and Parma) and other EU-cities in the future**. Indeed, the objectives of the Liaison Groups were to:

- Develop an **overarching innovation and implementation framework** to guide and coordinate the implementation of the smart solutions on Energy and E-mobility, ICT, and Innovation and new business models in the Lighthouse Cities;
- Sustain coordination and enhance coherency of implementation (of smart solutions) among the Lighthouse Cities by ensuring that relevant knowledge and experiences are shared in a facilitated fashion, which allows for extracting relevant **lessons learned**;
- Develop **tools and guidance for decision support and implementation of smart solutions** in Fellow Cites, and other EU-cities, based on lessons learned.

The results achieved according to these three aspects are highlighted in the following paragraphs.

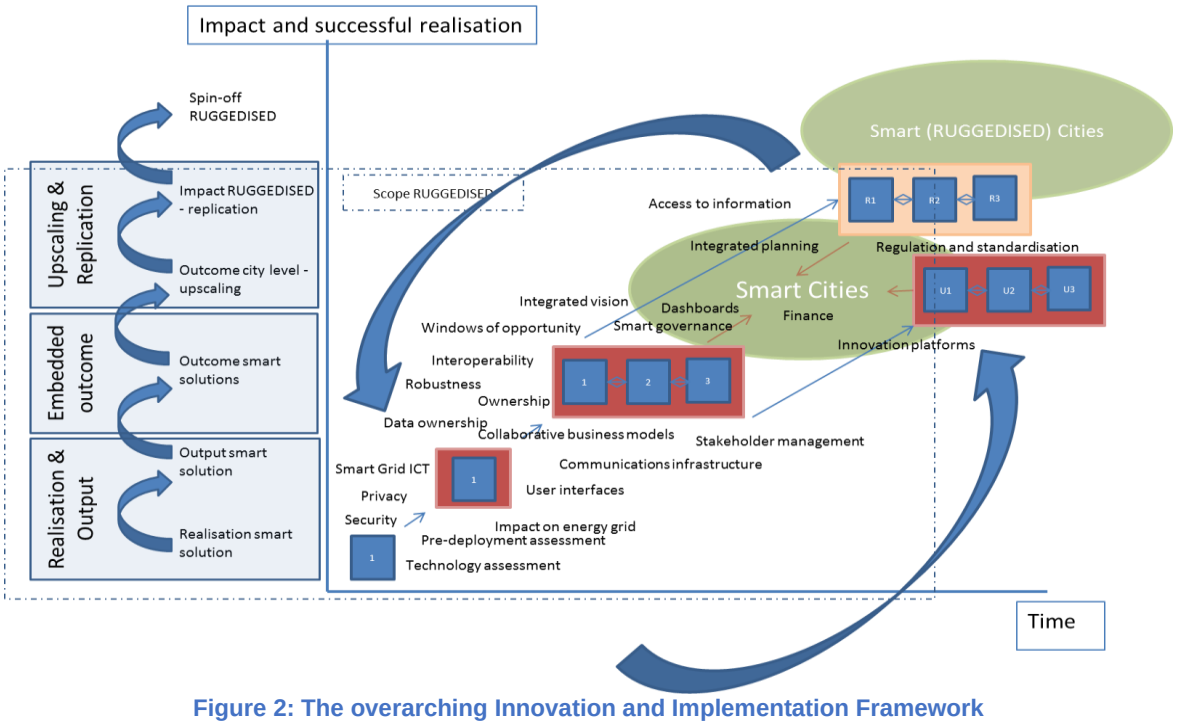

Figure 2: The overarching Innovation and Implementation Framework

1.1 The Overarching Implementation and Innovation Framework

The Overarching Implementation and Innovation Framework was collaboratively built with the RUGGEDISED partners to discuss – and keep track of – important factors that influence successful implementation of smart solutions. Apart from these factors, the framework showed three levels of successful implementation: (1) realisation and output, (2) embedded outcomes, and (3) upscaling and replication. A determining feature here is the way in which the Lighthouses and their partners succeed in embedding smart solutions in the existing urban configuration (also in terms of governance and organisation) and the extent to which connections between smart solutions could successfully be made on a system level. The Overarching Implementation and Innovation Framework acts as a framework of reference that highlights the level of complexity of the solutions (a single solution, a system solution, a complex system solution) and the different aspects that need attention to create an impact. The higher the level of complexity of the solution, the more aspects come into play that need to be considered for embedding the solution in the city context. In this sense, smart city projects are different from traditional urban development projects and require a different approach, as many new challenges will be met while implementing the smart solutions. How these challenges should be tackled, needs to be "discovered" by the team which is implementing the smart solutions. The contexts of each city differ, and the way how to deal with bottlenecks and hurdles for implementation also differ in these contexts, which means that specific and tailored ways of dealing with the challenges need to be found.

1.2 Lessons learned

Discussing the implementation of smart solutions in the Liaison Groups delivered a myriad of lessons learned. The lessons learned that are important for dealing with societal challenges and transformative change in cities are summarized below. For further details on the lessons learned we want to point to the respective deliverables of WP1 in which the reports of the liaison groups are taken up.

Treat the implementation of smart solutions as an urban innovation program
Projects, such as RUGGEDISED, are no traditional urban development projects. Instead they require a mind-set of collaboratively shaping a transformative Innovation Program; a set of projects that together meet the objectives on climate, energy, mobility, ICT, etc. This innovation program will challenge many existing institutions, structures and ways of working and tests the limits of the innovation capacities and skills of the cities.

Create a joint and binding vision
To avoid the pitfall of a traditional project management approach towards innovation projects, it is key to develop a strategic vision at the start of the project, together with the innovation partners. An overarching strategic vision will improve the coordination and collaboration between departments and partners in the city.

Position the program on a strategic level within the organisation
The position within the municipal organisation not only affects the ease with which the team can align with other departments, it also influences the access to the decision-making - and political levels in order to secure political support. Moreover, the position within the organisation also makes it easier to adjust the innovation program approach when necessary.

Culture
Culture is an important aspect for successfully building trust and for creating mutual gains. The RUGGEDISED Lighthouses deal with different cultures, as Umeå has a more community based cooperative culture, Glasgow has a strongly market based culture, while Rotterdam is in between these two cultures looking for public and private incentives. Experience shows that a mix of public and private partners (and also a mix of incentives within the municipality itself) requires more time to strategically discuss common goals.

Vertical alignment
Vertical alignment points at a smooth connection between people in strategic policy making and decision departments and people in operational departments. Implementation hurdles are often of a very operational character but normally lack the attention on the strategic level that could solve these issues. To exploit the

innovation potential and transformative power of innovative solutions and to deal with unexpected events, smooth connections between different levels in the organisation are needed. Lessons learned should be extracted as to facilitate a learning process at all levels within the organisation.

Embeddedness
The overarching framework underlined the importance of a pre-deployment assessment in order to carefully embed the smart solutions in the existing urban infrastructures. Each Lighthouse has struggled with this issue, especially regarding the capacity of electric grids to accommodate new solutions (Glasgow), the connection between the smart thermal grid and the existing heat infrastructure (Rotterdam) and the location of EV charging polls (Umeå). This assessment requires a systems approach. Detailed information and knowledge on the functioning and capacity of different systems/grids is necessary before making any further (strategic) plans. Embeddedness also relates to the use of new infrastructures.

Flexibility
The implemented smart solutions in RUGGEDISED are part of a (local) system, that continuously contests the project boundaries. A public transport mobility system does not match the optimisation boundaries of an energy system, and does not match the cadastral urban planning system etc. Therefore, the team managing the innovation program needs to continuously reflect on the project boundaries and needs to keep a certain flexibility in the approach. From a "project perspective", flexibility is often perceived as a risk. Therefore, partners need to make clear process arrangements on how to deal with flexibility.

Cross-departmental challenges
Changing urban systems requires an interdisciplinary and integrated approach towards urban development, which may have consequences for how cities are organised at this moment. Very often they still rely on a departmental organisation that hampers the integrated view, planning and implementation. Interdisciplinarity and integrated planning are still profound challenges. The municipal organisation should be aware of this challenge and should organise the transformative change in the city by specific units that can coordinate the implementation of systemic solutions and can "breach" the existing organisation structure when necessary.

Continue the developed approach beyond the life span of the project
RUGGEDISED provides the Lighthouses and their innovation partners with the opportunity to create a long-lasting cooperation and to sustain the developed approach. This approach resembles characteristics of a Living Lab: geographical embeddedness, experimentation and learning, participation and user involvement, leadership and ownership, and evaluation and refinement. However, the sustainability of Living Labs is a known challenge. For the continuation of the local partnerships the RUGGEDISED consortium may be inspired by the organisation and financing models of Open R&I Innovation PPPs that aim to address scientific, technological or innovation objectives that contribute to "the public interest" and "societal challenges".

1.3 Guidance for decision support and implementation of smart solutions

The discussion in the Liaison Groups delivered also lessons learned on developing and realising low carbon energy systems, realising city decision platforms and on governance of the smart solutions. These lessons learned were translated in guidance for cities to foster the replication of these systems to other European cities. The guidance is published on the RUGGEDISED website: D1.5 - "Prototype Smart Energy District Planner", D1.6 - "Guidance on Smart City Design and Decision Platform", and D1.8 - "Guide on RUGGEDISED implementation and innovation of smart solutions". After completing these guides, they were discussed and tested with the replication cities with the assistance of WP 7. There were specific comments on the "Guidance on Smart City Design and Decision Platform" that are taken up in the final Guide. After this test and validation round with the replication cities the guides are all final and ready for further distribution to other European cities.

Furthermore, a guide was published with guidance on how to develop and maintain cooperation with local innovation partners (D1.4 - INNOVATION PLATFORMS – WHY, HOW AND BY WHOM?). This Guide was a co-production between WP6 and WP1 and is based on the experience of the experts of TNO and RISE.

All guides are disseminated through the activities of WPs 8 & 9. A leaflet with concise summaries of the aforementioned guides will be published in 2022 to persuade the target groups (decision makers, managers, and operational people within the cities) to use the guides in their cities when implementing system solutions.

1.4 Contribution to maximising impacts

With the reported activities, WP1 has contributed to maximising impacts for different cities.
First of all, the Lighthouse Cities of Rotterdam, Glasgow, and Umeå, have been supported with the peer-to-peer learning processes which enabled the articulation of the lessons learned. This will help the cities with implementing smart solutions in future in other areas and districts of the city.
Secondly, the Fellow Cities of RUGGEDISED had the chance to test the guides and to receive guidance and first-hand knowledge based on the lessons learned. This will enable the Fellow Cities in maximising impacts in their contexts.
Last but not least the developed and tested guides will be actively disseminated to other European cities as to enable them to make use of the guidance that was developed to maximise the impacts in their contexts.

2. Effectiveness of measures put forward in WP6 - "Enabling upscaled deployment and business model innovation"

The objective of Work Package 6 (WP6) "*Enabling upscaled deployment and business model innovation"* has been to generate knowledge and capacity for the Lighthouse Cities to be able to accommodate an upscaled deployment[1] of the Smart Solutions to be implemented in the wider city. With a focus on the establishment of collaborative structures and deeper knowledge on upscaling potential of the smart solutions generated within the tree Lighthouse Cities, WP6 has aimed at supporting the cities to ensure that the smart demonstration projects become part of already existing eco-systems of Smart City innovation. It has thus been essential to assess the organizational, legal, and social aspects that influence the upscaling of smart solutions.

2.1 Establishment of Urban Innovation Platforms

The first phase of the work supported the establishment of an **Urban Innovation Platform** for each of the Lighthouse Cities. This step has served as the basis for the capacity building process. The Lighthouse Cities of Umeå, Rotterdam and Glasgow have been the main target group or "costumer" of the output of this task. Here Urban Innovation Platforms are understood as organizational structures that support Collaborative Innovation Networks (CoIN) based on stakeholders with a clear mandate to work together to support urban innovation. The Innovation Platforms developed in RUGGEDISED therefore aimed at two functions. First, as a platform for creative meetings between actors and the development of heterogeneous multi-stakeholder networks that could be fertile grounds for creative and innovative smart solutions. Second, as support to peer-to-peer learning between stakeholders from similar communities of practice with similar professional backgrounds and to develop bankable business cases based on one or several of the smart solutions developed within RUGGEDISED. In short, UIP could be described as a **means to opening up developmental processes**. To that purpose, the Urban Innovation Platforms are built on lessons learned and conclusions made by the other Work Packages (WPs), especially Work Package 1 but also to a large extent WPs 2, 3, and 4. The results from the Liaison Groups as well as contextual scenario analysis and analyses of existing urban innovation systems were the steppingstones for the development of the Urban Innovation Platforms.

The report D6.1 "*Initial findings from the establishment of Innovation Platforms"* is based on interviews with the cities and mapping of the relevant stakeholders, existing collaborations and other initiatives. It presents a general understanding of the concept of Innovation Platforms, gives an overview of similar processes from Europe and discusses these in relations to the Lighthouse Cities. Besides the interviews and the stakeholders, the report also discusses the process, tasks, results, and problems that needs to be addressed in relation to the construction of Innovation Platforms in the three Lighthouse Cities. Furthermore, it draws on upcoming work including barriers for upscaling.

Moreover, much of the work of an Urban Innovation Platform is to **identify barriers and find support to overcome them**. Cultural and social factors could function as drivers or barriers for further diffusion and upscale of smart solutions. Seeing that scaling up smart solutions to some extent is a different process compared to processes of innovation, Urban Innovation Platforms have been recognized as **keyways to support creative urban development and the establishment of multi-stakeholder networks**. Heterogeneous networks have been proven to be essential for the diffusion of innovation, which is the first step for upscaling and deployment. However, a great deal of evidence reveals that the diffusion of innovation often takes place through peer-to-peer networks, which tend to be rather homogeneous. Solutions or ideas that come close to what is already the norm seem to be much easier to implement and diffuse. This creates a paradox: although an innovative smart solution could be the perfect solution to a difficult problem, the solution could be too difficult to upscale and made bankable because it is viewed as too radical. Innovations must therefore be transformed and adjusted to be used in new contexts. Such transformations could take place in UIP.

[1] Upscaled deployment has been defined here as (post-project) implementation of smart solutions by local partners in wider lighthouse city areas and elsewhere.

Therefore, Urban Innovation Platforms can take many shapes, fulfil several roles, and be embedded at various levels in a municipality's ordinary organisation. **RUGGEDISED has focused on how the Urban Innovation Platforms can be a tool for upscaling and diffusion**.

2.2 Integration of Urban Innovation Platforms

The second phase of the work in WP6 has focused on how the innovation platforms could be integrated into the urban innovation systems and how they can be managed in the long run. The final deliverable from WP6 (D6.7 "*Innovation Platforms for innovative cities – conclusions and recommendations*") summarizes the work that has been done in the respective cities during the project with the aim to give a full description of the concept of innovation platforms, benefits, shortcomings and remaining difficulties and barriers. **The conclusions and recommendations should work as an inspiration and learning for other cities that are about to start collaboration activities similar to innovation platforms.** Key learnings in the report draw on the need for **adaption of innovation platforms to local needs and the specific context of the specific city or municipality**. It discusses cultural aspects as well as how the size of the city and different governance structures affect the possibilities to build a trusting and learning environment. Key factors identified are trust culture, the political climate and the amount of confidence between the politicians and the public administration, the size of the city (and the city's administration), how involved the local businesses are in societal development and collaboration, the possibility to find funding for continued work with the platform, upholding momentum and involvement of partners. Another crucial factor has been whether the platform is successfully linked to existing structures, and if it has a local sponsorship on all levels.

Furthermore, a **guide on establishing local innovation platforms** was produced. The Guide for setting up and sustaining Local Innovation Platforms was structured as a popularized publication in collaboration with WP1, INNOVATION PLATFORMS – WHY, HOW AND BY WHOM? (D1.4), a brochure with the aim to offer an introduction to the concept of Innovation Platforms.
The key questions answered by the guide were:

- What is an Innovation Platform?
- How it can be set up and function?
- What a city or municipality might gain from working this way?

The brochure is based on experiences from national projects, such as the Swedish six year-long project Innovation Platforms for Sustainable, Attractive Cities (VINNOVA, 2013-2019) giving examples from both The Hague and Rotterdam in the Netherlands and Borås, Kiruna and Lund in Sweden and is based on a research overview from the RUGGEDISED project. This Guide was a co-production between WP6 and WP1 and is based on the experience of the experts of TNO and RISE.

2.3 Contribution to maximising impacts

By the reported activities, **WP6 has contributed to maximising impacts for the three Lighthouse Cities, but also contributed to learnings that can be promoted to any other city or municipality**. The Lighthouse Cities of Rotterdam, Glasgow, and Umeå have gained support in the identification of barriers for innovation and upscaling, and analyses of how to overcome them. The cities have received support in identifying what kind of Urban Innovation Platform might work best for them, and where needed, in the setup of that platform. The lack of structures and methods for reflections often affects the uptake of innovation results. In that sense, **Urban Innovation Platforms have been recognized as a method to support creative urban development and the establishment of multi-stakeholder networks, and thereby innovation and upscaling**.
Crucial for enhancing the cities institutional capacity has shown to be the construction of good and vibrant relational resources such as networks, strong knowledge resources such as learning structures, which, added together, form the city's mobilization resources. **The studies conducted will not only help these three cities develop their innovation capacity further and help the cities with implementing future smart solutions in future in other areas and districts of the city but can also be adapted to any other city or municipality**.
Finally, the developed **guides will be actively disseminated to other European cities** as to enable them to make use of the guidance that was developed **to maximise the impacts** in their contexts.

3. Effectiveness of measures put forward in WP7 - "Replication to Follower cities and Knowledge transfer"

On the whole, **Replication activities** are crucial to **generate impact beyond the lighthouse demonstration projects** and contribute to create the conditions for the wider market up-scaling of the developed solutions.
Within RUGGEDISED, the replication process has been properly adapted and performed to foster the direct exploitation of the solutions demonstrated during the project timeframe and particularly centred on the strong and firm commitment of Fellow Cities in the future replication of the measures demonstrated within the Lighthouse Cities.
Concretely, the three Fellow Cities were assisted in the development of their Replication and Investment Plans (see D7.4 "*Replication and Investment Plans*") for the deployment of local smart city projects and, with the ambition of becoming Lighthouse Cities, their next step will be to start deploying the smart solutions identified in their plans immediately after the project has been concluded.
To reach this challenging objective and in order to maximise the impact of RUGGEDISED over time, an intensive process of capacity building and knowledge transfer has been set up and structured in four main blocks of activities unfolding both at European and local level (Figure 3).

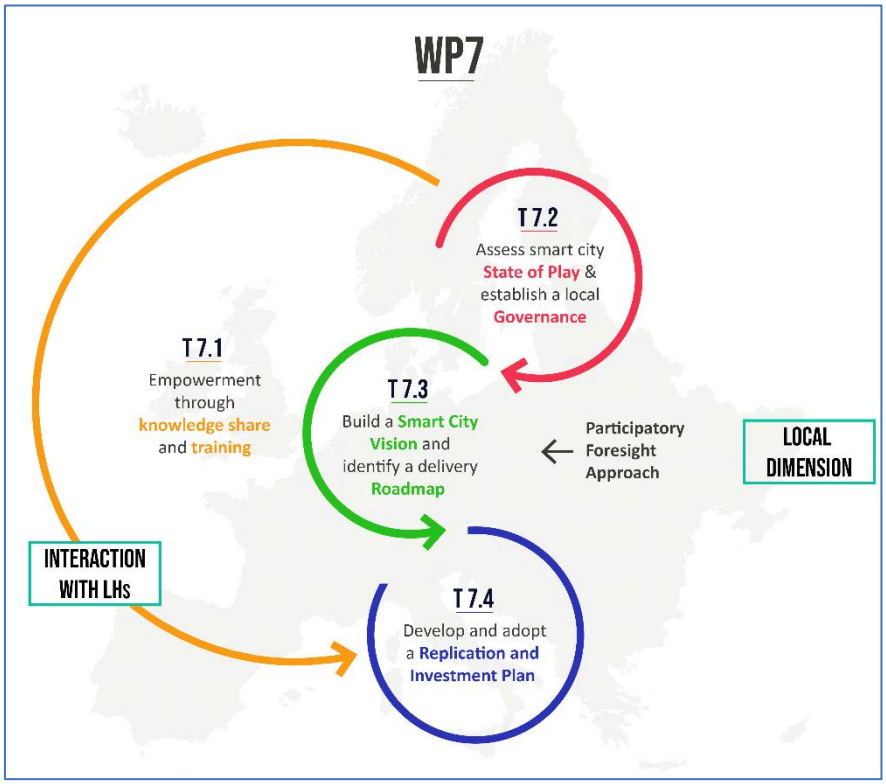

Figure 3: Replication process in RUGGEDISED (WP7)

This chapter provides a comprehensive assessment of the entire replication process, focussing in particular on the progress done towards the improvement of the **level of cooperation and capacity** achieved by the three Fellow Cities during the project's lifetime.
Moreover, it will be investigated the **potential for replication of the RUGGEDISED Smart solutions** in the different Fellow Cities' contexts. Methodology and results are described in the following.

3.1 Assessment of activities in the Fellow Cities

The evaluation process in the Fellow Cities focusses on all those activities aimed at enhancing an environment for the replication of the Lighthouse Smart Solutions. Specifically, two aspects have been monitored to assess the achievements in the Fellow Cities:

- the **improvement of the level of cooperation** among the relevant stakeholders taking part in the planning process of the smart city;
- the **improvement of the level of capacity** necessary to effectively replicate the selected smart solutions after the end of the project.

Improving cooperation in the governance structure of the city is necessary to ensure better management, communication and collaboration between the different city departments and relevant stakeholders, to guarantee improved services to citizens, to ensure that sustainability always comes first and to address all the relevant and essential aspects for the realization of the Smart City.
In this context, developing individual smart solutions is not enough and it becomes necessary to act at a higher level by setting up a proper governance body able to steer all these activities in a coordinated manner.
This aspect can make a real difference in the extent and duration of impacts in the long term.

Improvement of the level of cooperation

Thanks to RUGGEDISED, all three Fellow Cities established effective forms of governance, showing a strong commitment to carry on and steer smart city's initiatives. These entities have been carefully structured in such a way that they would be able to survive the numerous political elections and succession of local governments that normally take place in a city.
Each **Governing Group** was made up of a core team, a steering board and an advisory board.
Activities of knowledge exchange of local practice and the adoption of co-creation approaches involving all the key stakeholders were pivotal for ensuring the success of this process.[2]
As will be shown in paragraph 3.1.1, clear steps forward have been made by all three cities also in the level of cooperation internally perceived.

Another significant aspect, not to be underestimated, is the **level of knowledge and capacity** that the members of the smart city governance must acquire in order to be able to create, steer and manage the Smart City.
Learning from other experiences is a key step for strengthening know-how and boosting expertise on both technical and non-technical themes and, thereby, allowing Fellow Cities to consciously deal with eventual barriers that might be encountered, to anticipate potential failures and to be able to identify the best way to avoid them. Within RUGGEDISED, the concept of knowledge transfer has been applied making use of different modalities and means of implementation.

Improvement of the level of capacity

WP7 started off from the assumption that *replicating* does not simply mean copying and implementing what has been done elsewhere, but it looks more at *understanding* and *adapting solutions* according to the context. Therefore, it was fundamental on the one hand to ensure a process of **knowledge transfer** between RUGGEDISED cities and, on the other hand, accompanying this process by enabling and supporting the governing groups of the three Fellow Cities in the **planning process**, which meant the definition of a **shared long-term city vision**, the establishment of a **roadmap** outlining the main milestones and steps towards the Smart City and, finally, the development of **fully-fledged Replication and Investment Plans**.

[2] Details on the governance-set up process are reported in *D7.2 "Visions and Roadmaps"* and *D7.3 "Intermediate Replication Assessment"*

In this regard, the acquisition of organizational and technical competences necessary for the actual smart solutions deployment was tracked and closely monitored through the execution of several activities, in particular: **participatory foresight process**, **replication workshops**, **study tours** to the Lighthouse Cities and i**nternational cooperation with Japan**.
This varied path brought cities to perceptibly increase their overall capacity level (see paragraph 3.1.1) and each of these events contributed in its own way to that.

Participatory Foresight Process
The participatory foresight was one of the focal points of the replication process and has been developed at local level in each Fellow City. The application of this method facilitated the **strategic planning** and the effective establishment of a **collaborative platform** able to collect and catalyse all the **interests of the community,** thus strengthening it and creating new networks of society. This combination of foresight methodology with principles and techniques stemming from organizational development has been steered and adapted in each Fellow City by the respective **Governing Groups**.
At least four stakeholder forums have been held in every Fellow City: kick-off governing forum, scenario forum, vision forum and roadmap forum. These forums were jointly designed and evaluated by the Community of Practice (CoP), which supervised the Smart City leaders and core team members in the local foresight processes.
The foresight process also contributed to the improvement of the cooperation internally perceived by all the parties involved in the stakeholders 'group.[3]
A detailed report of this activity is reported in D7.5 – "*Reports from the governing groups meetings*"

Replication Workshops
The topics addressed during the Replication Workshops ranged from how to structure effective governance in the city to more technical and managerial aspects, often offering the Fellow Cities implementation and monitoring updates from the Lighthouse Cities, providing the opportunity for peer-to-peer discussion on progress, problems, solutions and results.
Six Replication Workshops were held during Ruggedised General Assemblies, with the involvement of experts responsible for the different smart solutions in the Lighthouse Cities and members of the governance of the Fellow Cities. These events have been the venue for fruitful discussion and the perfect occasion for transferring knowledge and establishing a dialogue and an exchange among cities.

Study Tours
Study tours are considered the most effective means of face-to-face, peer-to-peer knowledge exchange. In RUGGEDISED these visits have been organised to allow Fellow Cities to foster deeper engagement with the stakeholders and experts of the Lighthouse Cities, to benefit from an operational, hands-on observation of the smart solutions and to further knowledge of implementation and technical aspects.
Although travel restrictions due to the Covid-19 emergency have hampered the realization of study tours, 7 visits could be arranged (reports in D7.6 – "*Reports from the technical workshops"*).

International Cooperation with Japan
International Cooperation with Japan is an activity proposed by ISINNOVA after the interest shown by the Mission of Japan to the EU in the Smart Cities and Communities initiative of the European Union, and positively reviewed in the summer of 2020 by the Steering Committee of

[3] More details of the participatory foresight process and its results are reported in *D7.2 "Visions and Roadmaps"*

RUGGEDISED and subsequently by the European Commission. It was incorporated in Contract Amendment No. 3 of RUGGEDISED.

The aim of this activity was to foster facilitated knowledge share between international smart city programs, by involving the **6 RUGGEDISED cities** and **key smart city players in Japan**, i.e., the Government's Cabinet Office, responsible for the overall coordination of Japan's smart city program, and the selected cities of Hamamatsu, Kamakura and Tamana City. The expectation for both sides was to establish an environment in which inspiration, growth and long-term synergies could be unlocked.

The results of an initial survey showed that these were the most sought-after Smart City aspects, which were addressed over the course of the cooperation in a series of 3 workshops and 2 virtual study visits:

a. Establishing **partnerships** with other cities and smart city players.
b. Learning about overall **smart city approaches** for potential **replication**.
c. Learning about **governance approaches**.
d. Learning about the **role of public and private sector** and **PPP approaches**.
e. Learning about the **role of citizens /civil society/ end users**.
f. Learning about **working business models**.
g. Exploring the **technological features** of smart solutions.
h. Learning about local **policy and market trends** relevant for the smart city realm.
i. Learning about working **funding schemes** for smart city projects.

It can be said that this process fulfilled the initial expectation for both Japanese and European cities to establish an environment that cultivates mutual understanding and inspiration between cities committed to unlocking sustainable growth and a higher quality of life for their citizens through the deployment of smart city technology. The workshops also helped boost the interaction in the subsequent study visits by highlighting and selecting the most interesting subjects among all that were discussed. The digital city and all the related aspects that allow for an improved smart city governance leading to more sustainable and participatory processes were recognized as one of the topics which all the participants were eager to share experiences about and learn from each other.

To study and qualitatively assess all these aspects, different indicators have been defined and monitored: i.e. number of meetings of the local governing groups, number of participants, delivery of key planning documents, number of knowledge transfer events, etc. Error! Reference source not found. below shows more in details the list of activities above described, and the results achieved.
Moreover, specific **methodologies to quantify the increase in the level of cooperation and capacity** of the Smart City Governance Groups have been defined (see *D7.3 - Intermediate Replication Assessment*) and the results of the final assessment are shown in paragraph 3.1.1 below.

Lastly, over the last 5 years, ISINNOVA has been developing a quantitative approach for estimating the **Replication Potential** that specific smart solutions might have in different contexts.
This work has been applied to the Smart Solutions implemented in the cities of Rotterdam, Umeå and Glasgow and their replication potential has been estimated in the 3 Fellow Cities of Ruggedised.
A short description of the method and the analysis of results are illustrated in paragraph 3.2[4].
The results and conclusions of this analysis could be relevant for other cities with similar characteristics and priorities of the Fellow Cities of RUGGEDISED.

[4] Full methodology here: Paolucci L. "Estimating the Replication Potential of Urban Solutions for Socially Integrative Cities", Chapter 14 from the book "*Towards Socially Integrative Cities*", Muller B. et al

Table 1: RUGGEDISED final results vs expected outputs

Expected result	Objectives	Outcomes	Expected Outputs	RUGGEDISED final results
Improvement of the cooperation	Create physical and virtual environments for stakeholder and community interaction and involvement in the follower cities	Local smart city cooperation (institutions, utilities, industries, businesses, civil society)	• **3** running and permanent local Governing Groups • Governance Steering Groups meetings (Core Team+ Expert Group + Decision Group): - **10** in Brno - each attended by **15** individual participants - **10** in Gdańsk - each attended by **12** individual participants in Gdańsk - **12** in Parma - each attended by **15** individual participants in Parma	• 3 Local Governing Groups established (see D7.2 and D7.3) • Several meetings organized whenever appropriate and necessary
			• Improvement in the level of local cooperation[5] (calculated in % improvement over 2016 baseline).	• BRNO: from poor to good (+48%) • GDAŃSK: from acceptable to good (+23%) • PARMA: from poor to acceptable (+50%)
Improvement of the capacity	Define the vision and the path to smart solutions replication	Long-term and tactic planning	• Adoption of 1 strategic Vision and 1 Roadmap to implementation in Brno • Adoption of 1 strategic Vision and 1 Roadmap to implementation in Gdańsk • Adoption of 1 strategic Vision and 1 Roadmap to implementation in Parma	Visions and Roadmaps developed by the three Fellow Cities (see D7.2)
	Acquire the necessary competences to replicate the smart solutions	Local and inter-project capacity building	• 6 Replication Workshops, each attended by 4 experts in Brno, 4 in Gdańsk, and 4 in Parma	5 Replication Workshops (see D7.6 for details): - 1st RWS – Glasgow – "Smart City Governance set up" - 2nd RWS – Umeå – "Sharing knowledge on RUGGEDISED Smart Solutions" - 3rd RWS – Gdańsk – "Deepening Technical and Non-technical aspects of Smart Solutions" - 4th RWS – Brno – "Learning from the most innovative" - 5th RWS – Online – "Using the Business Model Canvas to discuss Smart Solutions" - 6th RWS – Rotterdam – "Smart change in cities: reflections from the Fellow Cities. The concept of Replication and the experience in RUGGEDISED"

[5] The percentages are calculated according to the methodology of Evaluation in Fellow Cities reported in D7.3

Expected result	Objectives	Outcomes	Expected Outputs	RUGGEDISED final results
			• 4 Governance Workshops, each attended by: - 20 individual participants in Brno; - 20 individual participants in Gdańsk - 20 individual participants in Parma	All Fellow Cities **finalised their local participatory foresight process** and their medium-long term city visions and roadmaps**.** - Brno: 5 Governance WS held with more than 20 participants - Gdańsk: 4 Governance WS held with more than 20 participants - Parma: 3 Governance WS held with more than 20 participants + 3 online WS with experts
			• 3 intensive Study Tours, each attended by 4 experts from Brno, 4 from Gdańsk and 4 from Parma	Fellow City decided to organise its own study tours independently form the others so as to have the chance to deepen with proper time and details the aspects of major interests for each of them. • Brno: 5 STs (2 in Glasgow, 2 in Rotterdam and 1 in Umeå), with more than 4 experts • Gdańsk: 2 STs (Rotterdam and Umeå), with more than 4 experts • Parma: Parma planned a study visit to Rotterdam, but then, due to the COVID pandemic, replaced the in person visit with an online meeting.
			• International cooperation with Japan	• 3 workshops organised, covering the most interesting topics identified by the European and Japanese cities. • 1 virtual study visit in Rotterdam in September • 1 virtual study visit in Tamana City in October (tbc)
			• Overall perception of improved smart city capacity thanks to project activities (calculated in % improvement over 2016 baseline)	• BRNO: from POOR to GOOD (+119%) • GDAŃSK: from POOR to ACCEPTABLE (+155%) • PARMA: from POOR to ACCEPTABLE (+148%)
	Deliver Replication and Investment Plans	Detailed planning of smart solutions replication	• Adoption of 1 Replication and Investment Plan in Brno • Adoption of 1 Replication and Investment Plan in Gdańsk • Adoption of 1 Replication and Investment Plan in Parma	Replication and Investment Plans have been developed by each Fellow City. See D7.4 *"Replication and Investment Plans"* for the English summaries.

3.1.1 Increase of the Level of Cooperation and Capacity in the Fellow Cities

Level of cooperation

Generally speaking, "*cooperation*" can be interpreted as working together with a common purpose and toward a common benefit.

As mentioned, one of the key requirements for becoming a Smart City is to set up an effective and permanent city governance structure, that involve all city relevant departments (Energy, Mobility, ICT, Waste management, etc.). The aim of this governance group should be to open and maintain a communication channel across the different sectors, that would otherwise continue working with their silos-thinking approach and thus hinder a strategic, integrated and smart way of planning. It is within this context that the term "**cooperation**" gains its smart city prominence.

To best assess and quantify the "satisfaction with the level of cooperation" (see Table 1) in the Fellow Cities, the following six indicators have been identified as essential components for defining the cooperation level. The more successful these 6 factors are, the higher the city cooperation is:

- Leadership
- City Departments Involvement
- Balanced Project Team
- Clear Division of Responsibility
- Stakeholders Involvement
- Interoperability

The assessment has been done through the distribution of ad-hoc questionnaires to the members of the Core Team, Expert Group and Decisions Group as well as to other relevant stakeholders involved in the joint execution of the replication plans in Brno, Gdańsk and Parma.

The questionnaires were circulated in **two specific moments in time:**

- At the beginning of the project, when the **baseline** and an **ex-ante evaluation of city expectations was defined** (results of this assessment are reported in D7.3)
- At the end of the project (within this report), where an **ex-post evaluation** has been performed. This will in turn allow to identify the main barriers and success drivers to improve cooperation.

Level of capacity

For "*Smart City capacity*" we intend the level of capacity necessary to effectively replicate the selected smart solutions after the end of the project.

During the lifetime of RUGGEDISED, numerous opportunities were offered to cities to share, transfer and gather knowledge thanks to the dialogue with experts of other cities (within and outside RUGGEDISED). During these events, both technical and non-technical aspects related to Smart Cities have been deepened, with the aim to support the learning process and improve the capacity level of Fellow Cities on Smart Cities topics.

At the beginning of the project, a self-assessment on the governance capacity level was performed by the Fellow Cities on the following horizontal themes[6]:

- **Decisions:**
  - **Policy and regulation:** creating the enabling environment to accelerate improvement.
  - **Integrated Planning**: how to work across sector and administrative boundaries and manage temporal goals.
  - **Citizens Focus**: how to include citizens into the process as an integral actor for transformation.

[6] Strategic Implementation Plan, October 2013. http://ec.europa.eu/eip/smartcities/files/sip_final_en.pdf

- **Insights:**
  - **Knowledge Sharing:** how to accelerate the quality sharing of experience to build capacity to innovate and deliver.
  - **Metrics and Indicators**: enabling cities to demonstrate performance gains in a comparable manner.
  - **Open Data**: understand how to exploit the growing pools of data; making them accessible- yet respecting privacy.
  - **Standards**: providing the framework for consistency commonality and repeatability; without shifting innovation.
  - **Foresight:** systematic way to examine alternative futures in order to inform decision making today.

- **Funds:**
  - **Business Model, Procurement and Funding:** integrating local solutions in an EU and global market.

- **Technology:**
  - **Smart Electricity & E-Mobility;**
  - **Smart Thermal Grid;**
  - **Energy management and ICT**

This same assessment has been asked at the end of the project in order to verify the improvement and increase of capacity among the members of the governance established in the Fellow Cities, thanks to the capacity building and knowledge transfer process implemented in WP7 and carried on thanks to the cooperation with all the other WPs.

The final results of this twofold self-assessment are reported in the paragraphs below.

❖ BRNO

Before RUGGEDISED, the **level of cooperation** perceived in the city of Brno was poor. One of the weakest points had been identified in the unclear division of responsibility that, likely, had also an impact on interoperability and was reflected in a quite unbalanced project team. Low was also the level of stakeholders' involvement. On the other hand, the leadership as well as the involvement of the most relevant city departments weren't working that bad.

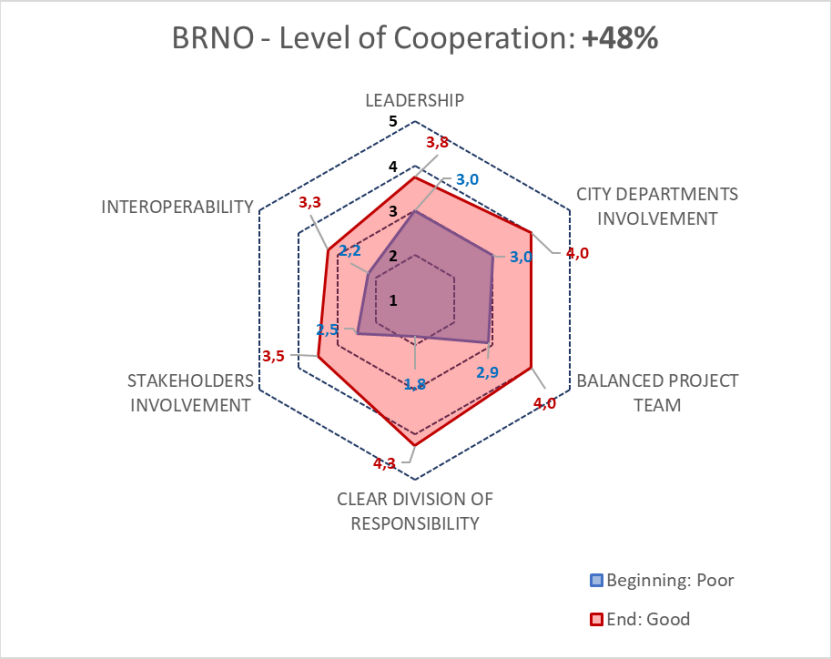

Figure 4: Increase of the level of cooperation in Brno

To date, thanks to RUGGEDISED, a significant improvement is visible in all these aspects. A wide network of actors working on replication of the Lighthouse smart solution in the Špitálka district was built. Creating synergies among departments was one of the assets on which the municipality of Brno could count. The department of strategic development led the entire process and involved several departments that worked together with a collaborative and dynamic spirit: data, analysis and evaluation dep., environmental dep., housing dep., the Brno City Chief Architect's Office and others.

The weakest point, even though there has been a visible improvement, is interoperability. In Brno's partners' opinion, this could be due mainly to the size of the city and the quite high number of departments and municipal

companies which do not communicate much with each other. The vertical division of municipal departments is a remnant from the time of the Austro-Hungarian monarchy and, in a way, persists to the present day. Setting up horizontal principles of management and cooperation and eliminating silo thinking is still a big challenge and this change is a long-lasting process.
At the same time, it may be supposed that this not so high increase could be also related to the relevantly low level of trust among the different stakeholders, an aspect where, compared to the Nordic countries, the Central-Eastern European countries are still disadvantaged.

With regard to the knowledge acquired thanks to the exchange carried out in RUGGEDISED, Brno was able to improve know-how in several aspects, enhancing the **overall capacity** level **from "poor" to "good"** (see Figure 5).

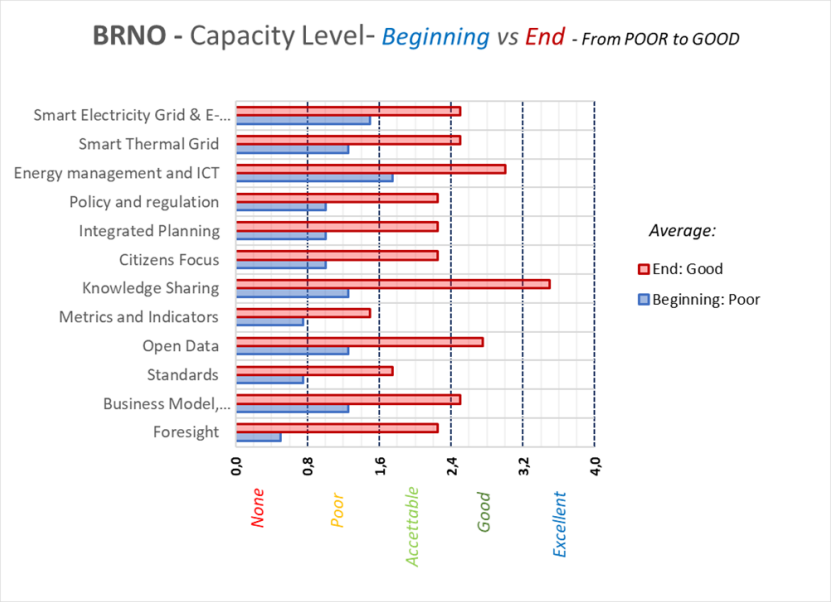

Figure 5: BRNO's capacity level

A significant increase is especially evident in the topics deepened during the study tours. Whether it is the data portal in the case of the study trip to Glasgow or the topic of business models that was the scope of the visit to Rotterdam. Replication workshops were also an important aspect of the newly acquired knowledge, focusing mainly on smart solutions and topics around thermal and electrical grids, energy management and ICT. Hence the good scores for these topics. A separate chapter was the topic of participatory foresight which Brno had little awareness of at the beginning. Thanks to the very good collaboration with AIT in the conceptualization of the foresight fora and an extensive experience with workshops organization itself that Brno's team could boast, the know-how acquired thanks to RUGGEDISED was crucial to carry on this process in an excellent way with outstanding results.

BRNO experience

"...at the beginning of the project, we had no idea how far our participation would take us. After six years, we are quite close to the realization of the first smart district in Brno and in Czech Republic as a whole. Without RUGGEDISED it would not have happened at all.
It is also very positive that, because the planning and design of the construction of an innovative district are very complex and integrate many topics and expertise, it has been possible to activate a large number of stakeholders and relevant institutions. Such projects are a very good opportunity for successful horizontal cooperation.
If we succeed in the construction of the smart district of Špitálka, there will be a huge impact on other development projects in the city and this district can become an inspiration for other cities, in Czech Republic and beyond. This would not be possible without the cooperation and exchange of experience between cities and other partners within the Ruggedised project."

Lukáš Grůza, project RUGGEDISED city manager

❖ GDAŃSK

In Gdańsk, before RUGGEDISED project started, the initial situation was recognized to be not so bad from the cooperation point of view.

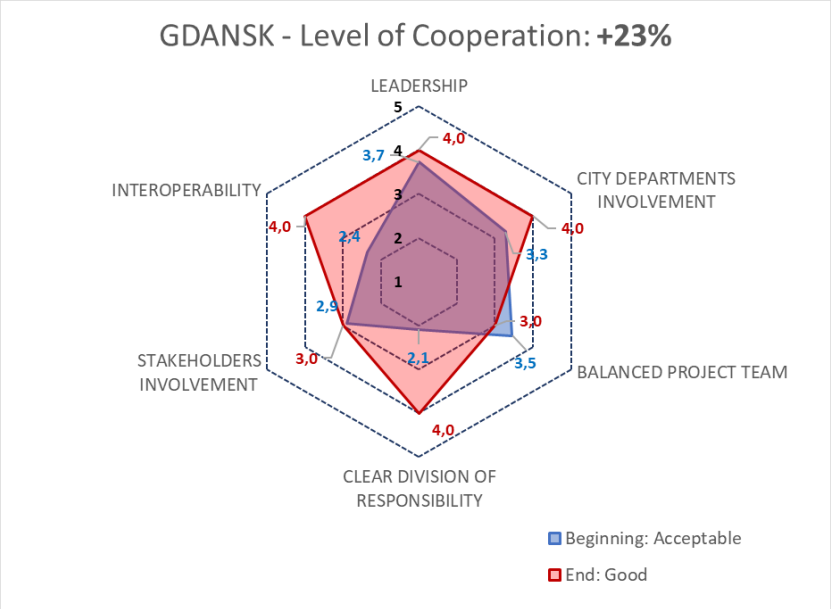

Figure 6: Increase of the level of cooperation in Gdańsk

The strongest point upon which Gdańsk could count was the robust leadership of the city that put a lot of efforts into attracting a wide range of stakeholders, including big companies, start-ups and NGO's. Already before the start of the project, Gdańsk secured partners such as Gdańsk Water Utilities and PICTEC to join the consortium. Moreover, since "Gdańsk 2030+" strategy was prepared, the city increased its interest and capacity to involve relevant stakeholders.
Before RUGGEDISED, the weakest points had been identified in a low engagement of other departments of the city beyond the three already collaborating (i.e. the Department for the Environment, IT Office the Energy Office) and in the need to involve more experts from the mobility and ICT sector, as well as from the energy and academic world.
Moreover, big problems had been identified in the division of responsibilities, often not so clear. High expectations on the project were placed on this regard as well as on the possibility to achieve, thanks to the local participatory process of WP7, of a greater stakeholders' involvement necessary to establish and maintain a long-term partnership. Significant progresses were expected also on interoperability, where the main challenge identified was in the low level of interaction and the presence of many data bases with overlapping information.

During these six years RUGGEDISED concretely contributed to several advancements. In particular, noticeable results have been achieved on the involvement of different city departments in the foresight process which facilitated the dialogue between sectors. This cooperation was encouraged also by the organization of the study visits to the Lighthouse Cities.
Roles and responsibilities of the project team involved in the foresight process towards the Smart City were clarified and well defined from the beginning, this helped also in the identification and engagement of stakeholders, whose role was crucial in the definition of the shared long-term vision of the city.
RUGGEDISED stimulated also advancements in the interoperability among systems and processes. Good cooperation between various departments has now improved thanks to the functioning of internal communication systems regarding electronic document management and financial matters. The exchange between departments is fast and effective now.
However, some difficulties arose in keeping the project team involved. Experts from various fields were engaged at different stages of the project implementation and, unfortunately, during the COVID pandemic, the intensity of meetings slightly decreased, and their replacement by online meetings was not entirely conducive to a wide exchange of experiences and cooperation. Another obstacle hindering cooperation is the office's silo structure, municipal executive units and municipal companies carrying out specific tasks are also separate, partially closed silos.

All in all, the activities undertaken under the RUGGEDISED project contributed to strengthening the organizational structure of the city towards smart governance. An important organizational change was the establishment of the Energy Office within the structures of the City of Gdańsk. The main tasks of this unit include conducting the city's energy policy and more efficiently respond to the challenges we face in connection with the increasingly perceptible climate crisis. The idea behind its establishment is to prepare the city to achieve goals consistent with the assumptions of the Green Deal. The appearance of the Energy Office in the city structures will contribute to better cooperation and coordination in the implementation of smart solutions in the field of energy efficiency and air protection.

In addition to that, thanks to the RUGGEDISED, Gdańsk had the opportunity to **gain knowledge** in different fields. Among the issues that have aroused special interest and in which tangible improvements are found, there are Foresight, Integrated Planning, Knowledge Sharing and Open Data. More technical themes have seen a minor but still visible improvement. In general, the knowledge sharing and capacity-building activities of WP7 have brought the level of capacity of Gdańsk's core team and expert group from "poor" to "acceptable" (Figure 7).

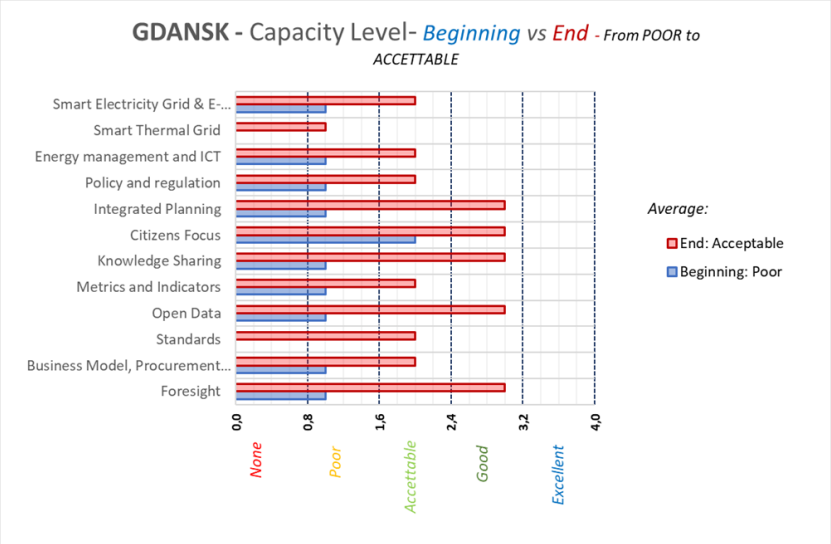

Figure 7: GDAŃSK's capacity level

As said, participation in the RUGGEDISED project contributed to the improvement in leadership and smart integrated planning. This was largely due to the participation of a well-planned and verified group of stakeholders in the Foresight process.

GDAŃSK experience:

"…Thanks to this project, we can learn from other people's mistakes. The partners loyally share their failures, successes and weaknesses of the tested solutions, thus saving us from trouble in the future. By taking part in the project, we show Gdańsk as a city open to modern solutions. Rotterdam is currently testing balanced energy management at the Ahoy exhibition and entertainment complex. For us, such a model place may be Amber Expo, Stadion Energa or selected office buildings in the future. In Gdańsk, we also have to think about what to do to achieve the maximum effect with a minimum of financial and energy expenditure. The point is not to add to the carbon dioxide emissions produced by CHP plants. We need to learn how to use the heat of municipal wastewater to provide air conditioning on hot days.

The same atypical source of energy can be used, for example, to heat pavements in winter. There is no need to sprinkle them with sand, let alone salt."

Joanna Tobolewicz, former plenipotentiary of the Mayor of Gdańsk for Energy

❖ **PARMA**

Before the start of project activities, the **level of cooperation** perceived was very low. The concept of integrated Smart City governance was not sufficiently considered in Parma before RUGGEDISED.

Initially, a clearly defined leadership directing and driving smart city initiatives and defining a city strategy in an integrated way was not in place. Moreover, activities of stakeholders' involvement were not adequately addressed.

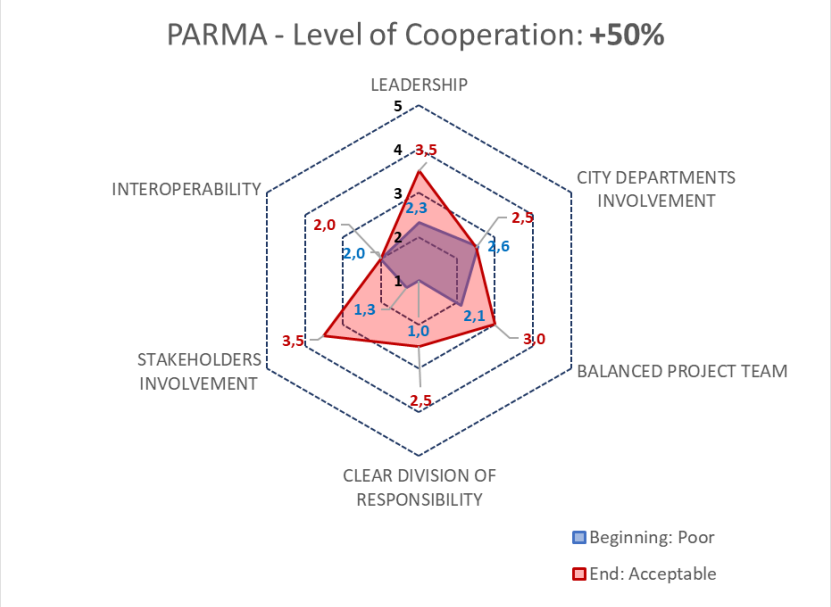

Figure 8: Increase of the level of cooperation in Parma

To date, thanks to the process undertaken over the past six years, there has been a marked improvement.
RUGGEDISED helped to establish a leadership and supported the realization of a structure that would guide the process even in the future.
Thanks to RUGGEDISED, a context of exchange and dialogue has been created. City stakeholders were deeply involved and are enthusiastic about being part of the smart city planning. The process was successful, Parma Futuro Smart turned out to be a great experiment, even though the length of the action and COVID pandemic didn't help to keep everyone motivated - and perhaps this last aspect could have been carried out in a better way.
Indeed, one of the areas that remains problematic is the involvement of the different city departments. This change in the silo-thinking approach, regrettably, didn't take place in the city of Parma and probably this was due to the fact that the decision level was not involved from the beginning, so it has been difficult to create synergies with other departments and, perhaps, roles and responsibilities were not always clear.
These aspects, along with the scarce level of interoperability, should be addressed with more attention by the municipality in the future. Nevertheless, the group directly involved in the process was perfectly able to keep up the momentum and pursue the initiatives in the best way and with tangible results.

According to the experts interviewed in Parma, there has been a visible improvement in the general **level of capacity** (from "poor" to "acceptable", see Figure 9). Thanks to the Replication Workshops, Study Visits and other occasions made possible within RUGGEDISED, topics such as Open Data, Knowledge Sharing, Policy and Regulation have been addressed allowing participants to increase their knowledge on them. Technical themes such as Smart Electricity Grids, Smart Thermal Grids, Energy Management and ICT have been explored in more than one occasion during the General Assemblies and this has contributed to spreading knowledge also on these vertical issues.
An evident leap was made on Foresight, an aspect the city had never worked on before the project. Here the sharing and experimentation of a method directly in the field have ensured that the core team and the expert group of Parma saw first-hand and got the chance to learn aspects very far from their daily work but essential for developing the Smart City. All this has been possible thanks to RUGGEDISED.

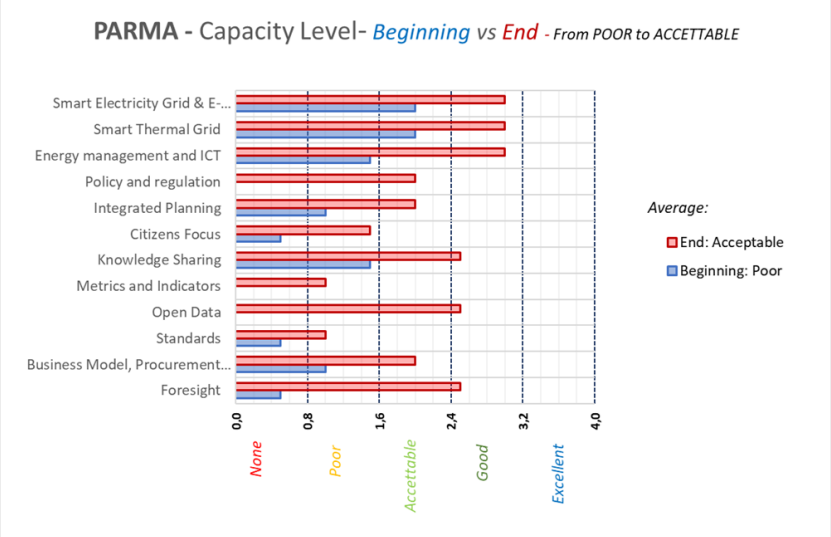

Figure 9: PARMA's capacity level

PARMA experience:

"After joining the project, the city of Parma has taken a step forward in terms of permanent involvement of stakeholders and local companies. Before RUGGEDISED, the dialogue with industrial partners was mainly institutional, while now, thanks to the project activities, a more participative approach has been adopted and this has been possible through the organization of workshops, round tables and other related events extended to a wider group of stakeholders and through the creation of a dedicated website (https://parmafuturosmart.comune.parma.it/en/).

RUGGEDISED determined and supported the set-up of a local governance able to guide and support the development of the Replication and Investment Plan of Parma."

Enzo Bertolotti, Energy Manager of Parma Municipality

3.2 Replication Assessment of the Lighthouse Smart Solutions in the Fellow Cities

The notion of "Replicability" is widely used in the context of Smart Cities and Urban development projects and, according to literature[7], it refers to the possibility of applying the same solution implemented in a city to a different context with the aim to achieve the same objective. More broadly, replication can be defined as the application of a successful model, approach, strategy, technology, product or policy in another location, even completely different. In this regard, it is important to specify that "application" is not intended as the exact copy of the same product/solution/etc. in other contexts but should rather be understood as its adaptation to a different environment.

The same study points out that assessing the replication potential of Smart Solutions, or more in general of urban solutions, is complex and an exclusive focus on technical aspects is not sufficient to guarantee the effectiveness of replication. It is for these reasons that, beyond the technological dimension, socio-cultural as well as environmental, legal, institutional and economic aspects must be taken into account.

Within RUGGEDISED, the replication potential of the Smart Solutions implemented in the Lighthouse Cities has been assessed, taking into account both factors that inherently characterize every solution as well as the context-dependent factors that are proper of the cities where we want to estimate its replication potential, i.e. the Fellow Cities of RUGGEDISED.

This analysis has been carried out through a new methodology developed by ISINNOVA: SITEE©

3.2.1 The methodology in a nutshell[8]

Based on the assumptions explained above, ISINNOVA has developed a decision support tool able to determine the replication potential of different urban solutions in a specific place, taking into account the full range of local factors that could influence their applicability, with the ambition to support cities in the selection of the most suitable solutions for their local context.

The approach is based on the analysis of 5 dimensions: **S**ociocultural; **I**nstitutional; **T**echnological; **E**nvironmental and **E**conomic – **SITEE replicability tool**.

[7] EC DG ENERGY, *Analysing the potential for widescale roll out of integrated Smart Cities and Communities solutions*, June 2016

[8] Paolucci L. "Estimating the Replication Potential of Urban Solutions for Socially Integrative Cities", Chapter 14 from the book "*Towards Socially Integrative Cities*", Muller B. et al

SITEE relies on a mathematical approach that can be easily represented through cartesian diagrams built on variables dependent on:

- factors that characterize the solution itself (horizontal axis)
- factors that are inherent to the local context (vertical axis).

According to those variables, every solution can be represented as a point in the diagram (See Figure 10).
The correlation with the replication potential, expressed on a scale 0-100%, is given by the intersection between the points representing the solutions and the "iso-replicability" lines (diagonal lines with constant value of replication - see Figure 10).

In SITEE, different Solution and Context variables are associated to every dimension (Table 2) and the general approach explained above is likewise applied to each of them.

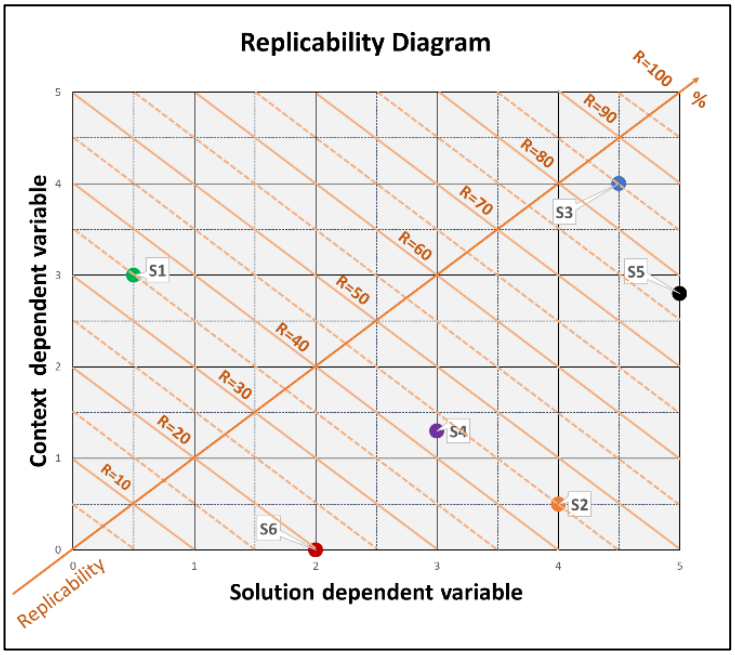

Figure 10: Replicability Diagram

Table 2: Solution and Context variables in SITEE

SITEE Dimension	SOLUTION Variables (LIGHTHOUSE CITIES)	CONTEXT Variables (FELLOW CITIES)
Socio-cultural	• User Interaction Independence	• Population Acceptance • Responsiveness to population needs
Institutional	• Public-Private Cooperation	• Responsiveness to institutional priorities • Responsiveness to institutional needs
Technological	• TRL[9] (or SRL[10]) • Interoperability/Standardization Level	• Interest from Research/Industry/Private sectors to invest • Integrability in the existing infrastructure (hardware/software)
Environmental	• $CO2_{eq}$ reduction	• Legal viability
Economic	• Investment Costs • Operation Costs • Revenues/Savings *If those above are not available, qualitative assessment of "Cost-Effectiveness"*	• Affordability of the solution by the city

The Context Variables can be informed through questionnaires addressed to institutions, stakeholders, citizens from the city targeted for replication, while the Solution Variables should be elicited from the industrial/private entities and local administrations who implemented the solutions or, alternatively, can be obtained through desk research activities and experts' estimations.
Once all variables are collected, a Replicability Diagram can be obtained for each dimension and the five values of replication obtained are then averaged to estimate the ***Overall Replication Potential*** of the selected smart solutions in the specific context under assessment (e.g. city, district, etc.) (Figure 11 and Figure 12).

[9] Technology Readiness Level

[10] Solution Readiness Level

Figure 11: SITEE expected results – Overall Replicability Potential

	Socio-Cultural Replication	Institutional Replication	Technological Replication	Environmental Replication	Economic Replication	Overall Replication Potential
Solution 1	?	?	?	?	?	?
Solution 2	?	?	?	?	?	?
Solution 3	?	?	?	?	?	?
Solution 4	?	?	?	?	?	?
Solution 5	?	?	?	?	?	?
Solution 6	?	?	?	?	?	?

Figure 12: Solutions Ranking in City X

This multi-dimensional assessment allows for the identification of the most relevant factors that may limit or facilitate replication, **supporting other EU cities** in the selection of those urban solutions that could be best replicated according to the socio-cultural, institutional, technological, environmental and economic aspects proper of their local context.

In RUGGEDISED, SITEE has been applied to estimate the replication potential of the Lighthouse Smart Solutions in the three Fellow Cities.
The activities carried out in this analysis provided for:

- preparation and distribution of the questionnaires for collecting:
  - the *Solution Variables* from the Lighthouse Cities (see the questionnaire in Annex I)
  - the *Context Variables* from the Fellow Cities (see questionnaire in Annex II)
- running of the tool: the *Solution Variables* estimated by the experts from the Lighthouse Cities have been combined with the responses received to the questionnaires on *Context Variables* distributed to the Fellow Cities which were asked to evaluate the Smart Solutions in relation to different factors related to their local context: responsiveness to population's needs and citizens acceptance; priority level in the city plans; level of integrability of the technology in the city environment and interest in the technology from research, industry and private sector; legal viability and economic affordability.
- elaboration and analysis of results: see the next paragraph.

It's important to note that, while the Solution Variables give a measure of how a solution is inherently replicable independently from where it would be implemented, the Context Variables determine how easily this could be replicated in a certain context. This combined analysis makes it possible to identify the solutions with a considerable replication potential that, therefore, could be adopted and implemented in a specific city with a certain ease and without encountering major barriers.
In the following paragraphs, the results of the Replication assessments are summed up.

3.2.1 Results

This paragraph reports the results calculated by the tool and provides an in-depth analysis of the reasons why some solutions resulted more (or less) replicable than others.
For the sake of brevity, we have not gone into the details of each single solution but only the most relevant cases are reported here.

Since part of the information requested in the questionnaires of the Solution Variables is qualitative -therefore subject to the perception of the expert who was questioned who could use different scales of values from other experts of a similar solution installed in another city - the analysis is carried out separately for the solutions of each Lighthouse as it would not be fair to make a comparison between them.

Replication Potential of ROTTERDAM's Smart Solutions in the Fellow Cities

The table below shows the Replication Potential values obtained for the Rotterdam's solutions in the three Fellow Cities.
The most replicable solutions are highlighted in green, while those with the lowest potential are in red.
The values are between 40% and 72%, therefore it is not a very large interval, and this indicates that there are no perfectly replicable solutions, nor completely impractical solutions among those proposed by Rotterdam in RUGGEDISED.
The graphs in Figure 13 show the rankings obtained for each fellow city more clearly, while Figure 14 shows the scores obtained for each of the SITEE's dimension.

Table 3: Replication Potential of Rotterdam Smart Solutions in the Fellow Cities

ROTTERDAM's SMART SOLUTIONS	BRNO		GDAŃSK		PARMA	
	Rank	RP	Rank	RP	Rank	RP
R1 - Geothermal H/C	7	50%	7	47%	6	45%
R2- Thermal Energy from Waste	3	61%	3	59%	8	40%
R4 - Thermal energy from asphaltic pavements	5	58%	6	51%	7	41%
R7 - E-busses optimization	8	49%	4	59%	4	55%
R8 - Energy Management System	6	54%	5	52%	2	61%
R9 - 3-D city operations model	4	58%	2	63%	1	63%
R11 - Smart Street lighting	1	72%	1	67%	3	61%
R13 - Smart Waste Management	2	62%	1	67%	5	51%

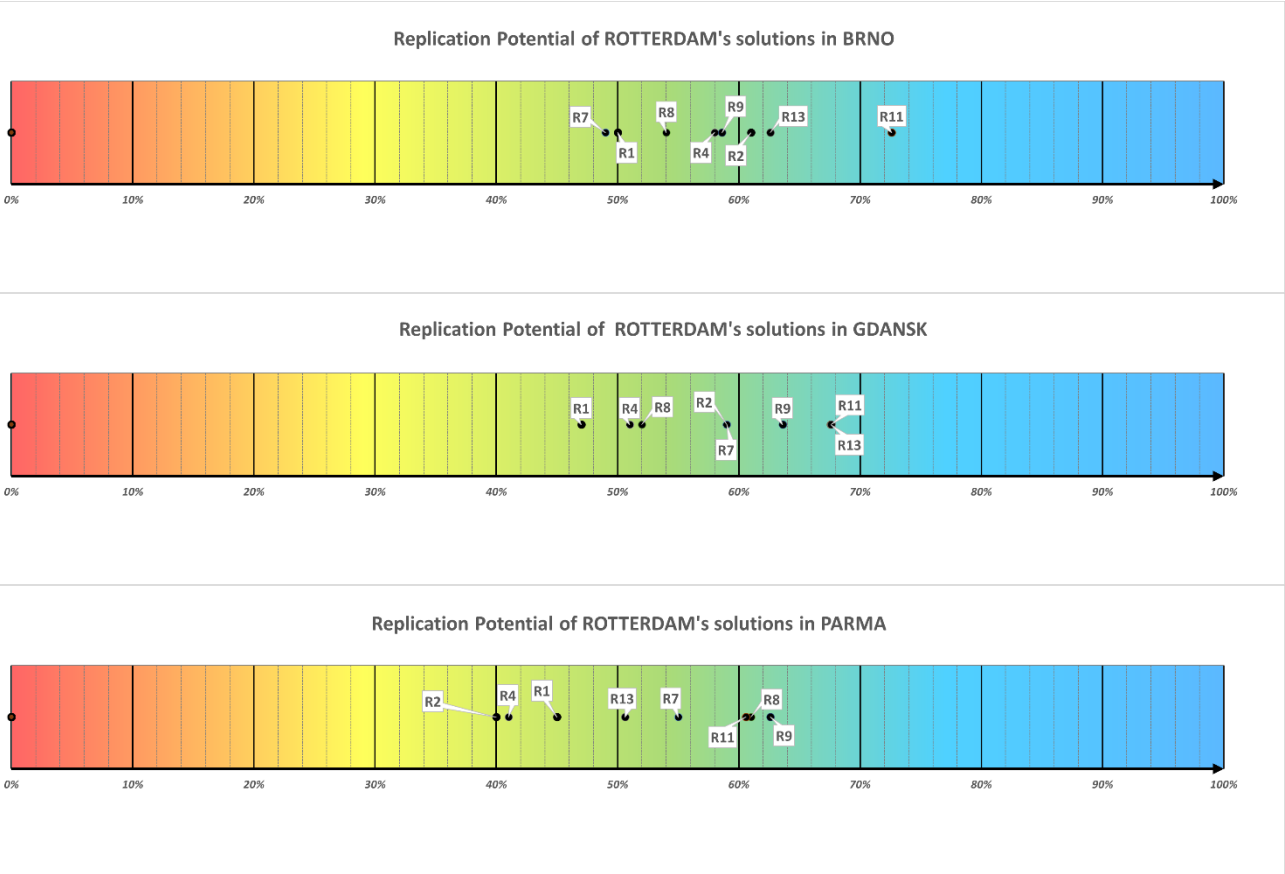

Figure 13: Replication Ranking of ROTTERDAM's Smart Solutions in BRNO, GDAŃSK and PARMA

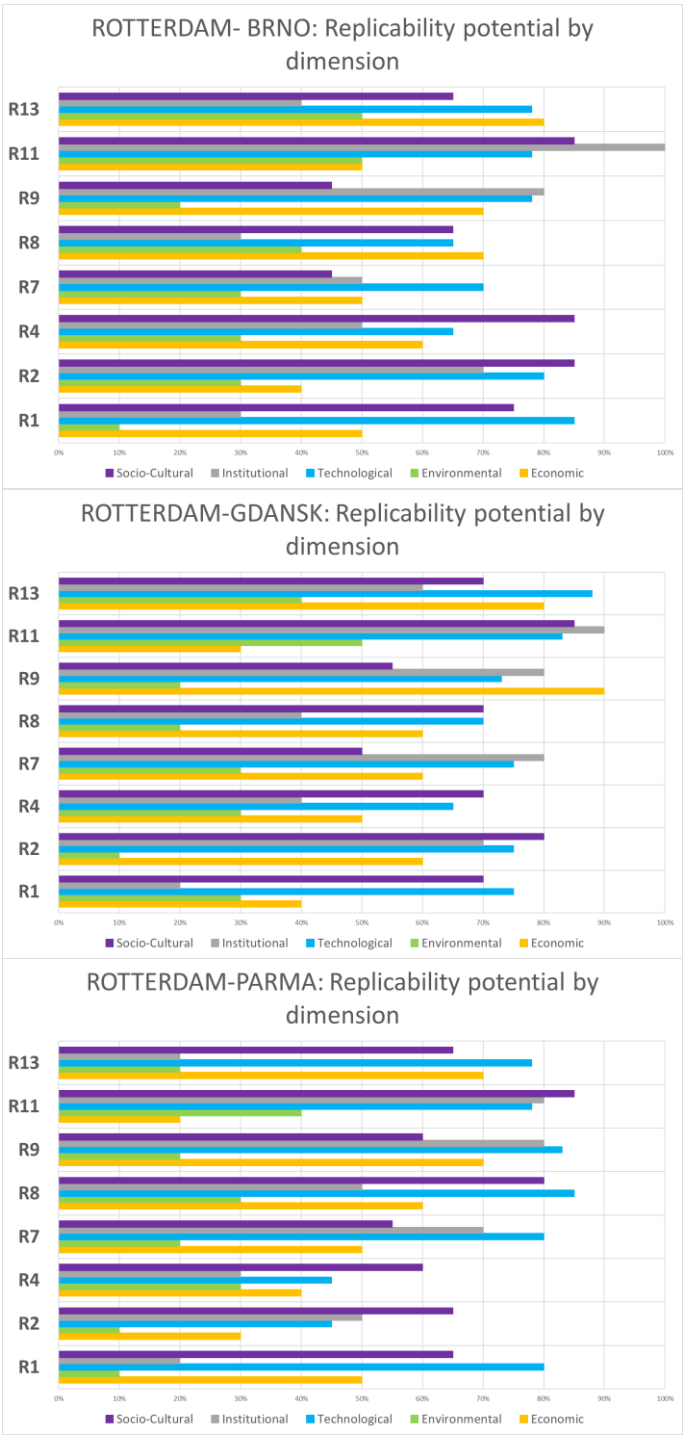

Figure 14: Replication Potential of Rotterdam's Smart Solutions by dimension

As is evident from the ranking above, the most replicable solution for both Brno (RP 72%) and Gdańsk (RPI 67% on a par with R13) is **R11 - "Smart Street lighting".**
Smart Street lighting has been implemented in the Heart of South area in Rotterdam. The objective of this solution is the reduction of energy use for street lighting as well as the usage of data that can be gathered from light poles. For this solution, street lighting has been used in relation to the real-time needs of pedestrians and vehicles that use public roads. LED lights and modern sensor

The Smart Street Lighting in Rotterdam (R11) is the most replicable solution in Brno and Gdańsk

technology have been used to lower energy demand by adjusting lighting intensities in relation to the real-time needs of passers-by. Furthermore, commercial parties have been allowed to put sensors on the lamp posts.

The reasons behind this result are different.

First of all, the solution has a high potential for replication from the socio-cultural point of view. The **Socio-cultural Replicability** is assumed to be dependent on the degree of interaction of the solution with citizens, intended as the final users and beneficiaries of the solution. A solution that does not require any active role from the population is more likely not to encounter any cultural roll-out barriers. In other words, the higher the level of interaction required, the higher the chance of facing risks in the replication of the solution.
In this case, R11 does not require any active interaction from the user, who is just a beneficiary of the technology: lighting goes on when the user is approaching.
Furthermore, the social acceptance of the solution as well as the extent to which it responds to the population needs represent two further important factors affecting replicability.
In Brno, this solution is very well received and supported by the public, and the municipality has already in its plan to develop an intelligent LED streetlight system.

The same applies to Gdańsk, where the "Brighter Gdańsk" program has been implemented for several years, divided into several stages. In the first - in 2016-2017 - 38 locations were illuminated. The second stage, implemented in 2017-2018, included another 58 locations. In 2016-2018, a total of approx. 36 km of streets and pedestrian routes were illuminated. The works under the next stages will be completed by 2025 and will cover over 400 locations. At the same time, the modernization of lamps and the transition to LED are carried out. These activities are accepted and supported by residents.

Moreover, **Institutional Replicability** resulted to be high for R11. The institutional dimension encompasses all those aspects related to the administrative and regulatory framework, also taking into account any political priority that can stem, for example, from a medium–long-term city strategy. These aspects must not be confused with financial support from public resources, which is equally important but not the objective of this specific analysis. Therefore, along with a favourable socio-cultural framework, a supportive institutional context is a crucial driver that cannot be overlooked to ensure the successful implementation of a solution. Additionally, the deployment of urban solutions, especially if complex, requires a firmer engagement of both the public and private sectors. The more this cooperation takes place, the more replication is likely to be successful.
The Smart Steet Lighting of Rotterdam is the result of Public-Private cooperation (50%-50%) and this influenced the high potential for Institutional Replicability.
In Brno, the installation of LED lights is supported by the public administration. This is an ongoing project and there are currently more than 40,000 lighting points on Brno streets. Some of them are already equipped with modern LED luminaires, automation elements or motion sensors, and the number of such upgraded points is increasing year by year.
In Gdańsk, this solution is considered a high priority. The city's policy is aimed at the possible reduction of energy consumption while maintaining the standards of urban lighting or even improving them thanks to the use of new technologies, incl. LED.

From the technological point of view, one of the limiting factors for the large-scale deployment of a device is related to interoperability issues. Interoperability is defined as “the ability of a system to work with other systems by providing services to and accepting services from other systems and to use the services so exchanged to enable them to operate effectively together” (ISO/TS 37151). This concept applies both to the technology behind the solution itself as well as to the context, which should be prepared to “receive” the solution.

The solution adopted by Rotterdam relies on technologies (hardware and software) already widely spread and highly standardized, and this, together with the high TRL (TRL8), played a major role in favour of **Technological Replicability**.
Furthermore, both in Brno and Gdańsk the local infrastructure is ready to integrate such solution and there are no major hurdles from the technological point of view.
However, as previously mentioned, the technological challenge is hardly ever the main barrier to the replication of an urban solution. This is even more true when the presence of a "city ecosystem" able to facilitate the deployment of projects that have been successful in another location is deeply rooted. In other terms, when industry, academia, institutional players, private businesses, etc., collaborate and act as interfaces between the projects and the social, institutional, environmental and economic contexts, they significantly contribute to the creation of the right conditions to effectively introduce, kickstart and foster the development of a specific technology.
In this regard, the interest from the industry, research and private sector to invest in this solution has proved to be moderate-high, and that was a point in favour of the replication of this solution in these two Fellow Cities.

Environmental Replicability is another dimension assessed through SITEE. Environmental variables often play an important role in this type of project and constitute a crucial factor that influences decisions and might determine the choice of one solution over another. Thus, comparing the environmental impacts of several (even similar) solutions can have great leverage on potential replication and contributes to facilitating the prioritization process.
It is estimated that this solution should lead to a city-wide reduction in the use of energy of around 50 to 70%, which is a quite high saving.
Environmental impacts aside, the regulatory constraints that a city is bound to respect must also be considered along with any other constraint that may hinder the implementation of a solution in a specific area of the city or limit its cases in compliance with the local laws and regulations in force.
From this point of view, this type of solution is not so hard to implement in any of the Fellow Cities, which confirmed that it does not require particular efforts in obtaining permits.

Finally, there is no need to emphasize how economic aspects are key and decisive elements for the selection of the best solutions to replicate, especially for the city administration interests as well as from the major industry players and private investor perspectives.
A project with a positive business model that, concurrently, does not entail major obstacles from the regulatory and technological points of view and, in addition, brings environmental benefits while responding to the main needs of the population and institutions, is undoubtedly the perfect example of a solution to be replicated.
SITEE's **Economic Replicability** analysis is based on the net present value (NPV) method which is a valid tool for the assessment of the profitability of projected investments. It must be made clear that SITEE is not designed to carry out a detailed cost-benefit analysis, as it rather aims at providing a credible estimate of the economic worthiness of the individual solutions. A specific and targeted study is, therefore, necessary to evaluate the cost-effectiveness case by case.
In the exercise carried out in RUGGEDISED, economic data were not always available, thus an adaptation was needed, and a more qualitative approach has been adopted. Accordingly, Lighthouse Smart Solutions' experts were asked to provide an estimation on the cost-efficiency level of the solution (on a qualitative scale 0-5).
Considering a monetary savings of € 12 million for the city of Rotterdam with the implementation of this solution, the level of cost-efficiency established for R11 is "quite good".
This information is then combined with the Context Variable provided by the Fellow Cities: i.e., the extent to which the implementation of the solution would be affordable for the city.
In this regard, the city of Brno states that the ROI is very good for the installation of LED lights, and this justifies very well the initial investment. However, this is not enough for the city of Gdańsk,

whereby the Economic Replicability value is lower than in the case of Brno, as they confirmed to be able to carry on this initiative depending on whether EU funds are obtained.

Rotterdam 3-D city operations model is the most replicable solution in Parma

The Rotterdam solution found to be more replicable for the city of **Parma** is the **3-D city operations model (R9, RP 63%).**
Thanks to this solution, data on the energy use of the buildings, provided by the energy management system, are matched and transferred into a new 3-D city operations platform.
This platform discloses and visualises actual use of energy as well as use over a period of time (by individual buildings as well as the whole area). The 3-D model is connected to the platform, and together with real-time data it forms a 3-D Digital Twin of the city.
This forms the basis for further innovation by making data available for everyone.
The high value of replicability for Parma is due to different factors, both solution's inherent and context dependent.
The Socio-Cultural replicability levels are quite high as the solution requires a low-moderate interaction from the user who could query the system to get information. Moreover, this solution is considered useful for the population of Parma and would be well accepted both by citizens and by the administration, as end users of the services.

In Rotterdam, this solution was the results of a Public-Private cooperation. In the first stage, the municipality was in the lead (75%-25%), but, in the later phases, companies took over as much as possible (25%-75%).
As said, cooperative projects involving both the municipality and local private companies generate favourable conditions for replicability. This contributed to the high level of Institutional Replicability that was enhanced in Parma by the fact that this solution is among the top priorities.

Moreover, thanks to the assessment performed it resulted that the 3-D city platform has one of the highest levels of Technological Replicability. At the moment, the Technological Readiness Level is not that advanced yet (TRL6): a proof of concept and a prototype of the Open Urban Platform has been developed and Rotterdam is now preparing the development of a Minimal Viable Product that will be the first implementation of a minimal form of the platform in the "real world". Nonetheless, the philosophy of the development of the platform is based upon data interoperability and on the use of open data standards. This aspect elevates the intrinsic value of technological replicability.
At the same time, it must be taken into account the high interest to invest in the technology from the industrial, private and research players in Parma along with the fact that similar systems have been already developed by other Italian cities.
For what concerns environmental dimension, it can be predicted that digitalization will have an impact on the current (physical) workflows, and thus will help reducing CO2-emissions. On the other hand, digitalization itself generates CO2-emissions, thus, what the estimated net-outcome of this will be, is not determined. In connection with this, Environmental Replicability is not that high, even though there wouldn't be major difficulties in the regulatory procedures to proceed with this solution in the city of Parma.
Economic Replicability is the highest among the solutions implemented in Rotterdam. It has been considered a very cost-efficient solutions as it is estimated that the possible gains are quite high for the use of an open urban platform with 3-D Digital Twin, although there is no hard evidence for this so far. Moreover, the city of Parma states that this solution would be possibly affordable with a combination of own municipal funds, PPP and EU funds.

Smart Waste management (R13) is very promising for Gdańsk but less replicable

On a par with R11, also the Rotterdam solution on **Smart Waste Management (R13)** turned out to be particularly promising and easily **replicable for the city of Gdańsk** (RP 67%).
The objective of this solution is to lower the energy consumption of waste collection vehicles by monitoring their degree of filling and optimising the route of the collection trucks. Sensors are installed at waste facilities to measure the filling percentage and indicate when the container has

reached its maximum fill level - or when it has been emptied. Data are communicated through a network to a centralised management system and transferred to the data hub of the 3-D city model (R9).
The Socio-Cultural Replicability resulted to be medium-high. Low interaction is required from citizens who use the waste bins like any other waste bin and there is no extra interaction necessary for the proper use of them. However, it must be considered the high interaction required from the maintenance department of the city. The waste bins collect data of degree of filling, and this is translated into a driving route for the waste collection lorries drivers. The drivers make use of a tablet with the most efficient route for that day. Considering both these aspects, the level of interaction has been considered medium.
Moreover, this solution responds very well to the need of the population of Gdańsk who would not be against the implementation of this service.

for Brno and Parma.

In addition to that, one of Gdańsk's priorities for the coming years is to continue implementing effective solutions for responsible waste management. According to European Union regulations, by 2035, 65% of municipal waste is to be recycled, and no more than 10% of this waste may end up in landfills. This presents the city of Gdańsk with two key challenges: improving the quality of the separate collection of waste in homes and finding a way to optimally manage non-recyclable or reusable waste. Currently, the city's most important priority in the field of waste management is the construction of the municipal waste incineration plant that will support this challenge and achieve the goals related to the circular economy. The installation, which is to be completed by the end of 2023, will enable the thermal transformation of the most burdensome municipal waste, additionally recovering and returning the energy contained in it to the environment. The city is also looking for other pro-ecological ways of waste management, and this is one of the city's most important priorities. All these aspects contribute to increase the Institutional Replicability of R13 in the city of Gdańsk.

Technological Replicability is also very high (among the highest values ever). The hardware and software used for this solution are standardized and applicable to other cities and places (TRL8-9), and to this intrinsic feature of the solution is added the high interest of the research and industry world of Gdańsk to invest in the technology.

Not very high, although better than many other solutions, is the Environmental Replicability.
Thanks to this solution it is expected a reduction of 20% in the mileage of waste trucks that will run to collect waste from 5 days to 3 days per week, from 10 routes per week to 6. This translates into a reduction of CO_2 emissions produced by the city. In the city of Gdańsk, it is expected that this kind of waste management projects can be implemented without very time-consuming process, and this corroborates the high values of replicability.

Regarding cost reductions, it was calculated that scaling up the technology to all underground containers in Rotterdam could potentially save the Municipality 1.37 million euro per year (25% reduction of the costs for personnel and equipment). Thus, it is a very cost-efficient solution with an attractive business model for other cities. In the case of Gdańsk, the success of waste management projects depends on private sector involvement and external funding opportunities that could make it affordable for the municipality. Due to both these aspects, the final value of Economic Replicability is medium-high in Gdańsk.

It is interesting to see how this same solution has a much lower potential in the city of Parma (RP 51%), placing itself in the middle of the ranking. This proves how the presence of a favourable context, as in the case of Gdańsk, makes a difference in this type of analysis.

Rotterdam's least replicable solutions in the three Fellow Cities

As done for the most replicable solutions, it is interesting to see what are the reasons that make a solution not very applicable in a given context.

The least replicable solution to the **Brno** context is **R7 - E-busses optimization (RP 49%).**
The objective of this solution is the large-scale deployment of zero emission e-buses in Rotterdam. This solution includes developing and implementing a software to effectively plan a bus fleet with a large number of e-buses, diesel buses and special vehicles like hydrogen buses. A DC network is also installed to connect solar panels with a battery and charging point for buses.
The inclusion of electric buses in the city fleet would be very well received by Brno population, especially for reasons of noise and emission reduction.
However, the transition from conventional diesel buses toward battery powered electric buses is a process not yet started in Brno and not among the priorities of the administration yet, even though would be supported in a wider perspective.
Moreover, it should be considered that a massive expansion of the electric bus fleet would require a relatively significant investment in the current infrastructure. Currently the city of Brno does not have an infrastructure that could support this solution, and this is a crucial aspect negatively affecting replicability.
At the same time, the replicability of this solution in the other Fellow cities was not so low (mid-ranking) as both Gdańsk and Parma consider these options of primary importance for their cities. In particular, the Gdańsk Buses and Trams Company announced a tender for the supply of 18 electric city buses, including 10 standard buses and 8 articulated buses. The Gdańsk fleet is to be supplied with new vehicles in 2023. The buses selected in the tender are to have the greatest possible range and the greatest possible battery capacity.
Parma also is looking at more sustainable and zero-impact vehicles to be introduced in urban areas. Moreover, there is a high interest from industry and private sector in the possibility of integrating the production of electricity from photovoltaic panels with charging points in the bus stations. In addition, the procedures to implement the solution are not particularly complex even though should be developed in collaboration with the utility company managing the grid, and the local LPT company. Nonetheless, all that isn't enough motivation to make this solution highly replicable like the others described above, and this is because the Solution Variables here have a non-negligible weight and bring down the replicability values.
Indeed, this specific solution is not fully mature from the technological point of view (TRL7). Electric buses operate in real world environment, but the solution is still in the early stage, not yet fully interoperable. Another aspect is economic related: driving electric buses is as cost efficient as diesels, if comparing the Total Cost of Ownership. However, if also the investments in the charging infrastructure are kept in the calculations, the deployment of battery electric buses is up to 20% more expensive.

For the city of **Gdańsk**, the solution with the lowest replication potential is **R1- Geothermal heat-cold storage and heat pumps** (RP 47%).
The purpose of this solution is to enable local heat-cold exchange, to maximise the use of waste heat-cold through geothermal storage and lower the total cost of ownership.
All buildings are connected by a low-temperature grid and each building will get a heat pump to provide it with the heat it needs. The waste heat of the condenser is fed back into the heat-cold geothermal storage. High-temperature cooling is provided directly from the smart geothermal grid.
Although this solution presents quite promising characteristics from the solution and technology point of view (i.e., medium-low interaction with the end user, TRL9, high technological interoperability…), for the city of Gdańsk, many barriers have been identified to the potential implementation of this solution. First of all, it is not among the main needs of the population even though it is believed that it would be probably accepted by the people living there. Moreover, it has low priority in the city administration's strategy.

In addition, the factor that goes most against a possible replication of this solution is the fact that the project wouldn't be easily integrable with the existing city infrastructures, and it is recognised that it would be a technically and organisationally complicated work and permitting procedures could be really difficult. Not to mention the costs that that makes it not affordable without external resources.

Finally, for the city of **Parma**, the less viable solution is the **production of thermal energy from waste streams** (R2, with RP 40%).
In addition to thermal storage and heat pumps in solution R1 (see description above), other thermal waste streams are used by making further connections to the Smart Thermal Grid: the district sewage water from nearby households can be used to extract heat or cold for use by the grid. Depending on the need, it can be used directly or stored to refill storage and create a thermal balance.
This solution in itself has promising characteristics in favour of a good replication, as far as socio-cultural, institutional and environmental aspects are concerned. In particular:

- no interaction from the user is required, indeed both the collector for the waste streams and surface water are placed where no user is involved: the basin of a pumping station and under water.
- Good level of public-private cooperation (60%-40%). The municipality is leading the project, with co-operation from Eneco and from both partners subcontractors are involved in the engineering and installation of the work.
- The TRL is high (TRL8) and also interoperability is good. Energy from waste streams is mostly installed inside sewage piping and there are several companies across Europe familiar with this technology. So, there's a high level of standard systems available.

However, in this case, the Context variables have a strong impact on replicability. For Parma, there is no interest in implementing such a solution, which is considered unhelpful and unneeded by the population, with low if not almost no priority within the city's strategy. Hardly practicable from the bureaucratic point of view and the permits to be obtained, it appears it wouldn't arouse any interest from the research and industry world in this specific technology.
Anyway, the overall replication potential is not that low (RP 40%) and this is justified by the fact that in any case, it is a solution that would have a certain potential to be applied but that - in the absence of a context capable of accepting and integrating it, of a political will as well as of an evident need from the population - finds less fertile ground for replication.

Replication Potential of Umeå's Smart Solutions

As for the Rotterdam's solutions, we proceeded in the same way with those of Umeå - and subsequently with Glasgow.
Therefore, in Table 4 it is possible to consult the Replication Potential values calculated by the tool, the graphs in Figure 15 show the ranking on a 0-100% scale, while the diagrams in **Figure 16**Figure 16 highlight the scores obtained for each dimension.
Compared to Rotterdam's, with Umeå's solutions the range is a little wider with values ranging from 31% to 74%. These differences are evident and can be reflected in the arguments well explained below.

Table 4: Replication Potential of Umeå's Smart Solutions in the Fellow Cities

UMEÅ's SMART SOLUTIONS	BRNO		GDAŃSK		PARMA	
	Rank	RP	Rank	RP	Rank	RP
U1+U3 - 100% RES + geothermal H/C	8	32%	8	31%	8	33%
U2 -Peak Load Management	4	58%	7	43%	3	61%
U4 – Gamification (Intelligent building control)	9	31%	7	43%	7	45%
U4b - Intelligent Building Control	2	61%	4	58%	2	62%
U5 - Climate-friendly bus stop	7	45%	6	53%	5	55%
U6 - E-charging Hub & charging infrastructure	3	58%	3	59%	1	63%

U7 - Flexible Green Parking Pay-Off	6	51%	5	56%	6	52%
U8 - Smart City open-data decision platform	1	74%	1	67%	4	58%
U9 - Demand Side Management	5	56%	2	63%	5	55%

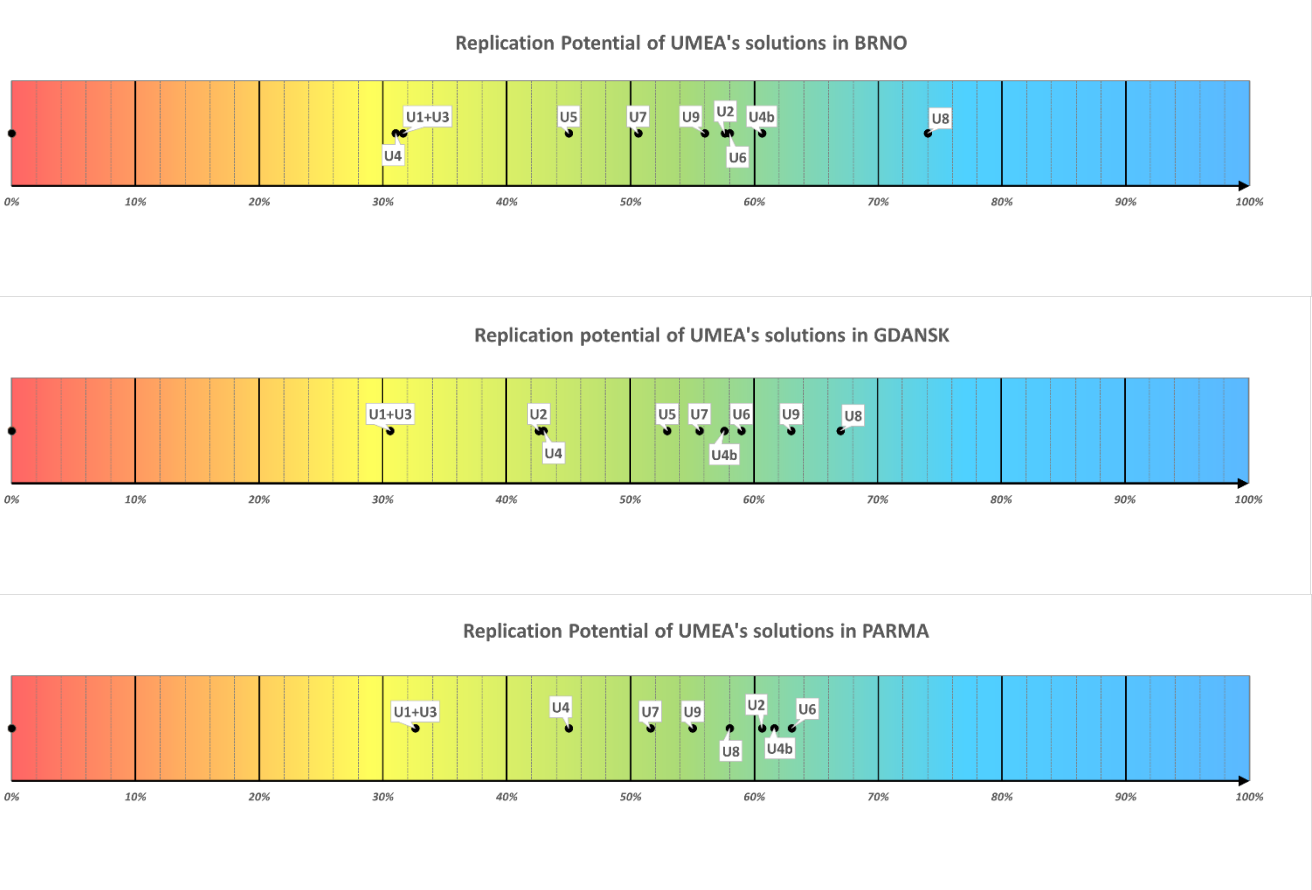

Figure 15: Replication Ranking of UMEÅ's Smart Solutions in BRNO, GDAŃSK and PARMA

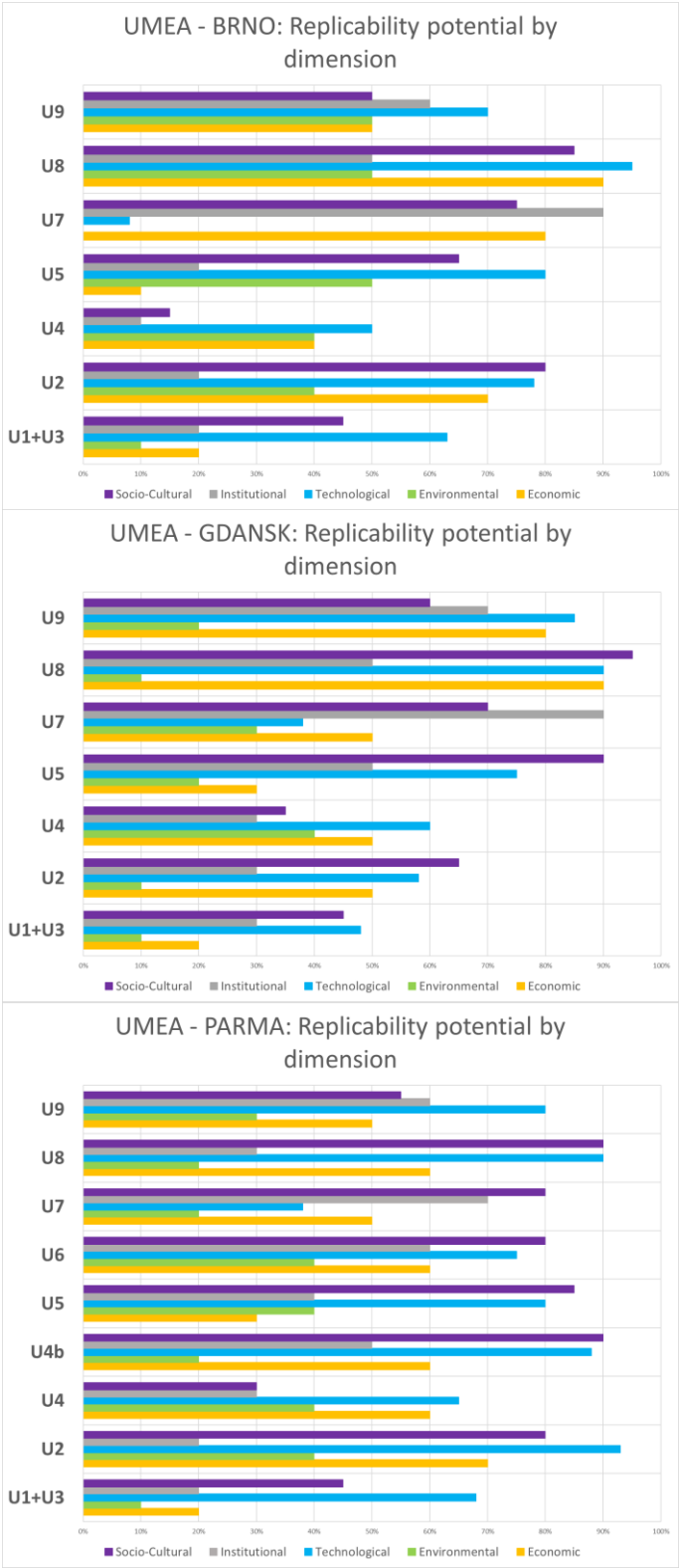

Figure 16: Replication Potential of Umeå's Smart Solutions by dimension

Umeå's **Smart City open data decision platform (U8)** turned out to be the solution with the highest replication potential for the city of **Brno** - with RP 74% - and for **Gdańsk** - RP 67%. This result does not surprise as both the Fellow Cities have already started working on this front.

Umeå's Smart City open data decision platform (U8) is the most replicable in Brno and in Gdańsk

Beyond this, it must be said that the solution itself has characteristics that facilitate its replication.
From a socio-cultural point of view, the solution does not present major obstacles as it does not require any interaction with the end user to work correctly, not going to affect the success of the replication. In both Brno and Gdańsk, this solution would be widely accepted by the public who recognize its usefulness. Furthermore, it must be said that it is an important tool for ensuring the transparency of the activities of local government authorities and communication between the local government and residents.
As for Gdańsk, an open data platform (Open Gdańsk) has been operating on the official webpage of the municipality (www.Gdańsk.pl) for several years. The data are published, among others about city finances, public transport timetables, demographics etc.
In Brno, the Open Data Platform is an ongoing project and has a high priority for the current city administration. This is reflected in the considerable Institutional Replicability.
Same thing for Gdańsk, for which the open data project is an important priority for the local authorities because it serves to ensure the transparency of local government activities, especially in terms of finance, and also serves to communicate with various groups of stakeholders and residents[11].
From the technological point of view, this solution is highly interoperable, having also maximum TRL (TRL9). In particular, in Umeå, they have not built their platform, but they bought a "service" for this. Data can be harvested from other systems by using an API, or by uploading files to the platform. This same service is used in many other cities, and also by companies, hence Umeå's experts deem it that this solution has *Global Solution Readiness*. This aspect can only go to favour the integration of the solution in the local contexts of Brno and Gdańsk which also declare the presence of a favourable environment to invest in this solution. Just as they confirm there are no bureaucratic and economic barriers for its implementation.

Among Umeå's solutions, the one resulted as most replicable for **Parma** is **U6 - E-charging hub & charging infrastructure** (RP 63%).
This solution consists of a charging hub for e-vehicles that serves e-bikes, e-cars and promotes car-sharing. The main goal is to even out power consumption and find an optimal distribution between building loads, battery storage and solar panels. As e-vehicle charging can increase strain on the power system, different batteries and storage solutions - within this solution as well as a smart power control management system, including a dynamic payment system for charging - have been tested. The integration of small-scale photovoltaic (PV) installation within the overall system and the upscaling of battery storage has also been carried out.
From the socio-cultural replicability side, the hub is promising as very low interaction is required by end users, moreover the built-in control function has been implemented with the intention that the tenants do not notice any changes. This aspect is combined with the fact that, in Parma, this solution substantially responds to a pressing need of the population who is also aware of this kind of system and would accept it without major problems.
Institutional replicability is medium high. E-Mobility is one of the priorities of Parma and is integrated in all the strategic documents (SECAP, SUMP, etc.), nevertheless the value of institutional replicability is pulled down by the extent of the Public-Private involvement that for the business model adopted by U6 is quite unbalanced: 80%-20%. As previously said, the highest is the balance between public and private involvement, the highest is replicability.
The technological replicability is rather high. Despite the solution having a not very high TRL (TRL7) and a low level of interoperability, it seems it would not present major problems to integrating it into the city infrastructure of Parma, moreover the industry and the academy, as well as different private entities have a high interest in investing in such solutions.

In Parma the most replicable solution of Umeå is E-charging hub & charging infrastructure (U6)

[11] https://www.gdansk.pl/otwarte-dane

On the environmental side, CO2 reduction is not that bad, around 19%, while it seems that no major difficulties and time-consuming procedures are foreseen by Parma in obtaining permits or the license for implementing the solution, whose implementation would be easily viable in this sense.
Medium-high is also Economic Replicability. It is estimated that this solution would be neutral from the economic point of view (balanced relation between costs and revenues) and, at the same time, Parma's experts consider it quite affordable to integrate the solution into the existing network, especially taking into account that the city has already invested in 138 e-charging points.

The least replicable solutions of Umeå

The solution with the lowest score confirmed by **all three Fellows cities** is **U1 + U3 - Smart City connection to 100% renewable energy and geothermal heating / cooling storage and exchange** (RP: 32% Brno, 31% Gdańsk, 33% Parma).
The purpose of the U1 and U3 solutions is to develop a new business model to make it possible to share excess renewable energy between stakeholders in a value chain and ensure better usage of geothermal storage. The overarching goal is to help the stakeholders reduce their climate impact and lower the costs of energy. Three different business models were tested and applied to nine ways of optimising energy use in the Innovation Area and evaluated to show how value creation might occur in the different scenarios.
Solutions such as this require a particularly ready and suitable context to be replicated. Indeed, the solution/-s demands a lot of cooperation between different stakeholders and beneficiaries to obtain the values of an integrated energy systems approach. Especially around the valuation of margin pricing (of energy) and climate impact of margin power. Moreover, the business model is 100% public driven in the case of Umeå and this aspect played against Institutional Replicability.
From the technological point of view, the supply systems (hardware) are well established, and have been so for a long time (TRL9), while the optimizing systems (software) are still under development, and need real world testing to establish functionalities etc. (TRL6). Moreover, the interoperability level is still very low.
Concerning environmental impact, the study proves that by finding a business model, it is possible to reduce the GHG emissions by 15% without increased investment costs, while no information is available on economic data, as no investments are made at this point.
Looking at the context of the Fellow Cities where the replication potential is estimated, several aspects came up in confirmation of this low potential for replication.
In **Gdańsk,** renewable energy solutions are popular and have considerable social acceptance. However, the implementation of these solutions faces financial barriers and their implementation in the public sector is a slow process. In Gdańsk renewable energy systems (PV and solar panels) can be installed on 153 public buildings with a total roof area is approximately 256,229 m2. Moreover, striving for energy efficiency and zero emissions is one of the city's current priorities. As for specific RES projects, the city is preparing a major project to install photovoltaics in school buildings.
However, such solution must deal with the scarce level of interoperability with the existing city infrastructures in combination with the fact that these projects would be technically and organisationally complicated, as well as procedures that would be time-consuming.
For what concerns the affordability of this solution by the city, Gdańsk's experts point out that it is surprising that despite the huge emphasis on energy transformation and the need to achieve climate neutrality, the planning documents announcing EU funding for the coming years do not provide for subsidies for installing renewable energy on public utility buildings (providing educational and social services). Therefore, for Gdańsk, two forms of financing would be available: preferential loans, and bank loan interest subsidies. To conclude, this project is associated with several significant risks, because in the business model, the city implements the project and this consists of a heavy burden, because it involves employees, resources, and burdening the ability to incur debts.

In **Parma**, considering the current international situation and the high cost of energy, the application of RES is starting to be an inevitable requirement and surely would be accepted by the population. Nevertheless, this is not a priority at this stage, although the research and the private sector are really interested on this topic and already working on a small scale on this, similarly to what done by Umeå with U1+U3. On the other hand, permits would not be easily obtained, but there is a new legal framework on national level that would probably fasten the process. Finally, this solution would be possibly viable only with PPP or EU funds.

Similar reasons have brought this solution among the last places in the classification for **Brno**, but not the last place that, in this case, is held by **U4 - Gamification for the end user behavioural change in energy consumption**.
This solution aims to involve building tenants to encourage more sustainable behaviours toward energy usage and other parts of day-to-day life.
The idea was to use gamification methods to encourage tenants to alter their habits and behaviours. Through an app called The Green Coach, produced as part of the RUGGEDISED project, participants were provided with information designed to inspire them to rethink their behaviours, this included: providing challenges to encourage them toward particular actions; enabling continuous feedback regarding the results of their actions; holding group events to engage a larger number of participants, thus generating a bigger combined effect and a sense of accomplishment within the community.
Solution such as this, which is strongly based on citizen participation, have a strong risk component which therefore determines low replicability values. It should also be said that this has been implemented in Umeå as a testbed, for now still not upscaled and very little interoperable with other systems, even if the TRL of the software used is not so low (TRL7).
From an environmental point of view, the solution aims to change habits, and this certainly leads to reducing the environmental impact even if, for now, it has not been possible to quantify the extent as well as for the economic data.
As for the specific applicability to the Brno context, several difficulties emerge.
First of all, experts from Brno are not sure that there will be a demand for such a solution among residents. In general, the interest of citizens to participate in similar gamification solutions is rather low. Similar difficulties are found concerning Institutional priorities: awareness of the potential benefits and advantages of gamification applications for reducing energy consumption is very low across the administration.
From the technical point of view, it is assumed that the technical implementation would not be too difficult as it would be necessary to create an application and an interface to use the software and also, from a regulatory point of view the implementation of this solution would not be difficult (just focusing on treating data collection in terms of GDPR).
However, the interest of the private sector and academia to invest and implement such a solution is very low.

Replication Potential of Glasgow's Smart Solutions in the Fellow Cities

Also in the case of Glasgow the Replication Potential of the solutions stands at average values including an interval ranging from 39% to 72%.
The greatest variability occurs in the case of Brno, where (Figure 17) it is noted that the most replicable (G8) and the least replicable (G1) solutions clearly distance themselves from the group of solutions with intermediate replication potential (difference +33%).
The distancing is less evident in the case of Gdańsk, where the solutions seem to be all agglomerated in a single group with the exception of the first (G8) which distances itself more evidently.
For Parma the situation is similar to that of Gdańsk, but a substantial difference can be noted between the least replicable solution (G7) and all the others that are on very close scores (from 50 to 59%).
These cases are analyzed in greater detail below.

Table 5: Replication Potential of Glasgow's Smart Solutions in the Fellow Cities

GLASGOW's SMART SOLUTIONS	BRNO		GDAŃSK		PARMA	
	Rank	RP	Rank	RP	Rank	RP
G1 - District H/C	7	39%	7	47%	2	55%
G2+G4 - EV Charging Hub battery + RES	4	57%	6	49%	5	50%
G5 - EV charging hub in city centre car park	3	60%	4	54%	2	55%
G6 - Intelligent LED streetlights	5	55%	2	60%	4	51%
G7 - Smart open data Decision Platform	2	61%	3	55%	6	41%
G8 - Implementation of DSM in street lighting	1	72%	1	71%	1	59%
G9+G10 - DSM in domestic & non-domestic properties	6	54%	5	52%	3	54%

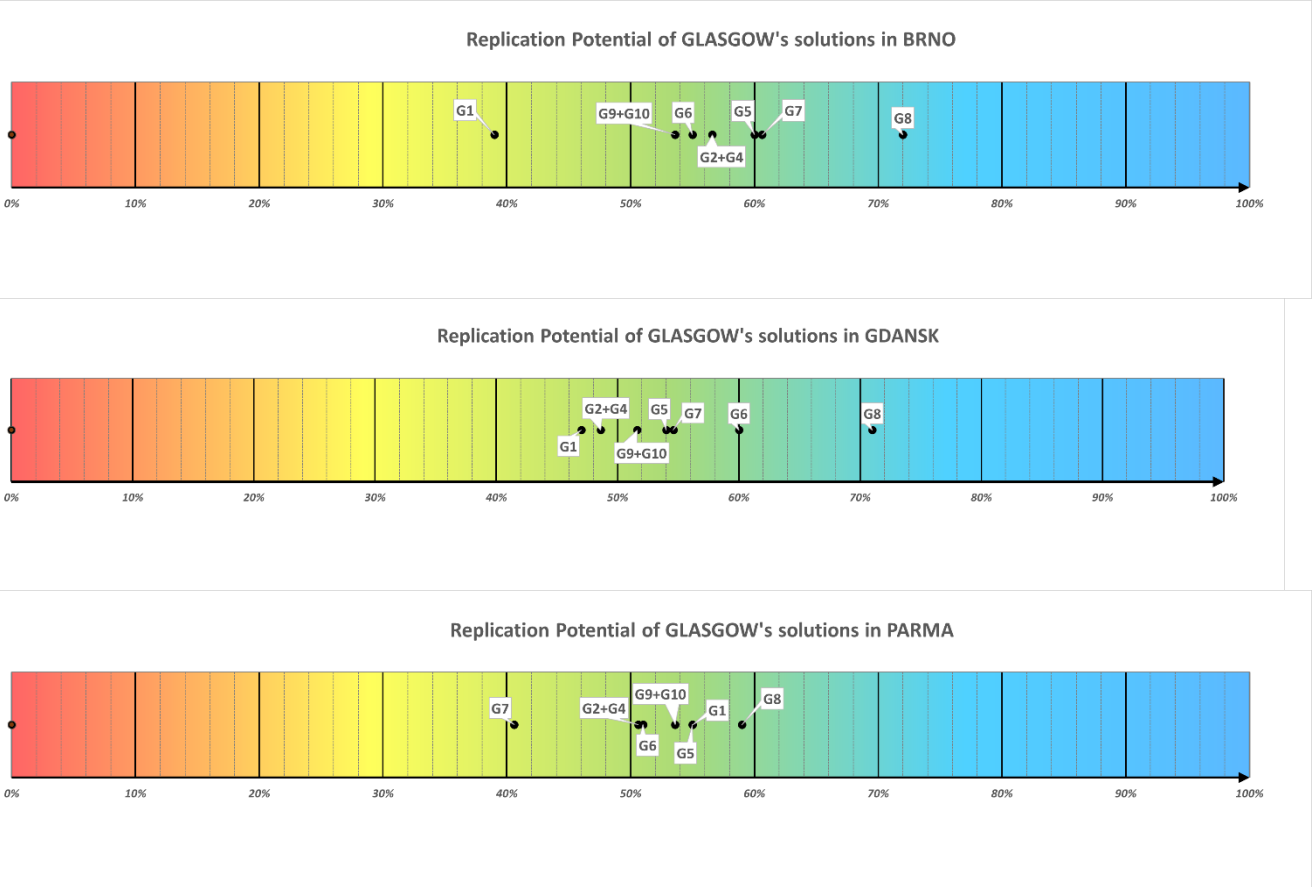

Figure 17: Replication Ranking of GLASGOW's Smart Solutions in BRNO, GDAŃSK and PARMA

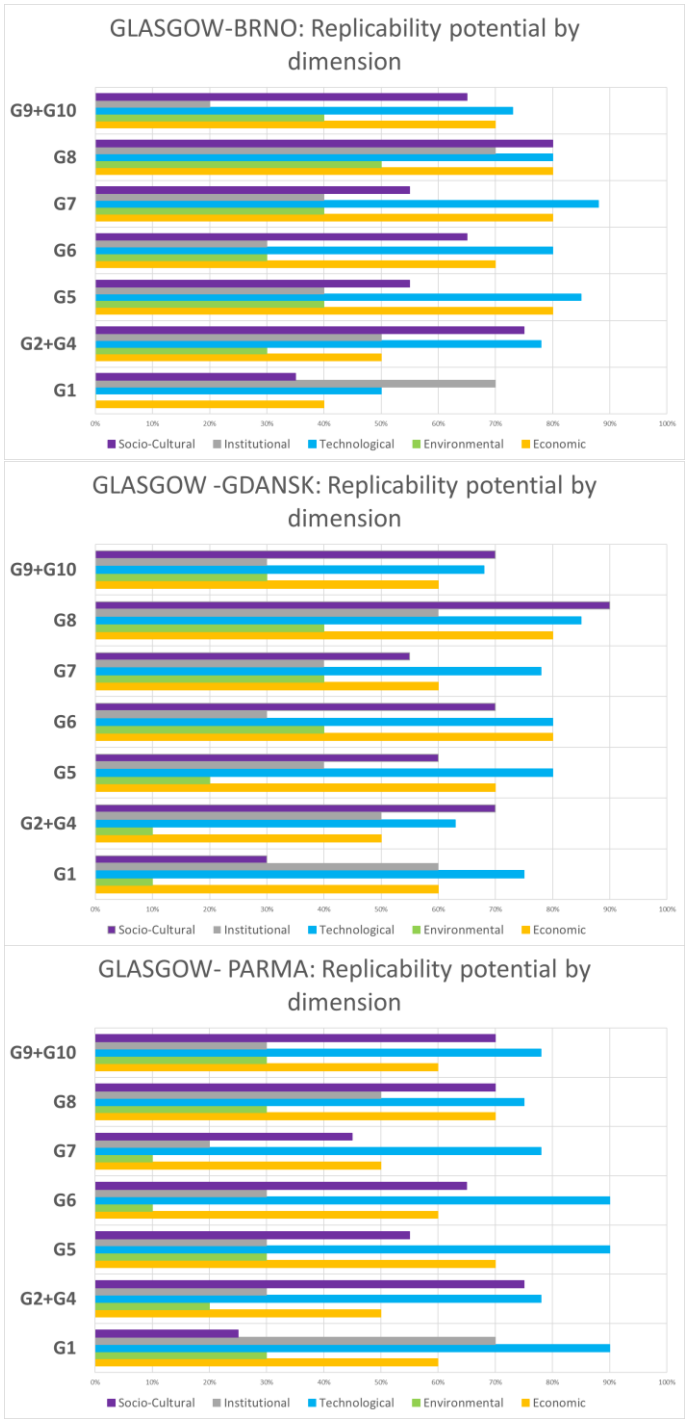

Figure 18: Replication Potential of Glasgow's Smart Solutions by dimension

As we have already seen in the case of Rotterdam, the Smart Street Lighting (R11) is a solution that, due to its intrinsic characteristics, lends itself well to replication in various contexts. In the case of the solution of Glasgow, where the focus is on **the implementation of demand-side management technology in street lighting** (G8), some further considerations can be done. The most important fact is that the LED over fluorescent lighting is a proven technology well established in the world and using dimming is now becoming standard, nevertheless demand side management will change how it is used and what can be done and how it will impact on savings.

G8 is the undisputed best for the three Fellow Cities even at a considerable distance (Brno and Gdańsk) from the rest of the ranking

Furthermore, we have already seen how R11 turned out to be the best solution for both Brno and Gdańsk, where it is already an ongoing project and, for this similar reason, also G8 appears promising.

In Brno (RP 72%) there are currently more than 40,000 lighting points on the streets. Some of them are already equipped with modern LED luminaires, automation elements or motion sensors, and the number of such modernized places is increasing year by year. Moreover, the development of centrally controlled LED public lighting is highly supported by the city administration and during 2022: Technical Networks Brno built a test polygon in the centre of Brno, that demonstrates how individual types of luminaires differ or how other technologies, such as automatic regulation or motion sensors, work. This solution was applied on a relatively small area and a total of sixteen poles.

As said above, another reason in favour of the replication of this solution is that it is recognized by all three Fellow Cities that the full realization of this type of solution is not demanding from a legislative and permitting point of view.

In Gdańsk (RP 71%), several projects on street lighting are ongoing and there is already a lighting control system, although the one in Glasgow is more advanced and is certainly a solution to be considered easily adaptable to the existing infrastructure.

Indeed, traditionally -that is in the first years of the 21st century - the control of switching on and off all lamps in Gdańsk was based on an astronomical clock with the annual cycle of sunrises and sunsets appropriate for its latitude. The control device "turned on" the lighting at the time specified by the clock, without taking into account the degree of cloudiness on a given day. This method of managing city light or controlling each cabinet individually with a lighting detector still applies to 25 % of lighting in Gdańsk. About 50 light points are controlled from each cabinet (a pole plus a lantern). They are most often located in the road lane.

Currently, drivers of the modern CPAnet system are installed in them. There is still an astronomical clock in the modernized cabinet, but with electronics. In this version, the clocks have certain time bands, e.g., for December it is the interval between 15 and 16 when the lighting must come on. The specific moment, however, is determined by the twilight detector, which detects a decrease in the level of natural light intensity and sends a signal to its controller in the cabinet. The controller sends it to the server room of the Management Board and from there the signal is sent to 340 lockers in the city covered by the CPAnet system and the lighting turns on.

With a visibly lower score, but still in the first place (RP 59%), this solution has a fair potential for replication even for **Parma** although it is not indicated among the current priorities. However, the experts interviewed in Parma confirm that it will become of paramount importance given the sharp increase in energy costs due to the Russo-Ukrainian war. Furthermore, as for the other Fellows, similar projects are already in operation even if the demand side and consumption management part need to be improved.

To conclude it must be said that in general, this solution turns out to be an excellent investment as it presents a good payback thanks to significant energy savings.

Interesting differences among the Fellow Cities are more evident in the least replicable solutions.

G1 is in last place for Brno and Gdańsk but is a good option for Parma

For the cities of **Brno and Gdańsk**, it resulted that the solution **G1 - Heat and cold exchange: Connection of buildings to a district heating network** is the worst from the replication point of view (Brno RP 39%, Gdansk RP 47%).

The objective of this solution is to establish a contractual model that will facilitate the connection of district heating networks to customers outside the footprint of the original development. External legal consultants have been appointed to create a model contract that could facilitate the connection of public sector heat generators to public sector heat consumers, and private sector heat generators to public sector/third sector consumers.

The contractual models were developed to enable the organisational innovation required to allow future and developing networks to successfully connect to neighbouring customers or providers, and no longer serve only their own establishments. The ability to efficiently use excess heat elsewhere would reduce overall costs, benefiting both suppliers and consumers, and also significantly reducing carbon emissions with a positive impact upon climate targets.
In Brno, similar business models allowing usage of surplus heat - that would otherwise be left unused - would be very well received by the public. In general, better use of heat flows and energy savings is much needed in the current era of expensive primary sources. However, these contractual models require to have the participation and buy in of the producers and consumers of the energy. The end user/ beneficiary requires to be fully involved in the signing of the contract to ensure it is satisfactory and fit for purpose, and that fact makes this solution riskier in its application, affecting the value Socio-cultural replication.
On the other hand, Institutional Replicability values are quite good. And this is because of the high cooperative business model that includes high collaboration among different actors belonging to public and private sector in Glasgow. Indeed, the solution was developed with project partners from the university, housing association and tenant's brewery acting as the private sector organisation. Independent legal consultants were appointed to deliver the contracts and work with the project partners. Moreover, in Brno, similar solutions, if applied to the appropriate buildings and parts of the system involved, would have the support of the city administration. These two aspects together play in favour of good replication.
From the technological point of view, there are aspects that can facilitate replication. First of all, it is a proven solution that is based upon final implementation and success (Solution Readiness Level 9) and it is also interoperable, however, it seems that there's no interest in investing in the solution from industry, research and private sector in Brno and this has not a negligible impact on replication.
Moreover, it was not possible to estimate the environmental impacts and the economic data: these are contracts, so it is not possible to estimate savings until the contracts are used as well as costs and revenues. This is surely the reason why Environmental and Economic Replicability dropped by several percent.

In **Gdańsk**, this same solution is in the last position but with a higher score (RP 47%), due on one hand to a recognized major interest of the local stakeholders, research and industry in the establishment of these contractual models (this contributes to higher technological replicability) and, on the other hand, to probably minor problems that may be found in the procedures. However, these are negligible differences that do not change the substance of the result with respect to the other solutions of Glasgow.

For **Parma**, G1 reveals to be instead a good option, indeed it ranked second (RP 55%) after G8, this is mostly because the city has already a DH network serving 20% of residents, fed by a waste-to-energy plant. Moderate interest from the administration is mostly in reorienting the DH network with an integrated system with renewable sources towards reducing the city's emissions. To that end, an infrastructural evolution is necessary by integrating the existing network with other DH networks at the city level, and by adding investments in renewable energies. This is a fertile ground for replicating G1 and testing the contractual model in the city environment.

G7 is the least replicable for Parma

With a clear departure from the other solutions, **G7 - Smart Open Data Decision Platform** turned out to be the least replicable for **Parma** (RP 41%).
This solution consists of the creation of a query-based geospatial 'Data Based Decision Platform' (DBDP) that collects data related to city management (e.g. energy, air quality,

traffic flow, etc.) and provides analysis of multiple data sets to enhance energy planning in the city.
Glasgow City Council is using the existing Open Data Platform and building DBDP around the existing ICT infrastructure. This is a technical challenge.
The data-based decision platform put together existing open data sets, along with the data generated from the project district to create a dashboard that allows users to analyse and present the data in a meaningful way without the need for data analysts. The idea behind the system is to allow individual users to customise their own dashboard, which will allow them to view all of the chosen data sets at once in order to ensure the most efficient use of time, planning and resources across the city.
In general, the platform itself could be replicated to other cities, both across the UK and across Europe, as long as the data sets of other cities are already being used in the DBDP, and this is a not an insignificant constraint for replication.
Indeed, although the city of Parma and the local stakeholders seem to be highly interested in this technology, the extent to which such a solution would be integrable into the existing infrastructure is not that high.
Another aspect is economic: Parma estimates the necessary budget for implementing the platform around 2-3 M€ (there are no data provided by Glasgow at this stage) and this is possibly but not definitely affordable by the municipality.
Other difficulties could be found in the involvement of a large group of stakeholders and in the long and time-consuming procedures for launching tenders.

As general consideration, it can be said that this Replication Assessment was very useful in understanding how replicability is influenced by several factors that go well beyond the political priorities identified by a city and cannot leave aside from intrinsic and specific characteristics of the solution as well as from the context where the solution is supposed to be replicated.
It was interesting to find that most of the solutions found to be more replicable are already in progress or in the planning phase in the Fellow Cities and this helps to give truth to this methodology. In general, it should be noted that none of the solutions implemented in RUGGEDISED have particularly low replication potentials. This goes to show that all the solutions proposed are quite promising and can be, with the right precautions, adapted in various contexts, even if not of particular interest to some cities. However, it is important to look at the "ranking" obtained which helps to define the priorities of each city that intends to replicate the solutions of the RUGGEDISED Lighthouse Cities, taking into account different aspects (Socio-cultural, Institutional, Technological, Environmental, Economic).

The fact remains that a similar exercise could be done also with other cities that still have to undertake a path of implementation of the smart city and it could help to identify a package of solutions that, due to their intrinsic characteristics, can better adapt to the specific context of a given city concerned, contributing and knowingly inspiring strategic planning.

3.3 Contribution to maximising impacts

Replication activities are inherently a way to take the progress and results of the Lighthouse Cities outside the context where they are tested and implemented and therefore allow other realities to use the knowledge gained and lessons learned to undertake similar paths.
In this sense, it can be said that WP7 has concretely assisted in maximizing the impacts of RUGGEDISED.
In particular, the work carried out at the local level in the Fellow Cities - Governance setup and foresight process - contributed to a substantial change in the internal structure of the city and in the planning approach.
The deep commitment in guaranteeing a fluid and transparent exchange of information among the cities of RUGGEDISED, combined with a structured arrangement and planning of specific events, have strongly supported the

spread of knowledge, insights, best practices, etc. not just among RUGGEDISED partners but also outside the project and with other cities. This was possible also thanks to the collaboration of WP7 with the SCC01 Initiative through the involvement in the Task Group Replication (see D8.3 *"Report on Project Contribution to the SCC01 Initiative"*), where the experiences and the approach adopted in WP7 were presented on more than one occasion.

To conclude, what is expected is that the intensive work carried out in the Fellow Cities will last over the years to come and that many phases and milestones of this long and intense journey could be taken as examples and inspire other cities aiming at making the Smart City their daily reality.

4. Effectiveness of measures put forward in WP8 – "Interaction with other Smart City projects" and WP9 – "Communication and Dissemination"

RUGGEDISED has been a central partner in the wider expansion of the concept of smart cities and in the move towards Scalable Cities and the wider EU mission on Climate Neutral on Smart Cities, aiming to deliver the first climate-neutral European Cities by 2030.

This work has been centred in WP8 and has been supported by WP9 and has gone above and beyond the original ambitions of the Grant Agreement, as the developments and increased ambitions of the joint European collaboration have been immense since 2016.

4.1 SCC01 Cooperation

Since first starting, project partners, especially Rotterdam, ICLEI, AIT and Erasmus University have actively contributed to the joint work, and thus the increased impacts, of the Smart Cities and Communities (SCC01) Projects as a whole. The specific contribution has evolved over the years from working on a combined branding for the Lighthouse Cities as far back as 2017 into leading the Board of Coordinators and the Communications Task Group in 2020, to contributing to specific initiatives following the establishment of the Scalable Cities Secretariat, including helping to draft recommendations for establishing such a Secretariat to support the SCC01 Projects.

Throughout the past six years, the RUGGEDISED supported results include:

- Supporting the first joint branding work of the Lighthouse Projects;
- The 'Getting Better Connected' approach of the BoC in the run-up to the establishment of Scalable Cities
- Providing input to 'The green deal call' of Horizon 2020;
- Supporting numerous papers from the Smart City Projects as a whole;
- Providing final input for the Tender for the SCC01 Secretariat;
- Supporting preparations for the Urbis Fair on several occasions, the Smart City Expo in Barcelona, especially in 2018 and 2019 and Nordic Edge, as well as other joint events;
- Hosting joint events with other Smart City projects, for example the "Smart City Response to COVID-19";
- Supporting the ongoing Branding Task Group of Scalable Cities.

For a full overview of the joint activities, a report, on "Project Contribution to the SCC01 Initiative" has also been produced and is available on the RUGGEDISED website.

4.2 City Interest Group

The City Interest Group in RUGGEDISED has evolved following the establishment of several European Initiatives to focus more strongly on a local approach with other cities being invited for events more on ad-hoc basis. For example, Rotterdam has been heavily engaged with a group of other Dutch cities – all of which were invited to the 'RUGGEDISED Congress' taking place in Rotterdam Ahoy in November 2019- while Umeå alongside RUGGEDISED has been engaged with the network Sharing Cities Sweden building on (and alongside) RUGGEDISED. In Scotland, Glasgow has been a leading partner in the Scottish Cities workstream on Smart Cities. Finally, especially Brno has taken on a leading role as a Fellow City in exchanging knowledge and sharing their lessons with other Czech cities both through bilateral exchanges and through the yearly event URBIS Smart City Fair that, even in pandemic times, gathered a large group of Czech cities to discuss on smart city developments. The centrally managed City Interest Group in RUGGEDISED has given way to the more local approaches, but registered cities (five centrally) have been invited to various RUGGEDISED events and activities, especially those done in partnership with other cities and projects. This included, for example, the Umeå Deep Dive (an online workshop taking place in 2020 covering Umeå's work) and invitations for the final RUGGEDISED Event in Rotterdam in September 2022.

The overall impact of the centrally managed City Interest Group was lowered following the de-centralised approach agreed upon already in 2019 and exasperated by the COVID-19 pandemic making real-life meetings impossible. However, the local cooperation with other interested cities can hardly be overestimated, as showcased in the aforementioned countries, where strong national networks have been initiated, not because of the RUGGEDISED cities, but with support from them.

4.3 Research impact

RUGGEDISED is by definition an Innovation Project (IA) funded by the European Union's Horizon 2020 programme. Anyway, although the majority of investment, time and cooperation has focused on the *innovation* aspect in the real world of the Lighthouse Cities, research has not been neglected too. All research has primarily been focused towards conclusions and results of direct use to cities, practitioners, companies and other actors engaged with urban transformation.

The Scientific publications published (as of 7 June 2022) include:

- Conference Paper: Demand-controlled energy systems in commercial and institutional buildings: a review of methods and potentials (European Council for an Energy Efficient Economy (ECEEE), 2019.)
- Conference Paper: Enabling Sustainable Public Transport in Smart Cities through Real-time Decision Support (International Conference on Information Systems, December 2019))
- Journal article: Evaluating and Optimizing Opportunity Fast-Charging Schedules in Transit Battery Electric Bus Networks (Transportation Science, January 2020).
- Conference Paper: Application of occupancy and booking information to optimize space and energy use in higher education institutions (June 2020)
- Journal Article: Application of Internet of Things in academic buildings for space use efficiency using occupancy and booking data (Building and Environment, December 2020)
- Article: Online Optimization to Enable Sustainable Public Transport (November 2020)
- Conference Paper: Value Creation through Urban Data Platforms: A Conceptual Framework (January 2021)
- Conference Paper: A multi-stakeholder perspective on opportunities and challenges for energy efficiency improvement in university buildings (2021)

In addition to papers still being underway, the above list is not exhaustive when it comes to the impact RUGGEDISED's knowledge partners have had with the dissemination of their research. Most notably, RUGGEDISED have been active players in different European and national frameworks sharing insights gained from working closely with the cities.

This is especially true for the cooperation with other SCC01 projects and the Smart Cities Marketplace's Action Clusters which resulted in the report 'Governance, Trust and Smart City Business Models: the Path to Maturity for Urban Data Platforms' written by Erasmus University with input from TNO and RISE as RUGGEDISED's Deliverable 6.6. This report, and the underlying study, has found its way into both specialist media articles (AI opens new avenues for smart cities (Science Business, 2020)), info kits from the European Commission in support of the 100 climate neutral and smart cities (EU Commission Info Kit for Cities, 2022) and numerous presentations to other cities, at various events and to European Officials.

4.4 Impact of Communication activities

The impact of the specific Communication activities undertaken in RUGGEDISED is wide-ranging albeit difficult to quantify. With more than a thousand followers on both LinkedIn and Twitter, and several thousand visitors to the website resulting in hundreds of downloads of the project outcomes per month, positive numbers exist to be pointed towards.

However, the communication activities, including +30 individual factsheets on solutions, 4 thematic factsheets covering different topics within smart city developments, participation in numerous events, active promotion through relevant for a (Smart Cities Marketplace, Climate Neutral Cities Mission, Smart Cities World, ICLEI Europe

etc.) is often in support of the wider maximisation of impacts achieved through the strategic work in Work Packages 1, Work Package 6, Work Package 7 and Work Package 8.

The main outcomes of the specific communication activities are therefore tied to the previously described activities in this deliverable, and other public deliverables, such as Deliverable D9.18 detailing the 71 Media articles featuring RUGGEDISED as of June 2021, and, most importantly, the activities as the final results of the project becomes available in August, September and October 2022. Several activities were planned to share these final outcomes both inside the Lighthouse Cities and to the European Community. These will include or have included:

- The publication and dissemination of three final Implementation reports from the Lighthouse Cities, written in an accessible language a laid out professionally.
- The final event of RUGGEDSIED including three workshops with expected participation by both RUGGEDISED partners, externals and with input from important industry players such as BP and Google (tbc).
- Participation in Resilience Forum in Athens in September 2022.
- Participation in URBIS Smart City Fair in Brno, September 2022.
- A 'Climate Neutral and Smart Cities Day' at the ICLEI Europe stand during EUSEW in partnership with NetZeroCities.
- A legacy online website combined with the final brochure from RUGGEDISED, allowing the results, lessons and advice for others to live on and be exploited in the years to come.

4.5 Contribution to maximising impacts

The RUGGEDISED communication and dissemination efforts focused reaching out to other cities and potential industry partners across Europe. The impact of work in this area was strongly supported through joint European cooperation where smart has, in many ways, become a method to deliver climate neutrality in a fair, resilient way that increases life quality for all citizens, rather than an objective in itself. This has been integral to the RUGGEDSISED project since its inception. Opportunities for cross-collaboration have been sought through participation in European and international events from the SMART CITY EXPO, ICLEI World Congress to the European Sustainable Energy week.

Many other cities, most notable partner cities of the RUGGEDISED cities have already benefited from this and the outcomes developed can help serve as a blueprint for future developments towards climate-neutral and smart cities in Europe.

5. Conclusions

This report highlights how the combined efforts of the different RUGGEDISED WPs have led to remarkable results with lasting impact and strong resonance over time.
As extensively described in the previous chapters, each WP contributed to maximizing the impacts of RUGGEDISED.

WP1 - Cross-city Implementation and Innovation in the Lighthouses

WP1 has contributed to maximising impacts especially – but not only- in the Lighthouse Cities that have been supported with the peer-to-peer learning processes which enabled the articulation of the lessons learned that will help them implement and upscale the small-scale smart solutions in other areas and districts of the city.
Moreover, the Fellow Cities had the chance to test the guides produced in WP1 and received guidance and first-hand knowledge based on the lessons learned, thus fostering the building of good foundations for maximising impacts in their contexts.
Finally, the developed and tested guides will be actively disseminated to other European cities to enable them to make use of the guidance that was developed to maximise the impacts of RUGGEDISED beyond the project.

WP6 - Enabling upscaled deployment and business model innovation

In the same way, WP6 supported the maximization of the impacts in the three Lighthouse Cities, but also contributed to learnings that could be promoted to any other city or municipality.
As the lack of structures and methods for reflections often affects the uptake of innovation results, Urban Innovation Platforms have been recognized as a method to support creative urban development and the establishment of multi-stakeholder networks, and thereby innovation and upscaling.
Rotterdam, Glasgow, and Umeå have gained support from WP6 in the identification of barriers for innovation and upscaling, and in the analysis of how to overcome them. They also received support in the identification and set up of the Urban Innovation Platform that might work best for them.
Crucial for enhancing the cities institutional capacity has shown to be the construction of good and vibrant relational resources such as networks, strong knowledge resources such as learning structures, which, added together, form the city's mobilization resources. The studies conducted will not only help RUGGEDISED cities develop their innovation capacity further and help them implementing future smart solutions in other areas and districts of the city but can also be adapted to any other city or municipality.

WP7 - Replication to Fellow Cities and Knowledge transfer

Replication activities are inherently a way to take the progress and results of the Lighthouse Cities outside the context where they are tested and implemented and therefore allow other realities to use the knowledge gained and lessons learned to undertake similar paths.
In this sense, it can be said that WP7 has concretely assisted in maximizing the impacts of RUGGEDISED.
In particular, the work carried out at the local level in the Fellow Cities - Governance setup and foresight process - contributed to a substantial change in the internal structure of the cities and in the planning approach.
The deep commitment in guaranteeing a fluid and transparent exchange of information among the cities of RUGGEDISED, combined with a structured arrangement and planning of specific events, have strongly supported the spread of knowledge, insights, best practices, etc. not just among RUGGEDISED partners but also outside the project and with other cities. This was possible also thanks to the collaboration of WP7 with the SCC01 Initiative through the involvement in the Task Group Replication (see D8.3 "Report on Project Contribution to the SCC01 Initiative"), where the experiences and the approach adopted in WP7 was presented on more than one occasion.

The Replication Assessment was very useful in understanding how replicability is influenced by several factors that go well beyond the political priorities identified by a city and cannot leave aside from intrinsic and specific characteristics of the solution as well as from the context where the solution is supposed to be replicated.
The fact remains that a similar exercise could be done also with other cities that still have to undertake a path of implementation of the smart city and it could help identify a package of solutions that, due to their intrinsic characteristics, can better adapt to the specific context of a given city concerned, contributing and knowingly inspiring strategic planning.
To conclude, what is expected is that the intensive work carried out in the Fellow Cities thanks to WP7 activities will last over the years to come and that many phases and milestones of this long and intense journey could be taken as examples and inspire other cities aiming at making the Smart City their daily reality.

Last but not least, the RUGGEDISED communication and dissemination efforts, together with the intense and close collaboration with the SCC01 initiative and other Smart City projects, focused reaching out to other cities and potential industry partners across Europe. The impact of work in this area was strongly supported through joint European cooperation where smart has, in many ways, become a method to deliver climate neutrality in a fair, resilient way that increases life quality for all citizens, rather than an objective in itself. This has been integral to the RUGGEDSISED project since its inception. Opportunities for cross-collaboration have been sought through participation in European and international events from the SMART CITY EXPO, ICLEI World Congress to the European Sustainable Energy week.
Many other cities, most notable partner cities of the RUGGEDISED cities have already benefited from this and the outcomes developed can help serve as a blueprint for future developments towards climate-neutral and smart cities in Europe.

WP8 - Interaction with other Smart City projects & WP9 - Communication and Dissemination

To conclude, it can be said that the in-depth work carried out over the past 6 years on vertical topics, as well as on broader horizontal aspects, the production of guidelines, the sharing of experiences, the application of methodologies and mechanisms for knowledge exchange, and the strong commitment to transfer lessons learned into and outside the project are all aspects that combined together have contributed to creating a valid and solid project legacy that we expect and hope will lead other cities, research institutions, private and public bodies to take RUGGEDISED as an example for future smart city applications.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731198. The sole responsibility for the content of this document lies with the Ruggedised project and does not necessarily reflect the opinion of the European Union.

ANNEX I – SITEE: Questionnaire on Solution Variables

Name of the Smart Solution

Socio-Cultural dimension

1. Users Interaction: To what extent does the solution require interaction with the final user/beneficiary? [0-5]

- ☐ 0 - No interaction required
- ☐ 1 - Very low interaction required
- ☐ 2 - Low interaction required
- ☐ 3 - Medium interaction required
- ☐ 4 - Substantial interaction required
- ☐ 5 - High Interaction required

Please explain in few lines the reasons:

Institutional dimension

2. Public-Private Cooperation: To what extent are the Public and Private sectors involved in the development of the solution?

- ☐ 100% Public or 100% Private driven solution
- ☐ 90%-10% (or 10%-90%)
- ☐ 80%-20% (or 20%-80%)
- ☐ 70%-30% (or 30%-70%)
- ☐ 60%-40% (or 40%-60%)
- ☐ 50% - 50%: Public-Private-Partnership

Please provide a short description of the public-private cooperation model adopted in the solution:

Technological dimension

3. Global Solution Readiness (a): Is the technology well-established? Specify the TRL:

- ☐ TRL 1: Identification and observation of basic principles and properties.
- ☐ TRL2: Definitions of practical applications. Formulation of concepts.
- ☐ TRL3: Observation and analysis through analytical research, laboratory research or experiments.
- ☐ TRL4: Proof of concept that is based upon the integration of applications and concepts to demonstrate viability.
- ☐ TRL5: Validation defined as the refined integration of applications or concepts to confirm validity.
- ☐ TRL6: Simulated demonstration of a near-end state solution and testing in a simulated environment.
- ☐ TRL7: Real-world demonstration of a near-end state solution and testing in an appropriate real-world environment.
- ☐ TRL8: Qualified solution which is the completion of end state solution and refinement through testing.
- ☐ TRL9: Proven solution that is based upon final solution implementation and success.

4. Global Solution Readiness (b): To what extent is the technology standardized and/or interoperable with different systems (hardware and software)? [0-5]

- ☐ 0 -Not standardized nor interoperable
- ☐ 1 -Very Low level of interoperability with other systems
- ☐ 2 -Low level of interoperability
- ☐ 3 -Medium level of interoperability
- ☐ 4 -High level of interoperability
- ☐ 5 -The solution is highly interoperable with other systems and is compliant with the standards

Environmental dimension

5. GHG savings: Please provide general estimates of the potential $CO2_{eq}$ emissions reduction:

0 %

(% compared to the situation before the implementation of the solutions)

6. GHG savings: Please provide general estimates of the yearly CO2eq emissions reduction:

0 *tCO2eq/year*

(compared to the situation before the implementation of the solutions)

Comments:

Economic dimension

7. Cost-Efficiency: Please provide an estimation [0-5] of the cost efficiency of the solution.

- ☐ 0 - Completely Cost-Inefficient
- ☐ 1 - Underperforming
- ☐ 2 - Low Cost- efficiency
- ☐ 3 - Neutral, Balanced relation between Costs and Revenues (or savings)
- ☐ 4 - Cost-Efficient
- ☐ 5 - Very Cost-Efficient

8. Please provide general estimates of the following figures:

Total Investment Costs: _____ €

Operational costs: _____ €/year

Revenues/Costs savings: _____ €/year

Lifetime: _____ years

Number of users/beneficiaries of the solutions: _____ *

** This is an important indicator not always available. In that case, please provide an estimation. E.g. in the case of Street Lighting, the number of iinhabitants in the area could be a good proxi.*

Comments:

ANNEX II – SITEE: Questionnaire on Context Variables

Name of the Smart Solution

Socio-Cultural dimension

1. Need. To what extent does the solution respond to a pressing need of the population? [0-5]

- ☐ 0 - Not at All
- ☐ 1 - Very Little
- ☐ 2 - Little
- ☐ 3 - Somewhat
- ☐ 4 - Substantially
- ☐ 5 - To a Great Extent

2. Acceptnace. Would the solution be accepted by the population? [0-5]

- ☐ 0 - Definitely Not
- ☐ 1 - Probably Not
- ☐ 2 - Possibly
- ☐ 3 - Probably
- ☐ 4 - Very probably
- ☐ 5 - Definitely

Institutional dimension

3. Priorities. What level of priority does the project have for the current city administration (in terms of responsiveness to institutional needs and political will)? [0-5]

- ☐ 0 - None
- ☐ 1 - Very Low
- ☐ 2 - Low
- ☐ 3 - Moderate
- ☐ 4 - High
- ☐ 5 - Top Priority

Please argue on this

If you need more space, just extend this text box

Technological dimension

4. Integrability. To what extent is the project integrable/interoperable with existing city infrastructures (software/hardware) from a technological perspective? [0-5]

- ☐ 0 - Not at All
- ☐ 1 - Very Little
- ☐ 2 - Little
- ☐ 3 - Somewhat
- ☐ 4 - Substantially
- ☐ 5 - To a Great Extent

5. Interest on technology. Which is the level of interest from Research/Industry/Private sector to invest in the solution? [0-5]

- ☐ 0 - None
- ☐ 1 - Very Low
- ☐ 2 - Low
- ☐ 3 - Moderate
- ☐ 4 - High
- ☐ 5 - Very High Interest

Environmental dimension

6. Legal Viability.How difficult and time consuming is the procedure for obtaining the permit or the licence for implementing the solution?

- ☐ 0 - Extremely. The solution is not legally viable or can be implemented only after a very time-consuming process and big efforts so that it doesn't violate any legal constraint
- ☐ 1 - Substantially
- ☐ 2 - Moderately
- ☐ 3 - Somewhat
- ☐ 4 - Slightly
- ☐ 5 - Not at All. The solution is viable and minimum efforts are necessary to obtain the permits

Please argue on this

If you need more space, just extend this text box

Economic dimension

7. Affordability. Looking at the costs structure (see table below) , to what extent is the solution affordable by the municipality?

- ☐ 0 - Definitely Not Affordable
- ☐ 1 - Probably Not
- ☐ 2 - Possibly
- ☐ 3 - Probably
- ☐ 4 - Very probably
- ☐ 5 - Definitely Affordable

Please argue on this

If you need more space, just extend this text box