Project no. 691735
REPLICATE PROJECT
Renaissance of Places with Innovative Citizenship And Technology

This Project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement N° 691735

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REnaissance of PLaces with Innovative Citizenship And Technology

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H2020-SCC-2015 Smart Cities and Communities

Innovation Action (IA)

D7.6 Lighthouse cities' replication plans

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1. EXECUTIVE SUMMARY

The aim of Replicate is to find from lighthouses' pilot actions innovative technologies and approaches to be extended and exported in other smart cities, starting with the followers and observers involved in the project.

In the first three years of the project the measures included in the pilots' comprehensive sets have passed from the idea to reality, some of them going through adaptations due to the evolving framework and unexpected obstacles but collecting the first results and useful feedbacks.

The roadmaps for the roll out of the pilot actions are the final result of a long cross-cutting analysis, carried out in parallel with the implementations. Lighthouses, supported by technical partners, have analysed in detail the measures and shared the results, also outside the consortium, illustrating players, market analysis, impacts, management model scheme for the pilot implementation and for the possible extension / replication, scale up and SWOT analysis.

An analysis of the financing opportunities and sustainable measures has been carried out in cooperation with the other cross cutting Work Packages and summarised in the report.

Valuable lesson learnt have been collected for each type of action and reported for the benefit of followers and other cities together with adaptations worked out to optimise the extensions/replications as well as the identification of the key stakeholders involved for an effective roll out.

Those common features, reusable by any interested city, are the result of debate and discussion among the three lighthouses to enrich the test feedbacks and multiply the results.

With a further effort by the three cities, the road maps have been finally designed integrated into the existing planning framework where the extensions or replications have already been or are going to be embedded.

The short-term measures have been reported in detail in the document with a focus on impacts, including some test calculations on externalities when possible to support decision making, synergic approaches with other sectors and communication.

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2. REPLICATE

The main objective of REPLICATE project is the development and validation in three lighthouse cities (**San Sebastián** – Spain, **Florence** – Italy and **Bristol** – UK) of a comprehensive and sustainable City Business Model to enhance the transition process to a smart city in the areas of the energy efficiency, sustainable mobility and ICT/Infrastructure. This will accelerate the deployment of innovative technologies, organizational and economic solutions to significantly increase resource and energy efficiency improve the sustainability of urban transport and drastically reduce greenhouse gas emissions in urban areas.

REPLICATE project aims to increase the quality of life for citizens across Europe by demonstrating the impact of innovative technologies used to co-create smart city services with citizens and prove the optimal process for replicating successes within cities and across cities.

The Business Models that are being tested through large scale demonstrators at the three cities are approached with an integrated planning through a co-productive vision, involving citizens and cities' stakeholders, providing integrated viable solutions to existing challenges in urban areas and to procure sustainable services. Sustainability of the solutions is fostered in three areas: economic and environmental and finally, fostering transparency in the public management.

In addition, the Model features the replicability of the solutions and their scale up in the entire city and in follower cities, in three follower cities (**Essen** – Germany, **Lausanne** – Switzerland and **Nilüfer**–Turkey) that are involved in the project and therefore, have access to know-how and results achieved on the project so they can apply the developed model. At the moment, there are 2 observer cities, Guanzhou (China) and Bogota (Colombia).

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3. INTRODUCTION

3.1 WP7 "cross cutting activities": aims and links

WP 7 of Replicate project summarises the experience of the pilot actions providing materials for the following WPs (task 7.1 "setting the methodology for the peer review" and 7.2 "Analysis of the specific context") and extending the pilots with a concrete replication plan at city or metropolitan level (task 7.4 "design of implementation roadmap in the lighthouse cities"): following the FP7 STEEP project experience (http://www.smartsteep.eu/[1]), the three cities are working together, after the common planning phase and the recent test realisation phase in the field, to deliver a scalability analysis of the interventions (task 7.3 "cross-cutting analysis of the different technical realisations and management models") based on the concrete realisation results.

After the work done in the field (Lighthouses Pilot districts WP3, 4, 5), very valuable lessons in understanding the obstacles/results of the integrated measures set have been acquired: the three pilot actions have been analysed in detail and each city has also started thinking about the opportunities and barriers in replicating and scaling up this approach to the city level, but also in the other two cities contexts in order to have a wider landscape of the test phase.

The results from the technical comparison (D7.2 and 7.3 "Report on technical solutions") matched to the different management models and the business plans (D7.4 and 7.5 "Report on management models") offered the cities all the tools to develop reliable replication plans (D7.6 "Lighthouse cities replication plans").

The consortium had three assumptions:

- A district could be considered as a small city area where urban issues can be represented.
- The pilot in the districts will help to understand the complex system related to implementation of the integrated Smart City Plans.
- It is necessary to collate the knowledge of all stakeholders involved in the three pilots, to validate the relevance of the initiatives selected.

With these three assumptions, the objectives related to the cross-cutting WP were:

- Detect the optimal conditions for the replication of the solutions tested in the Smart districts in connection with industrial/SME partners
- Define the scalability potentials and the possible roadmaps for the extension of the pilot at city/metropolitan level
- Use stakeholders' knowledge for understanding, defining and validating interventions in the urban system.

[1] STEEP was funded under the European Commission FP7 funding stream

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The activity took advantage of the work being done to develop the actual Smart City Plans for the three cities (STEEP project). Thus, the resultant methodology has a solid guarantee, due to the fact that the three city replication Plans have been developed and properly validated following the plans' directives and the same approach with a tailored construction process.

3.2 Relation to Other Project Documents

Above the obvious close interaction with the three pilots (WP3,4,5), whose results and schedules it depends on, WP7 is strongly linked also to the other transversal workpackages regarding ICT platform and monitoring (WP6, 10) and it presents important synergies with the replication potential analysis at market sectorial level or in other follower cities (WP2, 8, 9).

In particular the City-to-City learning program (https://replicate-project.eu/city2citylearning/) for experience exchange among the six cities in the project and the following activities about networking, replicability and exploitation potential are interested in data harvesting from pilots and adaptations ideas which are the main goals of this document.

3.3 Reference documents

This deliverable has interacted with the following project documents:

Ref.	Title	Description
REPLICATE Grant	Grant Agreement	Grant Agreement no. 691735
DoA REPLICATE	REPLICATE (691735) GA Annex1-DoA	Description of the Action
REPLICATE CA	Consortium Agreement	Consortium Agreement signed
REPLICATE WP1 project management	D1.7 Data Management Plan	REPLICATE - data management plan
	D.8 -D.19 annual quality assurance reports	Annual reports by each lighthouse
	D1.24 Report of the Advisory Board	Advisory Board structure and plan
REPLICATE WP2 Strategic planning and business models	D 2.2 Business Models of the Lighthouse cities	First description of the BMs adopted
	D2.3 Internal report on findings	First findings from pilots
REPLICATE WP3 San Sebastian Pilot	D3.3 District Heating	Report on DH implementation in SS
	D3.8 Smart mobility platform	Report on smart mobility platform
	D3.9 Electromobility monitoring	Report on electromobility
	D3.10 High speed network based on post WIMAX technology	Description of the high-speed network implemented

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	D3.11 Smart Lighting	Report on smart lighting measure
REPLICATE WP4 Florence Pilot	D4.1, D4.3 Periodic Reporting on the state of the implementations in Florence.	Florence Energy Pilot –Report on the state of the project
	D4.2, D4.4 Pilot action measures advancement sheets	Monitoring report of the pilot at the 18th and 30th month
REPLICATE WP5 Bristol Pilot	D5.3 ENERGY DEMAND PLATFORM DEPLOYED TO MONITOR ENERGY GENERATION AND DEMAND	Report on EDMS action
	D5.4 Twelve E-bikes Deployed in a Corporate Scheme	Report on e-bikes deployment
	D5.5 Expansion of a Car Club in the Area with Electric Vehicles	Report on car club action
	D5.7. Transport Infrastructure Adaptation Including EV Charge Point Installation	Report on transport infrastructure adaptation
REPLICATE WP6 ICT Platform	D6.4 Integrated architecture and services catalogue	Description of the 3 pilots ICT platform and services
REPLICATE WP7 Cross cutting activities	D7.1 Peer review methodology	City Data Canvas and first data
	D7.2 & D7.3 Report on technical solutions	Pilot actions technical solutions analysis
	D7.4 & D7.5 Report on management models v1	Pilot actions management models analysis
REPLICATE WP8 Replication	D8.4 Report on Conclusions of the Interviews and the Focus Groups	Report on interviews and Focus groups in the follower/fellow cities
	D8.5 Open data platform to share the common outcomes	City2city learning exchange activities and program web platform
REPLICATE WP9 Exploitation of Results	D9.1 Baseline definition and integration and results analysis from WPs 3,4,5,8	Baseline for the 3 pilots
	D9.2 Methodology review and methodological framework definition	Business models analysis methodology
	D9.3 Sectorial Business analysis / Exploitation potential in the field of energy, ICT, sustainable mobility and other remaining sectors included in REPLICATE	Sectorial Business analysis / Exploitation potential
REPLICATE WP10 Monitoring	D10.1 Report on indicators for monitoring at project level	Set of indicators to assess each Replicate project intervention
	D10.2 Report on indicators for monitoring at city level	Set of indicators to assess the impact of interventions at the city level

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	D10.3 Baseline analysis of city level indicators for follower cities and benchmarking with lighthouses	Evaluating the baseline analysis of city level indicators for follower cities and benchmarking with lighthouses.

Table 1- List of reference deliverables

In the event of discrepancy between documents, WP7 Materials are overruled by the contract with the EU (Grant Agreement) including its Annexes and amendments, which takes precedence over all other documents.

3.4 Abbreviations list

ADS	San Sebastian municipality (Ayuntamiento Donostia San Sebastian)
BCC	Bristol City Council
CA	Consortium Agreement
GA	Grant Agreement
DoA	Annex I-Description of the Action
DH	District Heating
EEA	European Energy Award®
EC	European Commission
EDMS	Energy Demand Management System
EPC	Energy Performance Contract
ESCo	Energy Service Company
EV (BEV)	(Battery) Electric vehicle
FSS	Fomento San Sebastian
RES	Renewable Energy Sources
SCCR	Smart City Control Room
TES	Thermal Energy Storage
VCE	Value Creation Ecosystem (WP9)
WP	Work Package

Table 2- Abbreviations list

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4. DELIVERABLE DESCRIPTION

Based on the cross-cutting analysis carried out in parallel with the pilot actions, this deliverable includes the main conclusion resulting in a roadmap for the extension or replication of the measures with the adaptations and optimisations foreseen.

The work took into account the framework conditions and the approaches in use in the three cities and embeds the innovative solutions into the next periods policies/activity programs.

The methodology adopted, the steps followed and the resulting roll out are described under the present document which covers:

- **Section 5** – Methodology adopted for the roll out: guidelines and principles. The methodology adopted and the activities carried out are reported for the other cities to share the path towards the roll out definition.
- **Section 6 –** After the pilot action: shaping the new framework in terms of planning context to include the roll out. In each city the most suitable plans or activity programs to concretise the extension or replication of the selected pilot actions have been detected
- **Section 7 –** After the pilot action: outcomes and opportunities in the management models and transition financing. The results of the work carried out with the lighthouses in synergy with the other WPs in terms of innovative or simply effective approaches is illustrated with lessons learnt and hints about new financing opportunities for cities.
- **Section 8** – Roll out plan. For each macro-action a common table has been developed with the lighthouses with the measures, their main strengths, eventual adaptations after the pilot, the identification of the stakeholders to be involved for an effective implementation, the plan/strategy where it could be (or is already) included, the timeline for the implementations in terms of short/mid/long term in each of the three cities.
- **Section 9 –** Short term actions examples: the measures to be implemented soon after the pilot test have been reported in more detail
- **Section 10, 11, 12** – Lessons learnt, Innovation – impacts and scalability, Conclusions
- **Annexes** – references and the external costs methodology in use for the calculation of the impacts of some short-term actions

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5. THE METHODOLOGY ADOPTED

The methodology adopted and described in this section, is based on previous activities carried out with the lighthouses (from smart city planning to pilot actions analysis illustrated in the previous deliverables) and it has been defined with the support of the EEA (www.european-energy-award.org), the cross cutting workpackages leaders (WP2, 8, 9, 10) and the three pilot cities.

5.1 Guiding principles

The Guiding principles for the replication of best practices and innovative actions, as those implemented in Replicate, has been discussed with a wide sample of stakeholders including lighthouses, followers (WP8), but also external observers like the European Energy Award network.

In particular the following principles, stemming from the discussion, have been developed and adopted by SPES since the beginning of the roll out analysis:

- "*To multiply the impact of successfully tested innovations it is necessary to plan efforts in fostering policy development on a lasting basis*" (WP2 and EEA network). This is why the roll out actions have been embedded in the cities' planning framework and not just listed in a stand-alone dedicated plan not integrated in the policies and in the usual procedures. "Plan" mark scaling up as a guided process from cities' point of view, in contrast to the spontaneous diffusion of innovations; "on a lasting basis" highlights the importance of institutional capacity-building and sustainability.

- Innovation means that "something" has been perceived as new, but it doesn't involve only new technologies, typically it could consist also in management processes necessary for a successful implementation (WP2 and EEA network).

- Replicate doesn't mean "copy & paste" of a best practice but "adapt and optimise to local conditions". (WP8 City-to-City learning program)

The framework synthesized by SPES, after the discussion with the above-mentioned partners and supporting network, provides a way of systematically thinking about scaling up with strategy as the centrepiece and different strategic choices. The framework suggested is guided by four key principles which are:

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- systems thinking;
- a focus on sustainability;
- the need to determine scalability;
- and social impacts guided by participatory and citizen-centred approaches (target users).

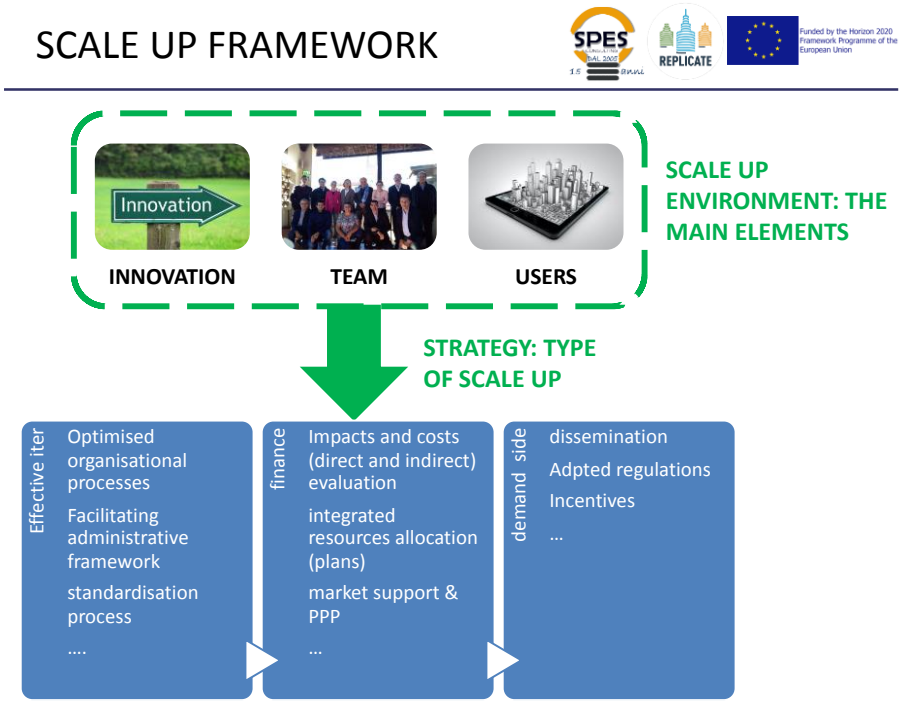

Figure 1 – the scale up strategical framework from a city point of view

The strategic choices consist of the best type of scale up to maximise the effect; it can belong to a specific action, like for example acting on the demand side or facilitating the implementation process, or be a combination of different types in the more complex models.

5.2 Benchlearning: integration of aspects and methodologies

The roll out plan is looking at the pilot actions from the cities' point of view, stating what they could program to do in the next years to facilitate the innovations extension, which are the measures which matched the local needs and how they can integrate them into their planning framework.

In Replicate project, the integration of the different aspects has been designed following a typical total quality management system as summarised in the following slide.

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ROLL UP PHASES:
BENCHLEARNING AMONG LIGHTHOUSES

Benchmarking as a TQMS for continuous improvement strategies:

- ✓ Identification of the strategic process to **benchmark** with quantified KPIs - WP10
- ✓ **Benchlearn** from best practices (not only numbers and technology but framework, environment, administrative and behavioral issues, participation, cross sectorial issues and synergies) - task 7.3 + WP2&8
- ✓ **Benchact** adapting your previous procedures to new configurations to obtain better results - Task 7.4 + WP8&9

Figure 2 –the integration of cross cutting WPs in the project workflow

To validate the relevance of the initiatives selected, the actions have been analysed in "WP7 – Cross cutting activities" and monitored in detail in "WP10 – monitoring" and info shared opening the discussion to any interested partner with the aim of cross fertilizing the scale up and replication plans also with followers within the city-to-city learning program coordinated in "WP8 – Replication" by Oxford University.

The private sector and market point of view has been analysed by Esade in "WP9 – exploitation of results" in parallel and in close cooperation as well as the financing models investigated in "WP2 – strategic planning & business models" by Exeter University.

The information exchange has been based on the previous Project outputs: the *City Model Canvas* provided by ESADE in WP2 (D2.2 "Business Models of the Lighthouse cities"), the related *City Data Canvas* developed in WP7 (D7.1 "Peer review methodology").

To complete the analysis and wrap up the lessons learnt, for each action a *SWOT & USP (Unique Selling Proposition)* analysis have been included.

For the management model schemes, the theoretical framework has been based on the *Value Creation Ecosystem* concept developed by ESADE developed under WP9 of Replicate project; all the implementations included in the present analysis have been modelled together with partners and lighthouses to illustrate the complex eco-system of the actual implementations and a first attempt of scale-up at municipal level or possible replication involving other municipalities has been designed.

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The viability and the performance of the interventions are the objective of the REPLICATE business models monitoring system (refer to Deliverable 10.7 "Report on monitoring business models"): evaluations have been updated continuously in WP10 and 7 to collect the evolving feedbacks linked with the implementations stage and achievements.

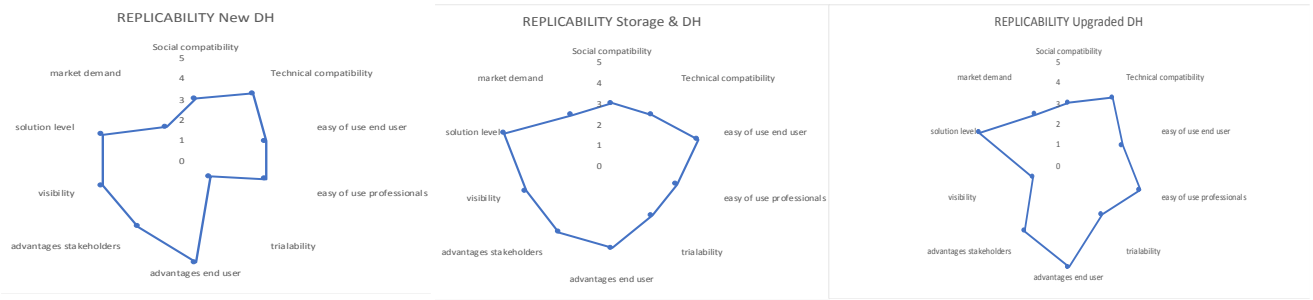

Figure 3 – example of replicability and BM monitoring developed in cooperation with WP10

5.2.1 The process

To put in practice the methodology a step-by-step process has been developed with the three cities starting from the detailed evaluation of results as well as of the framework at local level; the second step consisted of the definition of the local policy and vision with the temporal and spatial selection for the roll out implementing open methodologies to engage stakeholders.

Local/national Advisory Boards have been activated by the three cities since the first steps during the analysis to share results and collect useful feedbacks.

The third step consisted in the technical assessment of impacts to support the last activity of the final decision making.

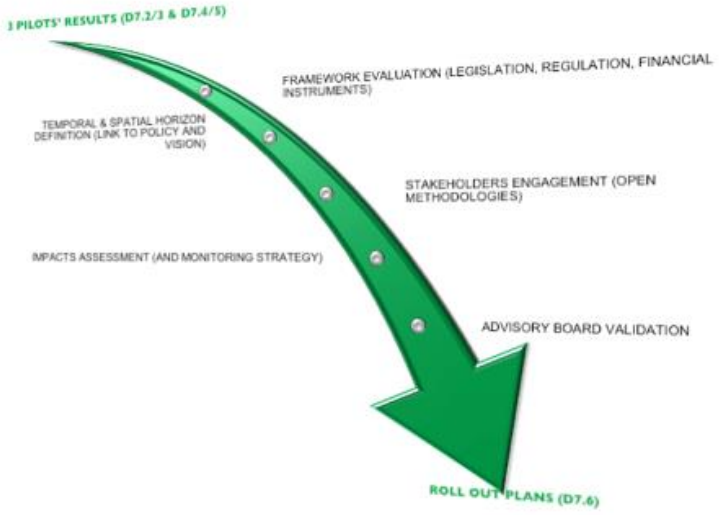

Figure 4 – the process

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- Guidelines

The lighthouse cities had to develop a replication plan to extend the most effective measures. SPES has developed at the end of 2018 a guide to support the replication planning: some common features have been set to make the plans reliable and homogeneous and to be in line with the STEEP methodology.

The guidelines have been shared among WP leaders, with the EEA supporting network and with the EIP planning action cluster.

The guidelines are also highlighting the flexibility of the scale up plans, listing all the degrees of freedom: for each topic some mandatory recommendations are reported together with flexibility aspects to personalise the cities' approaches.

The main principles defined with stakeholders have been declined in the guidelines provided by SPES to the lighthouses which reported that:

- ✓ *the approach is replicable*: the smart city plans developed during STEEP with a co-productive methodology have been tested in practice in three districts providing evidences and lessons learnt which will support the integration into the local planning framework with the full exploitation of their potential

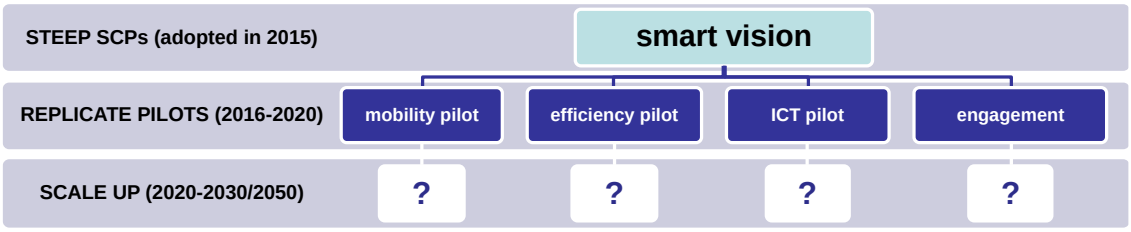

Figure 5 – the path of the three lighthouses

- ✓ *taking into account externalities* could be useful to highlight possible synergies with different sectors/departments for the management and financing and to support decision making and prioritisation.
- ✓ There should be several degrees of freedom in the roll out definition, it is not a fixed structure but a process of *adaptation to local context* and optimisation
- ✓ *Benchlearning from the others* (lighthouses, followers and Advisory Board members) is the main added value of the project: cross fertilisation and contamination could optimise the transition to the smart city

- Questionnaire

At the end of 2018 a questionnaire has been circulated among the lighthouses to collect information about the planning framework for the next years/decade and their interest in analysing

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the replication of actions implemented in the other two cities, since the extension of the local pilot had been already analysed in the previous months (D7.3 Report on technical solutions, D7.5 Report on management models).

- Meetings with stakeholders

The results of the previous deliverables together with the outputs of the questionnaires and the analysis of the updated data about energetic/environmental city profile have been presented to local stakeholders in the three cities to evaluate the gap to strategical targets and how to contribute with the extension/replication of pilot actions. Participants (from different city departments, local companies, public services providers, research& university…) have been able to capitalise the experience gathered by all the three pilots and interact about lessons learnt and future local adaptations. Knowledge sharing among cities was reinforced and translated into local programs.

Figure 6 – stakeholders' meeting in San Sebastian (WP7 & WP2 May 2019)

- Advisory Boards

In accordance with the structure defined with the lighthouse cities (D1.24 Report of Advisory Board), different levels of exchange have been set up.

The Advisory Board was structured in different levels and each level has been coordinated by a different leader/partner with the supervision of the project coordinator. It is important to highlight that each level of the Advisory Board has not had a static and fixed structure but a dynamic board, so the members participating in the advisory procedure might have been different depending on the topic or the specific need of the moment.

During spring 2019, the results of the analysis carried out on the pilots implementations from the technical and management model point of views have been made available: three thematic summaries (energy, mobility, ICT) have been provided to the lighthouses for those who would have asked more information after the discussions/presentations.

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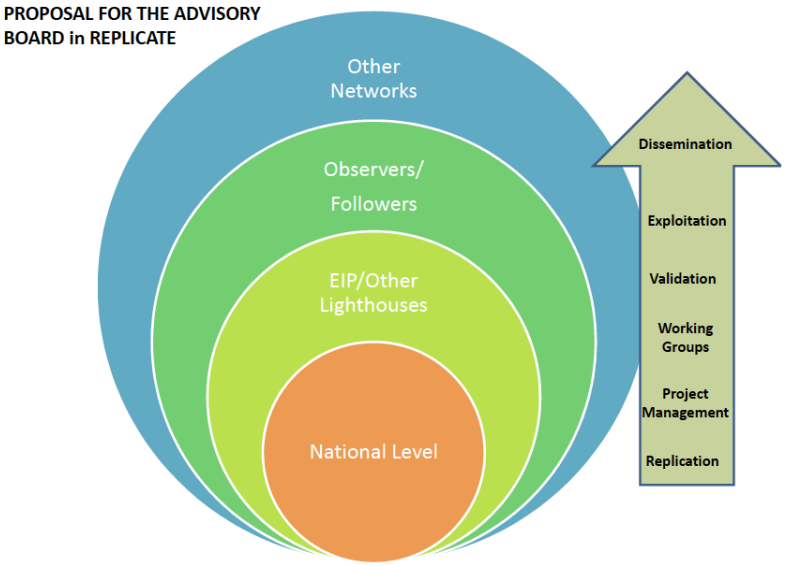

Figure 7 – Advisory Board composition (D1.24 Report of the Advisory Board)

Beside the international activities with the EIP and observers (Fomento San Sebastian, the coordinator), the EEA network (SPES) and with followers (University of Oxford, leader of WP8 "Replication Plans with follower/fellow cities"), national Advisory Boards have been consulted by the three cities gathering information about the extension/replication activities in terms of optimisations and possible adaptations, supporting framework, parallel experiences.

These 3 boards, one in each one of the Lighthouse pilot cities, consisted in some selected partner cities from their respective country participating in smart national or EU programs. Feedbacks have been very useful in the development of the roll-out plan details (supporting information, stakeholders' list, strengths, and obstacles, etc.).

Figure 8 – Italian Advisory Board meetings

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- Benchlearning

Who/what is better (at a particular process) than us? What could fit to our specific situation?

A successful implementation cannot be ensured by trying to transfer a certain implementation but understanding the key factors and the complexity of processes. Thus, for example, focus on understanding other city' ability to carry out tasks is transferred to the city itself, to the human resources in the municipality and the ability to use these.

After the meetings, the first outputs have been provided to the 3 lighthouse cities with suggestions, from SPES technical experience and meetings' results, for scale up and cross-fertilisation: for each action some adaptations, opportunities and obstacles have been provided for the scale up in the testing pilot city but also in the other two lighthouses environment. These suggestions have been further discussed with the cities to define the final set of actions to be extended or replicated in the roadmap.

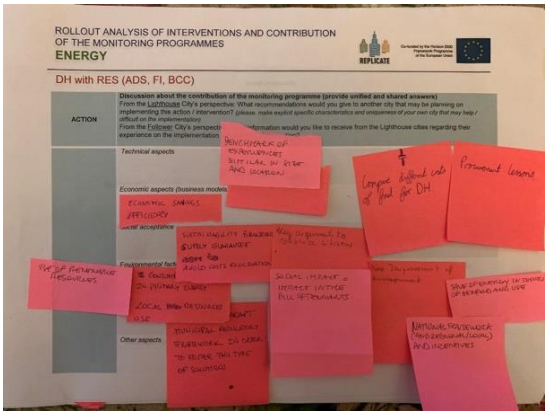

Figure 9 – discussion and information collection about replicability
(WP7 & WP10 Working session during general assembly in Florence, Oct 2019)

- Benchacting: integration in city plans and departments programs

The final step consisted of integrating the selected measures into the existing planning and programming framework of the cities, to embed innovation into the policies committing all related sectors and departments in the extension. The decision/policy makers and the working groups have been involved in the definition of the timeline (short, medium, or long term) and of the most appropriated policy tool between those under development in the next two years (see next paragraph) to concretise the roll out into the city programs.

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6. AFTER THE PILOT ACTIONS: OUTCOMES AND OPPORTUNITIES

6.1 Cross cutting outcomes: the REPLICATE approach

After six years of cooperation between the three lighthouses (STEEP project www.smart-steep.eu and REPLICATE), the pilot implementations and the interactions with the followers, it resulted clear the "Smart City" to be a "liquid" concept[2] with no rigid and static definition linked to the use of technologies: it is more related to a **continuous process** or an approach embedded into the municipal organization which has to respond to new challenges for its citizens' wellbeing and its own resilience.

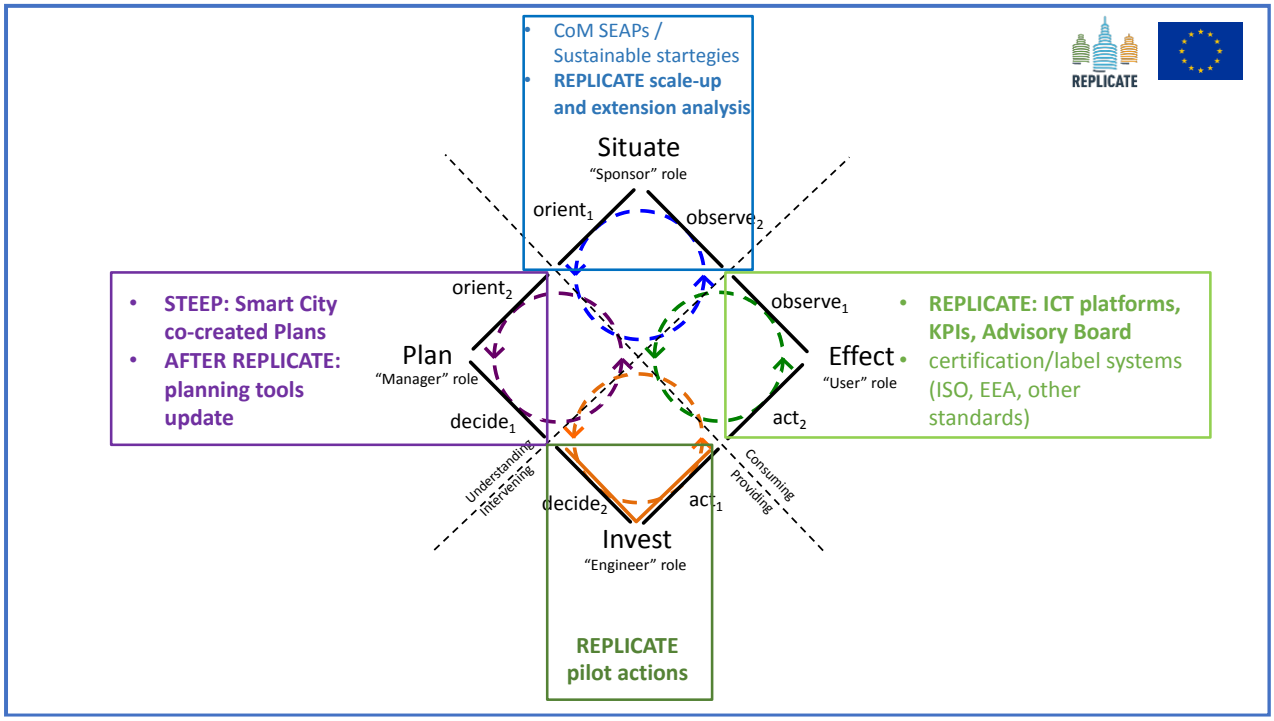

Figure 10 – the STEEP-REPLICATE process[3]

To become really smart and sustainable, a city should spread innovations in different sectors with a wide territorial diffusion: it is therefore necessary that pilot actions have a strong replicability index or can easily adapt to other boundary conditions to be extended within the lighthouses roadmaps or to any other interested city. Smart measures present barriers to diffusion linked

[2] Calzada, I. & Cobo, C. (2015), Unplugging: Deconstructing the Smart City. Journal of Urban Technology 22(1): 23-43. DOI: 10.1080/10630732.2014.971535.

[3] Yearworth, M., Willis Singer, J., Adcock, R., Hyberston, D., Singer, M., Chroust, G., & Kijima, K. (2015). Systems Engineering in a context of systemic cooperative praxis (SCOOPs): development and implications. In J. Wade & R. Cloutier (Eds.), *13th Annual Conference on Systems Engineering Research (CSER 2015)* (pp. 214-223). Hoboken, NJ. doi: 10.1016/j.procs.2015.03.048

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both to technological factors and to cultural factors (including those that are based on changing habits, bureaucratic aspects, ...) as well as financing: all the actions included in the replication plans have found a balance and a possible solution tested in practice to boost the transformation.

How should a Smart and Sustainable City prioritize its projects? Following the concept of the City Model Canvas, a business model assessment adapted to municipal vision in WP9 by ESADE, and in line with the UN Sustainable Development Goals concept, the city should take into account the sum of three different aspects, economy-social-environment, to define a **"Smart and Sustainable priority"**. The social and environmental impacts as well as the possible indirect externalities play a role also in the business model of the actions exploiting synergies from different funding opportunities.

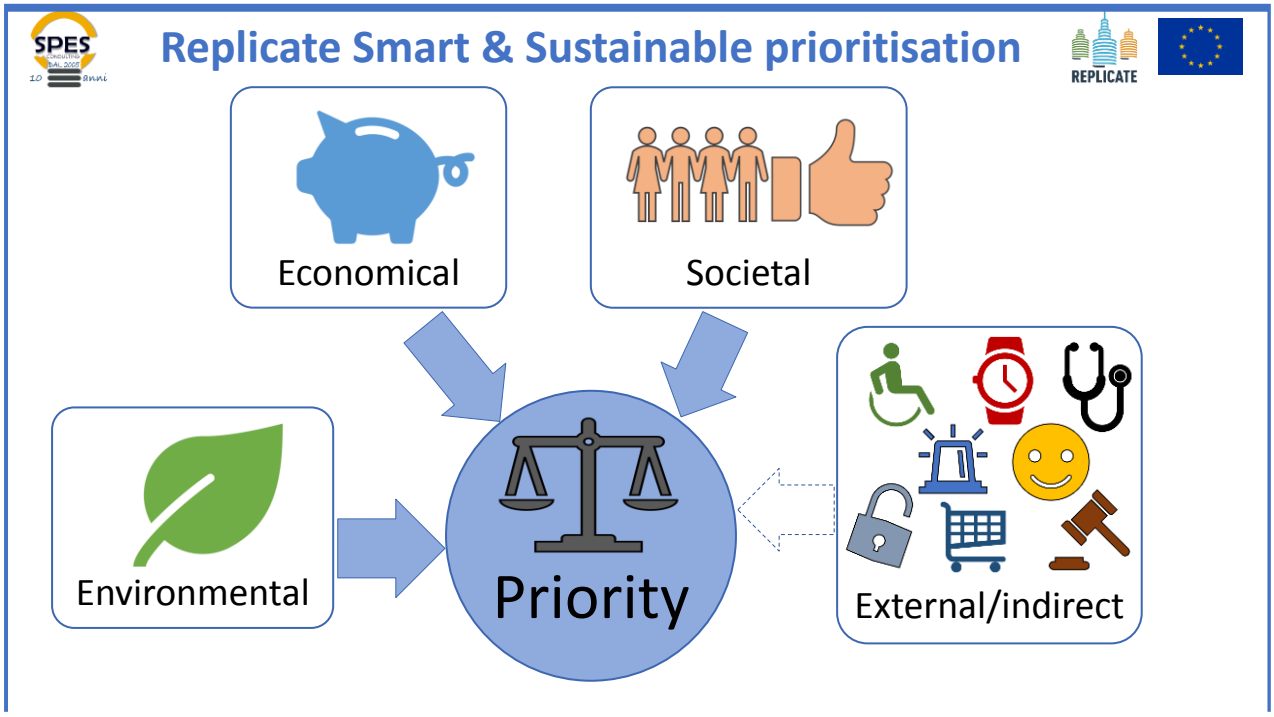

Figure 11 – the REPLICATE smart prioritisation process

This approach is perfectly in line with the ISO (adopted also by EIP) definition of Smart City: " *a city that increases the pace at which it provides social, economic and environmental sustainability outcomes and responds to challenges such as climate change, rapid population growth, and political and economic instability by fundamentally improving how it engages society, applies collaborative leadership methods, works across disciplines and city systems, and uses data information and modern technologies to deliver better services and quality of life to those in the city (residents, businesses, visitors), now and for the foreseeable future, without unfair disadvantage of others or degradation of the natural environment.*"

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Behind innovative technologies that are evolving faster and faster and, in few years, can also become cheaper changing completely their actual business models, the supporting factors for the diffusion of the Smart approach resulted in:

- *Municipal internal organization*: the usual structure should be adapted to new challenges, able to manage an integrated vision and open to innovative schemes
- *Local legal framework*: a city can influence the diffusion of smart services also through its regulatory tools
- *Externalities*: as explained in the Smart priority definition, all the different impacts (direct and indirect) should be clearly pointed out in the decision-making process (health, social inclusion, poverty, …)
- *Co-creation*: empowering stakeholders and citizens can multiply ideas, create consensus and increase participation and awareness.

Regarding the factors just pointed out, in STEEP and REPLICATE the lighthouse cities have already created interdisciplinary working groups within their organisations adapting the structure to cross cutting topics related to Smart Cities; they have also adopted co-productive methodologies for complex problem-solving, including stakeholders in the decision-making process. In Replicate pilot actions roll out, they have influenced their local planning framework for the next future to concretise the Smart City model at wider level, testing in the prioritization of some measures also an external impacts assessment simplified methodology developed.

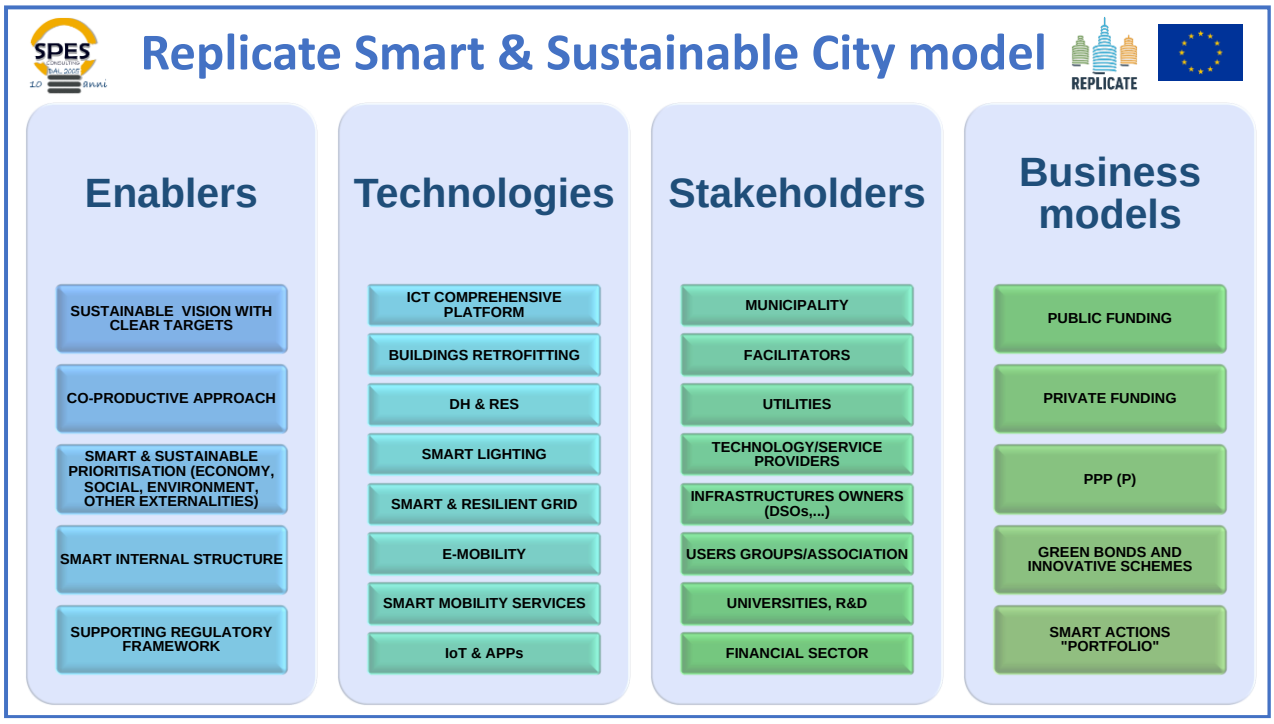

Figure 12 – the REPLICATE model for smart and sustainable city transition

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The stakeholders group is quite wide in all the three cities; among all the players listed in the previous figure and involved in the process, *the "facilitator" role has resulted very useful for the successful transition*: supporting agencies, third parties and technical external expertise have been crucial for the pilots realisation. Technological and process innovations often require paths that have not yet been explored for the Public Body, however, these solutions are attractive because they allow significant impacts (environmental and socio-economic) increasing the quality of life of citizens. These facilitators structures play a decisive role in overcoming procedural obstacles, internal silos and guaranteeing a path for implementation also through the involvement of political decision makers and stakeholders. It is an important role started in the planning and confirmed in the implementation phase that will find application in the scale up and repeatability of the solutions experimented in the pilot actions. This has been the case also in the WP8 with the Follower/Fellow Cities by utilising the Penta Helix multi-stakeholder policy framework by which facilitators (social innovators/entrepreneurs/activists) have proved being playing a crucial role by implementing the necessary agency to mobilise stakeholders in the decided direction (D8.4 "Report on Conclusions of the Interviews and the Focus Groups").

The experience showed *a big gap between the business as usual (technologies, stakeholders and management/financing models involved) and the implementation of the Smart City concept* adopted in the plans: the pilot action are trying to overcome this mismatch adopting Smart City project management mechanisms that allow to realign the interests of the various subjects in the field; the successful realization models are resulting from a different approach, which could enable the replication and the large-scale dissemination of Smart Cities: a possible key could consist in how to "pack" projects together creating a "smart city portfolio" optimizing the impacts for the community but remaining interesting for business, as it happens for example on small scale in the public lighting evolution integrating different services or sometimes on buildings and e-mobility.

Meeting cities' smart and sustainable commitments requires investment in a portfolio of projects of different sizes, involving many stakeholders: interdepartmental work and co-creating planning are part to establish the dynamic network of stakeholders which characterises smart cities.

Smart city structure resulted to be a network of links and relations not as rigid as a crystal lattice but highly adaptable like a liquid and always evolving. There are some similarities with fuzzy logic which is a sort of computer logic that is different from Boolean algebra because in a nutshell it is more accurate than on or off, allowing all things in between.

Fuzzy reasoning is able to model and manage nonlinear functions/problems of arbitrary complexity and to map in a convenient way input to output.

The theory of fuzzy sets relates to classes of objects with unsharp boundaries in which membership is a matter of degree: in a smart city the stakeholders group has no fixed boundaries and membership is related to the degree of interest about a specific topic in a specific moment.

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Systemic vision and networking are the pillars of Replicate pilot test, also in the roll out experience: a wide and well-connected smart structure at every level, as liquids do, naturally tends to adapt and extend itself.

6.2 Financing opportunities and supporting measures

To meet the objectives of the Energy Union and support the transition to a clean energy system, there is a need to further unlock private financing, in particular for energy efficiency investments, even if the EU has already increased public funds in these uncertain periods: it is estimated that an additional €177 billion per year will be necessary over the period 2021-2030 to reach the EU's energy and climate objectives for 2030.

The Commission has launched the Smart Finance for Smart Buildings (SFSB) initiative, as part of the 'Clean Energy for All Europeans' package, which includes practical solutions to mobilise private financing for energy efficiency and renewables in buildings in three main areas:

1. Optimised use of public funds
2. Support to project pipelines
3. De-risking investments

It is difficult for investors to assess the risks associated with smart cities investments. The Commission, in collaboration with the Energy Efficiency Financial Institutions Group (EEFIG), has developed two tools to support financial institutions, investors and project promoters in the evaluation of real benefits and risks of energy efficiency investments.

The first product is the De-risking Energy Efficiency Platform (DEEP), a database to share performance data of projects. The second tool, the "Energy Efficiency Financial Institutions Group (EEFIG) Underwriting Toolkit"[4], is a multi-purpose guide which has been analysed in detail: in particular the fourth section, "Value and Risk Appraisal", identifies the various sources of value that can be created by energy efficiency projects including non-energy benefits, in line with the REPLICATE approach adopted. An overall approach to risk appraisal is set out: while the discussion of the various sources of value resulting from energy efficiency investments may help the selling of energy efficiency projects and products, understanding the risk factors from the beginning of the project life cycle should lead to better developed business cases with lower risk and higher performance.

[4] http://www.eefig.com/images/pdf/EEFIG_Underwriting_Toolkit_June_2017.pdf
https://valueandrisk.eefig.eu

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7.2.1 Standardisation of flexible processes[5]

It seems a contradiction in terms, but also innovative processes to be easily adapted and replicated in different conditions, must find a shared and common approach that simplifies their understanding from different points of view (technical, administrative, financial ...) while maintaining the flexibility needed to adapt to specific boundary conditions.

Among EEFIG recommendations, it is worth to highlight the importance of the early involvement of financial institutions in project developments and, most important, to "speak the same language" it is suggested to establish a "standardised", clearly defined and commonly understood, process to reduce costs and decision times; the use of internationally recognised standards could be supporting, as reported in the conclusions of the present work, at any stage of the project, covering all the different phases from planning to measurement and verification.

Thanks to the intrinsic characteristic of a "technical standard", it can be used as risk reduction tools as based on universal criteria of transferability, essentiality, transparency, sharing or, in other words, materiality. These principles find an equal correspondence with Accounting (IASB-IFRS) and Sustainability protocols (Environmental Social Governance - GRI) adopted by credit and finance system.

"Climate change, with its complex, global and interrelated character, requires a collective effort in order to find the necessary long-term solutions. For this reason, participation at all levels, and across all sectors, is fundamental. Standards, as long as they are inclusive, can be part of the solution." (CEN/CENELEC)

Whilst the importance of innovation to boost economic growth, to create jobs and to address society's grand challenges is very well understood and addressed in all strategic roadmaps, standards are playing a major role in bridging to successful innovation. Indeed, standards are developed through a consensus-based process, considering the most recent technologies and best practices, with the permanent objectives to contribute to meeting strategic engagements and commitments with benefits for the entire Society, the Environment and our Competitiveness.

Thus, standards play a key role in facilitating the market potential of innovative ideas, by setting the frameworks needed to unleash creativity and force choices. But among the most important benefits of standards, contribution to the dissemination of knowledge is key. Standards create reference frameworks for efficient replication of best solutions and innovative models, ensuring safety and security for the Society, so that others can build on them and improve them further without having to reinvent the wheel.

[5] *Written in cooperation with Dr. Bernard Gindroz CEN-CENELEC SFEM Chairman Sector Forum Energy Management-Energy Transition*

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In Europe, the Standards developed by CEN and CENELEC, are common to 34 countries including all European member States, which contributes to accelerating the market change at large scale by setting a common reference framework to all, and then paving the way to global changes.

Considering sustainable challenges – economic, environmental and societal –, such as at the heart of this REPLICATE project, knowledge sharing, public awareness raising, public acceptance, innovative technologies and organisation models are essential for meeting their related targets and transforming the markets with a rapid transition phase. In that sense, standardization plays again a major role, by creating trust and confidence in innovation among citizens and within the Society, as well as by bridging all different stakeholders and actors of the complete value chains through common understanding (terms and definitions) and consensus based and robust reference models (elaborated by experts from a variety of stakeholders (scientists, developers, producers, buyers, users, regulators and civil society). "*This inclusiveness is what makes the European Standardization System unique, as it ensures that standards reflect not only the scientific and technical state of the art, but also take into consideration the concerns and priorities of the society"*.

By providing new, voluntary references, based on consensus, standards facilitate the transition to innovation and greening our economy. Standards are valuable and efficient booster of innovation to market thanks to their unique capacities to motivate replication.

To make an example, a lot of different standards could be implemented at city level to boost the transition to sustainability and smartness facilitating the introduction of innovation in technical, administrative and financial approaches (i.e. energy and environmental management systems like ISO 50001, 14001 and European Energy Award, sustainable cities and communities ISO 37100 series, EN 16247-series about energy audits, EN 16231 about Energy efficiency benchmarking, etc) and many others could support specific technical challenges at project level.

7.2.2 Green Bonds

The financing can be achieved in several forms, the choice of which should be dependent on the type and size of the investment, the risk preferences of lenders/investors, and market acceptability; secondary financing, beside savings or equity or loans etc., can be also achieved through bonds, which seem to be the most promising way to cover the gap to 2030.

Green Bonds enable capital-raising and investment for new and existing projects with environmental benefits.

The situation is still uncertain, but Corona virus crisis is offering green and social bonds chance to prove their worth: "*Greater emphasis on social finance and sustainable development will likely be one of the lasting outcomes of the coronavirus crisis*" (Matthew Kuchtyak, AVP-Analyst at

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Moody's). The latest surveys of the corporate index, the financial market thermometer, in fact record better performance by green bonds than traditional bonds. One reason is to be found in the composition of the green bond index which does not include companies and sectors more affected by the effects of coronavirus but only marginally by the collapse in the price of oil; another reason could be the rise of ethical issues in times of crisis. In essence, according to Bram Bos – lead portfolio manager Green Bonds di NN Investment Partners, *the current market context will favour long-term green bonds and companies that believe in ethical finance*.

ICMA[6], the international capital markets association, indicated the characteristics of green bonds internationally: the Green Bond Principles (GBP), updated as of June 2018, are voluntary process guidelines identifying the characteristics so that an obligation can be defined as green (there is also a list of potential issues environmental to be financed, but not exhaustive list).

	Environmental objectives				
GBP-project categories	Climate change mitigation	Climate change adaptation	Biodiversity	Natural resource conservation	Pollution prevention and control
Renewable energy	●●●			●	●
Energy efficiency	●●●				●
Pollution prevention and control				●	●●●
Environmentally sustainable management of living natural resources and land use	●	●●	●●●	●●●	
Terrestrial and aquatic biodiversity conservation		●	●●●	●●●	
Clean transportation	●●●			●	●●●
Sustainable water and wastewater management		●●	●●	●●	●●●
Climate change adaptation		●●●			
Eco-efficient and/or circular economy adapted products, production technologies and processes	●●		●	●●●	●
Green buildings	●●●	●		●●●	●

Contribution to objective:

primary ●●● secondary ●● tertiary ●

Figure 13 – Mapping of the GBP categories to the environmental objectives (source ICMA)

[6] https://www.icmagroup.org/green-social-and-sustainability-bonds/green-bond-principles-gbp/

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On 18 June 2019, the EU Technical Expert Group on sustainable finance (TEG) published its Report on EU Green Bond Standard: the TEG proposes that the Commission creates a voluntary, non-legislative EU Green Bond Standard to enhance the effectiveness, transparency, comparability and credibility of the green bond market and to encourage the market participants to issue and invest in EU green bonds. The proposal builds on best market practices. The standard would solve several barriers in the current market, including reducing uncertainty on what is green by linking it with taxonomy, standardising verification and reporting processes, and having an official standard to which incentives could be attached.

Building on best market practices, the EU Green Bond Standard would comprise four critical elements:

1. Alignment with EU-taxonomy: proceeds from EU Green Bonds should go to finance or refinance projects/activities that

   (a) contribute substantially to at least one of the six taxonomy Environmental Objectives,

   (b) do not significantly harm any of the other objectives and

   (c) comply with the minimum social safeguards.

   Where (d) technical screening criteria have been developed, financed projects or activities shall meet these criteria, allowing however for specific cases where these may not be directly applicable.

The six Taxonomy environmental objectives are:

I. climate change mitigation;

II. climate change adaptation;

III. sustainable use and protection of water and marine resources;

IV. transition to a circular economy, waste prevention and recycling;

V. pollution prevention and control;

VI. protection of healthy ecosystems.

		Do No Significant Harm criteria identified?				
Activity	Can climate change mitigation criteria change in future?	Adaptation	Water	Circular economy	Pollution	Ecosystems
Construction of new buildings	✓	✓	✓	✓	✓	✓

Figure 14 – example of taxonomy for construction of new buildings

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2. Publication of a Green Bond Framework, which confirms the voluntary alignment of green bonds issued with the EU GBS, explains how the issuer's strategy aligns with the environmental objectives, and provides details on all key aspects of the proposed use-of-proceeds, processes and reporting of the green bonds.
3. Mandatory reporting on use of proceeds (allocation report) and on environmental impact (impact report).
4. Mandatory verification of the Green Bond Framework and final allocation report by an external reviewer. The TEG recommends that external verifiers are formally accredited and supervised.

The crucial steps of this procedure seem to be the taxonomy definition and the verification/review. The Taxonomy will be developed gradually including more and more activities that contribute significantly to the environmental objectives.

The systemic and synergic approach and the importance of the framework are underlined also in the taxonomy definition by the group: *"The Taxonomy helps to define the universe of activities that will remain in a net-zero emissions economy in 2050 and beyond, and the types of activities that can support the transition to a low-emissions, climate resilient economy. The nature, pace and priorities for making this transition happen remains the remit of businesses, citizens and policy-makers at EU, Member State, Region and City level. An economic activity cannot truly be considered sustainable independently from the wider system in which it operates. In general, investors can finance individual companies or projects rather than systems. The Taxonomy development approach has therefore aimed to identify activities that make a substantial contribution on their own but also enable the overall transition of critical systems such as the energy, transport, urban, water and food systems. However, the nature of the transition in each country or region is influenced by how entire systems evolve, including local strategies and policies. A Taxonomy eligible activity may only contribute to an individual country's or region's transition pathway when it is also coherent with the transition of the overall system the activity is part of. It is important that investors consider the overall systems that activities are part of and the local transition pathways for such systems. By choosing to finance activities that are the most coherent with the transition of the overall system in their specific context, investors can maximise the sustainability impact of their investments, as the multiple individual activities reinforce each other and result in greater combined benefits."*

The aim of Replicate project was to test innovative solutions to try to provide cities and markets with inputs for the underwriting process as shown in the following picture.

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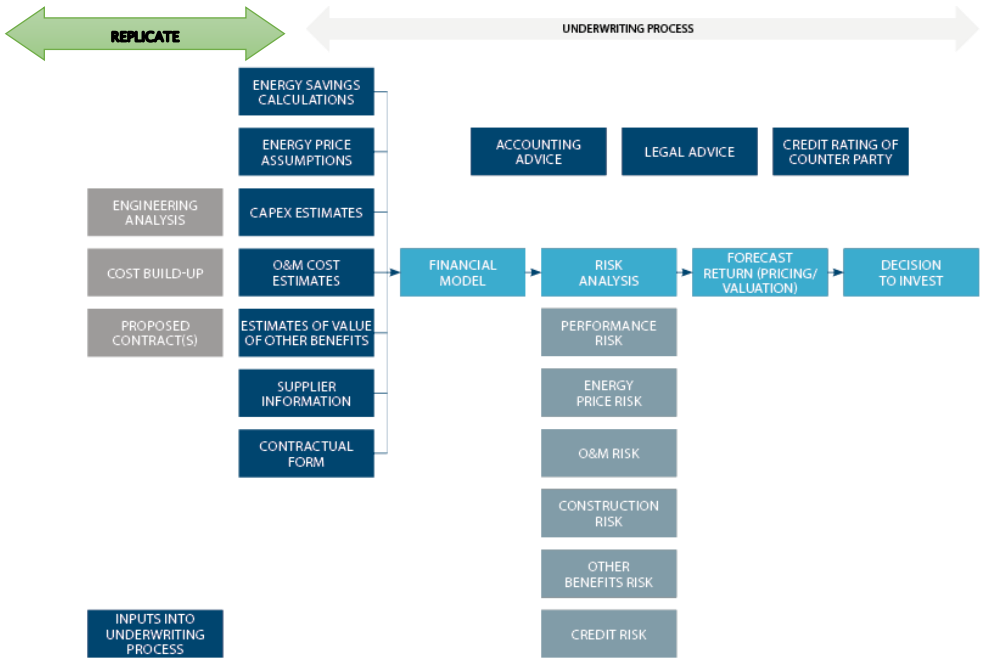

Figure 15 – Information flows from development into underwriting (source: EEFIG Toolkit)

7.2.3 First results from WP2[7]

The research undertaken in WP2 "Strategic Planning and Business Models" finds that the financialization of the city is an inevitable political operating context for the smart city (Pike, O'Brien, Strickland, Thrower, & Tomaney, 2019). Scenarios discussed by the European Innovation Partnership on Smart Cities and Communities (2016) predicting further reductions in funding across the EU reinforce this view. The scale of this gap and the deadline that a city sets for meeting its targets convey both *ontological weight* – expressed in terms of how much investment, or the rate of investment, that is needed in what sectors by when – and *epistemological depth* – in that the idea of a gap with a deadline conveys the *emotional* sense of the magnitude of the challenge a city faces together with a powerful sense of urgency to act and the clear driver for new organisational capabilities, partnerships and skills that will enable them to act effectively in this new and rapidly developing financialised field of operations. Bridging this gap will require cities to explore new partnerships with the private sector and new approaches to access the requisite capital. An inevitable characteristic of the transition is that city administrations are having to shift

[7] Yearworth, M. (2020). REPLICATE Project Deliverable D2.3 EU H2020-SCC-2015 (691735) project REPLICATE (REnaissance of Places with Innovative Citizenship and TEchnology). (pp. 92): University of Exeter.

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their worldview, and indeed entire strategic capabilities, away from familiar funding models and towards adopting a *financing* perspective. The consequent *financialisation* of the city is not only a profound shift in thinking and doing things, it is also one that it is emerging and adapting as the REPLICATE and other Lighthouse Initiatives are underway. It therefore provides the dynamic context in which the aims and objectives of the REPLICATE project are to be interpreted. The consequences of this logic are that the approaches we see emerging from the Lighthouse Cities studied in this project are essentially *creative and entrepreneurial* at the city governance level.

A combination of semi-structured interviews and the STEEP Methodology for system modelling was used to collect during the 4th year of the project, in addition to data collected from the REPLICATE Strategy Survey. An updated literature review was also conducted as a considerable amount of highly relevant literature has emerged since the project started. Analysis of interviews with key strategic actors in Bristol and Florence was conducted together with the application of the STEEP Methodology in San Sebastián. Overall, the data collected for this Work Package are presented and analysed from the perspective of the strategic capability of the city-as-a-network.

The findings from Work Package 2 reflect the complexities of the transition from funding to financing smart city interventions. The REPLICATE Strategy Survey and derived Smart City Strategy Index from the Structural Equation Model provide the theoretically grounded approach to surveying the strategic capability of the city-as-a-network, and this is probably of most relevance to scholars and policy makers focussed on developing a deep understanding of how strategic capability is developed in the smart city-as-a-network. Whereas the analysis of interview data from Bristol and Florence has led to a practical description of the contributory processes that are needed by a City to make the transformation towards realising replicable smart city business models. Analysis has shown that these are achievable through a new financing model that has been expressed using a Value Creation Ecosystem (VCE) approach. The STEEP Methodology workshop in San Sebastián led to the creation of an evaluation model presented that can be used by cities to self-evaluate their performance in transforming to a new model for financing smart city interventions.

Translating these findings into practical action requires linking together the strands of work into an approach to transformation that can be used by city managers. Replicable business models and financing mechanisms are closely related but cities as networks need to develop the strategic capability to join the two together to achieve their transformational goals. The use of the STEEP Methodology – or some other Soft OR/Problem Structuring Method-based strategy-making interventions such as the Strategic Choice Approach (SCA) (Friend & Hickling, 2005) or Strategic Options Development and Analysis (SODA) (Ackermann & Eden, 2011) – is recommended for any level of transformation goal. The evaluation model can be used in its entirety, or a new one

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constructed using the approach described to fit the needs of the transformational goal that has been agreed.

This overall approach developed in Work Package 2 can be summarised at a meta level by a set of 9 processes that would be required to *initiate* any transformation in the smart city context. These are set out in the following Figure.

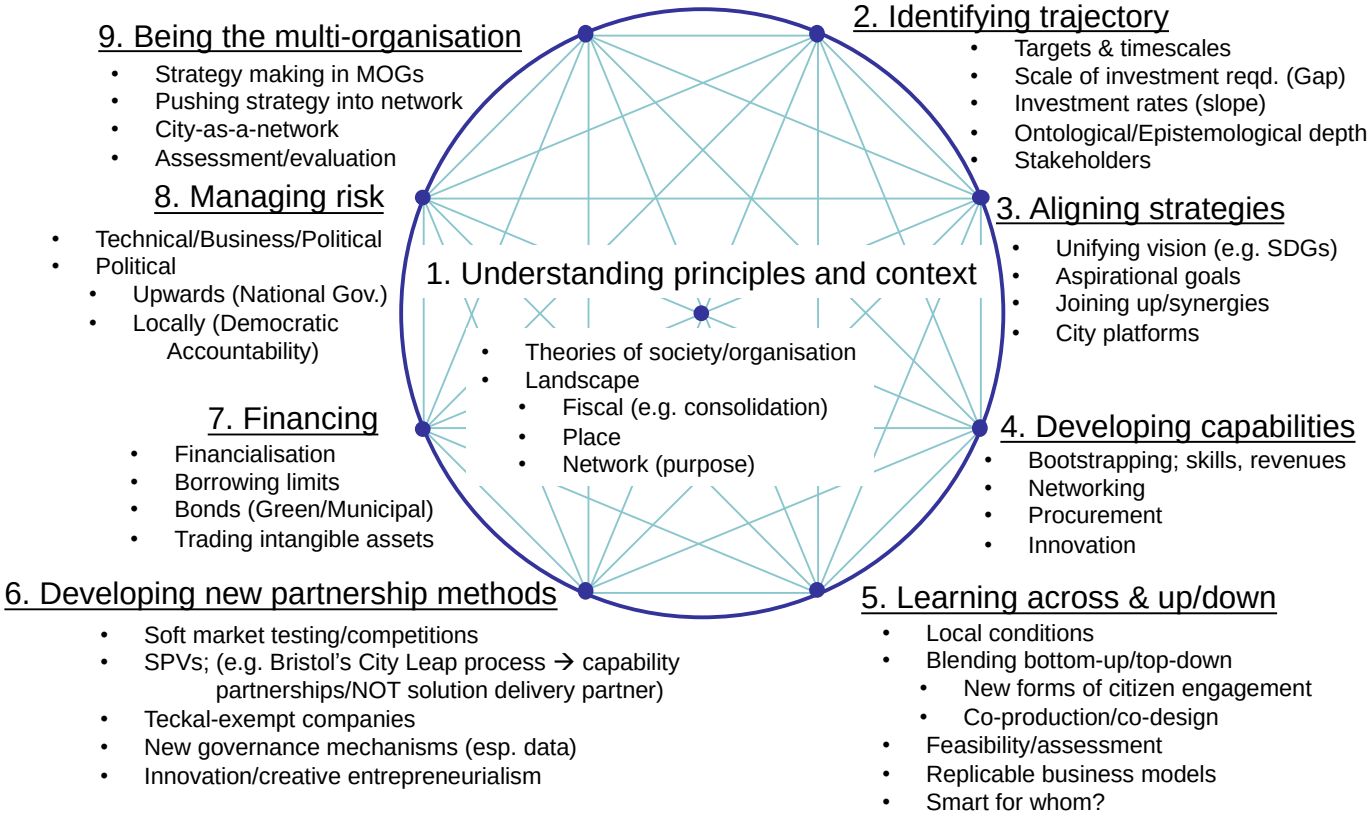

Figure 16 – the 9 processes to initiate transformation in a Smart City context (source: WP2)

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7. AFTER THE PILOT ACTIONS: SHAPING THE NEW FRAMEWORK

Lighthouse cities, as every smart city, are based on a very dynamic environment following closely societal and technological evolution and at the same time they are located in multilevel national systems with own policies and strong influences in some sectors. In the lighthouse cities the framework has slightly influenced the implementations and the analysis of the differences and the changes from the national to the local level has become important to understand the adaptations and the optimal conditions for the replication/scalability of the measures.

In previous analysis (last version is included in Annex 1of D7.5 Report on management models) an update of the existing framework from the three cities to contextualize the actions, considering the three main sectors involved (energy efficiency, sustainable mobility and ICTs/Infrastructures) has been made available together with a short overview on energy prices and ESCo markets with a focus on the three participating nations to better compare the intervention and understand the cross-fertilisation chances of the different measures implemented in the three lighthouses.

For the roll out, cities should influence future policy framework, taking tailored decisions based on their specific profiles and needs: the plans under development or foreseen for next two years have been analysed for the direct integration of project results as well as mid-long term trends of related sectors (energy, emissions, population growth, services management,...).

The actual Covid emergency is influencing plans but, even if it is a very early stage to assess impacts, the overall targets of the 3 cities towards sustainability are confirmed or even improved.

7.1 San Sebastian

6.1.1 Trend of city level KPIs

The city of San Sebastian has committed long ago in promoting a combination of innovation, sustainability and tradition which could suite to its peculiar territory characterised by natural landscape, heritage and tourism.

Fomento San Sebastian (FSS) works on the promotion of sustainable economic development of the city. FSS, among its different initiatives, promotes Smart City projects in collaboration with members of the Smart Cluster, Municipal Departments and other public and private entities (Universities, research corporations, companies, associations). FSS is coordinating Replicate and SmartKalea Projects and participates as a partner in Hotmaps, Clean, Bodah projects, among others. During these last years FSS has also coordinated Steep project and has taken part in other projects, such as Opteemal, that are already completed. Fomento San Sebastian works on the

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positioning of 5 districts of the city: Txomin, Old Town, Altza, Amara and Bera Bera and the use of different, complementary and convergent models and financing sources.

The city's policy framework is articulated and inspired by EU main targets.

Trends of the last decades show the results of the efforts oriented to sustainability matched with economic development.

As analysed in deep in WP10 – monitoring, the population is increasing moderately in San Sebastian (+0,7% between 2014 and 2018) and the tourism intensity has significantly increased (+35,2% in the same period thanks to many initiatives and the "2016 European Culture Capital"). From the economic point of view, unemployment ratio in the city has decreased to 8,6% in 2018 and the gross domestic product of the city increased around 15% between 2014 and 2018, with a 26-27% constant production by the ICT sector.

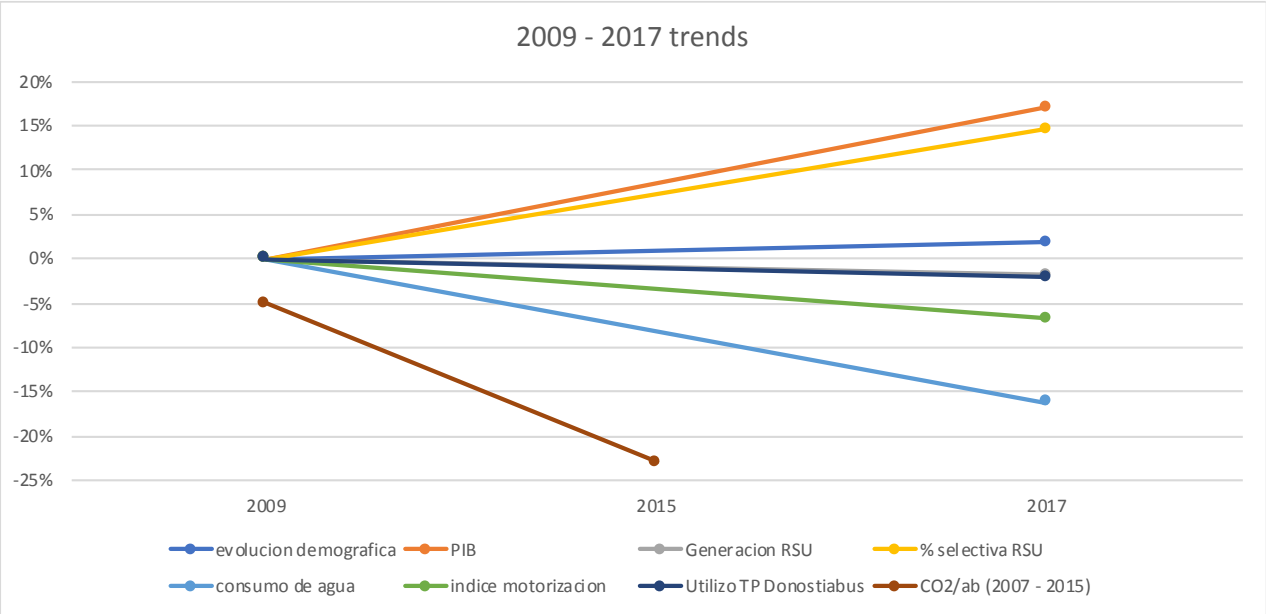

Figure 17 – some trends of city level KPIs in San Sebastian
(source Environment Municipal Department and WP10)
Blue-Demographic evolution; Orange- GDP; Grey-Solid Urban Waste Generation;
Yellow-% selective RSU; Blue-Water consumption; Green; motorization index;
Blue-utilization of Donostiabus; Brown- CO_2/ab

San Sebastián is working hard in the energy and environment sustainability of the city and between 2009 and 2018 some good achievements were reached:

- Emissions of CO_2 have already decreased of about 23% but the gap to 40% has to be covered in the forthcoming ten years
- Other Environmental KPIs are improving (water consumption -2,6%, waste recycled 37%…)

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- The number of vehicles is decreasing (0,41 four-wheels and 0,14 two-wheels vehicles per capita)
- In Donostia – San Sebastián, the 99,5% of people have access to public transport and the annual public transport trips per capita has increased around 3,15% between 2014 and 2018.
- Donostia – San Sebastián is a pedestrian- and bike-friendly city, as the 13,7% of the area of the city is restricted area (2017 data) and the 1,3% of the roads are only for bike-riders.
- Between 2014 and 2018 Reduction of the PM10 concentration of around -13,4% and of the noise pollution due to the increase in the length of the road with a limited speed at 30km/h and to the new bypass second belt.
- Regarding energetic aspects of buildings, in 2017 the 2,30% of buildings in Donostia – San Sebastián were refurbished obtaining energy performance improvements and in 2018 other 1,71% of buildings are renovated too. All of these buildings have smart energy meters, and in 2018 the 2,88% of buildings have connection to a district energy network (100% in the Txomin-Enea District).
- In 2018, more than the 80% of the houses have access to the internet and more than 75 thousand people over 100.000 use internet in the city

6.1.2 Policy framework for the roll-out

The city of San Sebastian works on the transition to a sustainable city involving the different departments and public entities of the city. This involvement has conducted to the development of different strategies and plans by the different departments and entities. These strategies and plans are complementary and transversal among the different departments of the city council, entities and sectors. The objectives and actions described in the different documents might be linked and impact on different areas of the city. Each department or entity works on their specific actions according to their objectives and budgets. Collaboration among departments and entities is key and it is also reflected in the elaboration of the plans where the different areas contribute. Here below a short summary of each plan is included, both the implementations of the Replicate project as well as the short term scale up actions that are described in section 9 might contribute to the objectives described in the different plans of the city.

- Smart City Plan

San Sebastian (through Fomento San Sebastian) started a planning process following the methodology -defined in the FP7 project STEEP – Systems Thinking for Efficient Energy Planning, together with the cities of Bristol (UK) and Florence (Italy). The process had two main goals: to

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establish a main strategic line with shared objectives on one hand and giving coherence (consistency) and Coordination in the Public Action on the other hand. All of the socioeconomic agents participated in the development of the Smart City Plan, and an integral plan for the local smart strategy was established. The plan took into consideration the different municipal strategies and projects, European policies and strategies and the background and good practices of the city.

Under the coordination of Fomento de San Sebastián,187 people from 96 different public and private entities met reaching the definition of the actions/major projects included in the plan.

The governance main task was to ensure coherence (consistency with programmes and strategies in place) and coordination in public action.

The Plan presents four main parts:

- Strategy for the Smart City concept in the city (provides a long-term vision).
- Governance model, suggesting the creation of structures for better interdepartmental coordination.
- An action plan for the period 2016-2020
- An evaluation & monitoring system.

Energy efficiency, sustainable mobility, ICTs/Infrastructures, Smart and Open Government and smart living axis are considered in the Smart City Plan and 6 intervention areas (Services sustainability, Energy, Mobility, ICT, Government, Living).

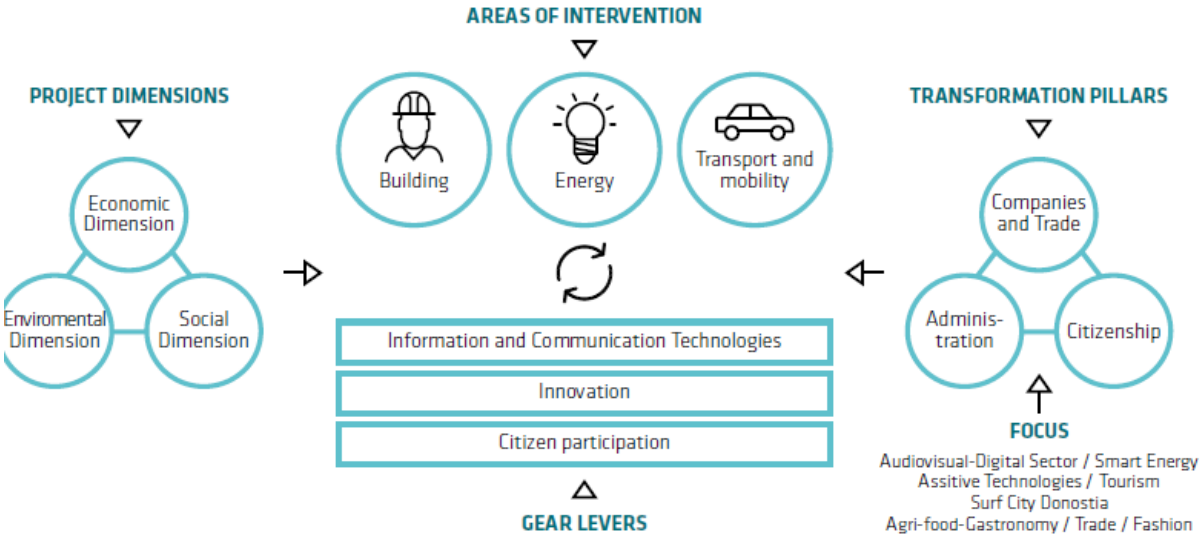

Figure 18 – Dimensions, areas of intervention and transformation pillars of Donostia Smart City Plan.

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An important issue that has been included in the plan is 'social innovation' for Smart Cities based on innovative solutions, new forms of organization, new interactions and how to tackle social issues in cities.

- DSS Klima 2050 Action Plan launched in 2018

The Klima 2050 Action Plan is the document developed by the Environmental Department of San Sebastián City Council and stablishes the objectives and actions in response to the challenge of Change Climate. The Klima 2050 Action Plan links the activities of different areas of the City Council, covering the period between years 2018-2050 and establishing intermediate objectives for the year 2030.

It is not a completely new document, but the continuation of a process of planning and reflection started in the city a decade ago, which has reached in this document a new and fundamental milestone.

The action plan is unfolded in sectorial objectives to meet the climate commitments, and covers the following areas:

- energy: efficiency (retrofitting), exploitation of renewables (biomass, solar energy…), energy poverty and vulnerable sectors support
- Territory: green infrastructures (charging network, District heating), sustainable urban development (smart districts)
- Circular economy: waste and water (IoT and consumption/production awareness)
- Mobility: sustainable transport (electric mobility), reduction of the number of vehicles: soft mobility (bikes) and sharing

This long-term plan has set the perfect framework to support the implementation of smart actions and REPLICATE approaches: an intermediate target is foreseen at 2030 in line with the EU policies and the commitment of the Covenant (40% savings of GHG considering as baseline the year 2007). The vision at 2050 involves ambitious targets in different sectors such as: limits to soil use, decrease of mobility emissions, support to circular economy, 80% of the buildings with high energy performances and more than 80% of the final consumption provided by renewables.

Investigating the lines of action provided for each of the mentioned topic, it resulted that many measures included in San Sebastian pilot as well as in the other lighthouses pilot tests are perfectly in line with this master plan providing the ideal framework for the extension/replication:

Regarding the approach chosen to concretise the targets, it states that "every person and every activity count and can contribute", empowering citizens and providing a vision made of small-medium size implementations instead of big interventions not suitable to the territory. Finally, the five thematic axes chosen to concretize the targets are also in Replicate experience the best ways to act; usually they work together and to optimise their effect they ought to be coordinated in

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planning tools. Each of the actions can be focussed on one axe but the others should also be exploited to support the feasibility and to enhance the achievements.

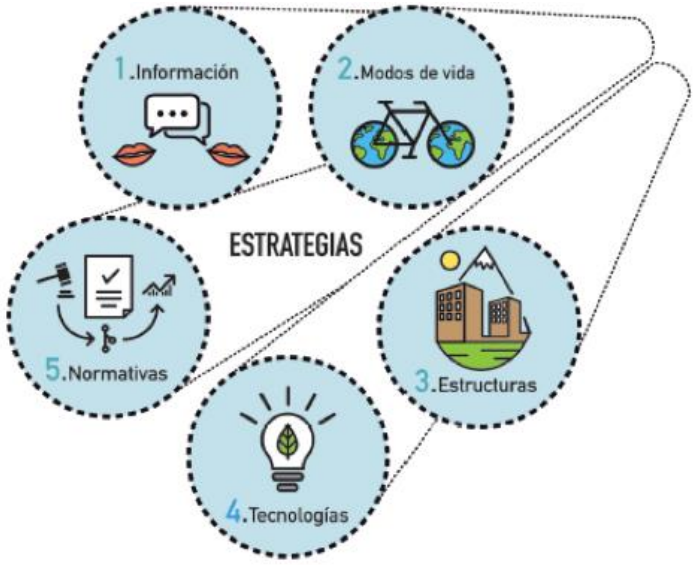

Figure 19 – the DSS Clima Action Plan strategies
(1-Information; 2-Lifestyle, 3-Structures; 4-Tehnologies; 5-Regulation)

- The strategic plan E2020DSS covering 2010-2020 and the next E2030DSS under development

The strategic plan E2020DSS aims to provide a vision of a shared city of the future, being a tool to stablish the itinerary for achieving that shared vision by the different public and private agents. The E2020DSS is based on the previous plan from the year 2010 and a new plan is being drafted covering the period until 2030; E2030DSS.

The strategy plan E2020DSS covers four areas: Innovation, Science, Knowledge, Creativity, Culture, Gastronomy under the tittle "Designed in DSS", people and values, connected city and quality of life.

The procedure followed for the definition of this plan is in line with the Replicate project concept and roll out requirement:

- it is a "living" process open to ideas and contributions and able to tune the activities on the basis of the previous years results targeting the expected objectives: after having defined and agreed the lines of action and the strategic projects, it proceed to a coherence analysis (fitting to the objectives, prioritization) and to the establishment of the mechanisms of monitoring (system of Indicators).

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- The SWOT analysis ("Análisis DAFO: Debilidades, Amenazas,Fortalezas, Oportunidades") has been used as starting point for the planning phase as we have done in WP7 previous analysis on single actions.

Contents of the plan, included many energy and mobility topics in the "designed in SS" and "connected city" sections, as for example the promotion of infrastructures to enable research, development and innovation in the field of Energy and the creation of new companies related to this sector or the possibility structuring / organizing share projects at metropolitan scale especially with regards to connectivity.

- Sustainable Urban Mobility Plan (SUMP) 2008-2024

The reference document in the mobility department is the Sustainable Urban Mobility Plan (SUMP) that covers the period 2008-2024 The plan sets three different time horizons for the implementation of the different measures (short, mid and long term which were 2013, 2016 and 2024 in this case) and stablished intermediate objectives for these years.

The plan encompasses all urban mobility policies to be developed by the City Council. Thus, it is an integrating document of the different actions aimed at modifying and influencing the mobility patterns of the people of San Sebastian. The SUMP plan covers both public and private mobility sectors, since it is a plan that is aimed at addressing the activity of the city The plan includes a diagnose of the mobility of the city. The objectives of the plan are oriented to the contribution of:

- a higher quality of life for the people of San Sebastián
- education of the environmental impact of transport
- achieve a better energy balance
- promotion of a sustainable urban planning

The plan describes and some areas of intervention in relation to the different areas of the mobility: pedestrian, bicycle and vehicles mobility, parking, management, transport infrastructures as well as communication or training activities, among others.

The last point underlines an important element for effective sustainable mobility planning, i.e. its link with urban planning: in this way, San Sebastian municipality has established a joint path between general land planning and sectoral mobility planning. This relationship is usually broken in many sustainable mobility plans, which hardly consider the growth of the city in the medium and long term.

Furthermore, perfectly in line with Replicate approach, it states that the interpretation of sustainability itself as a necessarily participatory process, suggests that the PMUS should be carried

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out through processes of intervention, consultation and citizen participation that are as broad and profound as possible.

- Municipal buildings regulation

The new Municipal Regulation about Energy Efficiency on buildings, that is in approval stage after a participation process involving citizens, aims to promote the implementation of the design, savings and energy efficiency measures, and the promotion of renewable energies in buildings, installations and constructions, new and existing, whether they are public or private. Thus, it is the objective of the regulation to obtain a new and existing energetically efficient building development and give continuity to the path started with the previous energy efficiency ordinance as well as with the Replicate pilot (retrofitting, biomass DH and energy management system). For this purpose, the limitation of consumption and energy demand, the use of energy efficient facilities and the introduction of renewable, alternative and clean energy. The Regulation also seeks to solve and improve the structure, comprehension and the procedures related.

There are also other regulations, plans and strategies in the city that have different objectives and that also contribute to the sustainability of the city: Housing Municipal Plan, Sustainability Report among others.

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7.2 Florence

6.2.1 Trends of city level KPIs

In Florence the city council is strongly committed with the EU climate targets: with the SEAP adopted in 2011, Florence has started the path towards sustainability, especially in the transport sector which resulted as the most pollutant in the emission inventory of 2005, and the milestones set for 2020 represent just a first step for its ambitious targets at 2030 set in its Smart City Plan.

Several goals have been already achieved due to a set of many different actions activated in the last decade:

- Reduction of CO_2 emissions of about 40% and 28% for the annual final energy consumption per capita

Figure 20 – Emission and energy path per capita, Florence (green) , Italy (brown) and EU (blue) (Source H2020 CoME EAsy)

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- Reduction of the PM10 concentration of around -41%.
- The significant recycling rate of 56% has been reached and maintained constantly in the last years, while water consumption per capita descended moderately.
- Italy was the first European country to introduce large-scale electric smart meters for low-voltage end customers and is still the world's leading country in terms of the number of electricity smart meters in service: in Florence the 100% of the users are provided with smart meters for electric consumption, while the 50% in case of methane gas meters.
- the city population has grown very moderately while the tourism intensity in Florence has significantly increased of about the 25% between 2015 and 2018 (2.831.042 nights / 100.00 in 2018)
- Referring to vehicles in Florence, in 2018 there were 0,52 four-wheels fossil fuelled and 0,20 two-wheels vehicles per capita, 125,7 EV per 100.000 inhabitants (39,5% public cars, 9,4% taxis, 4,5% public transport and 0,26% private EVs). The recharging infrastructure reached in 2018 the impressive number of 125,7 electric charging stations for EVs per 100.000 inhabitants.
- Florence is currently the most pedestrianized city in Italy, with restricted areas extending for 400,000 m2, or 1.07 m2 per capita, i.e. two times more than the second Italian city; there are also 4.13 km2 of limited traffic zones (LTZs) restricted for non-EURO 4 vehicles (even motorbikes) and 137 km of bike lanes and a parking garage for 800 bicycles at the main train station. The number of public transport trips per capita has increased significantly in the last year, due also to the availability of the new tramlines.
- Regarding the car-sharing services available, in 2018 there were 1.197 vehicles (80 fossil-fuelled cars, 58 EVs and 1.059 bikes) accessible for sharing every 100.000 inhabitants in the city.
- Thanks to the Digital Manifesto and the Smart City Plan adopted by the city, significant steps have been done in this field to achieve the mid-term targets with the city playing a driving role:
- In 2018, more than 75 thousand internet connections were established per 100,000 population, about a third of the area of the city has access to WiFi, all the public transport stops have provided real time information along with e-ticketing service and the number of users of digital services has significantly increased from 2015 to 2018
- Regarding the expenditures made by the municipality for the transition towards smart city, in 2018 the city council invested 711,6€ per inhabitant. And in addition, the total incentives for final users for low carbon measures (RE, Energy Efficiency, mobility) have risen in more

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than 10€ between 2015 and 2018, from 42,3€/person in 2015 to 52,8€/person in 2017, with a maximum peak of 69€/person in 2017.

6.2.2 Policy framework

- Sustainable Energy and Climate Action Plan – SECAP 2020

The municipality of Florence has engaged with the Covenant of Mayors initiative since the beginning, developing between 2010 and 2011 a SEAP with targets to 2020. Actually, it has committed also to Mayors Adapt and Global CoM and, participating as Ambassador city in the H2020 CoME EAsy project to develop supporting tools for other municipalities, it will submit a SECAP in 2020 with targets at 2030.

The Replicate actions roll out will be part of the SECAP under development and some of them (the ones related to electric mobility and the solar thermal seasonal storage) have been already published as Best Practices in CoME EAsy framework for the EEA and CoM communities.

The SECAP, as the SEAP or the Smart City Plan, is meant to be a cross-cutting tool integrating objectives of different sectors and their related planning instruments (urban plan, buildings regulation, environmental/air quality plans, mobility plan…).

Thanks to the very good results already achieved and confirmed by monitoring and by the EEA energy management system in place, the next CO_2 reduction objectives will be ambitious for the local context, exceeding significantly the national ones.

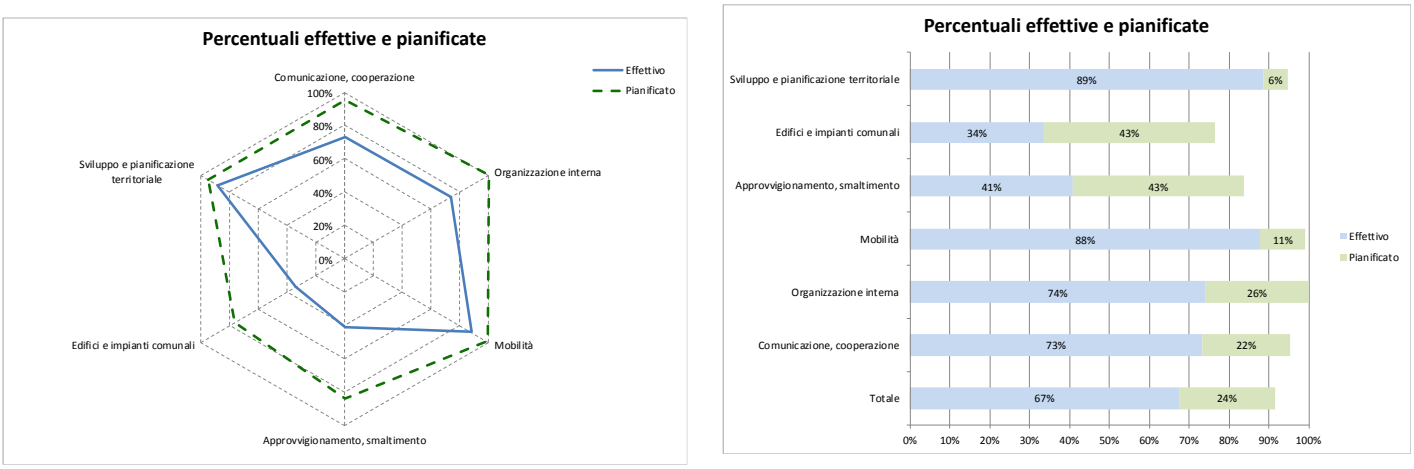

Figure 21 – Florence EEA® results and planned measures at 2020 (strategies, public buildings/plants, services, mobility, organisation, communication)

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- Sustainable Urban Mobility Plan (SUMP) – 2019

The Urban Plan for Sustainable Mobility of the Metropolitan City (http://www.cittametropolitana.fi.it/pums/) has been adopted in the second half of 2019 after a long process where the municipality together with the metropolitan city and the Region have contributed and agreed contents with local stakeholders.

The first phase of the work, started in 2018, was aimed at the reconstruction of the cognitive framework in relation also to the local and supra-local planning tools and at starting the participatory path that allowed the objectives to be declined; the second work phase concerned the design of the scenarios which have taken advantage from the Replicate pilot action and all the previous experiences of the municipality of Florence in terms of electric mobility, ICT platform and traffic supervision, mobility infrastructures, bike and pedestrian areas, parking management, multimodality, etc. The final draft of the plan has been subjected to a strategic environmental assessment as required, pointing out all the environmental benefits/costs and the monitoring methodologies foreseen.

The plan reports in detail all the actions agreed at 2030, which has been taken as reference scenario, with an implementation program, the related costs and impacts as well as the monitoring KIPs. The measures included have been divided into two different groups depending on the years of implementation (2021-2025 and 2026-2030).

This document is the main tool for the extension of the measures to the whole metropolitan area in short/mid-term period.

- Smart City Plan update/annexes

The Smart City Plan, adopted in 2015 after a co-productive path in the framework of FP7 STEEP project, has been designed with mid (2030) and long-term targets (2050) in all the sectors where the municipality could have any influence.

After the adoption of the Smart City Plan, the municipality of Florence has started to implement measures or supported the implementation of private actions in line with the defined policies to achieve the targets at 2030.

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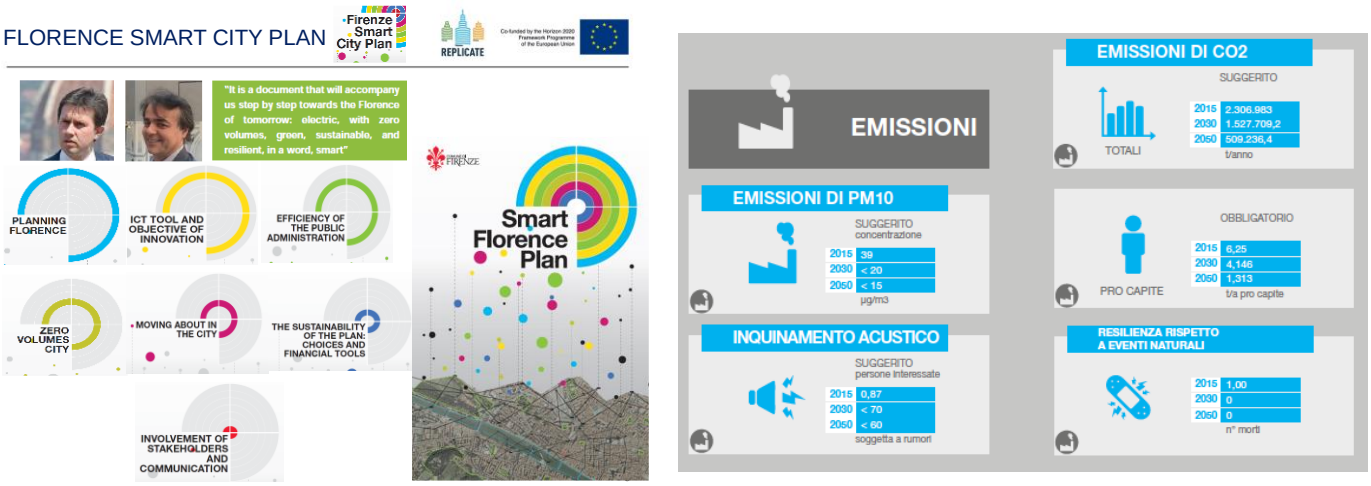

Figure 22 – Florence Smart City Plan sectors and targets example

The smart district model developed, including as many aspects as possible of those foreseen in the Smart City Plan, has become a concrete testbed for its implementation: after the pilot, many specific actions have been already started in the city with different implementation sizes and many others are foreseen.

An addendum to the original document is under development, to give evidence to the results already achieved, illustrating new best practices and advancements, and to re-tune the actions taking into account lessons learnt and new ideas. Replicate pilot action will be the core part of the annex with the experience gained, the results achieved and their future extension.

- Update of the urban plan: The municipal Operational Plan (2020-25)

In December 2019, the procedure for the revision of the planning tools in accordance with current legislation (LR 65/2014) was initiated. The current discipline (LR 65/2014) confirms the division of the planning process into two parts:

- *the Structural Plan*: planning tool, strategic planning for sustainable development, which concerns long-term large territorial choices, non-conforming of private property, of indefinite duration;
- *the Municipal Operational Plan* (which nominally replaces the Urban Planning Regulations while keeping its role unchanged), conforming to private property, consisting of two parts:
  - one of limited duration (5 years), relating to the areas being transformed (implementation plans and areas to be expropriated);

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- the other of indefinite duration which manages the ordinary discipline of interventions in the area.

The Structural Plan, as already mentioned, has no time validity and therefore, even if 10 years have passed since its approval, it could remain unchanged except for two fundamental factors:

1. the Knowledge Framework, or the changed conditions of the territory to be taken into consideration;
2. new and / or different programmatic choices by the Municipal Administration.

The Operating Plan will be adapted to the changes that have taken place: the Municipal Administration will reassess each of the town planning forecasts that have not been successful in the five-year period of effectiveness of the Town Planning Regulations, verifying their relevance and interest in any maintenance. At the same time, it will adapt the instrument to the new programmatic choices contained in the program of the mandate that has just started.

The Procedure Initiation document[8] contains a detailed examination (as required by current legislation) of the state of implementation of the Urban Planning Regulations which on the one hand represents the budget / monitoring of the implementation of the forecasts introduced with the instrument on the other hand also a moment of general reflection on how this worked on the territory; it highlights the link with the sustainable strategies of the city (SEAP/SECAP, Smart City Plan) and the related actions and targets.

Following the general reflection induced by the five-year lapse and by the necessary regulatory adjustments described above, the municipal administration decides to proceed with a first act of listening and participation of the city in the process of defining new tools through the publication of a public notice (open until next May).

- Green regulation

The Administration intends to work in parallel with the municipal operational plan described above, to a sector tool, the Municipal Green Plan (Law 10/2013), which is born together with the new urban planning instrument and is strongly correlated with it, but which contains a very wide level of detail the implementation of green areas and their construction criteria.
In this specific tool, the pilot action implemented in the Cascine park or the smart watering system tested in some of the municipal gardens will find an extension program.

[8] https://accessoconcertificato.comune.fi.it/OdeProduzione/FIODEWeb5.nsf/AllegatiPerNumAttoFile/2019-G-00647-All_A_RelaUrbaPOVarPS_Avvio(firmato)_signed_2019sg419107.pdf/$FILE/All_A_RelaUrbaPOVarPS_Avvio(firmato)_signed_2019sg419107.pdf

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- Post-COVID Renaissance Plan

Florence decided to react at the Covid emergency with an open document to re-desing the strategies together with its citizens and stakeholders (http://www.comune.fi.it/rinascefirenze).

The most immediate goal is to support the socio-economic recovery of the city while ensuring the health security of citizens in the use of spaces and services without renouncing the objectives of the mandate program.

RinasceFirenze identifies nine thematic areas, with proposals and operational actions for the gradual reactivation of social relations, the restarting of economic and production activities, the optimal management of services and the use of public and private spaces:

- Polycentric city
- A new historical centre
- Living urban spaces
- Green mobility
- Development of the city economy
- Widespread culture
- Children and families in the centre
- Personal care: welfare, home, work
- An increasingly intelligent city

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7.3 Bristol

6.3.1 Trend of city level KPIs

Bristol City Council is a leading voice in the UK's local authority-level response to the Climate Emergency. The city was the first council to declare a Climate Emergency, the first to embed leadership of the New Green Deal in its Cabinet structure, the first to review the progress against the United Nations Sustainable Development Goals.

There have been many changes to the policy context affecting Bristol as a Smart City in the last three years, but Bristol remains in the vanguard of UK Smart Cities. Whilst there is no room for complacency, tough energy efficiency targets are, to date, being met, and Bristol is currently experiencing some of the largest investments in its transport system in recent times. The flagship ICT test bed infrastructure in the city, Bristol is Open, continues its development.

There have also been major changes to sub-regional governance leading to new strategies being developed. Fortunately, these changes have tended to strengthen the focus on cities becoming smarter; so, whilst the framework has indeed 'evolved', those changes are considered to be complementary to Bristol as a Smart City and to support the work REPLICATE is doing.

The data made available by Replicate monitoring and the voluntary local review 2019 with respect to the UN Sustainable Development Goals, show improvements in many sectors, but perhaps still not enough to cover the gap with the very ambitious target of becoming Carbon Neutral by 2030:

- Consumptions have already decreased of about 11% in domestic sector and emissions declined more than 30% in the economy since 2010. It has been estimated that more than 13% of households are affected by fuel poverty and this is one of the main challenges to take into account in the next years while pursuing decarbonisation goals.
- Per capita CO2 emissions fell between 2010-2016 from 6.44 tonnes per year per person to 4.68. Furthermore, total emissions have dropped from 2230.9 kt (2010) to 1547 (2018).
- Renewables quote overcomes the 30% at 2017 with the amount of installed renewable energy capacity in Bristol increased by over 30% from 2014
- Other Environmental KPIs are improving: the percentage of city waste in 2018 has been of 44.9% with a parallel continuous reduction in residual waste per household; Bristol is the greenest city in England with 29% of green spaces; a reduction of about 15% in the PM10 concentration has been achieved;
- In Bristol in 2018 there were 0.4 four-wheels vehicles per capita (-32% lower than in the 2016 year), 0.019 two-wheels, 2.7 electric vehicles per 100,000 inhabitants, more than double of those in 2015.

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- There has been a sensible increase in the total trips taken on public transport, almost doubled the numbers of 2010, along with a moderate growth in park&ride, cycling and walking.

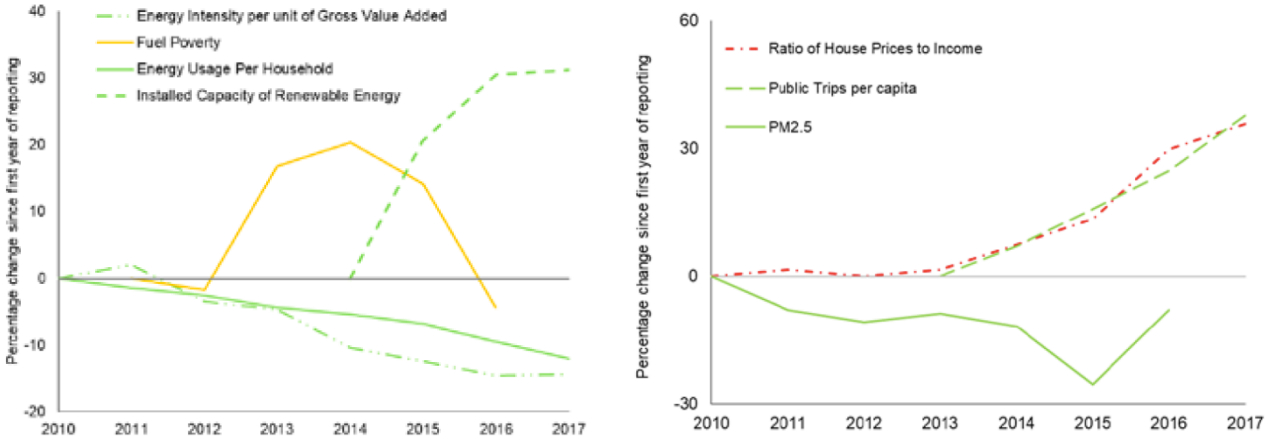

Figure 23 – energy and mobility KPIs trends

(Source: Bristol and the SDGs – voluntary local review 2019)

- the city population has increased more than 1% each year in the period between 2014 and 2018 and the tourism intensity in Bristol has increased around 9% in the same period.
- The employment ratio in Bristol decreased to 3.8 % in 2018, while the gross domestic product of the city was increasing with a 6% percentage of the contribution of the ICT sector to local economy (GVA) in 2016.
- Internet connections are more and more available (about 90% of the population)

6.3.2 Policy framework

- The Smart City Strategy (SCS) *Connecting Bristol*

Connecting Bristol is Bristol's first smart city strategy. Launched in September 2019 it will cover a 5-year period and contributes towards delivering smart and innovative aspects from the how the Bristol One City Plan will be delivered (detailed below). Initiatives in the implementation plan are being assessed up until 2030-2050 ensuring infrastructure and services are paved for the delivery time frames outlined. It explores the possibilities of future technologies to improve the lives of people who live and work in Bristol, working with business and communities to design and run pilots and report on developments across six key themes of Bristol Smart City Strategy as shown in the figure below.

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Figure 24 – Connecting Bristol key themes

A detailed action plan and communications plan will follow.

This approach acknowledges that smart cities need a smarter council willing to work in new ways conducive to innovation: working collaboratively with stakeholders, the City Office and other partners across the city. The strategy will be updated regularly and aims to ensure smart city projects will provide opportunities to more people and communities to assist in the city's inclusive growth and help towards solutions to issues such as public safety, traffic congestion, energy poverty and health and social care.

The SCS has been developed in consultation with various departments across the Council including the City Office (One City Team), the smart city steering group and selected external stakeholders/partners from various sectors (Energy, Transport & Highways, Economic, Health and Social Care, ICT, Community Development, Waste, Education & Skills, Public Protection, Sustainability, Civil Protection and the Bristol Operations Centre).

The Smart City Steering Group is made up of a mix of senior level staff and will continue to steer the need of the strategy's delivery.

It begins as a BCC strategy and will migrate to a city owned strategy (next version to be started by year 3).

This is where BCC sees most of the identified scaled interventions being integrated: It is envisioned that REPLICATE is referenced with more detail on specific intervention links in the supporting action plan. www.connectingbristol.org/strategy/

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- The One City Plan

In January 2019, Bristol published its first ever One City Plan setting ambitious targets for its future, decade by decade up to 2050.

The One City ambition is to articulate a collective vision, enhance the resilience of public services, support problem solving in the face of complex city challenges, and increase the sustainability and scalability of innovations in the city.

The One City Plan, which was developed through extensive engagement with citizens and city stakeholders over the course of more than a year, articulates a vision for making Bristol a fair, healthy and sustainable city for all. It is structured around 6 core themes:

1. Connectivity,
2. Economy,
3. Environment,
4. Health and Wellbeing,
5. Homes and Communities,
6. and Learning and Skills.

The One City Plan identifies three priority initiatives associated with each theme for every year from 2019–2050 (a total of 558 initiatives).

Bristol's One City Plan was first launched in January 2019, with the first annual refresh delivered in January 2020, alongside a city dashboard to demonstrate progress against the plan's goals. www.bristolonecity.com/

Many of the targets set are related to REPLICATE pilot action and its roll out.

The OCP: Environment

Year	Theme	Goal
2019	Environment	Establish a long-term, flexible 'City Leap Energy Partnership' to strategically develop, co-ordinate, deliver and facilitate low carbon, smart energy infrastructure that supports Bristol on its pathway to carbon neutrality
2021	Environment	Enable new developments to be run at carbon neutral levels due to local planning standards for energy efficiency
2022	Environment	Implement smart energy technology in over 50% of homes in Bristol to support the efficient use of energy, particularly from sustainable sources and contributing to ending fuel poverty
2023	Environment	Ensure that 20% of Bristol's taxi fleet and private hire fleet are in the Ultra Low Emissions Vehicle (ULEV) category
2023	Environment	First Ultra Low Emissions Vehicle (ULEV) Buses are introduced at scale across the Bristol bus network
2026	Environment	Ensure that 50% of the public sector fleet is in the ULEV category
2027	Environment	20% of all electricity consumed in the city is generated from clean sources
2027	Environment	Bristol has a comprehensive network of electric vehicle charging points which supports everyday electric car use
2028	Environment	The Bristol Heat Network provides district heating via a network of underground pipes, which are connected to a number of energy centres
2028	Environment	50% of the Bristol bus fleet is non-fossil fuel
2030	Environment	Every public building in the city meets the highest standard of energy efficiency
2030	Environment	It is standard practice that major developments in Bristol are net carbon negative and smart-energy-enabled
2031	Environment	75% of domestic homes in Bristol are insulated to a high standard (C+), reducing the energy needed to heat homes
2031	Environment	80% of electricity consumed in the city is generated from clean sources

The OCP: Environment 2031-2050

2031	Environment	Ensure that 75% of Bristol's taxi fleet and private hire fleet are in the ULEV category
2032	Environment	Data on all sources of energy generation will be shareable so consumers are better informed about the source of their energy use
2034	Environment	Domestic energy consumption data is shared openly with local authorities, as reported by connected applications
2034	Environment	Smart bins are common place and accurately track the amount of food waste collected from domestic and commercial premises
2034	Environment	A city-wide programme is in place to ensure all transport in Bristol is zero carbon at the point of use by 2040
2039	Environment	100% of electricity consumed in the city is generated from clean sources
2042	Environment	95% of all energy (power, heat and transport) consumed in the city is generated from clean sources
2042	Environment	Solar panels are commonplace on buildings with large roof spaces across Bristol
2045	Environment	All energy to heat homes in Bristol is obtained from zero carbon sources and 100% of homes are supplied with renewable energy
2046	Environment	75% of non-domestic buildings are insulated to a high standard, reducing the energy needed for heating
…	…	…

Figure 25 – example of REPLICATE extensions embedded in the One City Plan program to 2050

Biannual city gathering events are held at the city council to engage citizens and stakeholders and discuss how the city can take action towards achieving the initiatives outlined in the plan. Additionally, each thematic area has an associated board made up of city leaders in their respective

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areas. These boards meet at least every three months to assess progress, provide guidance and make recommendations for revisions to the Plan.

A new mechanism to harness resources locally has been developed: the Bristol City Funds is a mixed funding mechanism that provides, loans, grants and a mixture of the two to deliver key priorities that have been established in the One City Plan, operating as a source of investment and grant funding to support projects that will help transform Bristol.

In relation to the One City Plan development and it's close alignment to the Sustainable Development Goals (Global Goals) Bristol has established the Global Goals Centre. While this is not local policy, it is relevant to REPLICATE as a recognised set of goals aligned to. www.globalgoalscentre.org/

- Energy and Climate Plans

The "Climate and Energy Security Framework" (CESF), a 2015 document which covers a period of projects to be implemented over the next 10-20 years, this was followed by the Mayor's Climate Emergency Action Plan 2019 and recently superseded by Bristol's One City Climate Strategy, published in February 202. This strategy builds upon many years of achievement and environmental innovation, underlined by Bristol's status as the UK's first European Green Capital in 2015. It addresses the urgent challenge faced by the council and the city; one which is made harder because, compared to most places, Bristol has already completed the 'quick wins' and picked the 'low hanging fruit'. This means that moving forward at pace to achieve the targets will require significant investment of time, money and energy from the council, the government, our city partners and citizens. www.bristolonecity.com/wp-content/uploads/2020/02/one-city-climate-strategy.pdf These public commitments are matched with firm action, from setting a ground-breaking ambition for a carbon neutral and climate resilient city by 2030 to driving forward a £1bn programme of investment in cleaner, greener energy.

The Plan, in summary:

- ✓ provides an assessment of the city's emissions, with progress made since 2005, and their sources and explores likely future emission scenarios for the next decade
- ✓ sets a goal for the city to be Carbon Neutral for direct and indirect emissions by 2030 and a clear target for Bristol City Council to be carbon neutral for its direct emissions from energy and transport by 2025
- ✓ will soon set out the existing and new actions that will be taken to: create low carbon jobs and businesses, build and retrofit homes, provide for clean and sustainable travel, generate clean renewable energy, reduce the carbon footprint of city's consumption. REPLICATE pilot actions roll-out will contribute, in part, to this set of actions.

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- BESST: Bristol energy smart system transformation

BCC was involved in a 6 month Innovate UK funded concept design project as a part of the Industrial Strategy Challenge Fund from the UK Government and completed in July 2019. The learnings from REPLICATE have been brought into the BESST project in a different area of Bristol again (with 3 wards) but this time looking at including the local energy company (Project lead) Bristol Energy, industrial partners (the Port, and commercial) and community groups with renewable energy ownership. The funding call was for local energy systems – the focus was to understand these dynamics to allow Bristol Energy to create new customer energy propositions. BCC also explored the smart city platform development in this project.

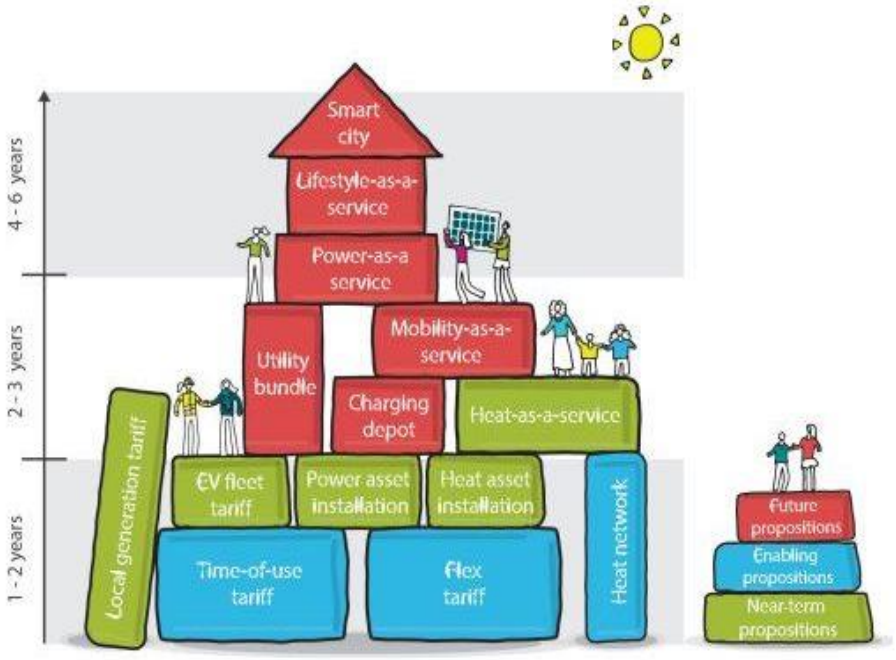

Figure 26 – Regen image explaining the integration of the BESST project

As a follow-on from this project, Bristol has teamed up with fellow lighthouse city GReater Manchester Authority under the Innovate UK Industrial Strategy Challenge Fund to run a detailed design project. The Greater Manchester Local Energy market (LEM) project will test the feasibility of a GM region wide local energy market which responds to `place-based' constraints and market needs. The learning taken from the demand side(DSR) response trial in REPLICATE will be taken into the project to explore opportunities.

This Project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement N° 691735

- The City Leap Prospectus

A prospectus, known as City Leap (https://www.energyservicebristol.co.uk/cityleap/), has been released outlining a series of energy and infrastructure investment opportunities available to local, national and international businesses.

The prospectus is designed to test the market and lays out big ambitions and opportunities, building on the work and innovative pilot schemes already taking place in the city.

As a part of the City Leap Prospectus developments, BCC has identified key areas from REPLICATE that could be scaled and possibly be financed through the City Leap. Expressions of interest closed in August '18 and it has taken some time to assess and agree partnerships which were presented to Cabinet in early April 2019. There were around 180 Expressions of Interest from organisations of all types and various countries. Learnings from REPLICATE supported the assessment with other inputs and formed part of the supporting documentation issued alongside the future City Leap tender for a Strategic Partner to enter into a Joint Venture with the Council.

- West of England Local Industrial Strategy

The WECA Local Industrial Strategy was published in July 2019 and highlights the need to embed innovation into our smart city strategy approach to tackling the infrastructure and productivity challenges of the region.

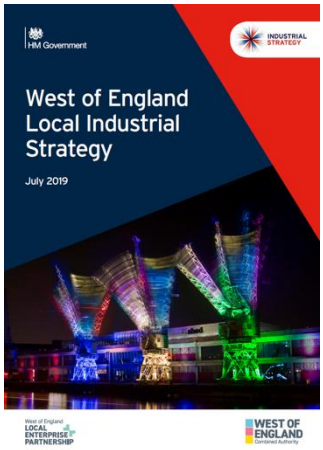

Figure 27- WECA LIS www.westofengland-ca.gov.uk/ourstrategy/

The city recognises that public sector innovation has a vital role to play in delivering the infrastructure required for economic growth and actively enabling greater business productivity, better access to economic opportunities and accelerated scale-up.

www.gov.uk/government/publications/west-of-england-local-industrial-strategy.

This Project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement N° 691735

- The West of England Combined Authority (WECA) transport vision and Bristol transport plan

Any climate-related action in Bristol will always relate to the regional, national and global context the city operates within. In October 2017, WECA published its Joint Transport Study in which it set out a Transport Vision that would build on the current investment programme with a continued strong focus on shifting travel behaviour towards sustainable modes and tackling congestion on the road network. It sets a target for no overall increase in the number of trips by car across the sub-region in the context of 105,000 new homes being delivered by 2036.

One of the key components of the Transport Vision is "Technology and Smarter Choices" consisting of behaviour change, effective marketing, use of new technologies (including on-demand information and smart-ticketing) and potentially increased use of Connected & Autonomous Vehicles.

Bristol City Council is also currently developing a Bristol Transport Plan, which will form a linking strategy between the WECA strategy and specific Bristol local plans for topics such as public transport development, parking management, cycling, walking and air quality management.

Other references to consider include:

- Key city statistics that inform policy and delivery. Statistics under "Transport" and "Sustainability and Environment" are relevant to REPLICATE but not a strategy as such https://www.bristol.gov.uk/documents/20182/32947/State+of+Bristol+-+Key+Facts+2018-19.PDF/263d5f0f-763e-9553-467d-c9704f307d7c
- Bristol: Global City – the international strategy. https://www.bristol.gov.uk/policies-plans-strategies/bristol-global-city
- BCC Digital Transformation although no published strategy as yet

8. Roll out plans

During the implementation of the pilot, several studies have been done together with the cities to understand the replicability potential of the actions. For a full analysis about single technical solutions, replication potentials, management models in use and for future implementations please refer to D7.3 ("Report on technical solutions v2") and D7.5 ("Report on management models v2") which were the basis for the discussion. Tables to summarise in a glance all the inputs collected have been developed with the three local consortia and discussed among partners of the different sectors (energy, mobility, and ICT/infrastructures) during local meetings in the three lighthouse cities and at the consortium General Assembly in Florence. Local stakeholders and advisory boards as well have been involved in the collection of suggestions and feedback on the replicability level.

These summaries could represent a guide first for followers/fellow cities in WP8 and then for other cities wanting to replicate a similar action adapted to their local reality; they include:

- the additional useful information for the decision-making process or the design phase
- the precious list of lessons learnt by the three lighthouses to avoid same mistakes and prevent problems
- a short SWOT analysis listing main strengths as well as critical aspects of the implementation
- the adaptations already planned by the lighthouses to allow an effective roll out
- the identification of the stakeholders that, from the pilot experiences, ought to be involved in the process

On the basis of this outcome and of the previous analysis, cities have been asked to take decision about the potential replicability of the actions in terms of realistic schedule in the programming tools landscape; the options where:

- No replication decided yet
- Long term planning (at 2050)
- Mid-term planning (at 2030)
- Short term roll-out in the next three to five years

In case of replication, the planning instrument appointed for the formal definition of the modalities has been defined to translate the project roll out analysis into implementation.

ACTION	SUPPORTING INFORMATION	LESSONS LEARNT	CRITICAL ISSUES AND STRENGTHS	ADAPTATIONS/MODIFICATIONS	STAKEHOLDERS TO BE INVOLVED	REPLICABILITY SCHEDULE
DH with RES	- city heating map or boilers database (available for safety and performance check) are useful to assess potential - analysis of local biomass availability for a sustainable short supply chain - information about eventual RES national/regional incentives frameworks	-**Energy demand** and buildings stock analysis are crucial (few new areas which are optimal for these implementations) -**Tailored size** is the key element for the replication and the sustainability of the BM -**Information campaigns** at different level (designers, final users) should support the interventions - **new procurement procedures** took time but now there's a template - Heat output and CO_2 Savings dependant on **external factors** such as building developments - Working with **existing road works programme** means programme of works was not fully controllable - Commissioning and confirming **water quality** take time and this needs to be programmed in to project timelines - **Data connections** need to be planned with the pipe installation programme and contracts on board at an earlier stage	- small distributed generation plants are suitable for cities that are starting from the scratch and have different boundary conditions in districts - possible extension of the network and interconnections could be planned as second step - local biomass supply chain integration could activate new business and optimise environmental impacts - supporting policy framework (regional, national or even local level) for DH and/or RES is the best promotion for these implementations - Set up contracting and procurement procedures to facilitate future projects	FSS/ADS: - Identification of the potential areas of the city for replication - Promotion of small distributed generation plants for existing buildings - Analysis of the local biomass - Public-private business model - Define possible range of fuel tariffs (€/ton) - Create dissemination materials and organise events (study tours, conferences, training courses, …) FI: - detect optimal conditions for replication (different size, different kind/mix of users, less boundaries) - analyse the heating map for scale up areas - add an EDM system for heating BCC: - new connections and further possible extensions providing resilience to the energy supply on the heat network - increase the RES integration/use in the network balance -Template documents and drawings, Procurement and contract documents to use on future projects - New method of Designing to target depth (rather than full 3D) - Controls Strategy has been designed for replication, expansion and future proofing for smart(er) technologies - setting up commissioning and water quality standards for the whole of the city's network (Replicability)	- Municipal departments: • energy, • urban development, • environment, • agriculture • economic development • technical services - Local biomass providers - Designers & technicians - Energy companies - Buildings managers - Social housing companies - Local business - Commercial activities - District users	FSS/ADS: **Mid-Long term** Related strategy/Plan ✓ **DSS Klima (with connections to urban and energy plans),** ✓ **Smart City Plan** FI: **Mid-Long term** Related strategy/Plan: ✓ **SECAP,** ✓ **municipal Operational Plan** BCC: **Short term** Related strategy/Plan: ✓ **CITY LEAP** ✓ **One City Climate Strategy** **BCC Corporate Strategy**

ACTION	SUPPORTING INFORMATION	LESSONS LEARNT	CRITICAL ISSUES AND STRENGTHS	ADAPTATIONS/MODIFICATIONS	STAKEHOLDERS TO BE INVOLVED	REPLICABILITY SCHEDULE
Retrofitting	- buildings stock detailed information is very useful to asses potentials - detailed changes (hours, air circulation systems management, number of users…) in the use of buildings to model their behaviour and performances	- **Financial support** and initial investments are critical issues for replication - **Integration** with heating/cooling systems refurbishment to improve BM -Alignment of local **policy framework** - **citizen engagement** is crucial - **local community** organisations and "Energy Champions": local community members have been very important for promotion - different use /management of buildings (both residential and tertiary) affect their performances and must be taken into account with models to foresee savings compared to **pre-COVID baselines** and business as usual	- Governmental funding for retrofit are lower than before in UK - Lack of awareness of good insulation benefits and importance among users - Some measures are low cost and have high impacts and they should be promoted as first step - specific energy prices/offers are fundamental to develop the business model - New subsidies are needed for larger cost items eg. windows	FSS/ADS: - Sustainable Business model development and Innovative funding mechanisms. for instance linked to the final energy performance level (ESE/ESCCO models, etc.) - Continue with Citizen engagement and stakeholders' coordination - Dialogue with financial sector to find facilitations - Promotion of Sustainable Energy awareness FI: -Facilitate fiscal detractions transfer (from 65 to 85%) from private single owners and buildings managers to ESCOs. -Promote the actuation of "volume zero" and SCP concepts -agreements with private sector for insulation BCC: - Continue to develop relationship with community stakeholders (Bristol Energy Network, Energy Champions) to help with engagement and participant recruitment for roll out and future programs - Look for funding to help incentive residents - Need Gov compulsory standards in both new build and retrofit - Develop new relationships with community Groups - Training and upskilling - Developing a sustainable supply chain - Work with further Education/Colleges and training providers/schools incl. secondary and Higher Educational routes	- Municipal departments: • energy, • urban development, • economic development, • environment - Designers & technicians - Energy companies - Buildings managers and owners - social housing entities - financial institutions - construction companies - designers -community organisations and associations	**FSS/ADS: Short - Mid term** Related strategy/Plan: **- DSS Klima Plan 2050** **- Smart City Plan** **- "Renove" Plan by Basque Government** **FI: Mid term** Related strategy/Plan: **- SECAP,** **-municipal Operational Plan** **BCC: Short term** Related strategy/Plan: **One City Plan** **WARM HOMES FUND** -Eco (Energy Company Obligation) Levy on electricity companies to pay for energy efficiency upgrades in Fuel Poor households -MEES Minimum Energy Efficiency Standard for rental properties -Rented properties EPC rating of E or above -BCC Currently offer grant to 'top up' above £3500 for Landlords

ACTION	SUPPORTING INFORMATION	LESSONS LEARNT	CRITICAL ISSUES AND STRENGTHS	ADAPTATIONS/MODIFICATIONS	STAKEHOLDERS TO BE INVOLVED	REPLICABILITY SCHEDULE
EDM systems, smart homes, energy APP	- more monitoring data from the EDM developed to appreciate performances - info about payback period for new appliances - possible information about predicted future cost of energy - Models about how users pay for energy	- **Electricity grid** and consumption control are **more advanced** and are including also e-mobility - **Cost of smart appliances** and related equipment are very high vs new non smart option - **Heating networks "intelligence"** should be supported; it is crucial to optimise the performances of the technologies and of users' behaviour - **Data ownership** and compliance with GDPR must be defined - For Smart Homes the '**weak links**' of the system – users, switches, plugs and cables create opportunities for Home disconnection with subsequent data loss. - **User engagement** and communication are vital. Ongoing support even more important and time required should not be underestimated - Value to market of residential DSR very low (This will change with EV uptake)	- API lock-in and update that are unknown initially - smart appliances expensive, but the smart control could be done on power line via smart plugs instead - Lost of complete control over data if it goes to third party supplier - energy savings through new machines could payback in less than 5 years - Fragility of smart home equipment - safety of smart appliance - Remote control -Smart charging for e-mobility relies on charge points that are OCPP1.6 protocol compliant to allow two-way communication between the charge point and the energy supplier. There are only a few OCPP1.6 compliant charge-point available on the current market. Similarly, the EV battery management system needs to support smart charging	ADS: - the EDM developed could be extended integrating smart devices: Analyse the smart homes experience and the possible technical partnership - analyse with DSO and system managers the data ownership issue - Evaluate the possibility of translating/adapting the APP FI: - Regarding electricity consumption, the BCC smart homes experience should be analysed for replication together with e-distribuzione (DSO) and industrial players (Symens as Milan partner). - For heating networks, the Piagge management model under development could be compared and "contaminated" by the SS experience. - inclusion of other topics (plastic-free, etc) in the APP on going - possible extension of the APP to any interested municipality in the metropolitan area/region	- DSOs and Energy companies - Smart devices producers - technical support (Tecnalia, UWE, UNIFI, …) - users associations - National Grid -Community Organisations	**FSS/ADS: Short- Mid term** Related strategy/Plan: **- URBAN PLAN** **- Smart City Plan** **FI: Mid term** Related strategy/Plan: **- SECAP,** **- URBAN PLAN**

	- Value of demand response - for the App, it would be useful to further test in different social environments	- High cost of ICT infrastructure - control of appliances with plugs does not work with dongles/ dryers - Metering arrangements cause installation issues - COVID effects are to be analysed in detail: the decrease of fossil fuels costs and the expected balance with the increased use of homes, different management of air systems and comfort requirements	(both technical issues). Smart charging could also be better supported with EV specific tariffs from electricity suppliers (commercial).	BCC: - Smart metering (or like e-distribuzione smart-info devices?) and a proper tariffs profile should be introduced to enhance users' awareness/engagement and consumption/monetary savings. - Also heating networks should be included - From Smart appliances to smart plugs? - Scale up of community engagement partners and approaches already taken place - Eco Home future demo facility possibilities - expand smart controllable devices in homes - Tighter partnerships with tech suppliers		BCC: **Mid- Long term** Related strategy/Plan: **One City Plan – Connecting Bristol SCS**

ACTION	SUPPORTING INFORMATION	LESSONS LEARNT	CRITICAL ISSUES AND STRENGTHS	ADAPTATIONS/MODIFICATIONS	STAKEHOLDERS TO BE INVOLVED	REPLICABILITY SCHEDULE
e-mobility infrastructure, e-taxi fleet & Smart Grid	- info from local Distribution System Operator for grid performances and recharging service potential/zones - contractual forms with charging point providers and commitments with their back office supplier. - Project planning phases should consider long term objectives for infrastructural implementations.	**Charging infrastructure:** - **Municipal mobility policy** and traffic management can support the demand increase (access, parking…) - Urban regulations can **facilitate** the **charging infrastructure deployment** (administrative procedure, new/retrofitted areas). - Info on underground utilities available is important for an efficient site selection process - Charging points **management system** is crucial and booking service can be useful for fleets - Different EV models means **different sockets** standards and exchange **protocols** to be tuned - **Technical training** for fast recharge use - **Surveillance** can avoid fuelled cars parking or vandalism **E-taxi and fleets:**	- EV demand can be supported also by permissions/restrictions and users' awareness - Lower operational costs and incentives for e-taxi and eVs drivers - clear and convenient energy pricing mechanisms is important to encourage users - Taxi operational needs fulfilment (example with fast recharge infrastructure) has to be analysed - Smart grid is more and more important to enable such services (smart grid is related also to resilience and climate adaptation for funding) - take into account the long administrative process for works to build the infrastructure and need of areas - there are investment costs for several stakeholders (both for the recharging infrastructure and for the e-vehicles) - Technology and legal framework have fast evolutions and updates - Smart charging for e-mobility relies on charge points that are OCPP1.6 protocol compliant to allow two-way communication between the charge point and the energy supplier. There are only a few OCPP1.6 compliant charge-point available on the current	FSS/ADS: - Facilitate authorisations (detecting areas, specific faster iter, dialoguing with DSO…) - evaluate facilitations in the mobility plan - Analyse the possibility of activating supporting measures like prioritisation and promotion of the green service, licence discount, providers' agreements… - Analysis of other possible fleets to be converted into e-cars (car-sharing, public sector fleets) - Promote private e-vehicles - Business model development FI: - Monitor the data and optimise the use of the network. - Update technology to reduce recharging periods in public network - Extend the network to metropolitan area (SUMP) - Exploit national supporting framework - Extend to the whole taxi fleet and to the neighbouring municipalities (SUMP) - Open the dialogue with mobility managers for other fleets - Promote installation on private areas (tourism and commercial sectors) - Involve more and more tourism sector to prioritize e-mobility - Definition with the DSO of extensions (replication in other cities already under development) and of the possible services connected	-Municipal departments: • mobility, • urban development, • environment -Heritage agency/dept - parking managers -neighbour municipalities - DSO -vehicles producers/providers - taxi associations -private fleets managers / mobility managers -tourism sector associations	**FSS/ADS: Short-Mid term** Taxi test on going Related strategy/Plan: Next Sustainable Urban Mobility Plan for infrastructure and e-fleets and SECAP under development **FI: Short term** Related strategy/Plan: **SUMP already adopted** at metropolitan level: - New stations by private sector and Fast recharge for 4M€ 2026-2030 -1,5 M€ for the complete conversion of the fleet 2020-2025 Smart City Plan & SECAP: - smart & resilient grid -E-mobility

		- Set of **supporting measures** (licence discount, e-vehicles producers' agreement, promotion of "green service", dedicated infrastructure). - Critical mass to achieve best **energy tariffs** on the market	market. Similarly, the EV battery management system needs to support smart charging (both technical issues). Smart charging could also be better supported with EV specific tariffs from electricity suppliers (commercial).	BCC: - Exploiting regional/national programs - Open a dialogue with the local DSO to detect best locations and grid limits - Spend efforts in the back-office management system		**BCC**: **Short term** BCC is currently replicating the e-mobility infrastructure through the **Go Ultra Low** project where they are deploying 120 charging points across Bristol.

ACTION	SUPPORTING INFORMATION	LESSONS LEARNT	CRITICAL ISSUES AND STRENGTHS	ADAPTATIONS/MODIFICATIONS	STAKEHOLDERS TO BE INVOLVED	REPLICABILITY SCHEDULE
e-bus & Smart flexible services (WeGo)	-analysis of routes compatibility for e-bus -analysis of routes coverage and use for flexible services -info about tariffs of sharing options for flexible services -Local knowledge of organisations motivated to support transport e.g. health providers; large employers; connecting transport. - Knowledge of available supply. This may include taxi, community transport operators and volunteer drivers.	**E-BUS:** - need of **Lines/routes selection** to overcome technological constraints. - **Dedicated charging infrastructure** to be deployed (night charge or terminal fast charge). - include externalities and possible **subsidies** (national/regional) in the BM development **FLEXIBLE SERVICE:** - **Demand analysis, intelligent routing** and integration into the multimodal public transport system are crucial - Be flexible. Explore different options as Esoterix have done and purchase a normal e-vehicle taxi that can provide on-demand journeys. Consider changing business model: the new Esoterix service is more successful than what initially could had been deployed.	- technical limits for e-bus - good acceptance by e-bus users - lower noise for e-bus - competition with sharing solutions for flexible service - business models can be affected by the different capacity of public transport in the post-Covid period	FSS/ADS: E-bus: - Monitor the results and further compare costs/benefits with traditional solutions. - Possible inclusion of supporting measures (charging infrastructure or others) in the next mobility plan Flexible service: - e-vehicles and on demand service introduction analysis for peripheral/suburban public transport FI: E-bus: - Analyse the on-going test results. - Involve the PT company and exploit the national subsidies to improve the fleet (80%) at metropolitan level (SUMP) - Support the infrastructure deployment (SUMP) - Promote information campaign (linked to the green shield) BCC: - Further analyse the demand to extend/tune the service. - Develop demand prediction for intelligent routing and scheduling - Further develop route brokerage - Integrate spare capacity into local travel planner e.g TravelWest Journey Planner	-Municipal departments: • mobility, • urban development, • environment, • school service - Public Transport companies - Private services - citizens groups - event organisers	**FSS/ADS: Short term** Related strategy/Plan: **-Sustainable Urban Mobility plan** **- Smart City Plan** **- DSS Klima Plan 2050** **FI: Short term** Related strategy/Plan: Already tested and **included in the SUMP** for the metropolitan area -40M€ for the urban PT fleet conversion into Electric/Ibrid 2026-2030 -70 M€ for the realisation of the "bus rapid transit" lines with electric busses and recharges at the stops 2021-2030 **BCC: continuation of the pilot** action, no additional services in the city at present - mid term with a view to fast track sooner if possible. Other replication opportunities for WeGO in UK cities are confirmed but not yet deployed One City Plan and Connecting Bristol SCS

ACTION	SUPPORTING INFORMATION	LESSONS LEARNT	CRITICAL ISSUES AND STRENGTHS	ADAPTATIONS/MODIFICATIONS	STAKEHOLDERS TO BE INVOLVED	REPLICABILITY SCHEDULE
e-bikes sharing system	- Info about available services to avoid/evaluate competition among sharing systems (and with PT). - presence infrastructure required (charging points and bike lanes) - Where bikes are being loaned to organisations (as opposed to individuals) the organisations must identify the need, and who will be using the bikes (otherwise bikes may be loaned but little used). - geography and climate of the location whereby the scheme is being replicated	- User friendliness and quality of the bike (robust, easy to manage and suitable for a wide range of users) are fundamental - Customer Service (providing a support package that is prompt, responsive and effective) and easy to use dashboard for booking are good supports -Reduced costs compared to cars - There is a need for greater clarity on responsibility for e-bikes within organisations which are using them. In some cases, the bikes are well used (often by one person). In others they have been very little used. - There is a need for stronger leadership - people who use their e-bikes for work purposes are generally doing so on their own initiative. - Women are more likely to borrow e-bikes (possibly as a trial) whereas men were more likely to buy -Key to success is to have early adopters that can filter across the organisation/area -Need of stakeholders' and local authority's support to facilitate the infrastructure	- Users are generally very satisfied, no big issues - positive impacts on health -Enabling better access to employment - important to evaluate which modality is substituting: walking, PT, private car, other sharing systems? Necessary to calculate the reduction of congestion and carbon emissions -Monitoring system development and data storage have to be tailored - Regular e-bike commuters are less likely to be shifting from a conventional bike. Occasional e-bike commuters are more likely to be shifting from driving to work. - bike sharing and sustainable sharing systems could help in the mitigation of COVID effects on mobility	FSS/ADS: - e-bike municipal service already deployed. - Scalability actions ongoing Supporting measures to be defined (charging infrastructure, monitoring, surveillance and education campaign to avoid vandalism…) FI: - Project on E-bikes started - Many other sharing opportunities already in place (cars, e-cars, bikes). - SUMP already adopted for the extension to the metropolitan area - sustainable Sharing systems revamped post Corona-crisis BCC: - From the market side: extension of the test and inclusion in the Car club offer. - The city could put in place supporting measures for bike mobility in general and for charging infrastructure - Strong message from users that more cycle paths, and better designed cycle paths would increase the use of e-bikes -Opening up bikes to general members of the public through booking system development and implementation of Hubs	-Mobility department -Neighbour municipalities - Sharing companies -Public & private transport operators - Parking managers - Users' groups -Community centres	FSS/ADS: **Short term** Action already on going promoted by the municipality in the framework of the mobility plan in place FI: **Short-Mid term** Related strategy/Plan: **included in the SUMP** for the metropolitan area: -Bid for additional 3000 e-bikes provided by private operator in free flow modality (2021-2025). -New parking areas for 1.250.000€ and new lanes (bicipolitana, super-ciclabile, new-lanes, "ricuciture", retroffiting of areas…) for more than 100M€ by the municipality BCC: **Short term** Related strategy/Plan: One city plan, WECA transport Plan: mobility plan to reduce the use of private cars

ACTION	SUPPORTING INFORMATION	LESSONS LEARNT	CRITICAL ISSUES AND STRENGTHS	ADAPTATIONS/MODIFICATIONS	STAKEHOLDERS TO BE INVOLVED	REPLICABILITY SCHEDULE
Mobility APPs: multimodal journey planner & ParkUs	- more test phase feedbacks -transport data available - user research/surveys to better fit their needs	- **Data uploading** should be facilitated/automated - **Critical mass of users** needed (ParkUs) This is required for data gathering and data input to app - **Continuous update** is necessary - **Competition** with other free APPs - Early **identification of relevant APIs** for example local bus timetables and Park & Ride, bike hire schemes for inclusion in the journey planner. - **Performing cruising detection for street level coverage.** Technology lesson: Within this project, we developed a second solution that detected the cruising activity of users (behaviour of parking search) through the use of mobile sensing. It enabled street level granularity reducing the requirement of a large number of users. - **Interface enhancement for making the app easy to use.** Usability Lesson: In order to overcome this, within the project, we further enhanced the user interface in order to clarify certain aspects of the app including button labels and providing data related information to users. - **Adoption Lesson:** ParkUs is focused on parking only, however, there are a few aspects that we identified through our trials that can enable such a critical mass up-take such as using ParkUs with in-car navigation or navigation mobile apps.	MJP: - There are other sources of information and competition with other apps but not all of them have multi modal service. Been a local service, the multimodal App developed is able to join with local services as it requires more detailed knowledge of the area. ParkUs: - Critical mass is biggest issue of usage - Users use other apps or services for navigation and start ParkUs when arriving to destination - the app can work anywhere in the world as long as the critical mass uptake is achieved. ParkUs can possibly be integrated with other commercial navigation systems (in-car sat-navs or mobile phone apps for navigation).	FSS/ADS: - Analyse possible implementation of ParkUs with additional features FI: - Comprehensive info mobility app foreseen at metropolitan level in the SUMP. - Parking app: info foreseen but gathered by sensors and ticketing system. Cost of about 1M€ but more income for 10 M€/y for a better use of free spaces -Multimodal app trial available since Sept 19. Differences with other systems (google): more precise local PT timetable, more updated municipal decrees and works blocks, few but targeted info notices, users' choices to be tracked and analysed, e-ticketing links available BCC: - Possible additional features: -price comparison -e-ticketing -traffic and incidents -record of individual journeys - The Parking app is only focussed on parking so would need navigation feature to make it more extensive and appealing to end-users: possible integration of ParkUs in a navigation app (e.g., Google Maps or Waze) such that users do not need to switch between the two or possible integration of ParkUs with in-car navigation systems - Development of ParkUs for other platforms including iOS - ParkUs marketing through different channels	- technical support for APP development and Data management -mobility department -public transport services (trains, busses, sharing companies, e-taxi…) - users associations -automotive companies or navigation systems manufacturers -e-ticketing and parking managers	**FSS/ADS: Mid term** Related strategy/Plan: **-Sustainable Urban Mobility plan,** Smart city plan **FI: Short term** Related strategy/Plan: Infomobility App already foreseen in **SUMP** and in **post-covid Renaissance Plan** to better manage possible congestion effects **BCC**: at short term the Improvement of existing APPs is foreseen by simply making better data available to them. ParkUs marketing will be promoted through different channels or integration into navigation systems Related strategy/Plan Mobility plan, connecting Bristol

ACTION	SUPPORTING INFORMATION	LESSONS LEARNT	CRITICAL ISSUES AND STRENGTHS	ADAPTATIONS/MODIFICATIONS	STAKEHOLDERS TO BE INVOLVED	REPLICABILITY SCHEDULE
Platforms (Smart City, Mobility, ICT), big data management & linked open data	- Costs for implementing the platform and the different modules/services - KPIs to monitor performances - Integration (EDM, CRM…) - Cyber security check	- **Need of Integration of different** platforms/**services** - **Interdisciplinary work** in the design and monitoring to select services and data - Need to develop different **dashboards tailored** for specific users - there are **multiple possibilities for financing** linked to different services involved -**training** for users and developers is very helpful - mobility platforms: **Interactive and predictive tools for mobility** are fundamental for smart cities also to manage post-COVID impacts - **Linked Open Data** is based in two notions that are difficult to grasp (Resources identified by URIs and Graphs) and **deployment is challenging for not experienced staff** on those domains.	- Open solutions (UNIFI, Eurohelp) are preferable instead of proprietary platforms -Possible connection or extension with other systems (public services, civil protection…) - User-friendliness -Extendible to wider territorial scales (metropolitan city, province/region …) - Citizens perceive the improvements due to platforms as well as to linked Open Data in a long-term, indirect way. - Open dataset selected are made public and accessible for anyone and anything (agents, machines). - Published open data becomes linked to other International Linked Data resources, augmenting the serendipitous discoverability of the published data - security	FSS/ADS: - Smart City Platform developed and under scalability process. - Evaluate the extension to neighbouring municipalities and the inclusion/connection at city level with other services (public lighting, waste and water management …). - Evaluate the open data development in the next years - Extension of the prediction models FI: - Smart City Control Room under development thanks to synergies with PON METRO financing - REGIONAL EXTENSION ALREADY DECIDED - Develop further dashboards and train more users. - Involve further services BCC: - Investigate the possibility of integrate/interact different platforms together	- Municipal departments: • ICT services, • Mobility • Energy/environment - neighbour municipalities - regional authority - DSOs - public services providers (waste, water management, public lighting, public transport, EVs charging infrastructure…) - other services managers - specific programs referents (BCC Connected city, Agenda digitale…)	**FSS/ADS**: **Short term** Related strategy/Plan: DSS CLIMA 2050 for infrastructures, Smart city plan, sustainable urban Mobility Plan **FI**: **Short term** Related strategy/Plan: -**SUMP**: 3M€ for integration of new services and 8M€ for full ITS system within 2025, -**Smart City Plan**, - **Regional agreement** (national exemplar test for PAs cooperation for AGID) **BCC**: : **Mid Term** Related strategy/Plan: -**One City Plan** for targets, -**Connecting Bristol**, -Bristol **Transport Plan**

ACTION	SUPPORTIG INFORMATION	LESSONS LEARNT	CRITICAL ISSUES AND STRENGTHS	ADAPTATIONS/MODIFICATIONS	STAKEHOLDERS TO BE INVOLVED	REPLICABILITY SCHEDULE
IoT	- Meteo data API for smart irrigation	- **Fast evolution** of the technology - **High impact** on citizens, low cost	- connection to the existing platform & data management - Energy/water savings - Service providers active involvement and formal commitment - vandalism - lack of consolidated standards in IoT implementations -People high digitalisation level -Sustainability commitments (energy and water savings) and tourism for benches -Multiple financing schemes related to innovation in urban context	FSS/ADS: - Analyse potential of implementation (smart irrigation, smart waste, smart benches) - Integration with the Smart City Platform - Connected to Open data, Linked open data FI: - Analyse the extension of smart irrigation to other parks - replication of smart waste in place by Alia - define the data management system or combination to be implemented among those in place in the pilot BCC: - Analyse potential of implementation (smart irrigation, smart waste, smart benches) - extend the SDN-IoT integration experience	- Municipal departments: • ICT services, • Mobility • Energy/environment - public services providers (waste, water management, public lighting, public transport, EVs charging infrastructure…) - IoT providers	**FSS/ADS: Mid term** Connected with the platform action Related strategy/Plan Smart city plan update, SECAP, Waste and water management plan, urban plan? **FI: Short-Mid term** Related strategy/Plan: **SMART CITY PLAN and GREEN PLAN** **BCC: Mid term** Related strategy/Plan: **One City Plan – Connecting Bristol**

ACTION	SUPPORTING INFORMATION	LESSONS LEARNT	CRITICAL ISSUES AND STRENGTHS	ADAPTATIONS/MODIFICATIONS	STAKEHOLDERS TO BE INVOLVED	REPLICABILITY SCHEDULE*
Smart Public Lighting	-Savings data to create a sustainable business model including additional services -In-house companies' potential (WP2)	- Legal/administrative and technical know how about all the services is required. -Interaction among different departments (cross-fertilisation and cross-funding). -Ownership and maintenance definition of all the services - Aspect/look of the components in cultural heritage areas must be tailored	- optimisation of the city infrastructures, less impacts on urban environment -connection to data management system (open, flexible) - Service providers active involvement and formal commitment - different standards and regulatory requirement in services implementations -Sustainability (energy savings) and security (surveillance) commitments -Multiple financing schemes related to innovation in urban context	FSS/ADS: - Analyse the scale-up potential together with the integration of the other services (ownership, maintenance and management of different systems) in an interdepartmental working group and further test the technology in other contexts, different than industrial areas (residential, commercial, transit…) FI: - Extension in place in the whole city (PON METRO) - Smart crosswalks within 2025 (2M€ PUMS) - possible replication in metropolitan area and region - possible exploitation of Silfi know how (design and tendering docs) BCC: - LED lights already implemented make business model less interesting	- Municipal departments: • ICT services, • Economic development • Mobility • Energy/environment - public lighting manager -other services providers	FSS/ADS: **Short term** Related strategy/Plan: **- DSS CLIMA 2050,** **- Smart city plan** FI: **Short term** **Already on going** with PON-METRO program support Related strategy/Plan: **Smart City Plan, SECAP** BCC: no interest at the moment

ACTION	LESSONS LEARNT	CRITICAL ISSUES AND STRENGTHS	ADAPTATIONS/MODIFICATIONS	STAKEHOLDERS TO BE INVOLVED	REPLICABILITY SCHEDULE
Citizens' participation: the Bristol approach & the platform	- **Continuous animation** is the key - Smart City narrative focus more on **citizen centric innovation** rather than smart city control technologies and tech for tech sake - Lack of **investment in citizen engagement** activity - **Specific skills required** to deliver programmes of engagement (very underestimated concerning creativity, social skills, communication, tech/basics…) - difficult to engage some citizens - training new trainers (engage young people) - use municipality attractivity to hire new experts - organise the work horizontally: work together (not top-down) - Costs - Amount and sources of funding available determine replicability - Ethics/Data issues will determine what data is collected and technology is used as well as whether data generated can be Open Data	- Social inclusion, active citizenship **Bristol approach:** - Key role of KWCM - Strong link with the market: economic development and skills build up -Innovative solutions to real problems -Uses and adapts "off the shelf" technologies -Iterative and agile approach -Identifies barriers to deployment -Identifies gaps both tech and systems - funding model: find the right mix of local/regional/central and private funds - inter-disciplinary - involve university with clear offers -use places linked to the challenges to build trust - extended connectivity on public events. Portable deployment - low civil works - use topics of interest for any age (walking, training…)	FSS/ADS: - Several initiatives ongoing and replicated in the city - Analyse the role of KWCM partner in Bristol pilot and the possibility to link some aspects to the citizens participation platform FI: - Evaluate together with Silfi/Linea Comune the possibility of replicating some aspects of the approach to arrange a feasible and sustainable model - surveys and citizens participation on the web will be enhanced (starting from the new Renaissance plan for post-Covid recovery) BCC: - Extend the model topics (health, social care, housing, jobs/enterprise, public realm, digital fabrication…)	- Municipal departments: • ICT services, • Health • Planning • Economic development • environment -animation providers (KWCM or other companies in other nations) - artists/creatives -technology/services providers -citizens associations/representatives -third sector -researchers/education -young people (Youth Mayors, local youth groups…)	**FSS/ADS**: **Short term** On-going activity. Related strategy/Plan: Smart City Plan **FI**: **Short term** Related strategy/Plan: -**Smart City Plan** - Cabinet decision to start the **Digital factory** for digital capacity building (CISPEL 90.000€/year) **BCC**: on going Related strategy/Plan: One City strategy

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9. Short-term actions

9.1 San Sebastian

The aim of Fomento San Sebastian is to drive the transformation of city economic model and knowledge into productive innovation. FSS works in different areas to promote the economic development of the city focusing on becoming an innovation hub and a specialized and smart city. FSS designs and implements projects of various kinds, all aimed at strengthening the economic fabric of Donostia-San Sebastián. Fomento San Sebastian fosters Smart City projects in collaboration with members of the Smart Cluster, Municipal Departments, and other public and private entities (universities, research corporations, companies, associations). FSS acts with the aim of positioning five city neighbourhoods: Txomin, Old Town, Altza, Amara, and Bera Bera. The short-term actions described below are planned to be deployed in these neighbourhoods following the objectives of Fomento San Sebastian. Replicate has deployed its implementations in the Urumea Riverside District (Txomin residential neighbourhood, Poligono 27 Industrial park, and Ametzagaina natural park).

The River Urumea, that characterizes Txomin neighbourhood, crosses the district acting as the main axis of the district, which also represents a barrier, as well as being the cause of the area's flooding problems. This area was urbanized during the first half of the 20th century, with low energy efficiency buildings, whereby it had connection problems with the city centre and it was at risk of social exclusion. To address this problem, San Sebastian City Council defined a special Urban Plan for the regeneration of the district in 2008, responding to the flooding problems, fostering the regeneration of the residential area, improving its connection with the city centre and fostering the transformation of the area's economic activity from the traditional industry to services-oriented activity. Almost 1.500 households are planned to be built in the neighbourhood (approximately 1.000 are already built), this makes Txomin a new neighbourhood in the city. On the other hand, the city of San Sebastian, through Fomento de San Sebastián, designed a Smart Plan for the city with an Action Plan for 2016-2020, establishing strategic line with shared objectives and some actions in this neighbourhood. Apart from the new houses that are being built, 156 households have been retrofitted in the Replicate project framework. Additional actions in energy efficiency, sustainable mobility and ICTs/Infrastructures are being implemented. Replicate project has boosted the scale up or replication of some of these implementations. In addition, Fomento San Sebastian continues working on the development of Smart Txomin, deploying complementary implementations, to continue working on the transition to a smart district.

Another city project fostered by FSS is SmartKalea, a pioneering public-private partnership project thatintegrates all the actors and stakeholders living together in a smart city area: citizens, shops, technology companies and local government departments in a single street. SmartKalea aims to turn Donostia into a smart city with higher living standards and greater benefits for companies and shops thanks to widespread use of ICT and rational use of environmental and other resources.

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Apart from Txomin neighbourhood, Fomento San Sebastian, through its smart strategy is also focused on the Old Town, Amara and Altza neighbourhoods. As part of SmartKalea project energy efficiency actions, among others, are being carried out in shops and household in the Old Town and in Altza neighbourhoods. Some of those actions are also planned to be implemented in Amara neighbourhood. These actions include among others, consumption monitoring, individual consulting services and ICT projects for smart cities. Platforms to monitor energy usage and smart water meters are also installed, individualized advice is offered and energy saving measures to raise awareness regarding the use of energy, joint energy purchasing, etc. Experiences and lessons learnt in Replicate project have also contributed to the deployment of some actions.

9.1.1 Retrofitting

- *General Description*

The 13% of the greenhouse effect gas emission in Donostia/San Sebastian comes from the residential sector in the city. The commitment of Donostia/San Sebastian in the reduction of these emissions establishes different actions for the short, mid and long term. In the residential sector, over the 30% of the building stock has more than 50 years old, so there is great potential for the reduction of the demand through rehabilitation actions.

There are 90.000 dwellings approximately in Donostia/San Sebastian, most of them private. Taking into account the retrofitting needs and making an estimate, it could be considered that the energetic renewal process of the buildings would imply to retrofit near 3.000 dwellings per year until 2050. Donostia/San Sebastian's City Council estimates that currently 1.500 households are being retrofitted per year (half of what is supposed). In consequence if additional measures are not taken, it might be difficult to achieve the compromised goals. It is estimated that each retrofitted dwelling decreases the energetic consumption in 40%. The following figure shows the distribution of gross floor area (GFA) of buildings with relevant heat demand in the municipality.

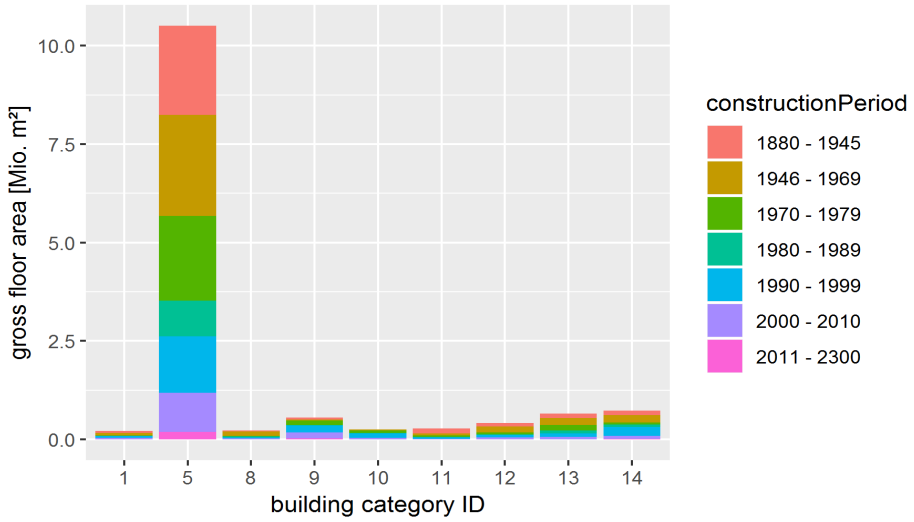

Figure 29. Gross floor area of buildings with relevant heat demand in San Sebastian differentiated between building types and construction periods (Source: Heating Strategy-Hotmaps project)

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Multifamily houses (building category 5) show to be the main part of the building stock with 73% of total GFA in the city (residential and service sector). The age of the buildings is nearly evenly distributed between the different construction periods. However, there exists a remarkable number of buildings built before 1969. Offices are the most relevant type of service buildings in the city, public and private offices together account for 24% of GFA in the service sector. However, buildings from the education and the health sector have also remarkable shares of GFA in the service sector with 20% and 18%, respectively.

As it is stated on the Sustainability Report of the city (2018) and shown in the picture below, the evolution of total gas consumption in the municipality has been representing asymmetric saw teeth; reaching a consumption peak in 2012. Since 2014, there is a tendency towards an increase, reaching in 2018 the second highest consumption in the series presented. In 2018, the per capita consumption of the domestic and services sectors increased while the industrial sector consumption decreased. The domestic sector represents just over two fifths of consumption, and the industrial and services sectors, about the 30% consumption each).

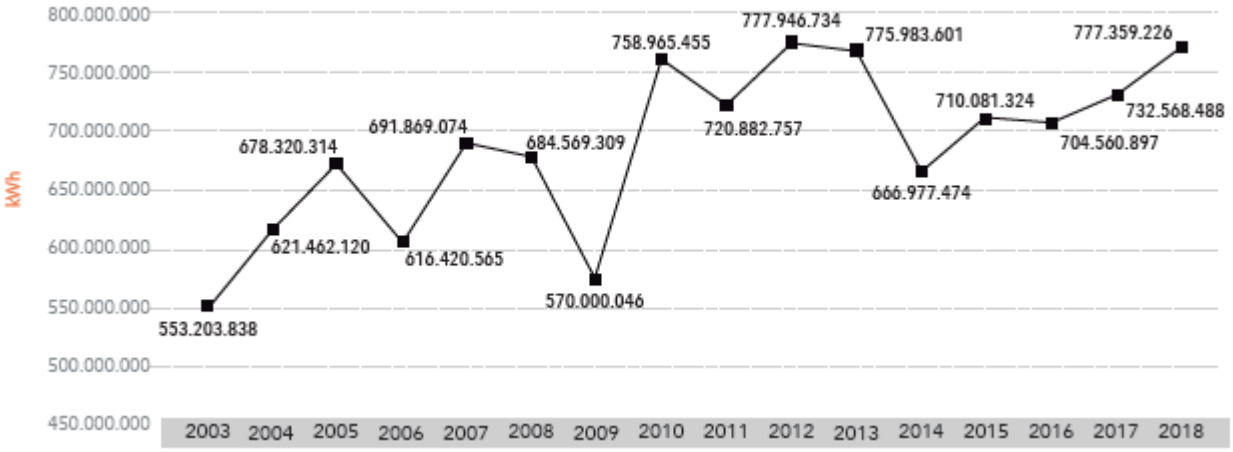

Figure 30. Evolution of total gas consumption in Donostia/San Sebastian

(Source: Sustainability Report 2018. Graph: Naturgas)

The scale up of the retrofitting activities will be conducted in many cases by community owners (boosted by incentives and legislation). Fomento San Sebastian also foresees to analyse possible retrofitting actions. The experience and lessons learnt in the retrofitting intervention of 156 dwellings and 34 commercial premises in the Replicate project framework, in Txomin Enea neighbourhood, will serve as a valuable lesson learnt for future actions. Approximately 1.000 new households have been built in Txomin neighbourhood while the retrofitting intervention contributed to the integration of these households in the new neighbourhood.

In addition to the activities promoted in Altza neighbourhood in the SmartKalea project framework, Fomento San Sebastian is also working on the characterization analysis of the district, taking advantage of the lessons learnt in the pilot in Txomin neighbourhood under Replicate framework. The study, that is being carried out during 2020, will characterize the neighbourhood from the

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urban, social, economic, and socio-environmental perspective, analysing the characteristics of the existing buildings, analysing the retrofitting needs and prioritising specific interventions with the introduction of renewable energy installations, while studying possible complementary actions in the ICT / Smart Systems field, to complete and improve the retrofitting interventions and contributing to the reduction of the demand, the increase of the renewable energy sources, reduction of emissions and maximizing economic savings. In summary, an improvement of the quality of life of the neighbourhoods and the city that might be replicable in other areas of the city and in other cities. The retrofitting interventions are a main activity in the roll-out process of the city.

- *Responsible for the roll out and policy reference*

Fomento San Sebastian is developing the characterization analysis of the neighbourhood. This work will allow to identify the areas and buildings of the neighbourhood that might be prioritised to develop retrofitting interventions with complementary Smart Systems.

One of the main challenges in retrofitting interventions is to engage the neighbours that might be beneficiaries but also might contribute economically to the solutions implementations. The efforts done in the Replicate project framework in retrofitting actions will serve as lessons learnt for other implementations and citizens engagement processes.

Different strategies and plans in the city include actions in the housing and building sector in San Sebastian. The objectives of those strategies and plans consider the housing sector from the social perspective on one hand and from the environmental perspective, on the other hand. Taking into account the social perspective, the Municipal Housing plan of the city stablishes that the city is characterized by the difficulty of access to accommodation, as a consequence of the prices and the limited available land for new buildings, among others. In particular, the 3rd Axe of the Municipal Housing Plan establishes in its objective the improvement of the habitability, accessibility and energy efficiency of the housing stock in the city.

Taking into account the construction period of the buildings in the city (more than 70% were built before 1980) and the regulation regarding energy efficiency at that time (with no efficiency parameters included), it is probable that most of the buildings suffer lack of good isolation. This poor isolation in buildings has the following consequences: the impact in the habitability conditions of the houses (humidity problems, heat loss, etc) that increase the energy bill and might lead in extreme cases to energy poverty situations. And on the other hand, the environmental impact, coming from the higher energy consumption and thus, more greenhouse gas emissions. From the environmental perspective, as it is described in the DSS Klima 2050 Action Plan, the 13% of the greenhouse effect gas emission comes from the residential sector in the city and the commitment of Donostia/San Sebastian in the reduction of these emissions stablishes different actions for the short, mid and long term. Taking into account the objective for 2050 of the reduction of the 80% of the greenhouse gas emissions, Donostia/San Sebastian has established for the year 2030 a 40% reduction in CO2 (and possibly other greenhouse gases) through energy efficiency measures and increased use of renewable energy sources.

The DSS Klima Action 2050 Plan of the city, establishes in the Energy axe, the following objectives:

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1. Decarbonization of energy sources
2. To boost the generation of renewable energy→ To achieve a 20% of renewable energy in final consumption of energy in the municipality by 2030
3. Efficiency improvement in the use of energy
4. Support vulnerable sectors on the satisfaction of basic energy needs.

The Smart City Plan also includes energy objectives and actions as one of the main axes. The preliminary analysis done showed that in the field of buildings and sustainable urban environment, the town had a clear goal to reduce the demand through energy efficiency strategies. As it could be seen in the different projects, these energy efficiency measures are applied to both residential and public buildings. In the outlines and actions of the plan different activities in relation to the retrofitting activities are included; studies, pilot actions etc.

The actions described in this document are in line and contribute to the above-mentioned plans and strategies.

The technical Inspection of the Buildings (ITE) promoted by the City Council is also a key factor in the retrofitting activities. Buildings with 50 years old since their construction, and also those that request public aids for retrofitting, energy efficiency and accessibility actions, are required to submit the Technical Inspection of Buildings. The regulation aims to stablish a system to describe the deficiencies appreciated in the buildings, the possible causes and the recommended measures to ensure stability, safety, tightness and structural consolidation. Likewise, it allows to estimate the conditions of the building envelope and its facilities, considering energy efficiency parameters, in order to certify the energy efficiency of the building. The ITE also informs about the basic conditions of universal accessibility and non-discrimination of persons with disabilities for access and use of the building, in accordance with current regulations, establishing whether or not the possibility of making reasonable adjustments to the building to satisfy them.

The Plan Renove of the Basque Government has two programmes oriented to the improvement of energy efficiency in retrofitting interventions. The Municipal Housing Plan of Donostia/San Sebastián plans to promote the realization of rehabilitation actions with energy efficiency criteria in the city, collaborating with the Basque Government in the dissemination of its aid programs and advising and facilitating the process of aids obtention to interested persons.

- *Timescale*

2020-2025 for some specific implementations in Altza neighbourhood.

- *Area*

Altza neighbourhood with its 8.800 dwellings, most of them built before 1970.

This district is located in the eastern part of the city of Donostia / San Sebastián. In the 1960s and 1970s the neighbourhood suffered great population growth due to immigration and there was an uncontrolled urban development. Currently, Altza counts 20.318 inhabitants (10.9% of the city) and a population density of around 4.053 inhabitants / km², being the third most populous city district. It is one of the farthest neighbourhoods from the city centre. The resident population has

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a weak socio-economic profile, with the lowest average personal income in the city (68.5%) and an average age around 44,36 years. (Source: Donostia City Council / San Sebastián December 2017).

Figure 30. Different neighbourhoods of Donostia/San Sebastian

The retrofitting interventions carried out in Txomin and the lessons learnt from the implementations and the characterization analysis of the neighbourhood, might lead to the scale up in other buildings or building blocks in the area.

- *Stakeholders and planning tools involved*

The main players involved in the replication are:

- Fomento San Sebastian
- San Sebastian City Council
- Municipal entities or departments (Etxegintza, Public entity for housing in Donostia/San Sebastian and Environmental Department)
- Architects
- Construction Companies
- Neighbours
- Owners communities
- Administrators
- Funding entities

- *Technical solution and management model for the roll out*

The study promoted by FSS will characterize the neighbourhood from the urban, social, economic and socio-environmental perspective, analysing the characteristics of the existing buildings and will identify and suggest short term actions. The study will be focused on the retrofitting needs of

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the area (identifying homogeneous areas that might facilitate subsequent intervention) and will also present an initial framework for intervention priorities in the neighbourhood. An area for short term interventions will be identified detailing the retrofitting needs and including the analysis of economic and energy indicators.

Additionally, complementary actions in the ICT / Smart Systems will be analysed, including an analysis of possible renewable energies to install and to complete and improve the retrofitting intervention.

- *Expected Impacts and contributions to the strategic objectives*

The characterization analysis will point out economic and energy indicators (estimation has been done taking into account a standard building in the neighbourhood). The prioritized interventions might be used as a reference for similar buildings interventions in the district that will be also carried out in the short and medium-term period. Best practices of the process will foster additional implementations in the area, the city and will serve as a reference for other European cities.

To implement the external costs methodology to the final results, the additional indirect savings of the intervention will consist in 1,204 €/MWh for gas consumption and 0,01344€/kWh in case of electricity savings (Annex 1 – table 11 and 13). Those savings are related to the environmental impacts avoided of the various emissions, as described in Annex 1, and are to be added to the direct savings on energy bills.

- *Eco-system: framework and interaction with other measures*

There are other energy efficiency actions that might be linked to the retrofitting activities and that contribute to the reduction of emissions. The District Heating (DH) that has been constructed and is operating since October 2018 in Txomin neighbourhood is one example. The ownership of the District Heating is from Fomento San Sebastian and a public-private collaboration was stablished, so the management is carried out by a private company. The District Heating is giving service to 1.000 households approximately and will be scaled up to more than 1.500 households in the Txomin neighbourhood, in accordance with the Urban Development Plan. The District Heating is also connected to the 156 retrofitted houses. It works with two biomass boilers and only energy peaks are covered by gas. This DH is the first one of this size in the Basque Country. Currently it would be difficult to replicate this system in the short term in other parts of the city because the civil works required in urbanized areas would make it difficult, and new district developments are not frequent in the city. Nevertheless, it would be possible to replicate the intervention in a smaller scale and it will be analysed as a solution for certain building blocks of a district.

A Demand Side Platform is being also developed to generate recommendations to residents for better use of the energy and to obtain savings which might also be replicated in other interventions of the city.

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- *Results from the pilot implementation*

The main outputs of the pilot have been summarised in the following SWOT table taken from D7.5 management models analysis:

Retrofitting	
Unique Selling Proposition: Retrofitting of dwellings to be integrated in a Txomin district, favouring energy savings to the tenants and, together with the District Heating, it is increasing the overall value of the houses.	
Strengths	Weaknesses
• Noise suppression • Energy and money savings • No additional expenses or charges • Municipal DH through FSS	• Inhabitants profile • Low-medium economic profile • Retrofitting subcontracted previously with other companies in one of the doorways
Opportunities	Threats
• Accessibility • Revaluation of the dwellings • Smart city district integration • New urbanisation of the district	• Previous problems in the neighbourhood (floods, etc.) •

Table 3 – SWOT analysis of the retrofitting intervention

The results of the retrofitting intervention contribute to different objectives described in the different plans.

The citizens' engagement activity was key for the success of the Replicate project. All residents of the different doorways agreed on the retrofitting project. Several meetings with neighbours, construction companies, architects, municipality and FSS were done to foster and assure citizen engagement. The neighbours' association of Txomin-Enea was informed and involved in the project from the very beginning. The meetings with neighbourhood were done in Txomin Enea district using a local community space in one of the buildings that was to be retrofitted. This space was chosen to encourage local residents to attend in a friendly and known space environment and create a sharing and participatory environment. Several communication materials were prepared to explain the main goals of the Replicate project, the retrofitting intervention benefits, the development of the District Heating system in the San Sebastian pilot using biomass and highlighting the costs reduction and improvement of the comfort that all this would entail. The response of neighbour was positive in general, but it was necessary to make an extra effort in the engagement process in order to reach 100% of commitment. Finally, all residents decided to participate in the project and 100% of agreement was obtained. The good disposition from the beginning by the neighbours was translated into neighbourhood proposals, improvement options,

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and the budgets took shape taking into account the limitations and suggestions of the whole neighbourhood.

During the execution, regularly meetings with presidents and neighbours have taken place. Continuous contact has maintained with the presidents of the communities and neighbours, giving information, answering questions, explaining technical and economical details, progress of the works, etc.

The management model of the retrofitting intervention as a district of 10 building blocks has been innovative for the city including the connection of all those buildings to the new DH system. The retrofitting and the installation of a District Heating system provides heat and DHW to the dwellings through a network that distributes the energy between 3 substations and the application of a transfer module in each dwelling that improves the heat exchange.

The project significantly contributes to the environmental impact with the change of conventional energies to renewable energies (biomass), with an important reduction of CO_2 emissions. Another important factor that causes great environmental impact is the reduction of noise by suppressing the gas boilers and also a greater efficiency, since building improvements mean greater thermal comfort and increase the use of energy resources. First results show that a reduction in the retrofitted houses in their demand of around 22% compared to the 2018 and the consumption of non-renewable primary energy is also significantly reduced around 67%.

Comfort, housing certification and security improvement: one of the great benefits of the retrofitting project in Txomin Enea is the centralization of a common heat network for the district as a whole. This District Heating network developed in the neighbour improves both comfort and energy efficiency assuming savings in the bills of all neighbours. In the energy field, housing certification has improved significantly, since the source of their energy comes from renewable sources. Inside comfort has also been improved considerably. Within the dwelling, and with the removal of gas boilers, there have been many changes in the kitchens from traditional (gas) to electric systems. This removes the gas from the houses and in this way offers greater security avoiding possible combustions. In some of the buildings the accessibility has been also improved thanks to the installation or renewable of the elevators.

Retrofitting interventions as well as complementary actions in the households have improved the buildings and so the value of the houses in the real estate market has increased.

As a conclusion, retrofitting intervention has been complemented with the connection to the DH based in biomass, which contributes to the energy sustainability of the district.

Furthermore, the retrofitting works in Txomin neighbourhood have promoted the employment of a large number of local workers: builders, architects, welders, metal carpenters, electricians, plumbers, etc.

- *Monitoring methodology including risks and adaptation measures*

All the retrofitting interventions implemented under Replicate project are under monitoring phase (two years monitoring till the end of the project). The monitoring procedure and the obtained

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indicators give a valuable information for an impact analysis that allows having information and reaching conclusions for the scalability and replicability of the interventions in the city. Short and medium term interventions described in this section will also be monitored taking into account the lessons learned in Replicate. Citizen engagement previous experience is also an important aspect to consider during replication. As a conclusion it might be said that Replicate project gives very valuable results that are being considered for the replication and scalability of this type on interventions in the city of San Sebastian. Monitoring details are included in previous sections.

9.1.2 E-bus

General Description

Two electric buses were acquired in the Replicate project framework to cover the Line 26 that connects the Urumea Riverside District with the city centre. The experience of these e-buses together with another electric bus that was previously acquired, have permitted to test these vehicles. This has been a challenging experience, due to the bus line characteristics.

Lessons learnt and useful experiences have been obtained to continue with the transition to a more sustainable bus fleet.

The municipal bus fleet renewal process is being carried out in the city of San Sebastian with the aim of becoming the 90% of the 12 meters bus fleet in a hybrid-electric fleet, in the next four years. The aim is to achieve the 100% of the bus fleet hybrid or electric by year 2030.

The acquisition of *12 hybrid buses* is included on a 4 year-contract that considers the acquisition of a maximum of 39 buses. The 12 buses already acquired will be operating in the next months.

DBUS has also planned to purchase *11 full electric* 18 meter-buses to deploy an Intelligent Electric Bus (BEI) in line 17, by year 2022. Currently, two charging systems for these vehicles are under analysis; night charge or opportunity charge at bus stops.

DBUS fleet is composed by 135 vehicles: 3 full electric 12 meter-buses, 38 hybrid 12 meter-buses, 56 diesel 12 meter-buses, 27 diesel 18 meter-buses and 11 diesel minibuses. The public transport service of the city of San Sebastian (187.000 inhabitants) is through 41 bus lines, with a huge use of 29.583.538 trips, in year 2019. The use rate of the buses is of 158 trips/inhabitant-year, which is one of the highest public transport use rates in Europe.

- Responsible for the roll out and policy reference

DBUS, Municipal bus company

The Sustainable Mobility Plan includes as one of the axes the improvement and optimization of the municipal public bus service: one of the objectives of this plan is to promote the use of the public transport and reduce the use of the private vehicles.

The DSS Klima 2050 Action Plan, stablishes the commitments of the city in the reduction of greenhouse gas emissions unfold in all sectors of urban activity and, in particular, in mobility, head

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of emissions. DSS Klima 2050 Action Plan and the 2018 Sustainability Report establish that the 41% of the greenhouse gas emissions in the city come from the transport. The commitment that the city has in emission reduction expect for the year 2030 a reduction of the 40% compared to 1990. Mobility has to contribute to this reduction. There are three factors that have an impact on this emission reduction: the technological improvement of fossil fuel vehicles, its partial replacement with hybrid and electric vehicles and, finally, the effect of the economic crisis of 2007, which has reduced emissions of mobility in Donostia / San Sebastian by 11% between 2007 and 2015. The European forecasts[9] for the introduction of technological improvements and the substitution in the number of hybrid vehicles and electric cars, reflect that the reduction of emissions derived from those changes in the car are not enough to meet the commitments of the city. There is a gap (see the picture below), which represents almost half the effort required to reduce emissions in the 2015-2030 period, which will have to be derived from a modification of the current model. This will include behaviour changes with regards to displacements and increase in the use of collective modes (especially electric buses and subway) and not motorized vehicles. The plan establishes a long-term objective of 80% greenhouse gases emission reduction (for year 2050) which expects 0 emissions in transport. A medium-term objective for year 2030 is stablished which expects 40% reduction greenhouse gases emission with specific plan for the mobility actions:

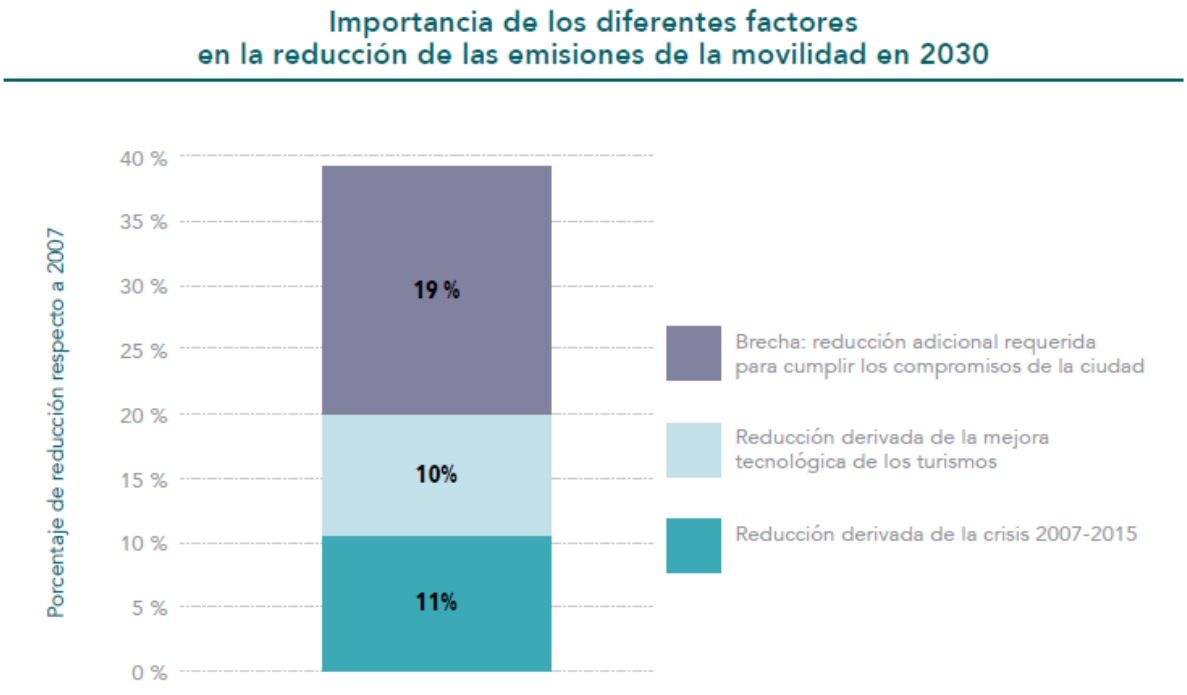

Figure 32. Facts that affect the emission reduction in mobility. Source: Action Plan DSS Klima

(Translation: Purple colour label: Gap, additional reduction required to meet city commitments, Light blue label: reduction derived from the technological improvement of vehicles, Medium blue label: Reduction derived from the crisis 2007-2015)

[9] EU Reference Scenario 2016: Energy, transport and GHG Emissions trends to 2050.

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Among the different objectives considered in the mobility axe of the DSS Klima Action Plan, objective number 4 stablishes the decarbonization and electrification of mobility and specifically the action of the electrification plan of DBUS as well as energy efficiency programmes for the use of renewable energies in the bus depot and offices.

Regarding the Smart City Plan, the sustainable mobility axe establishes the following outlines with specific actions in each of them:

- Electrification of transport
- Smart mobility
- Smart transport infrastructures

In Smart Mobility axe the electrification of the urban public transport is an important intervention to consider.

- Timescale

2020-2023

- Area

The scale up or renewal process is considered for the whole city.

This is also related with the City Council plan to create in the following years a Zero or Low Emission zone in the city centre, which will include restrictions to the vehicles in the city centre, except electric vehicles and public transport.

- Stakeholders involved and planning tools involved

The main stakeholders involved in the action are: DBUS, Mobility Department of the Municipality of San Sebastian, bus manufacturers and citizens.

The city of San Sebastian works on the transition to a sustainable city involving the different departments and public entities of the city. This involvement has conducted to the development of different strategies and plans by the different departments and entities in the city. The specific roadmap for the renewal of the bus fleet is drawn in DBUS Company.

- Technical solution and management model for the roll out

The hybrid 12 meter-buses acquired have a cost of 287.000€ per bus. The guarantee period has been improved for three years.

The full electric 12 meter-buses have a cost of 520.000€ per bus, and an expected battery life of 7 years. The battery must be changed after 7 years, and a new battery has a cost of 220.000€ per unit. Besides, an important retrofit would be needed in the depot if DBUS would decide to have more than 10 full electric buses, because the electric infrastructure has to be changed completely. Currently costs are being analysed, retrofitting characteristics and financial issues to be prepared for the acquisition of more full electric buses in the following years.

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For the deployment of the 18 meters BEI in line 17, DBUS and San Sebastian City Council expect to get funds from the Basque Government, that are currently being negotiating. Funding is important in the acquisition of full electric buses: with no supporting funds, for a public transport operator is going to be extremely difficult to tackle a purchase of full electric buses instead of hybrid buses.

According to previous experience, in the last 8 years there has not been significant difference between the maintenance costs of the different types of vehicles, that is diesel, hybrid or full electric.

There is still an issue with the range problem. The limit of full electric buses is a daily range of 210-220km. The 70% of municipal bus fleet operates mileages over 225 km and up to 300 km. There is still a gap to cover by the full electric buses with night charge to achieve a range of 300 km that is what public transport operators as DBUS need. To solve mileages over 225km other operators purchase full electric buses with opportunity charge at terminal bus stops. But there is also a time problem. Those fast charges take approximately 5-6 minutes charging at terminal stops. In case of San Sebastian, the option of charging in terminal stops cannot be considered for most of the bus lines, because of the duration of the stops in peak hours that is less than those 5-6 minutes needed for fast charging.

- Expected Impacts and contributions to the strategic objectives

The 38 current hybrid municipal buses operating in the city avoid 760 t CO_2 per year and the 3 electric buses currently in service avoid 240 t CO_2 per year.

90% of the 12 meters bus fleet, actually composed of 97 mixed vehicles, will be hybrid or electric in 2024 when it is expected a 1,780 t CO_2 reduction per year with the hybrid and electric buses operating.

Implementing the suggested methodology for the calculation of external costs avoided, the amount saved by the e-fleet is 1,25 c€/kmp considering the difference with a diesel fleet on air-pollution, climate, noise (100% reduction in case of full electric buses and 30% for hybrid vehicles) and also well-to-tank aspects (Annex 1 – table 17). Those costs should be added to fuel and maintenance eventual savings.

According to users' satisfaction, the improvement has been significant. Before the acquisition of hybrid buses, the grade of diesel fleet was 7.56, and in the surveys conducted during last year, users give a grade of 8.60 to DBUS current fleet, due to the deployment of hybrid and full electric buses.

- Eco-system: framework and interaction with other measures

The Smart City Platform gathers information about the buses in the city, part of this information is used for internal purposes and part of this info is published in the open data portal for the citizens.

The Smart Mobility Platform, that monitors and manages data from buses (among others) and centralizes, process and exploits data with Business Intelligence and Big Data Analytic tools for

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planners, operators and mobility authorities to visualize the info in a simple way to contribute to the management of the mobility in the city.

DBUS is active in communication and customer satisfaction measurement actions. Yearly DBUS makes surveys to more than 1.000 users, due to the compliment of standard UNE-EN-13816 about Public Transport Quality Service for users.

Several communication actions are carried out by DBUS, such as a press conferences or press releases, advertising campaigns in buses and bus stops, perching, etc. to inform citizens about new deployments.

- Results from the pilot implementation

The main results have been analysed in the following SWOT analysis:

e-bus	
Unique Selling Proposition: zero emission and silent public transport for a smarter, greener, and more connected city	
Strengths	Weaknesses
• Municipal sustainable mobility policies • Users acceptance (less pollution and less noise)	Some aspects to be improved: • Vehicle costs • Batteries life (minimum 6 years) • Infrastructure (costs and authorisations) • Bus range (currently about 200 km/day)
Opportunities	Threats
• R&D to increase bus range & batteries life	• Diesel buses (more operative and flexible) competition

Table 4 – SWOT analysis of the e-bus intervention

One of the main conclusions from the operation of the e-buses in Line 26 was that the Irizar i2e bus was perfectly capable of dealing with bus lines of around 150 km (like line 21 of DBUS), after the substitutions of the batteries the bus is capable of doing 210km per day.

The experience in Line 26 connecting the Urumea Riverside District to the city centre was one of the most demanding experiences of an electric bus. It was concluded that it was necessary to put in service the bus when the state of charge (SOC) was 100% in the morning, to be able to complete the filled service in that line. The conclusion of the full electric buses acquired in year 2016 was that those buses could achieve 210 km per day returning to the depot with less of 5% battery-charge. During the night-charge 8 hours were needed to achieve the 100% battery-charge

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required. The effective charge period was less than 8 hours, so, this made impossible for these buses to achieve 210 km per day during 5 consecutive days.

During Autumn-Winter 2017 difficulties were found to complete the electric buses service in line 26, as they ran out of battery and were forced to return to the depot. Therefore, new trials and tests were done in order to find possible improvements and reduce the electric consumption. Improvements in the traction system, maintenance of the climate control system, demisting service, new charging processes, assistance systems performance, driving techniques monitorization and replacement of batteries caused because of an assembly problem.

All these changes were implemented since January 2018 and the results confirmed that changes improved buses 'autonomy.

The batteries have degraded in 3 years instead of the 5-6 years expected. This point has been critical and DBUS has overtaken the decision to change batteries of the 2 full electric buses acquired in year 2016. The first full electric bus was retrofitted in October 2019, and the new battery achieves 210km per day returning to the depot with a 15-20% of remaining battery-charge. This makes possible to achieve 210km in 5 consecutive days. The new battery lifetime is unknown at this point.

After the experience carried out and the lessons learnt it was firstly concluded that the experience could be replicated in other bus lines in San Sebastian or other cities in bus lines that cover around 150 km a day (taking into account San Sebastian weather conditions, where normally temperatures do not go down under 4 degrees). After the substitution of the batteries the results have improved being able to deal with 210 km a day during 5 consecutive days. This experience with 12 meters 100% electric buses was the first step in the deployment of electric vehicles and electric bus lines in DBUS. In fact, this bus was the first electric bus operated in Europe manufactured by a European company in Europe and so San Sebastian was the first European city where an electric bus was operating.

REPLICATE experience has encouraged San Sebastian to continue trying and analysing electric buses´ performance. From June 2018 to February 2019, DBUS has tested a new pilot project related to electromobility, deploying its first 100% electric articulated bus (18 meters), also produced by Irizar manufacturer. This bus is also a silent bus with 0 emissions into the atmosphere. The project lasted 6 months approximately and made possible to test this new type of electric buses, in this case in line 28-Amara-Ospitaleak. A different technology was tested for this pilot project, in this case, the 18 meters bus was charged during the night in the depot and also a charge during the route was needed. This charge was about 6-7 minutes every time that the bus finalized a whole trip, that was every 50-60 minutes, with a 20km autonomy. 12 meters electric buses implemented in REPLICATE project, on the contrary, have only night charge and the autonomy reaches 220kms approximately. This experience with this first 100% electric articulated bus was very useful to analyse and calculate necessities for the total electrification of line 28.

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Figure 32. Electric articulated bus

In addition, from September 2018 to March 2019 DBUS has also tested a hybrid-electric bus manufactured by Vectia (CAF Group). This bus, Veris 12 12 meters Partial Electric model, operated East side lines of the city. This bus ran in hybrid and in electric mode, without the need for external loads, and did not require infrastructure for a night charge in the depot or charge during the route. The bus exchanged driving modes via GPS, so it does not need the driver's intervention.

Figure 33. Electric bus

In the last years, 38 hybrid buses have also been introduced. Additionally, related to DBUS´ commitment to sustainability and the quality of life of the people of San Sebastián, the Company is working and experiencing with different electric vehicles.

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- *Monitoring methodology including risks and adaptation measures*

The monitoring system includes the most important indicators to give the best public transport service to its users.

Several indicators are referred to the fleet, such as:

- Fleet availability: 91% (9% of incidents with buses that must move away to the depot)
- Punctuality: 97%
- Commercial Speed: 17,4 km/h
- Fuel Consumption: 47 litres/100km

DBUS has also deployed an innovative Antibunching & Efficient Driving system that has reduced the fuel consumption between the 4-6%.

Daily, buses operation are monitored in the control centre through the AVL (Automatic Vehicle Location system) and supervised by 4 inspectors, that are also in charge of solving all the incidents and problems that can take place during the offered service daily between 5:30 am and 0:30 am (4:00 am during weekends with the night bus services).

The CO_2 emission reduction is monitored taking into account the km done by each vehicle and comparing emissions from diesel to hybrid or electric vehicles.

9.1.3 Smart City platform

- *General Description*

The development and implementation of a Smart City Platform for the municipality of San Sebastian has been done within the Replicate project framework. The platform has allowed to integrate many data sources from the municipality, and create several dashboards oriented to the municipal staff that is dedicated to the management of services, so that they can visualize data in a friendly way. An open data portal has been also created for citizens: "www.donostia.eus/datosabiertos", which provides open datasets of the city municipality context. Additionally, the web called WWW.DONOSTIA.EUS/DONOSTIADATA has been created with part of this public data that can be visualized in a more friendly way so that, not only technicians but also general citizenship of the city can access and visualize this information.

In parallel, the Municipal Information Office was created with technicians dedicated to the data analysis within the Department of the City Council Presidency. This office is aimed to promote a transversal vision of the City Council in terms of data. This substantially changes the way the information is treated (approaching now to a transversal vision and big data oriented) and expecting to have improvements in the management.

The Smart City Platform includes data sources coming from actions deployed in Replicate, but it already includes also other additional information managed by the city council, out of the project framework. To further extend it, a public tender has been published (out of REPLICATE project funding) to identify all data sources managed and available in the municipality, so that in the

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following years the platform can be scaled-up to integrate the maximum number of data sources in order to offer a global data exploitation environment.

This will permit to the municipal government to exploit in an integrated way all different data sources available in the city and extract added-value data just crossing several information sources or providing the same data to different municipal departments so that it can be exploited from different perspectives. Additionally, the platform should be able to do the follow-up of municipal services in real time with a supporting tool for decision-makers.

- *Responsible for the roll out and policy reference*

DonostiaTIK (Municipal Department; ICT Department of San Sebastian City Council).

- *Timescale*

It is planned that the scaling-up of the Smart City Platform will be done during 2020-2025.

It is foreseen that data sources available in the city will gradually be integrated in the platform, starting from:

- housing related information
- Finance related information
- Demography related information
- Environment related information
- Etc.

DonostiaTIK, the ICT Department of the City Council is involved in several different plans promoted by other departments or entities. The Smart City Plan includes ICTs/Infrastructures and Smart and Open Government as two of the main axes. In the specific actions detailed in the Smart City Plan, the creation of a Smart City platform was foreseen and it has been already deployed in the Replicate project framework and it is being scaled up to the city.

As municipal strategy, a new data analytics department is being created on the City Council to define the data needs and develop a data management strategy. The department is working on the definition of the strategy for the forthcoming years and it is expected to have it ready by the end of the year 2020. This strategy will integrate the Smart City Platform and its deployment.

The implementation and improvement of the Smart City Platform contributes if not directly, indirectly, to other objectives included in the Mobility Plan, DSS Klima 2050 or the 2020 DSS Strategy Plan. It can be considered as a transversal tool for all the Municipal Departments and also available to citizens through Donostia open data portal.

- *Area*

The scaling-up of the Smart City Platform will involve to the whole city, from REPLICATE project related data sources to other data sources and services at city level.

Additionally, the integrated information will be available for the municipal staff, with access to specific information depending on the department but also used for other purposes and from other

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perspectives (for example, traffic-related information can be used internally by Mobility or also by Environmental Department for further analysis).

Finally, part of this data platform will be opened to citizens and users through Donostia Data portals.

- *Stakeholders involved and planning tools involved*

The stakeholders involved in the action are: DonostiaTIK (ICT Municipal Department), the technological providers (including consultants, data providers, services providers, etc.), the different municipal departments and citizens.

- *Technical solution and management model for the roll out*

The Smart City Platform is structured in three layers: Data Visualization Layer, Data Management Layer and Data Acquisition Layer.

The following image shows the current architecture deployment of the Smart City Platform in the Municipality of San Sebastian and its relationship with the services being developed in Replicate project framework, other municipal services already in place and several external data sources. It also shows the FIWARE components that have been selected to be integrated as part of the platform, CKAN and Orion Context Broker.

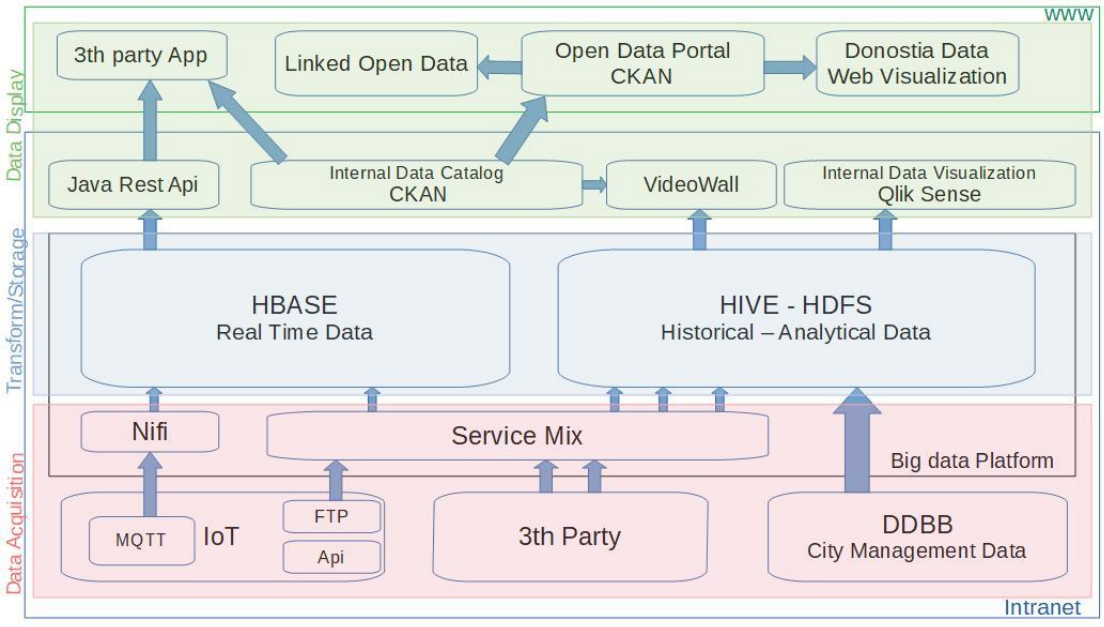

Figure 34. San Sebastian Smart City Platform architecture and software components.

In the data acquisition level, these are the data sources integrated in the platform:

Some of them as part of the Replicate project framework:

- Public bus information Line 26 (Dbus)

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- bicycle rental service (dbizi)
- underground parkings
- surface parkings
- people tracking by phone operators (Euskaltel)
- electric taxis monitoring
- smart lighting
- citizen participation

And some others as part of the scale up process already carried out:

- municipal management databases (such as: municipal register, map and names of city streets, financial information, social action, security…)
- public bus information all bus lines (Dbus)
- GPS sensor for municipal vehicles
- level of Urumea River

In the data visualization layer friendly interfaces for consultation and data analysis based on the B.I. tool have been developed in *Qlik sense*. Dashboards have been generated for the municipal staff that is dedicated to the management of services, as well as the open portal to citizens: An internal visualization tool which includes a specific control panel of the REPLICATE project for internal use of the municipal organization has been fully developed in Qlik Sense.

For the monitoring of the infrastructure, its own monitoring tool, AMBARI, is being used. The Hortonworks Apache AMBARI software is the performance monitoring tool that is used for the monitoring of the BIGDATA infrastructure, providing a joint view of the different parameters that affect performance. AMBARI allows system administrators to provision, manage, and monitor a BIG DATA cluster.

The security layer of the platform has been implemented with different access profiles for the management of the platform.

- *Expected Impacts and contributions to the strategic objectives*

The Smart City Platform-increases transparency and improves the relation among citizens and the City Council and promotes the exploitation of municipal data by companies in the city.
The platform is used by the municipal departments in decision making processes and improves the services offered to citizens. Seven datasets of thematic indicators have been created to help decision-making processes in municipal departments (work is being done to create more):

- Demography
- Taxes
- Vehicles
- Society
- Income (job)
- Citizen attention

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- Municipal activity

- *Eco-system: framework and interaction with other measures*

Different actions implemented have or could have interaction with the Smart City Platform as the data from different sources of the city can be included in the platform.

As an example, smart public lighting has been deployed in the industrial area of the district. This infrastructure is managed by a domain-specific platform, but it sends the information to the Smart City Platform to be fully integrated in.

- *Results from the pilot implementation*

The innovation comes from the experimentation of different modules developed with open source. At the moment, there is not a standard method for Smart City Platform architecture and protocols to be used, therefore, the solution is based on the different trials and the conclusions arisen from them. It has been used the (MQTT) protocols in the data acquisition layer.

These standards will allow the use of new easily connectable devices that will allow an empowerment of the City Council. Both, in the field of developing new solutions by itself, and in the field of reliably controlling third-party external solutions and contracts.

Until this standardization of protocols at the level of data acquisition was defined, the vertical solutions were too tied to the manufacturer. Remote reading devices, sensors, etc. were always linked to proprietary platforms. Adapting customer details to a proprietary platform is always expensive and difficult, so standardization will undoubtedly bring greater flexibility and certainly at a better price. The following SWOT analysis developed in D7.5 summarises the main outputs of the pilot test focussed on mobility sector.

Smart City Platform	
Unique Selling Proposition: A smart platform that gathers information from different sources and has friendly dashboard for visualization and decision making.	
Strengths	Weaknesses
• Standardization of protocols • Friendly and powerful query interfaces • Integration of different datasets and heterogeneous sources • Processing of large data streams	• Fear of staff sharing data • Large amount of data with low quality • Knowledge and personnel qualification in data analysis required.
Opportunities	Threats
New datasets to be included New functionalities to be developed	• Data privacy • Costs

Table 5 – SWOT analysis of the Smart Mobility Platform intervention

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- *Monitoring methodology including risks and adaptation measures*

The Big Data environment has its own monitoring tools, to know how many datasets are in the system, and their consumption.

On the other hand, data exploitation tools, both internal and external, have also their own tools. In the case of Internal tools, the BI has its system monitoring environment where the different data consumptions can be consulted. And in the case of the information published on the internet, the same statistical system of the municipal website (Google Analytics) is used for the monitoring.

Additionally, DonostiaTIK is continuously monitoring the environments and as soon as an error is detected, the cause is identified and an attempt is made to solve it.

There are different KPIs that have been defined to analyse the impact of the platform. These KPIs are oriented to measure data visibility, data category, data format and data access method. The following table shows the principal evaluation KPIs for the platform:

KPI ID	Classification	Name	Description	Datasets	Resources
SCP_KPI_1	Data visibility	Number of internal data sets	Only for internal use (municipality) or for city operation	29	120
SCP_KPI_2		Number of external data sets	Open data or Data sets offered by the Data Aggregation Platform via the Smart City API	69	229
SCP_KPI_3	Data category	Number of Dynamic/Real time data sets	**Dynamic/Real time:** Information about the "current state" of the city. (For example, it could be the "temperature in park", the "location of a bus", the "free space in a parking" and so on).	14	
SCP_KPI_4		Number of historic data sets	**Historic data:** data covering a specific period of time (or regarding a date in the past).	28	
SCP_KPI_5		Number of Static/Infrastructure data sets	**Static/Infrastructure data**: Data about the city that can change over time but not "every day". (street maps, bus stops, parking information not including real time availability, etc.)	84	
SCP_KPI_6	Data Format	Number of structured data sets	Structured formats: CVS, Excel, JSON…	80	
SCP_KPI_7		Number of semantic data sets	Semantic formats: JSON_LD,RDF, OWL…	98	
SCP_KPI_8		Number of geographic data sets	Geographic formats: GeoJSON, SHP, KML, etc...	6	
SCP_KPI_9	Data access method	Download		98	
SCPKPI_10		API		6	

Table 6 – KPIs selected for the platform impacts monitoring

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Some results of the platform are already available from the San Sebastian monitoring:

-Information about connected data in the platform: 6 real time data sources, 8 DDBB data sources, 3 external data sources

-integrated data in Replicate project: 259.500.000 records, and distributed as follows

- ebicycles (DBizi) 5.000.000
- Surface Parkings 5.500.000
- Subway Parkings 7.500.000
- ebuses (DBus) 103.000.000
- Mobile phone mobility (Euskaltel)56.500.000
- Traffic Beacons 82.000.000

-Information of the Open Data, in 2019

-N° visits 3.218

-N° Page views 29.427

-Federated Data: opendata.euskadi.eus, Datos.gob.es, europeandataportal.eus

-Donostia Data (info about 2019): the number of page views has been 66.157

9.1.4 Smart Lighting

- *General Description*

The city of San Sebastian has around 32.000 public lighting points. San Sebastian City Councils´ objective is to improve gradually the public lighting of the city to new and more sustainable modalities, reducing CO_2 emissions, with the aim of saving energy and reduce electricity bills. The substitution that is being carried out in the city, in most of the cases, consists of the substitution of the old luminaries with LED technology. Some pilots are being deployed to include intelligent systems and IP services. In the last three months of 2019 the Department for Urban Infrastructure and Systems/Maintenance and Urban Services of the City Council substituted almost 300 lighting points to LED technology in different streets of the city.

The first smart lighting system with movement detection in the city was deployed in 2015 by Fomento San Sebastian, as coordinator of SmartKalea project, in coordination with the Municipal Department for Urban Infrastructure and Systems/Maintenance and Urban Services on Calle Mayor, replacing the old streetlights. This action was replicated in the district of Altza, replacing 37 lights by a smart lighting system. The goal was to save electricity and reduce maintenance costs by substituting a new source of electric power for streetlamps, using remotely controlled dimmable LED lights and pedestrian and vehicle motion detection and analysis system. The system consists in a smart lighting model that saves energy, reduces costs, enables system monitoring and remote programming, and improves maintenance activities. During 2020, the action is going to be scaled up in Sancho el Sabio street, located in a different district of the city. The new public lighting

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infrastructure of the street will consist of 22 luminaires, with LED system with optics of contracted quality and with a photobiological risk certificate.

In the Replicate project framework, the substitution of existing sodium luminaries with new LED technology was implemented on 90 lampposts in the industrial park of Poligono 27 with the integration of remote and intelligent control system and IP services (motion detection, rain sensors and vehicle counting, among others). Fomento San Sebastian is analysing an extension of intelligent public lighting in Txomin neighbourhood: in addition to the LED lighting already installed, new smart management elements would be added, like presence detection system, rain sensors, etc. This scale up process will expand the installation done in an industrial state to a residential area, testing areas with different characteristics. Fomento San Sebastian is also analysing for the medium term another installation in the area, but in a street near the river where adaptations might be required due to the different use. These pilot implementations will provide valuable experiences and lessons learnt in areas with different characteristics: a street with limited access to pedestrians, a street with vehicles and pedestrian circulation, an industrial area and the riverside. The lessons learnt will be valuable for the design of the best smart lighting solutions to be implemented in different areas of the city.

- Responsible for the roll out and policy reference

San Sebastian City Council, Department for Urban Infrastructure and Systems/Maintenance and Urban Services, and Fomento San Sebastian.

The Smart Lighting implementation is in line with the different strategies and plans in the city. The Klima 2050 Action Plan of San Sebastian stablishes as one of the objectives in the energy field the decarbonization of energy sources. Improvement in efficiency in regard to the use of the energy and savings achievements are also considered in the plan. The Smart City Plan considered actions in Smart Lighting field oriented to implementation of measures to improve public lighting. The smart lighting implementations will contribute to these objectives.

- Timescale

2020 further installations in Sancho el Sabio and Txomin neighbourhood.

2020-2025, as part of the renewal process of the public lighting in the city.

- Area

The city of San Sebastian plan is to substitute old luminaries of the city with LED technology and new technologies and solutions are also being tested. This progressive substitution is being afforded in several years. For instance, during last months of the year 2019 substitution of luminaries by LED lamps was done in specific areas of the neighbourhoods of Egia, Ibaeta and Bidebieta.

Throughout 2020, Fomento San Sebastian plans to act also in Sancho El Sabio street in Amara neighbourhood.

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Sancho el Sabio Street is located in Amara neighbourhood that is the most populated district of the city with more than 30.000 inhabitants. The 16% of the people in the district is under 20 years old and the 25% is more than 65 years old. Both percentages are in line with the average of the city. The unemployment rate is near 12% (same as the average in the city). Amara is the third district in the city with highest rate of foreign people. Sancho el Sabio Street connects the city canter district with Amara neighbourhood. There are approximately 800 households and 51 commercial premises in the street. This street was selected as the third pilot area of the SmartKalea project.

The Smart public lighting implementation in Txomin District is one of the actions that Fomento San Sebastian is planning to deploy in the area. Other areas of the city might follow this process.

- *Stakeholders and planning tools involved*

- Municipality of San Sebastian, through Department for Urban Infrastructure and Systems/Maintenance and Urban Services Department.
- Fomento San Sebastian supporting the intervention of the smart public lighting in order to foster energy efficiency improvement of the public infrastructure and reduce energy consumption and CO_2 emissions.
- Awarded company in the tendering process for the deployment of the whole intervention. (manufacturer and distributor), specialized company in smart public lighting, which will be responsible of the installation of the whole system. and the maintenance company.
- Citizens: as beneficiaries of the new infrastructure

- *Technical solution and management model for the roll out*

The public lighting infrastructure of Sancho el Sabio street will consist of luminaires with LED system with optics of contracted quality and with a photobiological risk certificate. This LED luminaires with optics, will allow to direct the light so that a better performance is obtained. The luminaries will be placed on poles of 5 meters high at an approximate distance of 17 meters. The circuit for the lighting supply will be underground. In addition, it will have a Smart System consisting in the control of point-to-point lighting points. Its implementation in the Public Lighting network will allow tele-management, inventory, corrective maintenance, preventive maintenance and energy saving management. It will also comply with the CE Regulations and the Low Voltage Electrotechnical Regulation in force.

Moreover, the intelligent system will include an automatic regulation system based in presence, calendar, environmental parameters, etc. This system will be based on detection technology that enable motion detection of people and/or vehicles. The detector (radar or vision system) is an electronic device that detects presence and generates motion information for the system.

In the case of Txomin neighbourhood different technologies are being analysed for the implementation. The lighting in this neighbourhood was already installed using LED technology. The technologies that are being currently analysed are in relation to the intelligent systems.

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- *Expected Impacts and contributions to the strategic objectives*

The interventions in Pubic Lighting will help improving public infrastructure efficiency, promoting energy sustainable habits in the public service.

For the change that has been done in the last months in the neighbourhoods of Egia, Igara and Bidebieta 173 t CO_2/year savings are expected and near 36.500€ per year in monetary savings for direct impacts (energy and maintenance reduced costs) and 4560€ of external costs avoided per year Annex 1 – paragraph 2.1, table 11)..

The system installed in Sancho el Sabio will improve:

- the control and recording of electrical parameters
- energy saving in
  -control and elimination of night over-voltages
  - reduction of lighting during low usage hours
  - fine adjustment of on and off
  - power factor control
  - reduce costs of replacement of lamps for stabilizing over-voltages
- and maintenance functions will
  - improve the quality and safety of the facilities, by detecting in real time the damage allowing rapid actions
  - in addition, it optimizes the maintenance costs with plans that allow to avoid repetitive failures.

It is expected that the intervention will allow to have savings around 74% due to the renovation of the conventional luminaires to LED lighting, 53% of savings thanks to presence detection, 75% in management and maintenance due to an increase in the lifespan and remote management, which results in a total saving of 80% in energy consumption and reduction of CO_2 emissions. In any case, this savings will vary depending on the real presence in the street during the night and the light power selected by the municipal department in charge of the public lighting.

The savings in Poligono 27 already monitored consist in about 20 tCO_2 reduction per year and 56.750 kWh of energy reduction. The monetary direct savings are 6.000 € per year on energy bills and 1.700€/year maintenance costs while external costs are estimated around 760 €/y.

For the implementation in Txomin the expected results are in line with those already achieved.

- *Eco-system: framework and interaction with other measures*

The smart lighting implementation interacts both in SmartKalea project and Replicate project with the ICT platform deployed (in each of the projects) where the data is gathered and visualized. The information gathered might be crossed with other information available to work on different analysis or other kind of actions.

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- *Results from the pilot implementation*

Advantages generated as consequence of the implementation of the Smart Lighting in Poligono 27 as part of Replicate project:

1. Relevant reduction on energy consumption and reduction on maintenance costs.
2. 20 tCO_2 reduction per year (approximately) and 56.750 kWh of energy reduction.
3. A management system of the lighting service that offers the possibility to be adapted to the real needs.
4. The creation of a LAN network that can be used for creating services, based on the existing infrastructure.
5. The possibility of using different data collected through the management system and shared in the ICT platform for further analysis and improvement of implementation of other services.

The SWOT analysis of the pilot test is the following:

Smart public lighting	
Unique Selling Proposition: LED technology lights implementation and additional services deployment that allow energy and monetary savings thanks to the change of the luminaries and to the regulation system to adapt the light to the presence.	
Strengths	Weaknesses
• Flexible system from Software base and from device integration side. • Open source system able to integrate in all other systems.	Some aspects to be improved: • Need to gain experience on the IP services integration • Improve security devices for not disrupting power supply.
Opportunities	Threats
• Possibility to adapt the light and energy consumption to the real needs. • Capability to integrate other IP services with reduced or no communication costs. • Total control on every point of street lights (point to point).	• Appearance of new and more competitive technology. • Solar electricity use for lampposts.

Table 7 – SWOT analysis of the smart public lighting intervention

This action has been part of the City-to-City learning session by San Sebastian available at https://www.youtube.com/watch?v=ZUD9wz4IV74

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- *Monitoring methodology including risks and adaptation measures*

The information gathered in SmartKalea project is integrated in the ICT platform that generates KPIs, graphs and value-added data, crossing the available information with other kind of data.

The system installed in Poligono 27 (as part of Replicate project) permits real time control and remote failure detection. It is possible to configurate light level depending on hours, season etc. The energy and savings are increased. The control system sends alarms automatically by email if something is not working correctly, for example one node or light is broken, improving the service and reducing maintenance cost. Every week a revision is done about other general aspects like number of detections, energy consumption data and every month are adjusted light levels if is necessary.

9.1.5 Participatory process

- *General Description*

The city of San Sebastian is committed with citizen participation with the aim to promote the participation of citizens in municipal policies and initiatives, with the capacity of influencing them. In fact, there is an organic regulation from year 2016 that stablishes and promotes the participatory activities in the city. This commitment is reflected in the different initiatives.

On one hand, a collaborative process reflection has been carried out in the Txomin neighbourhood. The aim was to conduct a reflection process about the future of Txomin, to build a more efficient, modern, connected and sustainable neighbourhood. The process has been promoted by Fomento Sebastian.

On the other hand, a collaborative process is being carried out in the neighbourhood of Bera Bera during 2020. The process is being promoted by the neighbourhood association in collaboration with Fomento San Sebastian. The aim is to carry out a study to identify smart solutions to be implemented in the neighbourhood.

The citizen participation platform of the Municipality has been deployed as an action of the Replicate project and several participatory processes have been launched.

San Sebastian City council's aim is to build the city in an open, transparent, collaborative way and with the prominence of people. It promotes citizens to participate in debates, elaboration and modification of previous proposals or processes around municipal or regulatory actions and follow the process through the municipal webpage.

The City Council has launched an additional initiative called Belarri. The aim of this project is to analyze the contribution channels that citizens have in order to improve the management of the contributions as well as to improve decision making process.

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The different initiatives and activities in the city to promote the citizen participation are complementary and contribute to the involvement of the citizenship in the municipal decisions. The citizens are in the core of the different processes to contribute actively to the different initiatives. This document describes, among others, the participation process as part of the co-design of the Smart Txomin neighbourhood.

- *Responsible for the roll out*

The main responsible are: Fomento San Sebastian, San Sebastian City Council and the Agrupación de Comunidades Bera Bera (Communities Group of Bera Bera).

Participation is usually promoted in planning processes in San Sebastian.

- *Timescale*

The specific actions described in this document are planned for the years 2019-2021. Nevertheless, participatory activities constitute a regular activity of the city.

- *Area*

The participatory processes described in this document are being carried out in Txomin neighbourhood (promoted by Fomento San Sebastian) and Bera Bera neighbourhood (Communities Group of Bera Bera contacted Fomento San Sebastian for the collaboration in the participatory process).

Bera Bera is a neighbourhood where the residential land use predominates, being the dispersion of homes and population one of the characteristics of this extensive neighbourhood. Bera Bera has an Association of Communities (legally constituted in 1983) to, among other purposes promote, improve and raise the habitability and well-being conditions of the neighbours and owners. Represents the neighbours of Bera Bera, whose construction began in 1975 and currently brings together approximately six hundred homes, as well as shops, business premises and sports centres located in it, with a population close to two thousand persons. The neighbourhood has common services and infrastructure such as a District Heating and a unique television signal reception system (terrestrial and satellite), which reaches all homes through an underground distribution network that will soon become its own fiber optic network. The neighbourhood has 900 households approximately and the average age is 42 years old. Due to the characteristics of the area (hilly, difficult mobility) it is a relatively young neighbourhood and a characterized by a high motorization.

- *Stakeholders involved*

The main stakeholders involved in the implementation are Fomento San Sebastian together with San Sebastian City Council, citizens and neighbour associations ("Agrupación de Comunidades Bera Bera" -Communitites Group of Bera Bera).

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- *Technical solution and management model for the roll out*

The participatory process in Txomin (promoted by Fomento San Sebastian) was oriented to a reflection about the neighbourhood and the interests on implementing actions in energy efficiency, sustainable mobility, ICTs/Infrastructures and cooperative services. The objective was to build collaboratively among the different agents (citizens, local businesses and Development) proposals for the future of the smart neighbourhood.

The process that was carried out is described in the picture below.

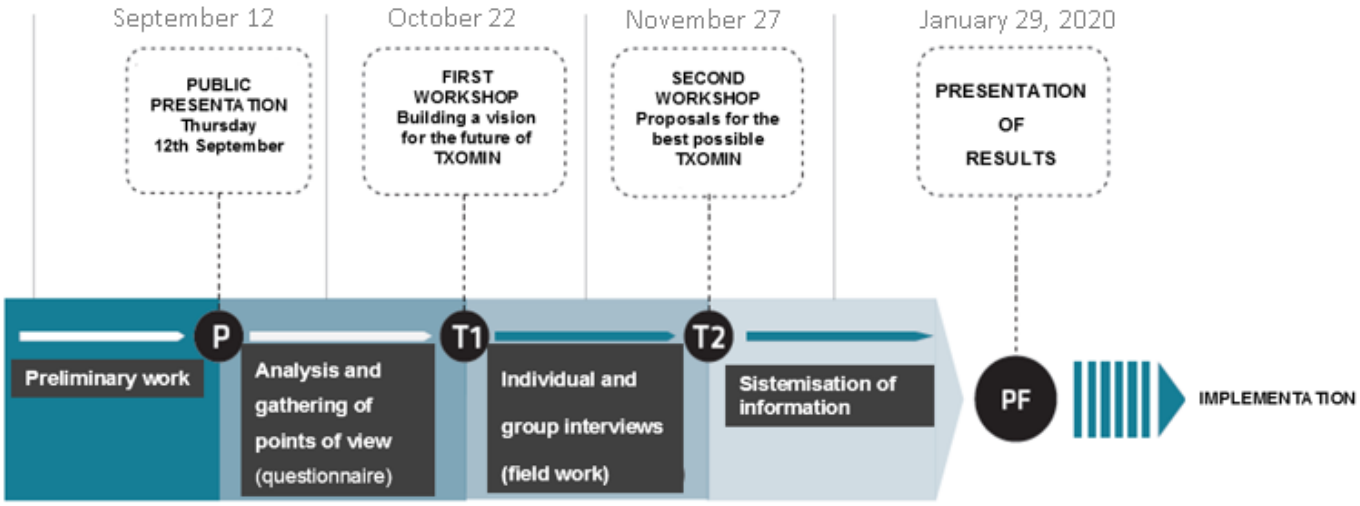

Figure 35. Phases of the participatory process in Txomin neighbourhood

The presentation of final results was done in January 2020. Fomento San Sebastian plans to implement some of the actions raised during the process. A stakeholder group is being set up for each area of work (energy, mobility and ICTs and Infrastructures) linked to specific areas and proposals. The aim of these groups is to provide continuity, analyse feasibility and to promote, implement and monitor initiatives in Energy Efficiency, Sustainable Mobility and in ICT/Infrastructures.

The process in Bera Bera is being promoted by Bera Bera Agrupación de Comunidades, supported by a Technology Centre and in collaboration with Fomento San Sebastian. The aim is to develop a participatory process with the neighbors in order to carry out a diagnosis of the district and analyse possible implementations to be deployed. First, a study about the sociodemographic facts of the neighborhood has been done. Questionnaires and workshops are planned for the discussion of specific measures barriers and opportunities in the areas of energy efficiency, sustainable mobility and ICT/Infrastructures. The process is being detailed and it is expected to be carried out during 2020. After the realization of the study it will be analyzed the relevance of carrying out a feasibility study of the initiatives that are decided to be prioritized.

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- *Expected Impacts and contributions to the strategic objectives*

Expected impacts are related to the citizen engagement. The implementation of the actions that emerge in the participatory process are also be considered an impact.

The contribution to strategic objectives is reflected because of the importance of the citizen participation and contribution, being in the core of all the transformational processes. Different plans of the city highlight the importance of the citizens involvement in the different actions. The importance of the citizens´ commitment is also reflected in the elaboration of the different plans and strategies, where citizens, together with other stakeholders have taken part.

A differentiator vector of Donostia is the promotion of citizen participation, the collaboration processes between public-private agents, the promotion of entrepreneurship and the creation of new companies. The activities related to participatory processes have contributed to Smart and Open Government axis of the Smart City Plan.

The actions described also contribute to the objectives established in the organic regulation about Citizen Participation from year 2016. The objective of the regulation is the promotion and development of the citizen participation in the city of Donostia San Sebastian, guaranteeing transparency and the quality of the local democracy.

- *Eco-system: framework and interaction with other measures*

The participatory process in Txomin neighbourhood was focused on engaging stakeholder groups in energy, mobility and ICT/Infrastructures initiatives to analyse feasibility and to promote implementations in these areas.

The results will be directly linked to these areas and so could interact with actions already deployed. Although the methodology and the nature of the process in Bera Bera is different, the participatory process is looking for contributions also in the areas of energy, mobility and ICTs/Infrastructures so the results might be also linked to these areas.

- *Results from the pilot implementation*

The citizen participation platform has been deployed in the Replicate project framework by Eurohelp. The platform was deployed in the Smart City Platform of the city. The participation portal has a public and a private area and was designed to divide the process in different phases. This platform allows to track participatory processes, consult appointments of face-to-face meetings, make online contributions, give opinions, create concrete proposals, support them ...

The Participation Platform is based in two web architectures:

- on the one hand, there is an internal management website, the participation technicians can manage all the participation processes, phases, actions, results, etc. This website is a Java based website, developed using these technologies: Java EE stack + Spring framework, DB2, HTML5, CSS3, JavaScript, JQuery, Bootstrap.

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- On the other hand, there is a public web site where citizens, companies and associations can access to participate into the participation processes (https://www.donostia.eus/ataria/es/web/partaidetza/home).

This website has been developed using these next technologies: Java EE stack + Spring framework, Liferay Portal + Spring MVC Portlet, HTML5, CSS3, JavaScript, Responsive Web Design, SurveyJS

The resulting SWOT analysis reported in D7.5 is he following:

The Citizen platform	
Unique Selling Proposition: A more responsible and engaged citizenship that means greater support in Smart City development because solutions are co-designed and participation is inclusive. The interest of citizens is protected in order to guarantee a more equitable society.	
Strengths	Weaknesses
• Easy and better management for the municipality of these participation processes. • Foster citizen active participation in decision taking	• Citizen participation through new channels may be difficult to manage for the municipality • difficult to use for some categories of citizens.
Opportunities	Threats
Smart City narrative focus more on citizen centric innovation.	• Data security • Lack of interest among citizens

Table 8 – SWOT analysis of the citizens platform intervention

- *Monitoring methodology including risks and adaptation measures*

The development and follow up of the different activities and workshops of the participatory process in Txomin neighbourhood has been done as part of the methodology of the process designed. It was important to achieve the required involvement of the participants: number of participants, replies to the questionnaires, active participation on the sessions etc. Two principle risks were detected in advance; on the one hand the achievement of enough number of people participating in the sessions and on the other hand, the active participation in the session as well as the topics covered. The lessons learnt will be used as valuable lessons for other participatory processes.

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9.2 Florence

9.2.1 Infomobility and parking APP in Florence

- *General Description*

Development of smart-parking systems connected to the single metropolitan multimodal info-mobility system.

An info mobility platform has been made available in Florence, starting from the traffic supervisor which is characterized by the presence of data collection systems and transport modelling algorithms that allow the real-time reconstruction of the state of the transport offer, intended as the traffic on the managed network, the position of public transport services, limitations and works on the road network, etc.

The availability of this information allows you to activate the mobility management and user communication strategies more appropriate to the current situation.

The Municipality of Florence therefore activated the Operational Centre of the Mobility (C.O.M.) which, using this information, provides the implementation of traffic management interventions, mainly through traffic light management, and communication to users, through an info-mobility platform.

A relevant goal is therefore to expand the output systems of the Supervisor that allow to improve both the activation of the traffic management interventions that the communication to users of mobility system, through the following actions:

• expansion of the system of variable message information panels;

• activation of data flows (e.g. DATEX / DATEX2) to exchanges operational and service centres at different levels (local, regional, national), including private entities, including through open solutions data / open service;

• and adaptation of information support solutions multi-channel to users, with particular reference to implementation an App for the creation and management of the community of users of the city mobility system.

Furthermore, the multi-channel ITS platform will be empowered with social sharing and crowdsourcing functions, which will allow the interaction between the Municipal Administration and the users of the system urban mobility in the city. In addition to allowing the collection and the sharing of mobility data between users and administration, the ITS platform will allow to offer support to urban mobility users and to activate green mobility policies.

It is important to note how the proposed ITS platform will enable the creation of a real community of mobility users (MUC, Mobility Users Community), and therefore it will not be one passive top-down information tool where users can only get information in pull mode, but it will configure itself as an enabling system with specific customized support functions for each user, where there

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will be type interaction services bidirectional push (e.g. users can send reports, the system sends personalized notifications).

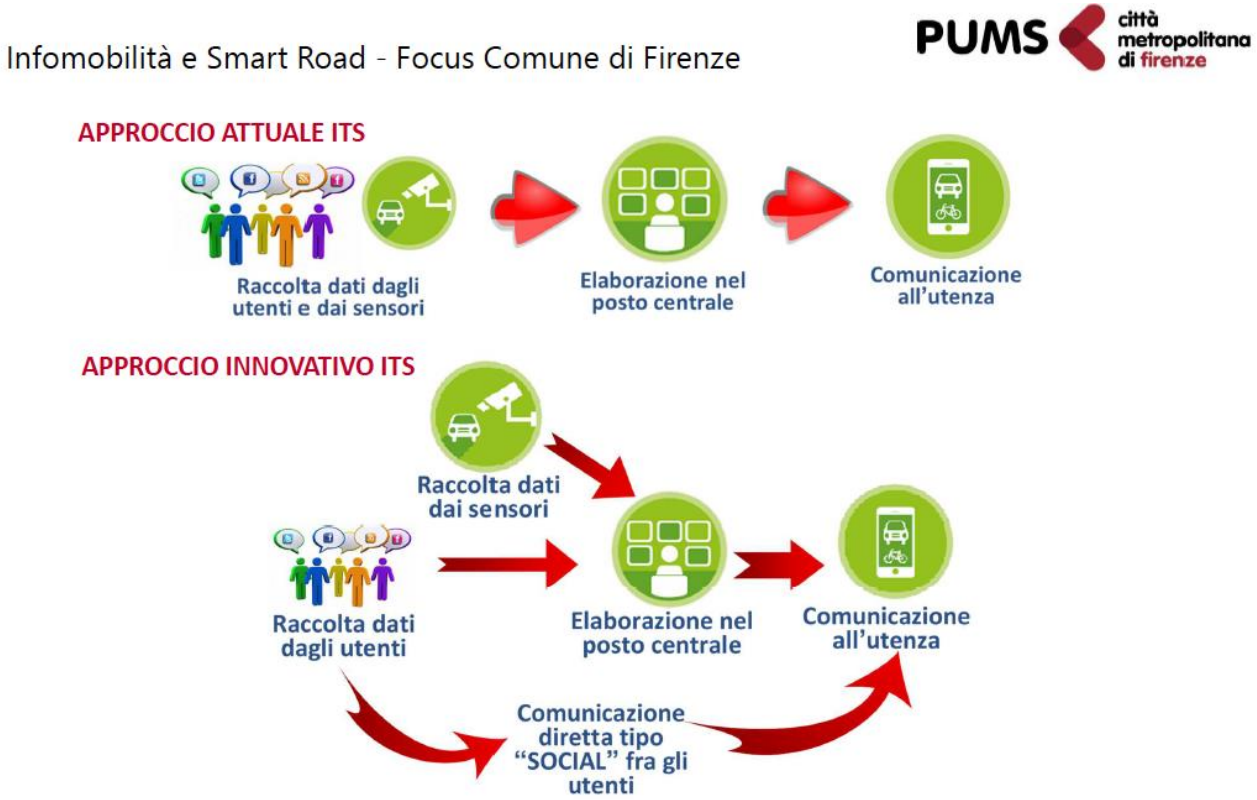

Figure 36 – old and new "socialmobility" approach of the info mobility platform in Florence

In Autumn 2019 the city has started the test phase for the "Infomobilità Firenze" which is the official app of the Municipality of Florence to update citizens with information on all aspects of city mobility, both public (bus, trains, trams) and private (parking, electric recharging, sharing).

The platform provides information certified by the Administration on road construction sites, changes in traffic conditions on the occasion of planned or unexpected events, news and alerts, and allows to evaluate the best travel solutions and to consult the timetables of public transport.

It is also possible to customize the services of the app, creating a profile with which to associate user's usual route and thus receive notifications on changes to traffic along that route or in a specific neighbourhood.

Following also what has been experimented in Bristol, the app will be developed to support the search for surface parking to decongest urban traffic and optimize the use of the available parking spaces.

- *Responsible for the roll out and policy reference*

Mobility Department in collaboration with information services and Silfi. The action was included in the Urban Plan for Sustainable Mobility of the Metropolitan City (2019)

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- *Timescale*

2026-2030

- *Area*

In consideration of the obtainable environmental and economic benefits, it is foreseen to realize a wide application of smart parking solutions starting from the urban area of Florence.

- *Stakeholders involved*

The Metropolitan Council of Florence has initiated the procedure for the drafting of the metropolitan PUMS and verification of the VAS with resolution no. 121 on the 19/12/2018 when also the schedule of activities has been approved.

With managerial act n. 390/2019 the metropolitan City working group was set up, foreseeing the collaboration of the Municipality of Florence, the Tuscany Region and external professionals.

The first phase of the work was aimed at the reconstruction of the cognitive framework in relation also to the local and supra-local planning tools and at starting the participatory path that allowed the objectives to be declined; the second work phase concerned the design of the scenarios (reference, independent of the plan, and of the plan, financed under the PUMS).

The metropolitan city, the city of Florence and the Region of Tuscany actively participated in the drafting of the plan.

The participatory process was divided into two phases:

- The first, "listening to the territory", carried out through some consultation activities with citizens and stakeholders: investigation activities and online questionnaires to identify priorities and collective perception (answers received from 4'824 citizens and 279 Stakeholders)

- The second phase of "strategic Orienteering" has directly involved the municipalities interested in thematic tables and inspections with contact with the public

Regarding the info-mobility app development, anyone who wished has participated in the final phase of the design of the app, using a preview of the beta version and reporting any possible improvements.

- *Technical solution and management model for the roll out*

Florence, on the basis of data from the ICT platform relating to covered parking lots and the experience of Bristol concerning the app for finding surface parking, intends to make decisive use of smart parking systems, which allow for the evaluation of the occupation of the surface stalls using a suitable technology (cameras and inductive sensors applied in the pavement) or even through statistical systems connected to the data provided by the parking meters or the payment apps. These systems must make it possible to make available the data relating to the occupation of the parking lots, via app and urban variable signage, so that the user can be directed towards

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the stalls that are actually available, reducing search times and therefore congestion and pollution. Furthermore, smart parking solutions allow more efficient use of parking stalls, reducing the time during which the stall remains empty (while vehicles are moving to look for it); this also entails an economic benefit for the Administration, deriving from the greater income for the payment of parking, which can be reinvested in active mobility policies.

The estimated cost for the intervention is around 1 million euros, but It is estimated that the economic benefit for a city like Florence deriving from the application of smart parking systems on 10,000 parking places can reach 10 million euros a year.

- *Expected Impacts and contributions to the strategic objectives*

The solutions are contributing to reach the environmental targets of mobility sector included in the SEAP and SECAP under development, in the Smart city plan for 2030 and 2050 and in the newly adopted Metropolitan Sustainable Urban Plan.

The Smart parking solutions directly support environmental policies related to mobility, as drivers find parking faster and travel fewer kilometres by car, which is equivalent to a reduction in CO_2 and NO_x emissions. For example, the European average of 15 minutes of parking search in a metropolis of one million inhabitants produces 2,300 tons of CO_2 per day. The use of smart parking solutions with a search time reduction of only three minutes – i.e. from 15 minutes to 12 minutes – produces a saving of 460 tons of CO_2 per day. The application of smart parking systems on 10,000 parking spaces for a municipality such as Florence can lead to an external costs reduction (considering only 3 minutes saving) of 1,800 € per day, i.e. more than 650.000€/y.

- *Eco-system: framework and interaction with other measures*

The measure in question interacts directly with the other smart mobility actions included in the PUMS and in particular with the traffic control centre and the info mobility system as described in the introduction.

- *Results from the pilot implementation*

No pilot action in Florence. The adaptation actions with respect to the version tested in Bristol regard the methods of identifying free stalls using sensors / cameras or exploiting the information available from parking payment systems to obviate the critical mass necessary for the start-up of the system and improve its accuracy.

- *Monitoring methodology including risks and adaptation measures*

The app itself will be able to monitor users' behaviour and its effectiveness, which can also be monitored through increased revenue and traffic congestion.

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9.2.2 E-mobility (charging infrastructure, e-bus & e-taxi fleets)

- *General Description*

Florence definitely aims to become the national capital of the electric mobility.

In Florence the transport sector has the largest impact, counting for the 34.5% of the total CO2 emissions according to the baseline inventory of the SEAP. What is required is a substantial, integrated action which makes possible – even in a difficult situation such as that of urban Florence, congested as it is by commuter and tourist flows – to achieve a significant reduction in the environmental impact of mobility in the context of the city.

The goal is still to bring down atmospheric and acoustic pollution levels, in compliance with international agreements like the Covenant of Mayors or the Conference of Parties COP21.

The tramway system under finalisation together with the Replicate pilot test, involving charging infrastructures and fleets, are the backbone of the electric switch promotion that aims to make Florence national e-mobility capital.

There are many assets and actions that set Florence as an example reference for the concrete and structured development of zero emission mobility:

• the current 4000 electric vehicles in the city, including the Administration's fleet of over 80 vehicles and 50 e-bicycles;
• the interoperable public charging infrastructure, with more than 370 sockets available throughout the municipal area including the new stations installed by Replicate in the pilot district and additional 50 points for the public fleet;
• the fleet of small electric buses that are in use in the historic canter and the first contingent of 30 12-meter hybrid buses put into service in 2019;
• the 100 new electric taxis with the dedicated 6 new fast recharge stations tested within the REPLICATE project and the 226 hybrid taxis in circulation;
• the electric car-sharing service with two operators and 220 vehicles;
• a strong European communication campaign, of which Florence is a partner, aimed at promoting the delivery of electrical goods and the use of electric scooters.

To continue on this path, it will be necessary to give new impetus to all electricity promotion activities, promoting:

- The extension of charging infrastructure with particular attention to the fast recharge, which best fits with new generation vehicles and the needs of the modern city
- The total conversion of taxi fleet and other fleets
- A decarbonization program for the fleet of buses serving local public transport system

- *Responsible for the roll out and policy reference*

Mobility Department in collaboration with Public transport manager, fleet managers, taxi associations. The actions have been included in the Urban Plan for Sustainable Mobility of the Metropolitan City (2019).

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The municipal Sustainable Energy and Cimate Action Plan under development is also including the promotion of e-mobility in line with the PUMS, but also with the Smart City Plan and with the Air quality and noise plans.

Regarding the public buses fleet, the action is in line with the provisions of the National Strategic Plan for Sustainable Mobility (including hybrid, natural gas, compressed methane, electric and hydrogen engines).

- *Timescale*

2020-2030

- *Area*

It is foreseen to extend the application at the metropolitan area of Florence.

- *Stakeholders involved*

The actions are included in the metropolitan plan for urban sustainable mobility; the Metropolitan Council of Florence has initiated the procedure for the drafting of the metropolitan PUMS and verification of the VAS with resolution no. 121 on the 19/12/2018 when also the schedule of activities has been approved.

With managerial act n. 390/2019 the metropolitan City working group was set up, foreseeing the collaboration of the Municipality of Florence, the Tuscany Region and external professionals.

The first phase of the work was aimed at the reconstruction of the cognitive framework in relation also to the local and supra-local planning tools and at starting the participatory path that allowed the objectives to be declined; the second work phase concerned the design of the scenarios (reference, independent of the plan, and of the plan, financed under the PUMS).

The metropolitan city, the city of Florence and the Region of Tuscany actively participated in the drafting of the plan.

The participatory process was divided into two phases:

- The first, "listening to the territory", carried out through some consultation activities with citizens and stakeholders: investigation activities and online questionnaires to identify priorities and collective perception (answers received from 4'824 citizens and 279 Stakeholders)

- The second phase of "strategic Orienteering" has directly involved the municipalities interested in thematic tables and inspections with contact with the public

- *Technical solution and management model for the roll out*

To continue the activities of the Replicate pilot action and give new impetus to the electric mobility promotion, first of all the plan focusses on

- the development of an extended recharging network with particular attention to the fast recharge tested for the Replicate taxis, which seems to suit better the needs of a modern

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city; a proposal for a regulatory change has already been submitted to include the charging infrastructure among the works admitted to offset urbanization charges, in order to encourage the development of the charging networks (Metropolitan Chart for electromobility, signed by Florence together with Milan, Turin .

- the expansion of the electric taxi fleet with a target of total conversion in the next years,
- the optimisation of the environmental performance of public transport. In parallel with the new electric tramlines, in the last 5 years, 197 buses have been replaced, achieving a fleet renewal of 55%. Within 2030, it is expected to be able to complete the renewal of the urban fleet, also thanks to the investments on the circulating fleet envisaged in the regional PT tender and to the funding made available by the central authorities for the decarbonation of the fleets. If so far it has been preferred to introduce new generation diesel vehicles, in the future, all-electric and hybrids will be preferred. In the case of the Rapid Transit Bus connecting Florence with neighbourhoods with a long round trip, the best option seems to be setting up fast charging systems at the stops as learnt also from D-bus in San Sebastian pilot.

The cost of interventions is estimated at € 4 million for the charging infrastructure, € 1.5 million for taxi fleets and € 40 million for public transport fleet.

- *Expected Impacts and contributions to the strategic objectives*

The expected impacts are related to the three targets set in the PUMS:

- Reduction of fossil fuels use
- Improvement of urban air quality
- Reduction of noise

The Smart City Plan targets for 2030 and 2050 related to air quality and noise pollution, number of fossil fuelled vehicles, number of recharging stations, quality of the public transport will also be addressed.

Figure 37 – Some of the Smart City plan (on the left) and PUMS (on the right) targets addressed by the measure

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In terms of savings, considering only the city of Florence and taking as baseline the yearly emission inventory of 2018, the public transport switch of 45% of the fleet could be able to save about 10.000t/y. The complete renewal of the rest of the taxi fleet will further contribute for about 1.000 t/y. Direct costs savings will depend on specific electricity tariffs compared to diesel price, while external costs avoided in case of a taxi could be evaluated in 1000-1200 €/y, while for each bus is expected to be 1,25 c€/kmp per year (Annex 1 – table 17).

- *Eco-system: framework and interaction with other measures*

The measure in question interacts directly with the other smart mobility actions included in the PUMS and in particular with the traffic control centre and the info mobility system as described in the introduction.

- *Results from the pilot implementation*

During the pilot implementation 70 new e-licences have been issued by the municipality with special tariffs and the e-taxi fleet, composed by 100 e-vehicles, has been provided with 6 dedicated fast recharging stations and an App to book the charging slot and to identify the nearest free public station. In the district, the public infrastructure has been empowered with additional 40 stations and the impact of the e-mobility on the grid has been analysed in cooperation with CNR (National research Council). Targets have been achieved and many lessons learnt have been reported from the technical and management model points of view in D7.3 and D.7.5 where the following SWOT analysis has been taken from.

e-taxi fleet and fast recharging infrastructure	
Unique Selling Proposition: e-TAXI: a green taxi is catchy for smart users, urban friendly (no noise and pollution) and it is cheaper for the owner. Fast recharge: the fast recharging infrastructure is what any e-driver dreams about.	
Strengths	Weaknesses
• Taxi operational needs fulfilment (fast recharge) • Lower operational costs and incentives for e-taxi drivers • Low emission mobility promotion • Smart grid potential exploited	Some aspects to be improved: • Administrative iter for the building works and the location of the recharging stations • Public room for the recharging areas • Investment costs (both for the recharging infrastructure and for the e-vehicles)
Opportunities	Threats
• national/regional supporting schemes	• technologies (vehicles, batteries and recharging stations) and their fast upgrade

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• private sectors (energy providers, fleets. Freight transport) interest • tourists' and city users' awareness	• drivers' skills (training for the recharge) • impact of e-mobility on the grid • impact in the restricted areas

Table 9 – SWOT analysis of the e-taxi fleet and fast recharge intervention

This action has been part of the City-to-City learning session by Florence available at https://www.youtube.com/watch?v=vlQtekRzVFQ

- *Monitoring methodology including risks and adaptation measures*

Three specific KPIs have been included in the PUMS, directly related to the promotion of electric mobility:

- Traditional fuels consumption (litres of fuels sold in a year)
- Air quality improvements (NOx and PM10 trends measured in µg/m3 and number of days above threshold)
- Noise reduction (% of inhabitants exposed to noise values >55-65 dBA)

9.2.3 Sharing services (e-bikes, e-cars)

- *General Description*

Progressive extension of the Bike & e-bike sharing service of Florence in the Metropolitan City according to a diversified approach based on the methods and frequency of use.

Creation and strengthening of Eco Sharing services (e-Cars, e-scooters ...) also to mitigate the impact of post-Covid private mobility.

- *Responsible for the roll out and policy reference*

Mobility Department.

The action was included in the Urban Plan for Sustainable Mobility of the Metropolitan City (2019).

The e-mobility promotion and the sharing systems have been already included in the Smart City Plan targets for the municipality of Florence as well as in the SEAP (2011) and SECAP under development (expected for June 2021). Post-COVID Reinassance Plan is enhancing sharing services and bike lanes (emergency mobility actions).

- *Timescale*

2021-2025

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- *Area*

In consideration of the obtainable environmental and economic benefits, it is foreseen to realize a wide application starting from the urban area of Florence to reach the whole metropolitan context.

- *Stakeholders involved*

The Metropolitan Council of Florence has initiated the procedure for the drafting of the metropolitan PUMS and verification of the VAS with resolution no. 121 on the 19/12/2018 when also the schedule of activities has been approved.

With managerial act n. 390/2019 the metropolitan City working group was set up, foreseeing the collaboration of the Municipality of Florence, the Tuscany Region and external professionals.

The first phase of the work was aimed at the reconstruction of the cognitive framework in relation also to the local and supra-local planning tools and at starting the participatory path that allowed the objectives to be declined; the second work phase concerned the design of the scenarios (reference, independent of the plan, and of the plan, financed under the PUMS).

The metropolitan city, the city of Florence and the Region of Tuscany actively participated in the drafting of the plan. The participatory process was divided into two phases:

- The first, "listening to the territory", carried out through some consultation activities with citizens and stakeholders: investigation activities and online questionnaires to identify priorities and collective perception (answers received from 4'824 citizens and 279 Stakeholders)

- The second phase of "strategic Orienteering" has directly involved the municipalities interested in thematic tables and inspections with contact with the public

- *Technical solution and management model for the roll out*

Florence holds the national leadership in innovation on bike sharing, not only for being the first city in Italy to have introduced the free flow bike sharing service, but also for the ever-growing numbers. Over 225 thousand registered users, 1.3 million km travelled and an estimated CO_2 saving of 400 tons. An average of 7,000 trips / day in the summer. During peak usage, an average of over 10,000 trips per day were recorded. Add to this that the city is among the best in the world in terms of vandalism, given that only 4 bikes out of 100 are damaged. The origin / destination data from the operator's platform can be used to verify the validity of the forecasts of the new cycle paths to be created.

As a next development, the introduction of a free-flow bike sharing system with pedal-assisted bicycles. The municipality will proceed by publishing an expression of interest for market operators. It is assumed that up to 3,000 pedal-assisted bicycles can be introduced over two years. In a city like Florence, like it was in the Bristol pilot, pedal assistance can be a decisive advantage in deciding to use the bicycle to go to work, even as a substitute for the scooter, combining respect for the environment and physical well-being. The cost of the intervention will be paid by private companies, while the municipality will make available new parking stalls and exchanger car parks for a value of € 1,250,000. The cycle paths will also be further improved ("bicipolitana", "super

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cycle", new tracks, conjunctions, areas renovations, ...) with funding by PON METRO, Council of ministers, Pact for the city, Tuscany region and private individuals for over 100 M€. In the Covid emergency, new temporary bike lanes have been deployed for testing the best networking options.

In parallel, the Municipality of Florence has strongly promoted the spread of car sharing services since 2014, now reaching 600 free flow sharing vehicles, including 220 electric cars, distributed among four different operators. It is therefore necessary to continue with the car sharing incentive policies, creating the conditions for a further increase in the number of vehicles, even higher than what the market would spontaneously lead to absorb. Incentive packages will be prepared for the scrapping of owned vehicles and facilities linked to the use of sharing services, as well as reserved parking stalls. The cost of the intervention will be paid by privates, while the municipality will make available new parking stalls for an estimated value of € 250,000.

- *Expected Impacts and contributions to the strategic objectives*

All the different aspects of these actions (e-bikes, e-cars and e-scooters) are meant to decrease the impact of mobility on air pollution, noise and greenhouse gases emissions, in line with the targets of the reference plans already reported. The impact of e-bikes is expected to confirm and enhance the results obtained by bike sharing systems in use.

Considering data of 2017, the use of e-cars in the sharing system could avoid external costs for a minimum of 35.000€ per year (Annex 1 – table 17).

The positive impact of car sharing in terms of environmental sustainability is twofold: on the one hand, the movements of car sharing users are made with vehicles that are on average smaller and more eco-efficient than vehicles owned by individual users, on the other hand, easy access to Shared vehicles can cause users to give up private car ownership also in the post Covid framework, mitigating the change in public transport offer and attractiveness.

Considering that a car sharing vehicle is used on average by 5 to 10 users per day, the availability of 600 vehicles in the city could lead to a reduction between 3,000 and 6,000 registered vehicles, allowing the city to free around 30 km of space on public roads.

- *Eco-system: framework and interaction with other measures*

The measure in question interacts directly with the other smart mobility actions included in the PUMS and in particular with the traffic control centre and the info mobility system as described in the introduction.

- *Results from the pilot implementation*

No pilot has been carried out in Florence about this action and Bristol experience is taken as reference for the analysis of the lessons learnt and the adaptation to the local reality.

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- *Monitoring methodology including risks and adaptation measures*

Companies managing the service are asked to support city planning and statistical analysis providing anonymous data about the users' trips.

9.2.4 Smart City Control Room and mobility platform empowerment

- *General Description*

The municipal Smart City Control Room is based on the use of the Replicate platform model to create a shared virtual and physical workspace, where the information from the various systems is concentrated and the different management interfaces of urban services are integrated.

It is the concrete implementation of the "Digital Manifesto" where all the public services operators engaged themselves in the cooperation for the optimisation of the city management.
The collaborative space, the exchange of information and the synoptic view in real time of information for decision-makers from all shared systems enable the possibility of profoundly improving the real-time management performance of the city from the transport network, to the smart city services, or the information to citizens, with an immediate impact on all users of the urban but also of the metropolitan area.

The Smart City Control Room is a new paradigm of operations control centre where routine operation of the city is controlled, monitored, and key performance indicators are reported to the top management.

From this successful experience, an agreement has been signed with the Region to extend the technology at wider level. The cooperation between the two bodies has been awarded by the national agency for digitalisation as a best practice at national level.

- *Responsible for the roll out and policy reference*

Regarding the SCCR, the main responsible are the ICT department in cooperation with Mobility Department supported by Silfi together with all the public services providers and technical support by UNIFI and Almaviva.

The Florence Smart City Control Room will be deployed also in facilities managed by the Municipality of Florence. The users of the SCC Room will be mainly employees of Florence Municipality and Florence public utilities, located in a shared equipped control-centre room with multiple displays.

The action was included in the Smart City Plan (2015) and in the Urban Plan for Sustainable Mobility of the Metropolitan City (2019) and will be further extended in the SECAP and Smart City Plan update.

An agreement has been signed with the Regional Authority in charge of the development of the regional platform starting from Replicate experience.

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- *Timescale*

2020-2025

- *Area*

Two levels of extension are actually foreseen: the SCCR for the city of Florence connected to a wider implementation at Regional level.

- *Stakeholders involved*

All the local stakeholders at municipal level have signed the Digital manifesto to start the cooperation and implement the SCCR.

Additional technical support has been activated by the municipality in parallel with the definition of the building and the departments to the involved.

For the metropolitan extension, the procedure of the Sustainable Urban Mobility Plan already described has actively involved the metropolitan city, the city of Florence and the Region of Tuscany it has also activated the participatory process consultations with citizens and a wide sample of stakeholders.

- *Technical solution and management model for the roll out*

A SCCR is an area in which all the data are collected, aggregated and where high-level data/results are summarized and made accessible for the decision makers and shared to the city operators. The SCCR under development includes large monitors in which the status of the city is reported in real-time presenting the view of the city with some synthesis, predictions, alert of data regarding: mobility, energy, social activities, environment, weather, public transportation, people flow, health, water, security, ICT, governmental, first aid, civil protection, police, fire brigade, hospital triage, and thus almost all the city resources expressed via Key Performance Indicators.

The two main target users/actors of the Smart City Control Room are:

1) Top management/Policy Makers (Mayor, General Director, Head of Departments)

2) Operators of the Smart City Control Room (belonging to the Municipality, to public utilities, etc.)

The first type of users will use the SCCRoom data from their Main Quarters or in mobility, most likely on mobile devices, and with very high-level of abstraction regarding the city operation levels. Actually, the Mayor himself is already using the SCCRoom dashboard to monitor the city daily operations. Head of departments will be able to access to specific dashboards dealing with thematic areas (e.g., the Head of Environment dept will access the section regarding environmental data). At the same time, he/she will be able to access dashboards regarding other areas, thus making it possible to correlate different and heterogeneous events and to better understand and approach critical issues.

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The second type of users will use desktop-version of the SCCRoom, either within a common control room where all the stakeholders have an on-site representative, or from the respective specific operation centres.

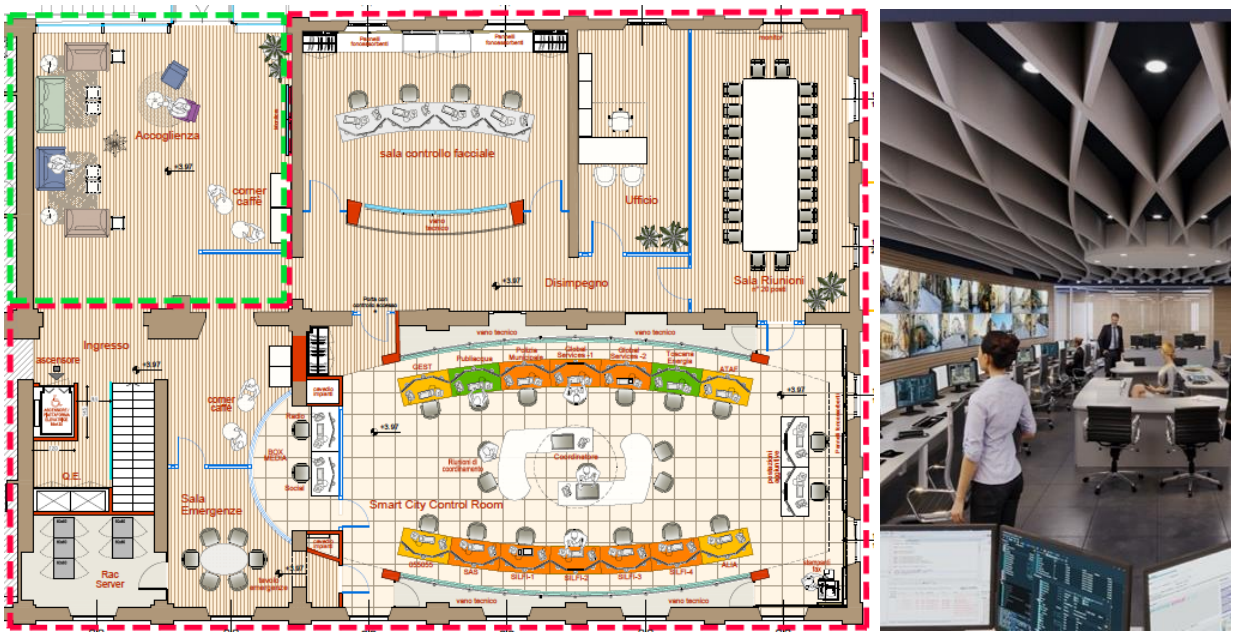

Figure 38 – SCCR layout

The REPLICATE dashboard and platform within the SCCRoom can be sketched as follows, in relation to the other internal management systems of the different utilities and operators involved in the Control Room:

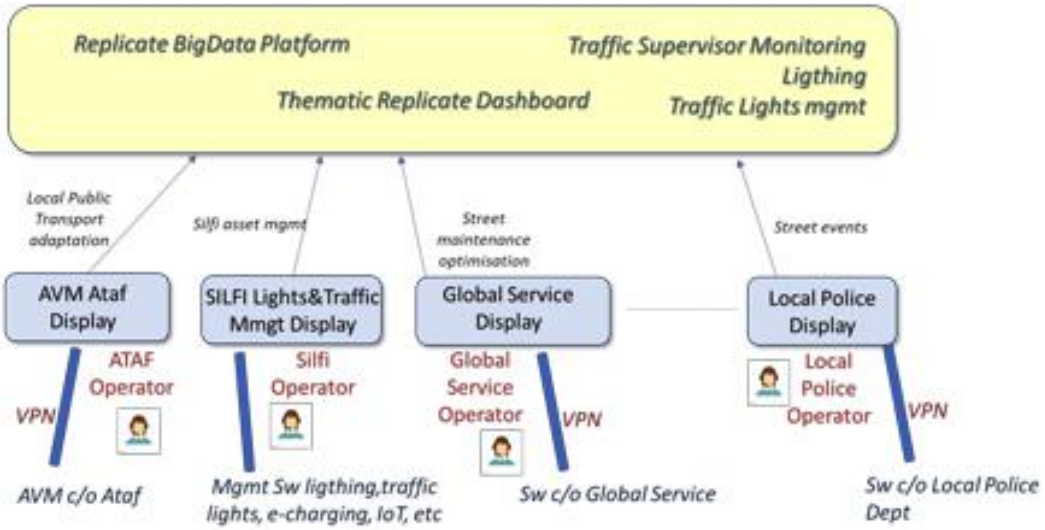

Figure 39 – Information Systems & Information delivery of the SCCR in Florence.

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Replicate is providing the city of Florence with an ICT platform on which its Smart City Control Room is built upon. The main functions of the platform are:

- Collecting data about the territory and the related services from available sources (with specific agreements)
- Integrating new infrastructures in the database (IoT, e-mobility, …)
- Storing and processing the data collected
- Analysing some data set (benchmarking, warning alerts, trends…)
- Visualising the data in tailored dashboards for the different city users
- Enhancing data transferability (thematic platforms, open sets, APP developers…)

The ICT Platform developed, listed on Fi-Ware official web site, includes all the following Open Source Components:

- Km4City Ingestion Processes based on ETL and DISCES tool.
- Km4City ServiceMap.
- IOT FiWare Orion Broker.
- IOT Applications.
- Dashboard Builder.

The extension of the Replicate experience will be pursued primarily through the improvement and completion of the traffic supervisor data acquisition and implementation interfaces with the various subsystems (information panels with variable message of various types, satellite positioning systems for public transport buses, of trams, tourist buses, control systems of the state of occupation of parking lots, management system of telematic gates, management system of traffic control cameras, etc. ..).

The further developments of the SCCR concern the improvement of the interfaces to manage the unplanned urgent interventions and to communicate the state of implementation of the measures.

In order to make the modelling reconstruction of the state of road traffic statistically more robust on the entire network managed, it is also necessary to proceed with the improvement in traffic predictive capabilities, to be able to proceed with the evolution of the remote-control systems of traffic.

The total cost is estimated at around 3 million euros (costs for modification of contracts with utilities, big data platform and physical location with hardware).

The physical implementation of the SCCR and the ITS developments that the Municipality of Florence intends to implement are funded by the PON Metro program.

- *Expected Impacts and contributions to the strategic objectives*

The main impact of the SCCR in the present implementation are related to:

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- More awareness for the decision makers about the city evolution and multiple problems that may occur. In the cases of events, they may exploit a virtual chat room for discussion attached to the dashboard.
- More effective response to the events. Increment of reactivity to problems. For example, it has been supporting the post-COVID mobility management as explained by the municipality in a recent webinar available on the web-site[10].
- Possibility to inform the city users according to a number of facts

ICT technologies present a wide range of indirect impacts being a tool for the main city departments for a responsive control on the territory.

The REPLICATE project allowed the City to go beyond the Open Data phase, to experience a real Big Data and smart city initiative, and this was done not just from a technical perspective, but also was accompanied by a cultural new approach from top decision makers (the Mayor and the City Manager themselves) to the technicians working in the field to manage the daily public services, to the citizens that are being physically brought with schools to touch the innovation systems and see live how the public services of the city can be managed and monitored in new ways thanks to the Control Room dashboards collecting data from different subsystems.

It is a shift of approach to the management of services, that also brought as a positive outcome a stricter cooperation among different technical departments of the Municipality that previously were working more as vertical silos. Synergies among Environment, Mobility, IT and Technical departments have considerably increased during the project lifetime.

The indirect impacts can be environmental due to the possible consumption savings in the different sectors monitored (buildings, mobility and services like watering and waste collection).

The main social impact is the improvement of citizens' quality of life (less time for travelling, better air quality, lower fees for services or improved services, security…) but there is also the encouragement of digital entrepreneurship and the enhancement of citizens engagement.

The proposed solution for data aggregation and dashboarding can be used to inform the citizens about eventual problems in city, for example via Dashboard, via Smart City API and the corresponding mobile Apps.

Financial impacts are inked to the improvement of city management even during critical events.

The opportunity to share good practices matured and solutions developed in the test phase by the municipality of Florence with the support of UNIFI, such as the centralized processing of the large amounts of data (big data) acquired by the various databases and by the different systems to evaluate the different performance indices (KPI), represents a competitive factor for the metropolitan area, which in a short time can actually enjoy the benefits offered by those solutions. Economic sustainability is favoured by the possibility of creating synergies and economies of scale, as well as by leveraging subsidiarity. It is also worth highlighting that through the SCCR

[10] https://replicate-project.eu/summary-of-the-the-smart-city-response-to-covid-19-webinar/

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infrastructure it will be possible to guarantee the implementation of some of the provisions of the PUMS, as well as the sustainability of the monitoring of the same plan.

- *Eco-system: framework and interaction with other measures*

The measure in question interacts directly with the other smart mobility actions included in the PUMS and in particular with the traffic control centre and the info mobility system as described in the introduction.

- *Results from the pilot implementation*

Replicate is providing the city of Florence with an ICT platform on which its Smart City Control Room is built upon. The main functions of the platform are:

- Collecting data about the territory and the related services from available sources (with specific agreements)
- Integrating new infrastructures in the database (IoT, e-mobility, …)
- Storing and processing the data collected
- Analysing some data set (benchmarking, warning alerts, trends…)
- Visualising the data in tailored dashboards for the different city users
- Enhancing data transferability (thematic platforms, open sets, APP developers…)

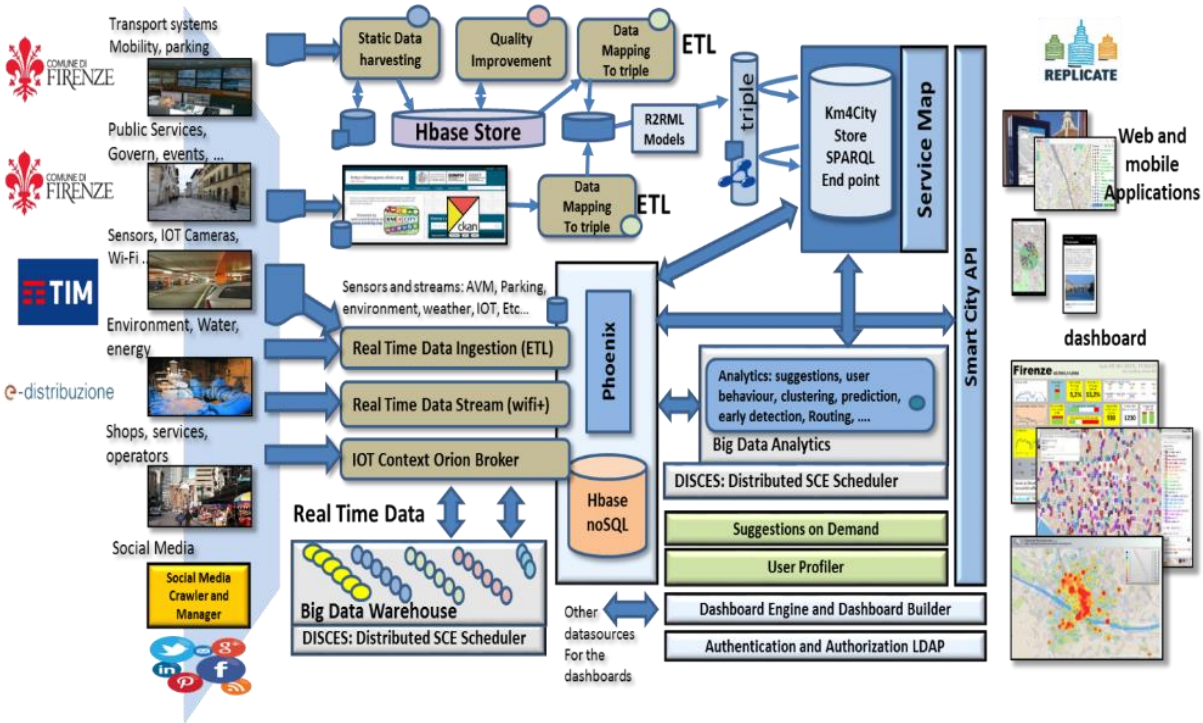

Figure 40 – Florence data aggregation architecture developed by UNIFI.

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The ICT Platform developed, listed on Fi-Ware official web site, includes all the following Open Source Components:

- Km4City Ingestion Processes based on ETL and DISCES tool.
- Km4City ServiceMap.
- IOT FiWare Orion Broker.
- IOT Applications.
- Dashboard Builder.

A specific focus has been made about the security of the platform thanks to the expertise of the consortium partners. Two Apps have been developed linked to platform data.

The SWOT analysis developed from the pilot experience is the following:

Smart City Control Room and ICT Platform	
Unique Selling Proposition: The Smart City Control Room has a unique multi-level governance model (Firenze Digitale) which is paving the way for a successful collaboration among utilities, public bodies, private sector and the Municipality (win-win solution). The whole smart city platform is open source, thus removing the problems of vendor lock-in	
Strengths	Weaknesses
• UNIFI know how and open tools • Governance model and Digital manifesto signed by major players (service providers) • Existing sectorial platforms (traffic supervisor) and ICT infrastructures • Existing Open data Library • ICT department • Smart city framework (SC Plan) and related targets	Some aspects to be improved: • Data transferability and graphical visualization tailored on each user • Training of dedicated personnel • Involvement of all the possible data providers • ICT focus in daily activities (tendering procedures, design, ...) of all the sectors • Agreements for data exchange (standardisation of formats)
Opportunities	Threats
• Supporting programs (PON METRO, EU programs...) for the Smart City Control Room creation • Innovative technologies providers links (E-distribuzione/Enel X, Telecom, Thales…) • Emergencies management tool	• Security issues • GDPR compliance and its updates continuous analysis • Technology fast development

Table 10 – SWOT analysis of the Smart City Control Room intervention

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This action has been part of the City-to-City learning session by Florence available at https://www.youtube.com/watch?v=vlQtekRzVFQ

- *Monitoring methodology including risks and adaptation measures*

The SCCR big data platform is a data eco-system specifically intended to monitor the effectiveness and operations of the city public services, but a specific set of KPIs has been developed in the framework of Replicate to monitor its performance in terms of uptime, used hardware and software resources.

9.2.5 Smart Lighting

- *General Description*

In Replicate, Silfi has implemented three different smart services exploiting public lighting infrastructure:

• more efficient public lighting with 1000 LED lampposts

• light surveillance (to watch on sensible targets like IoT installations) and security with 30 video cameras,

• traffic access control and environmental sensors with a test gate.

In Florence there are 40.500 lampposts and 3.500 traffic lights: the extension of the pilot through the improvement of the whole street lighting system with the use of LED all over the city and installation of additional services, with at least 4 other telematic gates integrated to regulate access to the Cascine Park, has already started.

- *Responsible for the roll out and policy reference*

Mobility Department in collaboration with information services and Silfi. The efficiency action is already in place thanks to the PON METRO program and the additional features have been included in the Urban Plan for Sustainable Mobility of the Metropolitan City (2019)

- *Timescale*

2019-2025

- *Area*

In consideration of the obtainable environmental and economic benefits, the replication has already started from the urban area of Florence but it is to be extended at metropolitan level.

The "revolution of light" is affecting streets in all five Florentine neighbourhoods.

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- *Stakeholders involved*

In the "Firenze cambia luce" program implemented by Silfi and financed by PON METRO open meetings were held with citizens to illustrate the project that is giving a new face to nocturnal Florence and provide an answer to the questions of the inhabitants by replacing the old lighting bodies with the new 30,000 LED lights. The initiative is an opportunity for the inhabitants to get to know the project in detail and to ask their questions about it.

For the metropolitan Sustainable Urban Mobility Plan, as reported in the previous measures, a working group was set up, foreseeing the collaboration of the Municipality of Florence, the Tuscany Region and external professionals. The participatory process was divided into two phases:

- The first, "listening to the territory", carried out through some consultation activities with citizens and stakeholders: investigation activities and online questionnaires to identify priorities and collective perception (answers received from 4'824 citizens and 279 Stakeholders)

- The second phase of "strategic Orienteering" has directly involved the municipalities interested in thematic tables and inspections with contact with the public

- *Technical solution and management model for the roll out*

The installation of the new lighting system is based on the Replicate pilot experience (see description in D7.3) and it is redesigned on a street-by-street basis according to the different lighting needs and the particularities of each place, with four main objectives: more safety, more smart cities, less consumption, less CO_2 emissions.

The municipality is implementing a tailored refurbishment plan of the public lighting infrastructure in the city trying to match for each area the best lighting conditions and the needed additional services (video surveillance, traffic control, WiFi, weather pluvial or wind sensors....).

The new lighting poles are equipped with LED technology and a standard socket for the integration of ICT devices. The Replicate pilot action has been deployed into two different modalities:

A. Integrated systems into city's public lighting: to this modality belong the adaptive lighting system which integrates the fiber optic cameras with the LED lighting on a pedestrian path in the Cascine park.
   The lights are activated by alarms of specific smart actuators (PLCs) that, interacting with the system of video cameras, allow the introduction of adaptive lighting, characterized by high environmental sustainability criteria according to which light activates with different luminous intensities in real time. The system can individually control each light and manage it remotely, enabling different road sections or areas.

   In addition to this, in Replicate an access control system into the park has been integrated: the intervention consists in the regulation of the vehicles accesses and the traffic in the Cascine park exploiting the public lighting infrastructure.

   The interaction between public lighting and access control system is made by the integrated assets system "video cameras – lights" which allows a significant increase of security levels and smarter control.

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The system is made of an entering door equipped with a camera which reads the vehicles licence plates, a laser camera controlling flows and a high efficiency lighting pole to increase visibility in the access area.

B. Systems integrated with public lighting and traffic lights: these systems were placed on public lighting poles in the north-west area of Florence, and 30 IP cameras were set up in 17 different sites, characterized by metadata detection in relation to the analysis of video streams, through detailed settings provided by the operator (Intelligence video analytics on board). These cameras allow detailed data analysis. The types of analysis being developed are listed below:

- Count pedestrian flows in predefined directions
- Abnormal movements and behaviours of people (e.g. presence of panic)
- Presence of persons in a closed area
- Vehicle counting
- Check for presence of parked vehicles on tram tracks
- Parked vehicles control in the driving lane (double row or traffic block)
- Checking the passage of public buses

The result of the video analysis is a flow of metadata from which it is possible to generate statistical reports, real-time alarms and implementation of traffic regulation systems.

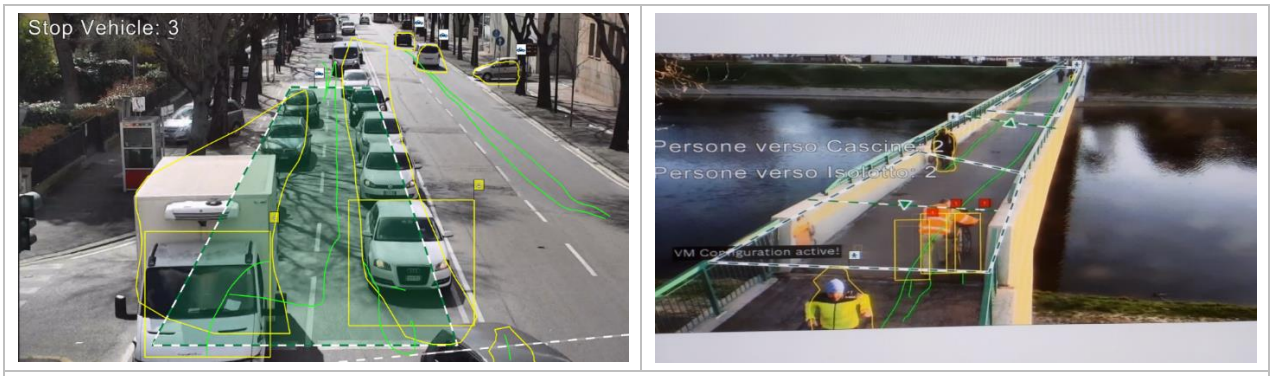

Figure 41 – examples of intelligent video analytics detecting pedestrians and vehicles.

The installation costs including design is around 400€/lamppost with a lifetime of 20 years for the infrastructure, 10 years LED lights and different values for the other components belonging to the additional services. The estimated cost for the intervention is around 8 million euros, but It is estimated that the economic benefit for a city like Florence deriving from the application of smart lighting systems on can reach 2,2 euros a year only for the energy and operational costs savings.

- *Expected Impacts and contributions to the strategic objectives*

The main impact is on the electricity consumption that, only for the city of Florence, is estimated to decrease of about 11,8 GWh, with a consistent savings on energy bills (between 1,5 and 2 million € per year depending on electricity tariffs).

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The external costs saved per year can be estimated around 340.000 €/y related to the pollutions savings in the electricity production (Annex 1 – paragraph 2.1, table 11). The external cost values take into account health, agriculture, materials and biodiversity damage associated with greenhouse gas emissions and of other pollutants (atmospheric gasses, heavy metals, trace pollutants) of the national energy mix.

- *Eco-system: framework and interaction with other measures*

This action is not interacting with any other measures, but it is taking part to the energy efficiency plan and the sustainable mobility plan.

- *Results from the pilot implementation*

The pilot action in the district has already achieved and exceeded target savings: 350 MWh/y instead of the 320 foreseen. The following SWOT analysis is summarising the main results and lesson learnt from the pilot experience.

Eco-lighting and smart services	
USP: Public lighting is the backbone of the city and can easily support other services reducing land use and costs.	
Strengths	Weaknesses
• Energy savings • Knowledge and skills in Silfi (design of the intervention, tendering procedure with high performances innovations and certifications, operation) • high replicability potential in the metropolitan area	Some aspects to be improved: • Aspect/look of the components • Management models of the additional services (maintenance, responsibility...)
Opportunities	Threats
• Supporting schemes at national level (white certificates) • Need of additional services/infrastructures for data Fiber network/WiFi system to be extended soon	• Systems regulations and standards (video surveillance, light, environmental and air quality sensors, ...) • Landscape restrictions • Cultural heritage area limits

Table 11 – SWOT analysis of the lighting intervention

- *Monitoring methodology including risks and adaptation measures*

The monitoring is counting real time consumptions and working data of the public lighting system developed in parallel, as an extension of the district test, at city level and it is to be connected with the smart city control room.

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9.3 Bristol

9.3.1 Retrofitting

- *General Description*

The Bristol Pilot through the REPLICATE project has delivered a number of retrofitting measures in the residential homes in the neighbourhood partnership area. These include retrofit traditional buildings combined with modern energy efficiency measures like energy efficient boilers, loft Insulation or LED lighting, with modern energy efficiency measures and renewable technologies like Solar Photo-voltaic Systems to owner occupiers and the private rented sector (PRS).

- *Responsible for the roll out and policy reference*

Future roll out will be through Bristol City Council's Energy Service. With policy driven by Mayor / Cabinet / City Innovation

- *Timescale*

2022 – 2030

- *Area*

The project could be delivered across the city of Bristol and built into different citizens' houses.

- *Stakeholders involved*

Working collaboratively with community engagement organisations was an innovative approach to retrofitting traditional buildings in the City of Bristol. This method was created and developed by Bristol City Council and Bristol Energy Network to help recruit participants to participate in the REPLICATE project. With the development of new projects and funding streams over the next few years, BCC expects a number of different stakeholders to be involved with the strategy. For example, BCC is currently working with We Care Home Improvements and the Centre for Sustainable Energy on a project which focuses on reducing fuel-poverty, within Bristol and the local areas, through the installation of energy saving measures.

- *Technical solution and management model for the roll out (including costs)*

The technical aspects of each initiative deployed as part of the retrofit measures are:

Solar PV

Three different modules of solar PV have been deployed which were of different output size. These were known as standard, superior and premium which gave the participant the opportunity of having fewer modules for the same output.

1 – Standard Solar Module

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The standard solar module is the lowest output producer and was offered as the most cost-effective system to the customer and was the first system scoped using PV Sol Software. This was the most popular module installed in the project.

The modules used were JAP60S01-275/SC which are manufactured by JA Solar Holdings.

2 - Superior

The superior PV Module produced an output of 325 watts and are produced by JA Solar Holdings. The specific module available was JAM60S03-325/PR.

3 - Premium

The premium module was the best performing, producing an output per module of 365 watts and would achieve a greater expected annual yield, however these are much more expensive for the customer and would take much longer to payback without a feed-in-tariff.

The module selected as the premium option was LG370Q1C-A

Inverter

Solar PV modules produce Direct Current (DC) which needs to be converted into Alternating Current (AC) before the power can be used in a domestic or commercial property. To do this, the Solar PV System requires an adequately sized Inverter. These differ in size depending on the total expected output of the system - for example, if you have a 10 x JAP60S01-275/SC (standard module) system, the Kilowatt Peak (kWp) would be 2.75kWp and an inverter capable of handling 3kWp.

The inverters used were from the Solis Mini 4G Series Inverter manufactured by Ginlong. These range from 700W - 3600W and were selected depending on the needs of the system.

Mounting Rail

A module mounting rail is needed to ensure the modules can be affixed to the roof securely and compliantly to domestic properties. The mounting rails used on this project were manufactured by K2 Systems.

Boiler

Participants interested in a boiler upgrade through the project had a choice of two boiler manufacturers - Worcester Bosch and Alpha. Worcester Bosch is a renowned manufacturer of boilers. The combination boiler available on the REPLICATE project was the A-rated Worcester Bosch Greenstar 30i.

The other option available to participants on the REPLICATE project was the A-rated Alpha EVOKE E-Tech 33 combination boiler

Loft Insulation

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One of the most popular measures on the retrofit project was loft insulation as this is one of the easiest and most cost-effective ways to improve your homes efficiency. The current regulation for loft insulation is 300mm in depth and the product used to achieve this in homes was KNAUF Earthwool 44.

LED lighting voucher

As well as providing funding for the above energy saving measures, all homes participating in the Smart Appliance or Retrofit project received an LED Voucher for 4 LEDs upon paying the final invoice. LED lighting is a cost-effective way of further reducing your home's energy consumption with up to 80% higher efficiency than incandescent lightbulbs. Due to deferring light fixtures and needs for the homeowner, it was decided an LED Voucher was the most effective way of providing even further energy savings measures. As this gave the participant the freedom to choose the bulb most suitable for the homeowner.

Funding towards the cost of installing the required energy saving measure was available to eligible homes. The funding offered differed per property to reflect the estimated kWh/m2 savings expected after installation. During the planning of the project the funding was to be in the region of:

- Loft (and initially Cavity Wall) Insulation – up to 90%
- Boiler upgrade – up to 25%
- Solar PV Systems – up to 25%

The total cost of 160 installations was €390,041.21 with the REPLICATE project committing €247,007.26 worth of funding to residents. This equated to 63.3% of the installation cost being funded due to the expected savings produced after intervention. For the majority of the participants, a contribution was needed to make up the shortfall after funding has been applied and the installation cost was usually the deciding factor for the homeowner. Without funding for residents, it would have been much more difficult to achieve these results and support with the cost is essential when looking to replicate this project elsewhere.

- *Expected Impacts and contributions to the strategic objectives*

One important impact energy saving measures bring to the homeowner is a cost saving when regularly heating your home during the winter months. A key concern for Bristol City Council is Fuel poverty reduction through energy efficiency and this project, with funding available, will result in 151 homes seeing a reduction in their energy costs.

The 'Energy Champions' who volunteered to support the project in recruiting has had a lasting impact and legacy as this is in place to continue to generate more discussions about the climate emergency and raise further awareness within Bristol.

During the monitoring phase in the next year, the University of the West of England will be researching the energy bill information for those homes who had an energy saving measure

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installed. The exact extent of the environmental impact this project will be better understood further on, but the impact is resulting in a carbon reduction of 150 t/y consequent to a 17,95 kWh/m2/yr saving for a total of about 105MWh/y and a PV production of 473,3 MWh. The external costs saved, using the factors reported in Annex 1 (1,8 €/MWh for gas savings and 0,010 €/kWh in case of electricity), are about 5000€/y (Annex 1, paragraphs 2.1 and 2.2).

- *Eco-system: framework and interaction with other measures*

Retrofitting measure could be matched with district heating as well as smart homes measures, tested in the pilot, to obtain the optimal result acting on energy demand, behaviour and energy production. Originally the retrofit works were to run in parallel with the smart homes measures, but timescales did not allow for this during the project.

- *Results from the pilot implementation*

Direct mailing residents in the partnership area was an effective way of generating initial interest in the project.

Requesting energy consumption information in the format of monthly bills, rather than using an innovative technological solution to monitoring (such as smart meters), proved to be extremely time consuming for the delivery team. When beginning the retrofit project, only SMETS 1 meters were available on the market and the data was tied to the energy provider. Individual homes choose their energy providers in the UK and gaining access to the data for each home would have been impossible. Therefore, the monitoring process has had to be done manually to ensure energy data can be collected. Working collaboratively with Energy Champion volunteers and Bristol Energy Network was of great benefit to the project delivery. This relationship helped to promote the project within communities where BCC has found difficult to reach historically. This has improved the reputation of the delivery team's work and is a relationship Warm up Bristol is keen to continue to develop to the benefit of future energy efficiency projects within Bristol.

Feedback from the Champions asked for more structured training with more detailed information to take away to reinforce the learning and that they would like training to be given by those delivering the product, in this case the installers. They felt this would enhance their understanding and enable them to answer questions rather than having to refer them on to someone else.

Engagement with homes in highly diverse and deprived areas as targeted through this project has taken considerable time. To fully engage with people in the project area, it has taken a multifaceted approach through mailouts, social media, events and calls, community organisations and champions. The management of this work and subsequent follow up customer enquiries was extensive and at times was hard to quantify when chasing people throughout the process. For example, the approach used to generate initial interest in the project through direct mailing, in some the areas proved to be effective; with roughly 75% of homes stating they heard about REPLICATE through a 'letter from the council'. This is something that will be considered for future domestic energy efficiency projects.

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Even though measures were subsidised, when engaging with fuel poor homes, this is still a significant cost to the customer. This should not be confused with the home not wanting or needing measures. It became evident that some measures were still more than the homes could afford. Additional funding or subsidies would ensure those most affected could still benefit from the outputs.

- *Monitoring methodology including risks and adaptation measures*

The funding offered differed per property to reflect the estimated kWh/m2 savings expected after installation. To calculate this, the Building Energy Specification Table BEST funding calculator was used (provided to H2020 projects by the European Commission).

Gathering energy consumption information as evidence was important for the research of the expected savings. As energy meters are not readily available throughout the UK, the chosen method was to collect monthly energy bills for the previous 1-2 years from properties. This made clear the amount of energy consumed annually pre-intervention. In general, this was suitable for most homes participating and data was received in the correct format. However, this was a barrier for residents interested in installing energy efficiency measures who had lived in their property for less than 12 months as they were not eligible for funding. On some occasions, residents waited a couple of months until they had been in their home for a year so they could take part and supply the necessary information before proceeding on the customer journey.

Billing data has been transferred to the University of the West of England who will conduct interviews and request post-installation bill information to compare the estimated savings to the real bill savings and the Best calculator.

9.3.2 District heating

- *General Description*

The purpose of the Bristol pilot district heating scheme is to provide a lower carbon and more efficient heat to the existing and new district heating systems. This links together the operational heat network connecting 13 social housing blocks with a new network that will be powered by a Combined Heat and Power Engine, which will improve the viability of gas CHP and make the most of the existing thermal generating assets. Each system has peak and reserve back up gas boilers but by linking the two energy centres the whole system will better utilise the low carbon heat from biomass and the CHP providing more efficient and cheaper heat across the network. The connection will link the 1 MW biomass boiler with a 0.8 MW Gas CHP and 3MW of peak and reserve gas boilers. The work allows the potential for the network to serve another 17MW of heat demand locally.

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- Responsible for the roll out and policy reference

Current and future roll out will be through Bristol City Council's Energy Service team.

- Timescale

City wide 2020 – Ongoing

Redcliffe Network –2020–2022

Old Market Network – 2020 –2023

Temple Network – 2021 – 2025

Bedminster Network – 2021– 2025

Other networks and city wide integration from 2023

- Area

The scheme focuses on the areas of Redcliffe (Broughton House) and 100 Temple Street which is composed of residential properties and the Temple Street system will be predominantly commercial and office use. It has connected a separate existing heat network to Council offices in 100 Temple Street which can partake in holistic energy demand management and enable future connections to this network. The initial connection supplying heat to 100 Temple Street is 100% renewably fuelled from the existing 1MWth wood pellet boiler.

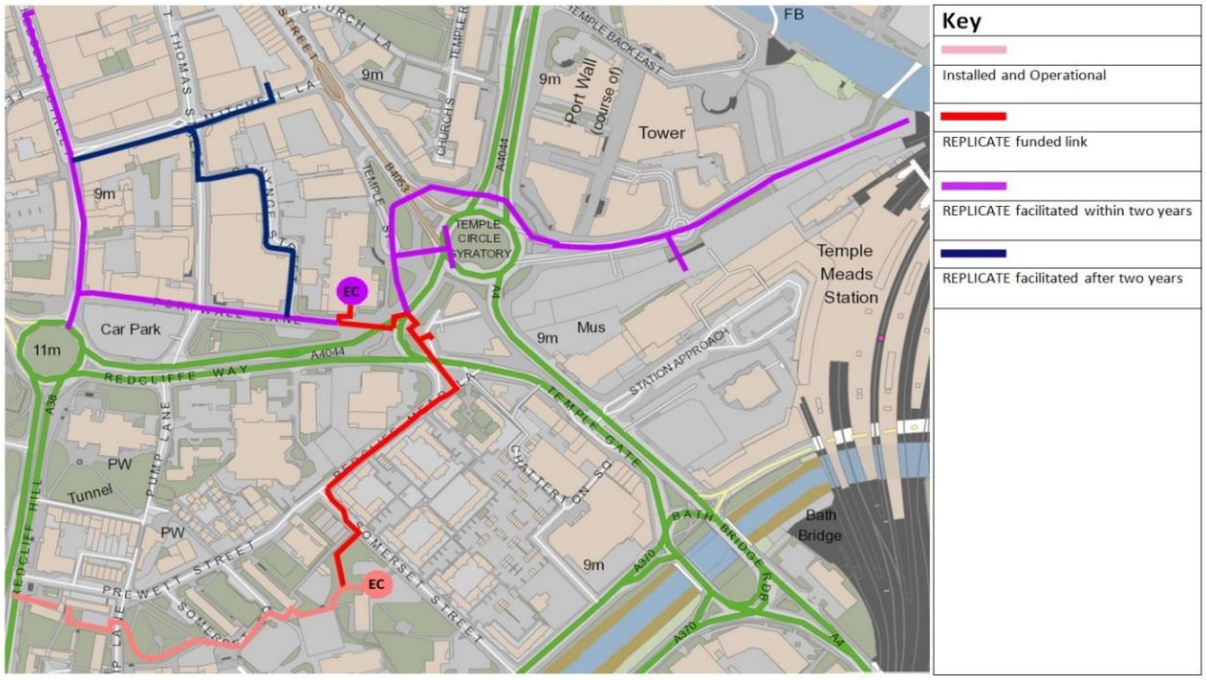

Figure 42 – the Replicate impact on DH network: funded link and facilitated extensions

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Bristol City Council has received £10 million from Central government funding for low carbon heat networks.

This will support the build out of the Redcliffe and Old Market networks and provide resources to plan and commercialise others.

Feasibility and design will also commence on the Bedminster branch of the heat network which will initially supply low carbon heat to new developments being built in this area of the city as well as existing buildings including Bristol South Pool.

An energy centre is being proposed that will use heat from the adjacent main sewer in addition to potential waste heat from the area's former mine infrastructure in the area.

- Stakeholders involved

The DH team instructed the same designers and consultant practitioners that had been working on an adjacent section of pipework to complete a detailed design of the Network route.

Bristol opted to proceed with a client led design on this project rather than procure under a traditional 'design and build' contract as it was seen that this would have several advantages in terms of timescale and quality control.

The same consultants were employed as designers, project managers, and supervisors under the contract and also to act as practitioners on the project as client advisors. The consultants employed were 3D technical design and HN Associates who have worked closely together in the past on projects.

Contractors will vary during the roll out as they are procured in line with public procurement regulations

Delivering Heat Network infrastructure in the UK brings together complex, technical, commercial, financial, stakeholder management, programming, and construction contract management requirements. The unique blend of closely dependent mechanical and civil processes requires strong governance and quality assurance to ensure delivered outputs are fit for purpose.

- Technical solution and management model for the roll out

The pipe material is a pre-insulated bonded pipe system for an underground hot-water network. The pipe assembly is steel service pipes, polyurethane thermal insulation and outer casing of high-density polyethylene.

The following norms are met as a minimum by the complete system:

- BS EN 253: Pre-insulated bonded pipe systems for buried heating/cooling networks;
- BS EN 448: Pre-insulated accessories for buried heating/cooling networks;
- BS EN 488: Pre-insulated valves for buried heating/cooling networks;
- BS EN 489: Polythene joints & connections for buried heating/cooling networks;
- BS EN 13941: Design & installation of pre-insulated pipe systems for buried heating/cooling networks.
- BS EN 14419: District Heating Pipe, Pre-insulated bonded pipe;

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- ISO 4200: Plain end steel tubes, welded and seamless -- General tables of dimensions' tolerances and masses per unit length

All piping material, valves and other equipment supplied for the distribution system, are designed and approved by the manufacturer for a minimum of 16 bar and 120°C continuous operating conditions. In order to obtain the optimum bond between outer casing and PUR-foam, the inner surface of the outer casing is subjected to a corona treatment during extrusion.

Pipes and fittings are equipped with two copper alarm wires for connection to an electronic moisture surveillance system.

The dimensions of the steel pipes are in accordance with BS EN253 and as a minimum be in accordance with the table below. The strength properties of the steel equal or exceed the minimum requirements in BS EN253.

The insulation material is CFC-free polyurethane and complies with BS EN253. The core density is not less than 60 kg/m3.

The thermal conductivity does not exceed 0.028 W/m,K at 50°C with the required min. core density 80 kg/m3 (before aging).

The existing Trend Exite Controller must be fitted with the hardware required to connect to the additional equipment, meters and functionality and therefore the project was required to supply and install the additional hardware, software and cabling:

A summary of the Mbus and Modbus cable requirements is given in the Control Communication Schematic shown below

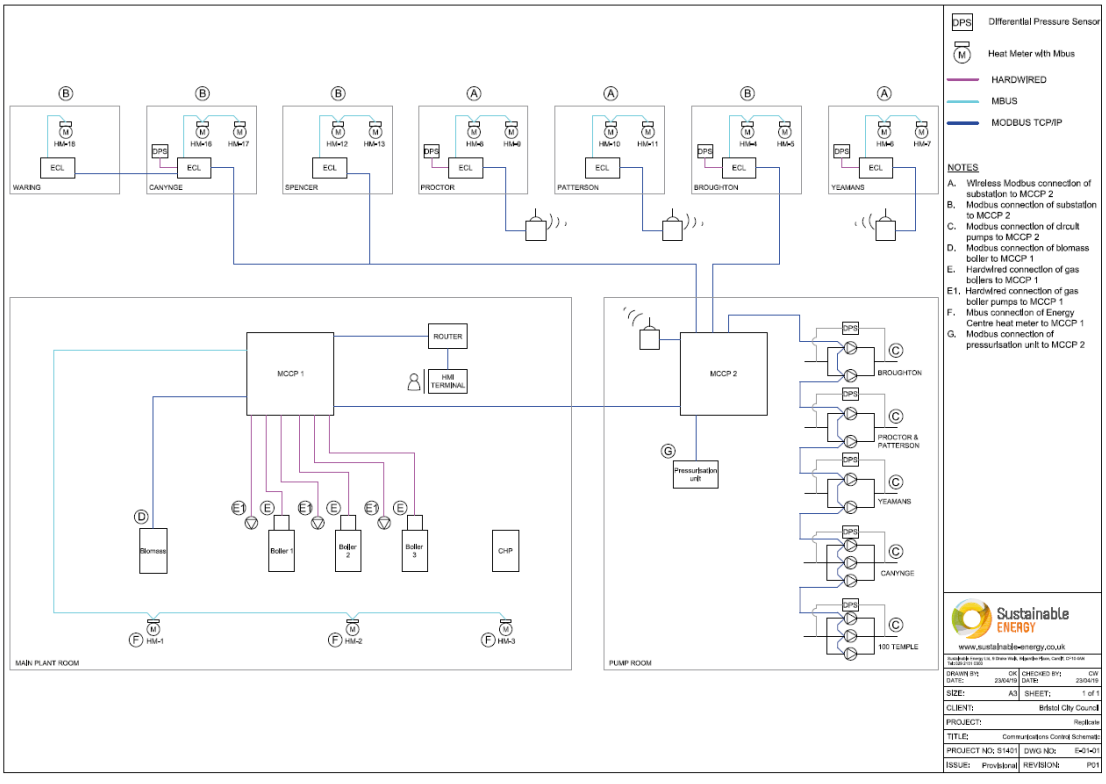

Figure 43 – Control Communication scheme

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Costs for roll out are the following:

Network	Total Capital cost	HNIP Grant funding element (secured or in application)
Redcliffe	£26.2m	£11.8m
Old Market		
Temple	£5.4	£5.2m
Bedminster	£6.2m	

Table 12 – the costs for roll out

Funding that is provided by prudential borrowing currently

Additional funding will be sought in particular via a partnership currently being sought through the City Leap prospectus that is currently in the tender stage (bids have closed)

https://www.energyservicebristol.co.uk/cityleap/

– Expected Impacts and contributions to the strategic objectives

The installation of a network extension between the biomass boilers at Broughton House in the Redcliffe network to 100 Temple Street will save up to 255 tonnes of CO_2, without considering future connections. This will be because the system will be able to utilise the Biomass boiler more effectively as well as displacing standard gas boilers with the more efficient CHP engine on the network.

The new scheme provides 17.235 MWh of energy across the scheme once all connections are complete. The amount of energy that is supplied to the connection that is certain to be delivered within the Replicate timescale is estimated at 14,611 MWh of energy supplied. Additionally, there will be an additional 4.332 MWh of energy supplied per year post Replicate. Scheme the estimation there will be 11,000 people benefiting from the building connections to the Heat Network within the replicate timescale and an additional 3500 benefiting post Replicate.

The calculation of the external costs will be possible in the next year when the data of the network balancing will be available, with the details on the use of the different components (biomass boilers, gas supporting boilers and CHP) and fuels efficiency. In principle, they will be proportional to the improvement of the efficiency from single boilers to the centralised production.

The impact in terms of CO_2 for the original DH proposal with the biomass boiler and the new solution proposed are 52239 tonnes / year.

Other impacts and contributions include:

- Increased security of supply as it connects two energy centres within a central location under the control of Bristol City Council
- The ability to offer connection for hard to treat properties including historic properties within Bristol centre.

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- Providing a larger scale heat network with a mix of public and private users, large and small scale developments, new and historic buildings, as an example for other local authorities and developers going forward.
- Improve viability for a low carbon Bristol and the Mayor's commitment to put Bristol on course to be entirely on clean energy by 2050.

- Eco-system: framework and interaction with other measures

The District heating action could interact and create synergies with the retrofitting of any connected buildings or with the Smart Homes program to manage their consumption.

- Results from the pilot implementation

Since the submission to implement district heating in Bristol, there has been a number of abrupt and unexpected changes to renewable energy subsidies and housing policy. This has impacted on projects linked to the REPLICATE Project and has affected the business case on which the original district heating scheme was based requiring a change in scope to the current scheme.

- Monitoring methodology including risks and adaptation measures

The monitoring strategy is provided through a cloud data host space with sufficient capacity to store a minimum of 2 years half hourly data for all buildings (including data from 100 Temple Street). This includes the development of data structure and management system to meet the data submission requirements of Replicate. Analysis of data into format required for Replicate data reporting including monthly CSV files. Final data summary for Replicate reporting (data provision only, no written reporting included).
Additionally, there is provision of multiple users' access to dashboard for data access for full monitoring access from a web browser. This includes overview web pages of network equipment operation, meters, summary cumulative statistics, daily statistics, monthly statistics and annual energy data.
This platform will be used by the network operator to control the network balancing heat provision to lower carbon, improve air quality while maintaining best value for the customers on the network. The wider strategy will be to utilise and invest in the city's fibre network to connect future building and customers. The Project has provided a start to this within the current scope and allowed for the strategy for this to be developed.

9.3.3 E-BIKES

- *General Description*

Implementation of 12 electric bikes in corporate, community and public sector settings in the Bristol project area. The bikes are housed and charged by the organisations. The bikes are serviced and maintained by Co-wheels. Each bike will have a bespoke tracking unit installed and managed

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by University of Bristol. The option also exists for the bikes to be integrated into Co-wheels online booking system.

- *Responsible for the roll out and policy reference*

Future roll out will likely to be through the BCC

- *Timescale*

2022 – 2030

- *Area*

It is anticipated that community organisations across Bristol will be able to apply for the e-bikes. This might also be deployed in some Bristol City Council buildings where staff need to travel as part of the daily job.

- *Stakeholders involved*

The BCC transport team will lead this process in creating a strategy/plan for action. The universities will continue to be interested in the outcomes and BCC transport colleagues will work with OLEV and the BCC energy service for future development and roll out, as well as Travel West who allow different organisations and citizens to try the e-bikes for a few months before purchasing them.

Some of the below partners will be involved in the partnership for roll out and the beneficiaries include community health organisations across Bristol similar the project rollout in *Ashley, Lawrence hill and Easton Neighbourhood Partnership area residents, businesses, public sector and community organisations*

- *Technical solution and management model for the roll out*

Co-wheels are trialling two versions of a business model for this scheme:

1) Firstly, there is the ownership model where Co-wheels purchases the bikes and works with a partner organisation to provide the service and support package. For this, Staiger Sinus BC30f electric bikes were purchased through Raleigh UK Ltd with two years warranty. Co-wheels have been working in partnership with Sustainable Travel Solutions Ltd (STS), a Bristol based company specialising in supplying and supporting businesses and public sector organisations with bicycle fleets, for provision of the servicing, maintenance and support for the bikes. As the bikes run on a Bosch system, it was essential that STS were Bosch trained and certified to enable swift diagnosis and resolution of any technical issues relating to the bikes.
   To prepare the e-bikes for deployment, puncture proof tyres and cycle panniers are fitted, a D-lock is provided, and a pre-deployment inspection is conducted.

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Once deployed, STS provide basic quarterly services, a full annual service, maintenance and repairs relating to wear and tear, and emergency call-out support (Mon-Fri 9-17 excluding bank holidays).
Each bike is replaced with a new bike after two years of use. In the event of a bike being stolen, this has been replaced with a Raleigh Motus e-bike due to its similarity to the Staiger and its faster availability through Raleigh.

2) Secondly, there is the e-bike lease model where Co-wheels leases the bikes from a 'one stop shop' that provides the full service and support package in addition to the bikes. For this, Co-wheels has been working in partnership with STS, who provide the bikes and the service and support package all together. The reason for trialling these two models relates to cost and convenience.

The table below shows the cost comparison, based on a two-year contract:

	Purchase	Lease
Bike cost	£1083.34/ €1,213.34 + VAT	£1995/ € 2,234.40 + VAT
Service & support	£720/ € 806.40 + VAT	Included
Puncture proof tyres	£74.64/ € 83.60 + VAT	Included
D-lock	£30/ € 33.60 + VAT	Included
Panniers	£75 / €84 + VAT	£75 / €84 + VAT
PDI check	£20/ € 22.40 + VAT	Included
Insurance	£120/ € 134.40	Included
Total	£2122.98 / *€ 2,377.74* + VAT	£2070 /*€ 2,318.40* + VAT

Table 13 – the costs comparison of different contracts

- *Expected Impacts and contributions to the strategic objectives*

The CO_2 saved is estimated about 0.36t/y per bike, while external costs are around 350€/y for each bike under the same hypothesis (Annex 1 – paragraph 2.3).

- *Eco-system: framework and interaction with other measures*

There are many actions belonging to mobility sector which could influence, affecting or supporting depending on the case, the e-bikes action.

The multimodality and the public transport policies, the availability of other competitor sharing systems, the access restrictions/permissions to specific urban areas, etc. In parallel, the stakeholders' engagement and the dialogue with citizens and companies is a powerful supporting tool for dissemination and optimisation/adaptation of the service to upcoming needs.

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- *Results from the pilot implementation*

The following SWOT analysis has been developed in the framework of the management model analysis in D7.5 and it points out the main lesson learnt from the pilot test.

e-bikes	
Unique Selling Proposition: e-bikes can break down barriers to active and sustainable travel reducing congestion, energy & emissions and sedentary without ownership problems	
Strengths	Weaknesses
• Existing booking system (car club) • Reduced costs compared to cars • Municipal sustainable mobility policies • Modular design	• Maintenance service reliability • Monitoring system development and data storage
Opportunities	Threats
• Externalities (health, trips time in traffic…) • Inter-modality	• Bike sharing service competition

Table 14 – the SWOT analysis for e-bikes

Looking to the future, the e-bike monitoring system has been designed with scalability and replicability of deployment in mind. On the manufacturing side, the modular design, use of COTS components, 3D printing and PCB layout files will ensure fast and efficient manufacture at significantly reduced cost.

In terms of delivery, Co-wheels have learnt a number of things. Firstly, schemes should be targeted at organisations that are historically providing combustion engine vehicles to transport staff around for short journeys in the community. Secondly, it is inevitable that there will be corporate e-bike users that are already riding their own bikes and there is value in developing e-bike 'champions' within organisations to encourage others to take up riding the e-bikes. Thirdly, it is worth reviewing the size of the scheme initially whilst keeping an eye on future scale up.

To create a sustainable scheme for the longer term there must be an emphasis on the benefits of the scheme to each organisation, with a strong focus on the cost savings created. The scheme has the potential for significant financial impact related to fleet solutions and human resources.

- *Monitoring methodology including risks and adaptation measures*

The monitoring system is from one side related to the vehicles use and from the other it is aimed at understanding which kind of switch has been done by users (from PT, private car, normal bike…) through surveys. However, electric cars and electric bikes use different tracking systems, but data will be analysed by the University of the West of England.

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10. LESSONS LEARNT

The upcoming results and lessons learnt about the different measures have been collected from all partners involved step by step since the beginning of the activities; in particular D7.3 Reports on technical analysis of the pilots and D7.5 on management models analysis make available the final updated collection for each specific intervention. During last General Assembly in Florence (Oct. '19), a joint-workshop has been organised among WP7 and WP10 to analyse the roll-out potential of the interventions valuated from a common cross-cutting perspective and to start identifying how the monitoring programs may help on these replicability and scaling-up processes that cities are facing. Partners attending the General Assembly were divided into 3 thematic groups (Energy, Mobility, ICTs) and work on some template-tables prepared to accomplish the objectives of the WS.

This common perspective and the cross-cutting discussion with the contribution of different experiences have further enriched the know-how about replication potential in new contexts.

To share the latest outcomes, in the present work all the lesson learnt from the three lighthouses have been collected in a unique table for each type of intervention, adding further details about possible adaptations and suggesting a list of stakeholders to be involved to provide the other interested cities with all possible support coming from the Replicate experience in the pilots as well as in the roll out definition (chapter 8 Roll out schemes).

The overall workpackage outcomes about successful and effective smart and sustainable actions planning have been illustrated in paragraph 7.1 of the present work including Replicate model resulting from WP7 cross-cutting activities.

Behind innovative technologies that are evolving faster and faster and, in few years, can also become cheaper changing completely their actual business models, the key resulted to be the *Smart city structure as network of links and relations not as rigid as a crystal lattice but highly adaptable like a liquid and always evolving together with its regulatory framework*.

This statement is valid also in case of the municipal internal organisation which has been adapted to be able to target new challenges, managing integrated and innovative project schemes.

The target vision is not usually related to innovation and technology, which are perceived as "tools", but to sustainability and well-being of citizens; this should be reflected in the decision making process, which is becoming more and more co-created, as well as in the assessment of all different direct and indirect impacts (air quality and health, social inclusion, poverty, …).

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11. INNOVATIONS, IMPACT and SCALABILITY

In the next sub-chapters, the innovations and impacts generated by the roll out planning activity of the three Lighthouse cities in the REPLICATE project are detailed and the scalability of the method is valuated.

The main concept is that smart cities are dynamic environments that are capable to adapt and evolve faster than the other cities due to the networking and management capacity on their territories. Their main strengths consist in the links they've been able to create at different level, from the international to the district stakeholders and citizens, exploiting synergies and in the capacity of developing visionary strategies involving and integrating all sectors of influence.

11.1 Innovation solutions

The innovation is not only technical, as resulted from the previous deliverable D7.5 Report on management models v2, but also methodological.

The three cities have developed similar approaches to tackle complex and evolving problems linked to smart and sustainable development. This approach, starting from STEEP model experience, has developed adapting to specific territorial needs but is still based on common features consisting in the Replicate approach defined in paragraph 7.1.

The methodology is based on innovative internal organisational processes, cocreation and participation into decision making processes to shape the vision and consequently the plans/programs frameworks; it implies also an innovative way to measure the impact of a project taking into account also "externalities" and indirect results that could be prioritised to enhance well-being and life quality because those cities are targeting sustainability beside smartness in line with the UN Sustainable Development Goals concept.

In the specific activity carried out to analyse the replication potential and to design the roll out plans, the bench-learning methodology adopted, in connection and in line with the City-to-City learning program, has been inherited by research and usefully applied to cities.

Regarding technological aspects, an effective innovation consists in the use of ICT as supporting tool for decision makers for the deeper and faster knowledge of the problem, thanks to the data acquisition and process (with the introduction of cyber security issue in the data governance development), as well as for the continuous monitoring which enables quick adaptation and optimisation as it happened for example in the recovery planning from Corona virus crisis.

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11.2 Social impacts

The extension programmes have direct and indirect social impacts that have been illustrated in the short-term actions as well as in the analysis of the pilots (D7.3 Report on technical solutions v2 and D7.5 Report on management models v2). The Replicate prioritisation approach in use, following the "City Model Canvas" concept developed by Esade and the UN sustainable development goals framework as reported in paragraph 6.1, has balanced economic factors with environmental, social and indirect impacts to implement innovation for the improvement of the overall quality of life of citizens. Replicate has targeted themes as inclusion with cocreation and participatory processes, energy poverty with retrofitting of social housing and improvement of energy bills of low-income districts, affordable and sustainable transport.

Security and emergency issues have been targeted as well with the support of intelligent infrastructures (data platforms supporting territorial management and APP development, smart lighting with surveillance systems, IoT, smart grid…), services (Energy demand management, sharing systems, e-mobility…) and information/engagement channels to prevent isolation.

11.3 Environmental impacts

Direct impacts of the pilot actions are actually in the monitoring phase, but from the first data available it has been possible to evaluate the possible impacts of extensions planned in the short-term period as well as of replications in other contexts.

For every measure on going or planned in this decade, the direct impacts have been reported together with an estimation of the external costs related to indirect impact on health or biodiversity or climate.

The total amount of savings triggered in the next years by the short-term actions of the three cities described is expected to be about 70.000 t/y, but it will increase soon with the definition of the mid-term strategies under analysis in the three cities to significantly contribute to the ambitious targets each of them has already set to 2030 and 2050.

11.4 Replication and scalability potential

The extension and replication potential analysis has started with previous deliverables where replication KPIs have already been evaluated and reported through radar diagrams for the comparison (D7.3). The set of KPIs will be further updated in the monitoring framework in the next deliverables belonging to WP10.

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Scalability has been also analysed from the management models point of view, detecting the value ecosystems that have allowed the implementation in cooperation with WP9 and the possible adaptations for the future (D7.5).

In the present work the main outputs have been further developed and summarised by the three cities together during the scale up plans definition, to provide an easy-to-use guide for followers, actually involved in the definition of their replication plans in the framework of WP8, and for any interested municipality. All the actions included in the pilots have been studied from the three different perspectives to point out the optimal conditions for the replication, adaption, scalation and uniqueness (information to be gathered, stakeholders to involve, possible adaptations, weaknesses to overcome and strengths to exploit).

11.5 Economic feasibility

The economic feasibility of the roll out plans is based on the business models developed of the pilot actions and their adaptation to the next period conditions with the lack of H2020 financial support and the market recovery post emergency.

From WP7 analysis, coherent with the results of the Critical Factors Analysis of WP8, the main characteristics of the business models in general are:

- they depend on specific framework conditions (national and regional programs, energy tariffs….)

- they could vary quite quickly in the next years because of changes in the regulatory frameworks or in the cost of technologies or even for pandemic effects

- they can benefit from synergies with different sectors indirectly impacted (social, health, agriculture, environment…).

For those actions reported as short term planned, the financial support has been provided with ad hoc decisions or in planning tools. In case of some medium term and all long term planned measures, the specific business model is often under development, depending also on previous results and possible impacts of on-going activities.

11.6 Impact on SME´s

Several SME have been involved in the pilot actions implementation as described in the specific value eco-systems. Most of them can still benefit from the extension of the measures in the three cities or, as under analysis in WP9, can exploit their knowhow on the market with other cities.

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Some technologies included in the cities' roll out strategies like smart lighting systems, energy management systems, APP development (energy monitoring, smart parking, info mobility…), sharing services but also participatory processes management or small size retrofitting can be very interesting for the SME sector.

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12. CONCLUSIONS

Pilot actions have been very interesting test and have provided very useful feedbacks, with strengths and weaknesses, to next plans and strategies under development from the technological point of view and from the methodological approach that is now embedded in the three cities and available for replication. Shaping vision and planning processes are never ending activities which follow a circular approach aimed at continuous improvements to reach more and more ambitious or new challenges. Smart cities are those who can reach more efficiently and more quickly ambitious sustainable targets thanks to their particular structure and network of links (see paragraph 6.1).

Some suggestions and recommendations for followers and cities interested in replicating are provided:

- Begin with the end in mind: try to plan suitable pilot projects for successful scaling up in your territory as the three lighthouse cities did.
- Consider organisational innovation: the innovation consists of a "set of interventions" including not only a new technology, but also the managerial and administrative processes necessary for successful implementation.
- Integrate different departments / disciplines to exploit synergies and evaluate interactions: Cities are addressing smart but also sustainable targets that involve many further topics together with energy, mobility and ICT/infrastructures as the UN Sustainable Development Goals framework shows. The impacts and synergies with all those aspects should be taken into account in the decision-making process. Eternal costs and a suitable KPIs monitoring program could support a wider perspective.
- Plan adequate efforts for replication:
    - "Successfully tested" doesn't mean copy and paste but adapt, confirming the four principles of replication, adaption, scalation and uniqueness developed with WP8 and followers;
    - to increase the impact of successfully tested innovations, extending benefits to more and more citizens, policy development ought to be fostered on a lasting basis.
- The implementation of ICT platforms could increase more and more the knowledge of the territory and its needs to support optimal management and planning. Cyber security should become part of digital governance since the beginning. Monitoring data outputs from platforms should be clear and targeted to users to be effective.

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- Stakeholders' and citizens' engagement are fundamental and must be managed (examples in WP2,7,8) giving clear information to participate at the debate, space for comments and new ideas, feedback on results.

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13. References

Calzada, I. & Cobo, C. (2015), Unplugging: Deconstructing the Smart City. Journal of Urban Technology 22(1): 23-43. DOI: 10.1080/10630732.2014.971535.

Davide Sartori (Centre for Industrial Studies [CSIL]), Lead author; Gelsomina Catalano, Mario Genco, Chiara Pancotti, Emanuela Sirtori, Silvia Vignetti (CSIL); Chiara Del Bo (Universitá degli Studi di Milano) for DG REGIO *"Guide to Cost-Benefit Analysis of Investment Projects Economic appraisal tool for Cohesion Policy 2014-2020"* ISBN 978-92-79-34796-2

Huib van Essen, Lisanne van Wijngaarden, Arno Schroten, Sander de Bruyn (CE Delft), Daniel Sutter, Cuno Bieler (INFRAS), Silvia Maffii, Marco Brambilla, Davide Fiorello, Francesca Fermi, Riccardo Parolin (TRT), Kareen El Beyrouty (Ricardo) *EU Commission: Handbook on the external costs of transport 2019* ISBN 978-92-79-96917-1INNOVHUB STAZIONI SPERIMENTALI PER L'INDUSRIA *Studio comparativo sulle emissioni di apparecchi a gas, GPL, gasolio e pellet*

International Capital Market Association "*Green Project Mapping"* June 2019

Marketplace of the European Innovation Partnership On Smart Cities and Communities, "*A Consultation Paper to Stimulate Action: TOWARDS A JOINT INVESTMENT PROGRAMME FOR EUROPEAN SMART CITIES"*

Michael Fertig and Natalija Ziminiene ICON-INSTITUT Public Sector GmbH for the European Public Employment Services: "*PES Network Benchlearning Manual* "

Miguel A. Garcia-Fuentes, Lisa Enarsson, Trinidad Fernandez, Sigrid Granström, Gustaf Landahl, Cristina de Torre, Sonja Stöffler, Simon Clement, Esben Pejstrup, and Carsten Rothballer *Policy paper "From dream to reality: sharing experiences from leading European Smart Cities"*

Sander the Bruyn Marijn Bijleveld, Lonneke de Graaff, Ellen Schep, Arno Schroten, Robert Vergeer, Saliha Ahdour (2018) Delft, CE Delft *Environmental Prices Handbook EU28 version: Methods and numbers for valuation of environmental impacts*

Technical Experts Group on sustainable finance "*REPORT PROPOSAL FOR AN EU GREEN BOND STANDARD"* June 2019

Technical Experts Group on sustainable finance Supplementary Report 2019 *"Using the Taxonomy*"

Energy Efficiency Financial Institutions Group ("EEFIG"), the European Commission and UNEP FI "*EEFIG UNDERWRITING TOOLKIT Value and risk appraisal for energy efficiency financing"* ISBN: 978-1-5272-1107-0

The European House-Ambrosetti, 2018 "*Electrify 2030: l'elettrificazione e i suoi impatti sulle filiere industriali: nuove opportunità per un futuro sostenibile in Europa e in Italia*"

U.S. Agency for International Development: "*Systematic approaches for scale up of best practices"*

Yearworth, M., Willis Singer, J., Adcock, R., Hyberston, D., Singer, M., Chroust, G., & Kijima, K. (2015). Systems Engineering in a context of systemic cooperative praxis (SCOOPs): development and implications. In J. Wade & R. Cloutier (Eds.), 13th Annual Conference on

This Project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement N° 691735

Systems Engineering Research (CSER 2015) (pp. 214-223). Hoboken, NJ. doi: 10.1016/j.procs.2015.03.048

For paragraph 7.2.3:

Aalbers, M.B. (2015). The potential for financialization. Dialogues in Human Geography, 5(2), pp.214-219. doi: 10.1177/2043820615588158

Ackermann, F., & Eden, C. (2011). Making strategy: mapping out strategic success (2nd ed.). London: SAGE.

European Innovation Partnership on Smart Cities and Communities. (2016). Towards a Joint Investment Programme for European Smart Cities: A Consultation Paper to Stimulate Action p.27. European Innovation Partnership on Smart Cities and Communities. Retrieved from https://eu-smartcities.eu/sites/default/files/2018-06/EIP-SCC_TOWARDS%20A%20JOINT%20INVESTMENT-Paper.pdf [accessed 7th July 2017]

Friend, J.K., & Hickling, A. (2005). Planning under pressure : the strategic choice approach (3rd ed.). Oxford: Elsevier Butterworth-Heinemann.

Halbert, L., & Attuyer, K. (2014). Introduction: The financialisation of urban production: Conditions, mediations and transformations. Urban Studies, 53(7), pp.1347-1361. doi: 10.1177/0042098016635420

Möller, S. (2017). Financializing town halls: Local councils, LOBO loans and the derivatives markets. Retrieved from http://speri.dept.shef.ac.uk/2017/06/25/financializing-town-halls-local-councils-lobo-loans-and-the-derivatives-markets/ [accessed 13th August 2019]

Pike, A., O'Brien, P., Strickland, T., Thrower, G., & Tomaney, J. (2019). Financialising City Statecraft and Infrastructure. Cheltenham, UK.: Edward Elgar.

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Annex 1: external costs methodology

1 EXTERNAL COSTS

Most of civil infrastructures and services do not only affect society in a positive way but also give rise to side effects. Road vehicles, for example, contribute to congestion, ambient noise levels and air pollution. Such side effects give rise to various resource costs that can be expressed in monetary terms: time costs of delays, health costs caused by air pollution, productivity losses due to lives lost in traffic accidents, abatement costs due to climate impacts of transport, etc.
When side effects of a certain activity impose a cost upon society, economists speak of such a cost as an external cost. In contrast to the benefits, the external costs are generally not borne by direct users and hence not taken into account when they make a decision.
The internalisation of these costs means making such effects part of the decision-making process. This can be done directly through regulation, or indirectly through market-based instruments (e.g. taxes, charges, emission trading, etc.) or combinations of these basic types.
In order to define external costs properly it is important to distinguish between:

- Social costs reflecting all costs occurring due to the provision and use of an infrastructure/building/service.
- Private (or internal costs), directly borne by the user.

External costs refer to the difference between social costs and private costs: based on the economic welfare theory, city users should pay all marginal social costs which are occurring due to their activity. Considering the private marginal costs, optimal infrastructure/service charges should reflect the marginal external costs of using.

To support the decision-making processes a methodology to take into account external costs in the analysis has become more and more important:

"In practice, environmental prices can support decision-making in two ways:

- *When analysing the social impacts of investment decisions, environmental impacts can be included along with financial data because they can be assigned a monetary value using environmental prices. A case in point is Social Cost-Benefit Analysis (SCBA), where environmental prices are used primarily for valuation, providing a means of comparing environmental impacts with financial items to arrive at integral consideration of all the impacts associated with an (investment) decision. In principle, valuation of environmental*

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impacts using environmental prices occurs in every SCBA in which external impacts are also monetized and by companies in calculating social business cases.

- *In environmental analyses like Life Cycle Assessment (LCA), Environmental Impact Assessment (EIA) and benchmarking, environmental prices can be used to weight the various environmental impacts identified. The main aim here is environmental weighting, as a means of comparing the contribution of different environmental themes. Weighting of environmental impacts is sometimes carried out as a final step in LCAs in order to express the results in a 'single-score indicator'. The welfare impacts of emissions are monetized within a standard welfare-economics framework. The EPS system (Environmental Priority Strategies in product design; (Steen, 1999)) also involves monetary weighting, but using premises based more on monetization of a hierarchy of principles than on welfare economics. Financial valuation is often applied as a weighting method in various LCAs and in concrete calculation tool.*

Social Cost-Benefit Analysis (SCBA) is a decision-support tool that can be used to clarify the considerations at work in government policy elaboration. Most policy alternatives have a range of impacts, and by expressing as many of these as possible in monetary terms, they can be compared, providing valuable information on the pros and cons of each alternative (in 2013 General Guidelines for SCBA were published in the Netherlands and in 2017 CE Delft drew up SCBA Guidelines for the Environment).

SCBA can be performed for a wide variety of purposes, including the following:

- *Concrete government investments, such as motorway construction or introduction of separated household waste collection. In this case there are (government) investment costs and social benefits in the form of reduced pollution, which SCBA allows to be compared.*
- *Environmental policy instruments, such as a waste charge or renewable energy subsidy. In this case the government is setting a framework for compelling or 'nudging' industries and consumers to invest or change their behaviour. In such cases, besides policy costs there are above all private costs to industries and/or consumers and social benefits through reduced pollution.*
- *Exploration of policy options, such as whether air-quality standards need to be tightened or recycling targets increased from the perspective of social welfare. In this case SCBA supports the problem analysis and explores whether additional environmental policy is desirable in welfare terms." (Environmental Prices handbook)*

The cost/effectiveness and cost/benefits methodologies, in use for big infrastructural projects, in the simplified versions could also be implemented at urban level to have a comprehensive view of the impacts and prioritise the interventions; these aspects could also be used during the stakeholders' engagement or in the search of funding from different departments or sources.

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1.1 METHODOLOGY

Spes has developed for the three national and local frameworks an easy-to-use calculation to work out the impact of externalities based on the following references:

- NEEDS (New Energy Externalities Developments for Sustainability) project results (FP6 2008)
- Guide to Cost-Benefit Analysis of Investment Projects (2014) – European Commission-DG for Regional and Urban Policy
- Environmental Prices Handbook EU28 version (by CE Delft)
- EC-DG MOVE "Update of the Handbook on External Costs of Transport", version 2014 (by Ricardo AEA) and version 2019 (by CE Delft)

The cost factors have been calculated in detail, based on the NEEDS approach and mentioned following studies, for the three lighthouses.

At the basis of the calculations there is the concept of "damage costs for units of pollutant" explained in the following picture in the Environmental Prices Handbook (CE Delft).

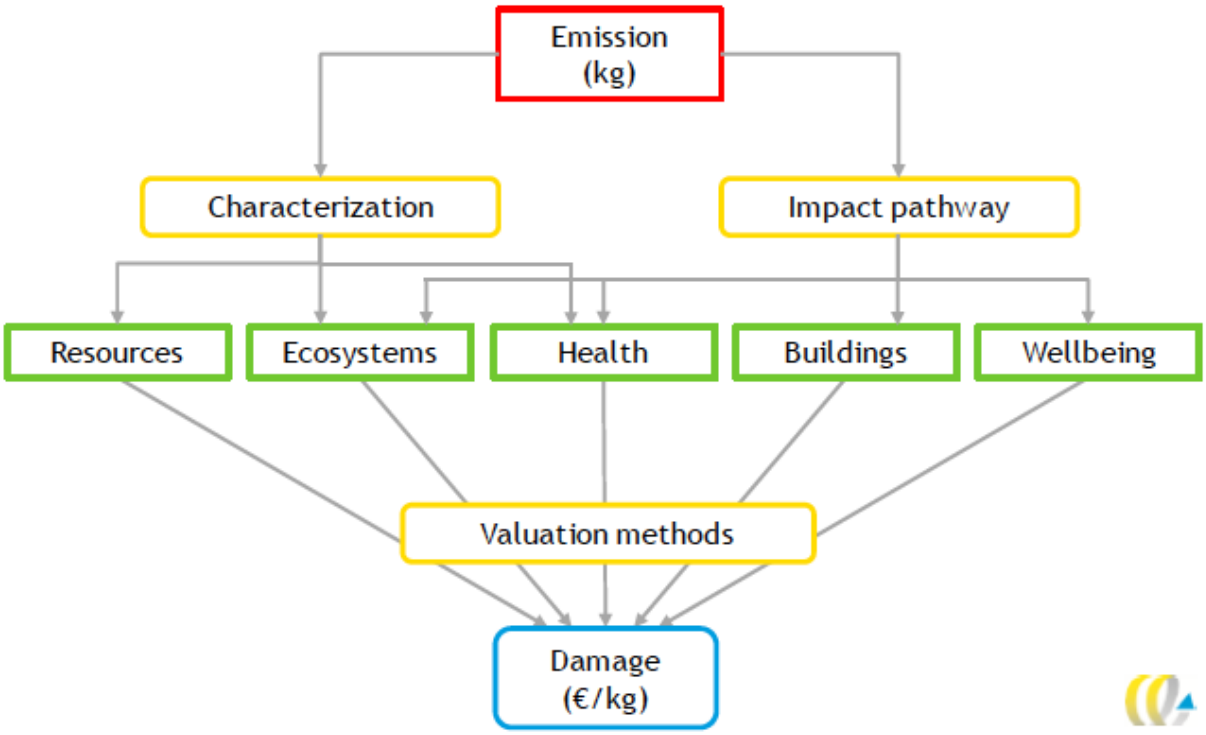

Figure 1 – Characterization model at the basis of the Environmental Prices handbook

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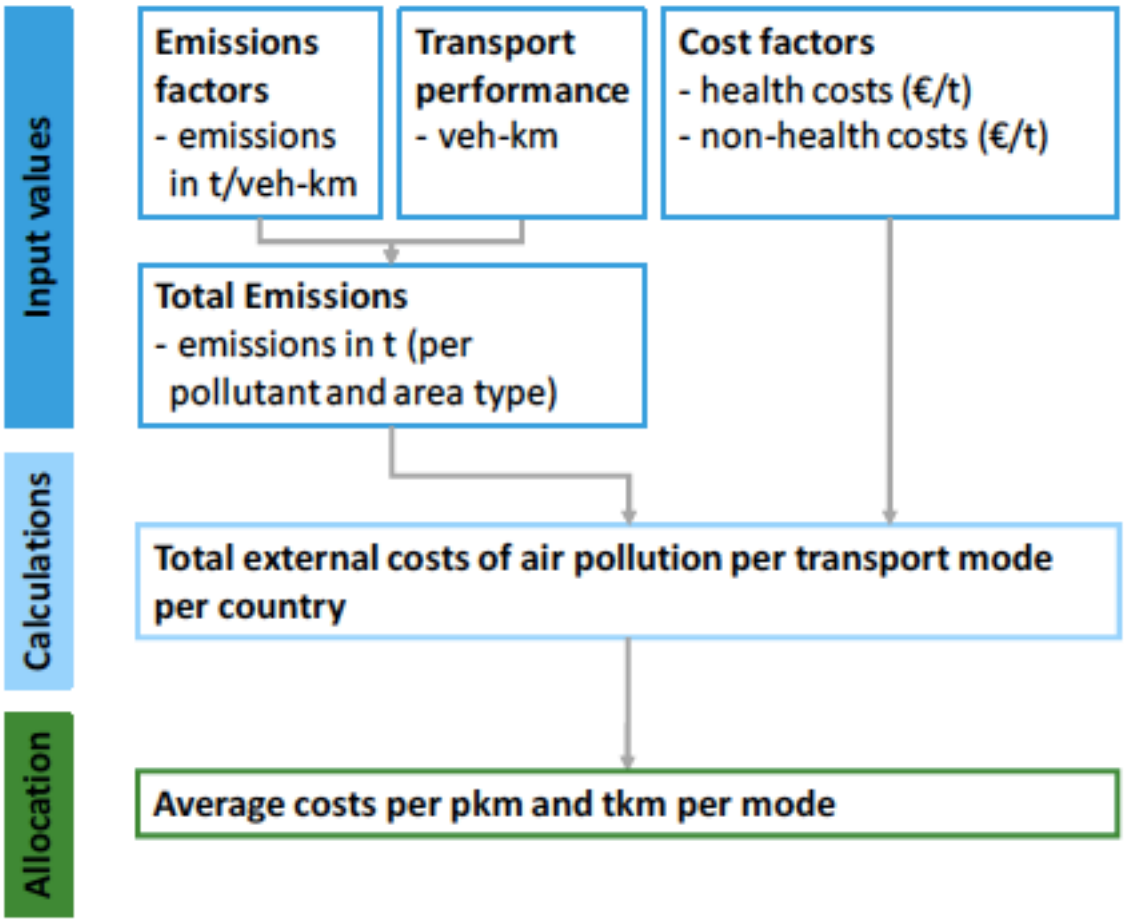

Figure 2 – Example of methodology for total and average air pollution costs calculation applied to transport sector (Delft Handbook 2017)

1.1.1 Cost/effectiveness analysis:

The investments costs and the environmental benefits have to be quantified versus a business as usual scenario.

Regarding the environmental impacts, the following formula has to be used:

$$\frac{a*t\ CO_2\ saved + b*\ t\ PM_{2,5}\ saved + c*\ t\ NO_x\ saved + d*t\ NMVOC\ saved + e*t\ SO_2\ saved}{Ci}$$

Where Ci are the investment costs and the tonnes of pollutants saved by the investment during its full life are weighted as damage costs by equivalence factors to CO_2 emissions [t CO_2eq saved/€].

For the three lighthouses the following factors are in use:

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	A	B	C	D	E
ADS	1	2055	52,6	11,58	73,7
FI	1	2077	113,7	12,63	104,2
BCC	1	2049	69,5	18,95	96,84

Table 1 – cost/effectiveness analysis factors for the three cities

The factors have been calculated taking as reference the EC-DG MOVE Hanbook (based on NEEDS project results), updated with the Eurostat Harmonised Indices of Consumer Prices.

For particulate the values for urban areas with high density has been used.

To use the formula, the action has to cause an emission saving.

1.1.2 Simplified cost-benefit analysis

In the case of simplified cost-benefit analysis, only the investment and operating costs (denominator of the benefit-cost ratio) and the environmental benefits (external environmental costs avoided – numerator of the benefit-cost ratio) of the energy-environmental intervention must be quantified compared to the alternative reference scenario.

1.1.3 Impacts considered

AIR POLLUTION COSTS

The emission of air pollutants can lead to different types of damages, from the most analysed health effects to building and material damages, crop losses, biodiversity loss…

Since the nineties a broad range of international studies and research projects have been conducted, particularly on European level.

The present work, in line with the EU Handbooks, covers the following four types of impacts related to air pollutions:

— Health effects: The inhalation of air pollutants such as particles (PM10, PM2.5) and nitrogen oxides (NOx) leads to a higher risk of respiratory and cardiovascular diseases (e.g. bronchitis, asthma, lung cancer). These negative health effects lead to medical treatment costs, production loss at work (due to illness) and, in some cases, even to death.

— Crop losses: Ozone as a secondary air pollutant (mainly caused by the emission of NOx and VOC) and other acidic air pollutants (e.g. SO2, NOx) can damage agricultural crops. As a result, an

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increased concentration of ozone and other substances can lead to lower crop yields (e.g. for wheat).

— Material and building damage: Air pollutants can mainly lead to two types of damage to buildings and other materials: a) pollution of building surfaces through particles and dust; b) damage of building facades and materials due to corrosion processes, caused by acidic substances (e.g. nitrogen oxides NOx or sulphur oxide SO2).

— Biodiversity loss: Air pollutants can lead to damage to ecosystems. The most important damages are a) the acidification of soil, precipitation and water (e.g. by NOx, SO2) and b) the eutrophication of ecosystems (e.g. by NOx, NH3). Damages to ecosystems can lead to a decrease in biodiversity (flora & fauna).

€2016/kg	NH_3	NMVOC	SO_2	NO_x transport city°	NO_x transport rural°	$PM_{2.5}$ transport metropole°	$PM_{2.5}$ transport city°	$PM_{2.5}$ transport rural°	PM_{10} average*
Greece	4.8	0.3	5.9	5.1	3.1	267	86	33	24.8
Hungary	18.9	0.8	9.9	26.8	15.8	317	102	59	8.5
Ireland	4.1	1.7	11.8	17.6	10.1	568	183	68	12.2
Italy	21.6	1.1	12.7	25.4	15.1	409	132	79	19
Latvia	8.7	0.4	4.8	7.2	4.4	251	81	28	17.2
Lithuania	7.9	0.6	6.4	12.1	7.1	300	98	38	27
Luxembourg	60.0	6.2	29.3	66.8	38.4	n.a.**	278	191	8
Malta	6.4	0.4	4.3	2.3	1.4	n.a.**	72	18	63.9
Netherlands	30.0	2.8	20.2	26.5	15.3	458	148	101	5.6
Poland	14.4	0.7	8.2	14.7	8.9	282	91	52	5.2
Portugal	4.3	0.5	4.1	2.8	1.7	292	94	39	47.3
Romania	9.4	0.5	7.3	19.4	11.2	272	88	42	16.1
Slovakia	24.4	0.7	10.1	24.8	14.7	328	105	59	12.3
Slovenia	23.8	1.2	9.2	22.3	13.7	n.a.**	93	52	12
Spain	6.4	0.7	6.8	8.5	5.1	348	112	46	10.2
Sweden	10.6	0.7	5.5	9.5	6	374	120	38	15.2
United Kingdom	17.6	1.4	10	13.6	7.9	380	122	65	16.2
EU28	17.5	1.2	10.9	21.3	12.6	381	123	70	22.3

Table 2 – Air pollution costs: average damage costs in €/kg emission at national level in 2016 (all impacts)

CLIMATE CHANGE COSTS

The effects of climate change are global, but nowadays cities in EU are suffering from extreme climate events. Long term impacts and risks are difficult to foresee and so are costs related to these effects. Energy use results in emissions of greenhouse gases (mainly Co2, N2O and CH4)

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contributing to climate change, therefore taking into account these impacts is as much complex as important.

In the mentioned sources there is a possible quantification of the costs for CO2 as well as for unit of fuel consumed.

	Low	Central	High
Short-and-medium-run (up to 2030)	60	100	189
Long run (from 2040 to 2060)	156	269	498

Table 3 – Climate change avoidance costs in €/tCO2 equivalent (€ 2016)

Fuel	kg CO_2 per litre of fuel	g CH_4 per litre of fuel	g N_2O per litre of fuel	Climate change cost, €ct per litre of fuel
Gasoline	2.25	0.81	0.26	21.1
Diesel (road and rail)	2.66	0.14	0.14	24.3
Marine diesel oil	2.99	0.27	0.08	27.2
Jet kerosene	2.86	0.02	0.08	26.0
LPG (50% propane + 50% butane)	1.77	1.74	0.01	16.3
CNG (methane)	1.57	2.58	0.08	14.9

Source of emission factors: IPCC Guidelines for National Greenhouse Gas Inventories (Chapter 3).
Climate costs evaluated at central value for CO2 eq.: €90/tonne.

Table 4 – Climate change costs per unit of fuel consumption

OTHER EXTERNAL COSTS RELATED TO TRANSPORT SECTOR

- Noise costs

  In general, noise can be defined as unwanted sounds of varying duration, intensity or other quality that causes physical or psychological harm to humans (CE Delft, INFRAS & Fraunhofer ISI, 2011).

  Noise emissions from traffic pose a growing environmental problem due to the combination of a trend towards greater urbanisation and an increase in traffic volumes.

  The exposure to noise results in a number of health endpoints due to prolonged and frequent exposure to transport noise.

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Lden (db(A))	Road transport			Rail transport			Aviation		
	Annoyance	Health	Total	Annoyance	Health	Total	Annoyance	Health	Total
50-54	14	3	17	14	3	17	34	5	39
55-59	28	3	31	28	4	32	68	6	74
60-64	28	6	34	28	6	34	68	9	77
65-69	54	9	63	54	9	63	129	12	141
70-74	54	13	67	54	13	67	129	16	145
≥ 75	54	18	72	54	18	72	129	21	150

Table 5 – Environmental price of traffic noise for EU28 (€$_{2016}$/dB/person/year)

- Congestion costs

  A congestion cost arises when an additional vehicle reduces the speed of the other vehicles of the flow and hence increases their travel time. Road congestion cost can be defined on the basis of a speed-flow relationship in a given context, for example at an urban or inter-urban level.

Vehicle category	Delay costs			Deadweight loss costs		
Passenger transport	Total EU28 [Billion €]	€-cent/ pkm	€-cent/vkm	Total EU28 [Billion €]	€-cent/ pkm	€-cent/vkm
Passenger car	206.2	4.37	7.03	35.6	0.75	1.21
Passenger car - urban	172.6	11.82	19.03	30.0	2.06	3.31
Passenger car - inter-urban	33.6	1.03	1.66	5.5	0.17	0.27
Coach *inter-urban* *	2.1	0.74	14.49	0.2	0.08	1.50
Total passenger	208.3			35.8		
Freight transport	Total EU28 [Billion €]	€-cent/ tkm	€-cent/vkm	Total EU28 [Billion €]	€-cent/ tkm	€-cent/vkm
Light commercial vehicle	38.5	11.63	8.05	6.6	2.01	1.39
*LCV - urban***	32.6	27.75	19.21	5.6	4.78	3.31
*LCV - inter-urban***	5.9	2.78	1.92	1.0	0.48	0.33
Heavy Goods Vehicle (HGV)	23.8	1.30	17.72	3.8	0.21	2.81
*HGV - urban***	17.6	3.81	51.94	3.1	0.67	9.11
HGV - inter-urban	6.2	0.45	6.20	0.7	0.05	0.69
Total freight	62.3			10.4		
Total road transport	270.6			46.2		

* Only inter-urban congestion considered for coaches.

** Simplified approach based on estimation for cars.

Table 6 – Total and average congestion costs borne by road vehicle categories in the EU28

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Vehicle category	Delay costs			Deadweight loss costs		
Passenger transport	Total EU28 [Billion €]	€-cent/ pkm	€-cent/vkm	Total EU28 [Billion €]	€-cent/ pkm	€-cent/vkm
Passenger car	196.1	4.2	6.7	33.5	0.7	1.1
Urban	160.8	11.0	17.7	28.0	1.9	3.1
Inter-urban	35.3	1.1	1.7	5.5	0.2	0.3
Bus/ Coach	4.5	0.8	15.9	0.8	0.1	2.7
Urban	3.9	1.8	35.5	0.7	0.3	6.1
Inter-urban	0.5	0.2	3.1	0.1	0.0	0.5
Total passenger	200.6			34.3		
Freight transport	Total EU28 [Billion €]	€-cent/ tkm	€-cent/vkm	Total EU28 [Billion €]	€-cent/ tkm	€-cent/vkm
Light commercial vehicle	55.5	16.8	11.6	9.4	2.8	2.0
Urban	46.5	39.6	27.4	8.0	6.8	4.7
Inter-urban	9.0	4.2	2.9	1.4	0.7	0.5
Heavy Goods Vehicle (HGV)	14.6	0.8	10.9	2.5	0.1	1.8
Urban	11.6	2.5	34.1	2.0	0.4	6.0
Inter-urban	3.0	0.2	3.0	0.5	0.0	0.5
Total freight	70.1			11.9		
Total road transport	270.7			46.2		

Table 7 – Total and average congestion costs borne by road vehicle categories in the EU28 according to the simplified approach used

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2 OPERATIONAL COEFFICIENTS FOR THE THREE CITIES

In the following paragraphs, the coefficients to be implemented in the calculation of external costs in the three nations of the lighthouses have been calculated. These could be used in a simplified analysis to evaluate the cost-benefit ratio.

2.1 ELECTRICITY PRODUCTION WITH RES OR ELECTRICITY SAVINGS:

The environmental benefit of the project is calculated on the basis of specific external costs (euro / MWhel) avoided, referring to the production of electricity through national mix. Table A provides the standard values of the external costs of the actual mix of sources, to be considered as benefits of renewable energy plants, calculated for 2016. The external cost values take into account health, agriculture, materials and biodiversity damage associated with greenhouse gas emissions (CO_2, CH_4, N_2O), of six atmospheric pollutants (SOx, NOx, NMVOC, NH_3, PM $_{2.5}$, PM $_{2.5-10}$), of nine heavy metals (Cd, As, Ni, Pb, Hg, Cr, Cu, Se, Zn) and some trace pollutants (dioxins and HCB).

In bioenergy plants, CO_2 emissions were considered void in accordance with the recommended methodologies in emission inventories (neutralization through corresponding absorption of the biomass CO_2).

Once the avoided external costs of the project have been identified, the absolute environmental benefits can be calculated in the technical life of the project.

Pollutant	Hard Coal	Brown Coal	Coal (avrg)	Heavy Fuel Oil	Gas (avrg)	Natural Gas	Derived Gases	Other liquid fuels
NO_x	310.0	360.0	335.0	215.0	114.5	89.0	140.0	180.0
SO_x	820.0	820.0	820.0	485.0	0.3	0.3	0.3	460.0
NMVOC	1.2	1.7	1.5	0.8	2.0	1.5	2.5	0.8
$PM_{2.5}$	9.0	9.0	9.0	13.0	3.0	0.9	5.0	1.0
PM_{10}	20.0	20.0	20.0	18.0	3.0	0.9	5.0	2.0

Source: EMEP/EEA Guidebook on Energy (EMEP/EEA (2010b)).

Table 8 – Pollution factors from electricity production in g/GJ – Source EEA

Electricity mix	RES	Other fuels	Oil	Nuclear	Gas	Coal
ES	38%	1,56%	6,15%	21,34%	19,6%	13,25%
IT	37,3%	1,76%	4,17%	0	44,5%	12,29%
GB	24,5%	2,3%	0,5%	21,13%	42,47%	9,05%

Table 9 – Energy mix for electricity production Source EEA – year 2016 (see following pictures)

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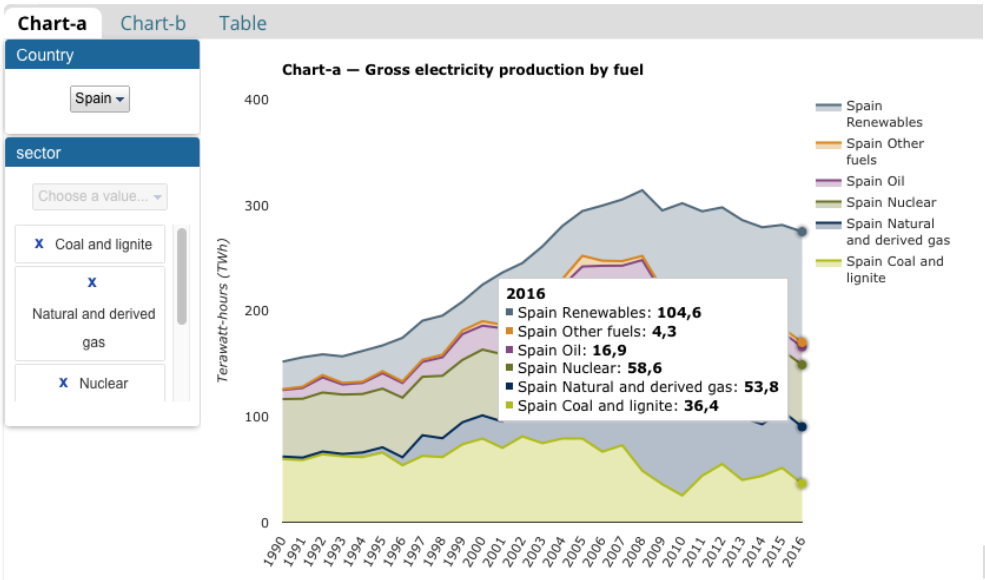
Fig. 2: Gross electricity production by fuel



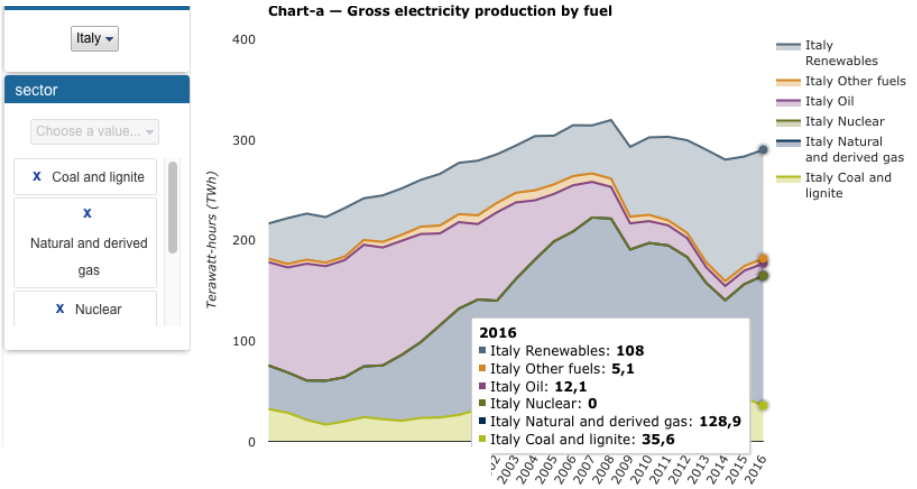


Fig. 2: Gross electricity production by fuel

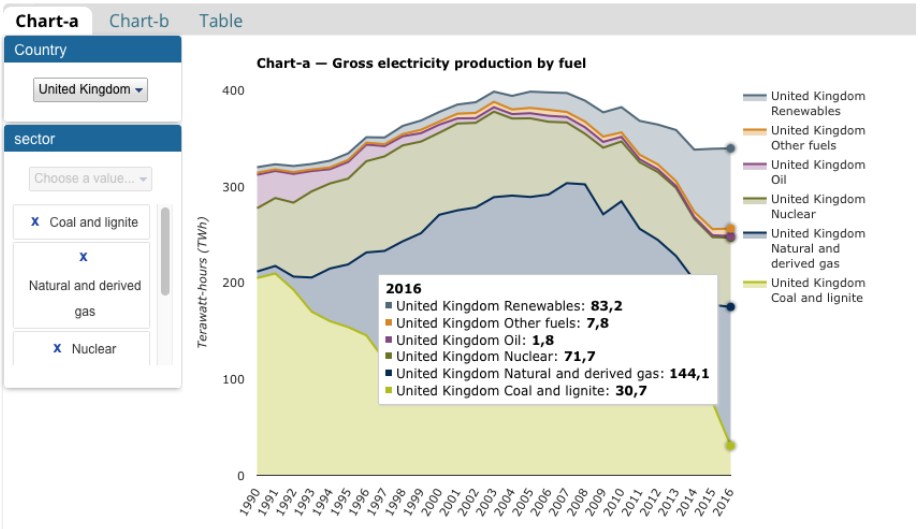


Figure 3 – gross electricity production by fuel in the three nations (source EEA)

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€/kg	NOx	SOx	NMVOC	PM2,5	PM10	CO2
ES	8,5	6,8	0,7	112	10,2	0,95
IT	25,4	12,7	1,1	132	19	0,95
UK	13,6	10	1,4	122	16,2	0,95

Table 10 – Damage costs for emission type and nation

The table above shows the damage costs for each nation the emissions €/kg, prices 2016 (the cost factors have been calculated in detail, based on the NEEDS approach, also taking into account the latest results from other studies; they include all effects: health effects, crop loss, biodiversity loss, materials damages).

In the following table the final result per nation.

Pollutant [t/MWh or g/kWh]	ES	IT	UK
NO_x	0,726705	0,6658092	0,33780834
SO_x	0,5245486	0,4651996	0,3143987
NMVOC	0,00213274	0,0038297	0,0035283
$PM_{2,5}$	0,00939566	0,01090022	0,0079217
PM_{10}	0,13752032	0,12053132	0,0732373
CO_2	0,298	0,344	0,288
€/kWh	**0,012**	**0,027**	**0,010**

Table 11 – final results per nation in €/kWh

For the cost-benefit analysis the final values €/kWh should be multiplied for the total amount of energy produced during the installation life time in case of electricity production by PV or wind; if the action is related to electricity savings, the value could be increased of the 12% due to average transmission and dissipation losses.

If the action involves the production of electricity by biomass plants, the calculations for both emissions and costs have to be done ad hoc considering the specific emissions values of the installation versus the grid mix (reported in the table above per each nation).

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2.2 ENERGY EFFICIENCY IN BUILDINGS:

In energy efficiency projects in heat production, the environmental benefit is given by the external environmental costs avoided in the production of thermal energy in relation to the primary energy of the fuel saved.

The pollutants emitted by civil and domestic heating systems are those typically produced by combustion processes and, as such, depend on three main factors that weigh to a variable extent and are not easily estimated a priori: the type and quality of the fuel , combustion technology and combustion operating conditions.

The nature of the fuel greatly affects the combustion mechanisms, as these are significantly different when a solid, a liquid or a gas is to burn. By way of example only, it can be stated that gaseous fuels (natural gas and LPG), being made up of simpler molecules, can reach a more complete degree of combustion more quickly and easily. Liquid fuels, and even more solid ones, undergo a more complex combustion process. Although even for these fuels it is possible to achieve complete combustion, this is in practice more difficult, especially for solids where incomplete combustion residues are always present both in the solid phase, as residual carbon in the ashes, and in the gaseous phase, under form of hydrocarbons of various nature.

There are several EU standards referred to boilers emissions like EN 297 and EN 483.

The average emission factors at 2016 for domestic plants are reported in the table below.

FUEL	AVERAGE EMISSION FACTORS FOR DOMESTIC PLANTS					
g/kWh	CO_2	CO	NOx	SOx	NMVOC	PM
Natural gas	0,202	0,20376	0,11628	0,00108	0,00054	0,000144
LPG	0,227	0,17208	0,08136	0,00792	0,00054	0,000144
Oil	0,267	0,01332	0,1224	0,06948	0,00396	0,00036

Table 12 – average emission factors in case of domestic plants

The external costs for every MWh produced has been calculated for each of the three nations consequently.

€/MWh	ES	IT	UK
Natural gas	1,20413	3,17873	1,802432
LPG	0,977572	2,40238	1,41967
Oil	2,510794	4,296882	2,662554

Table 13 – thermal energy external costs for fuel and nation

In the case of energy-environmental interventions that lead to a reduction in CO_2 emissions by changing the type of fuel used, the net environmental benefit of the intervention must be calculated with the same heat produced.

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2.3 SUSTAINABLE TRANSPORT:

Transport is the most analysed sector regarding external costs and many data and materials are available at EU level.

For the cost-effective analysis, the equivalent tonnes of CO_2 could be easily calculated starting from the fuels in use and its consumption.

For electric vehicles the emissions are not local and are mainly related to the well to tank aspect

[t/MWh or g/kWh]	Electricity ES	Electricity T	Electricity UK	Gasoline	Diesel	methane
CO_2	0,298	0,344	0,288	0,250	0,268	0,2

Table 14 – CO_2 emissions for fuel in transport sector

Regarding other pollutants, the fossil fuelled vehicles have to be characterised specifically following the emission standards. As in the example below for EURO4:

Vehicle class	Motorization	CO	HC	NO_x	Particulate	Unit
Cyclometers	2 wheels	1	0,63	0,17		g/km
	3 wheels	1,9	0,73	0,17		
Motorcycle	Vmax < 130 km/h	1,14	0,38	0,07		
	Vmax ≥ 130 km/h	1,14	0,17	0,09		
	Diesel or hybrid diesel	1	0,1	0,3	0,08	
Cars and light freight vehicles M	gasoline	1	0,1	0,08		
	Diesel	0,5	0,3 (HC + NO_x)	0,25	0,025	

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Light vehicles N ≤ 1.250 kg Light vehicles ≤ 1.700 kg Light vehicles > 1.700 kg	gasoline	1 1,82 2,27	0,1 0,13 0,16	0,08 0,10 0,11		g/km
	Diesel	0,5 0,63 0,74	0,3 (HC + NO_x) 0,39 (HC + NO_x) 0,46 (HC + NO_x)	0,25 0,33 0,39	0,025 0,04 0,06	
Heavy vehicles	any	1,5	0,46	3,5	0,02	g/kWh

Table 15 – example of emission table for vehicles class

For the calculation of the external costs, several aspects have to be taken into account beside air pollution and climate change, like congestion, accidents, noise, well-to-tank and habitat damage.

For a full description of the impacts and the methodology, please refer to the Handbook for the external costs of transport 2017 (CE- Delft).

The average impacts at EU28 level for passenger transport mode are shown in the following picture (without congestion costs).

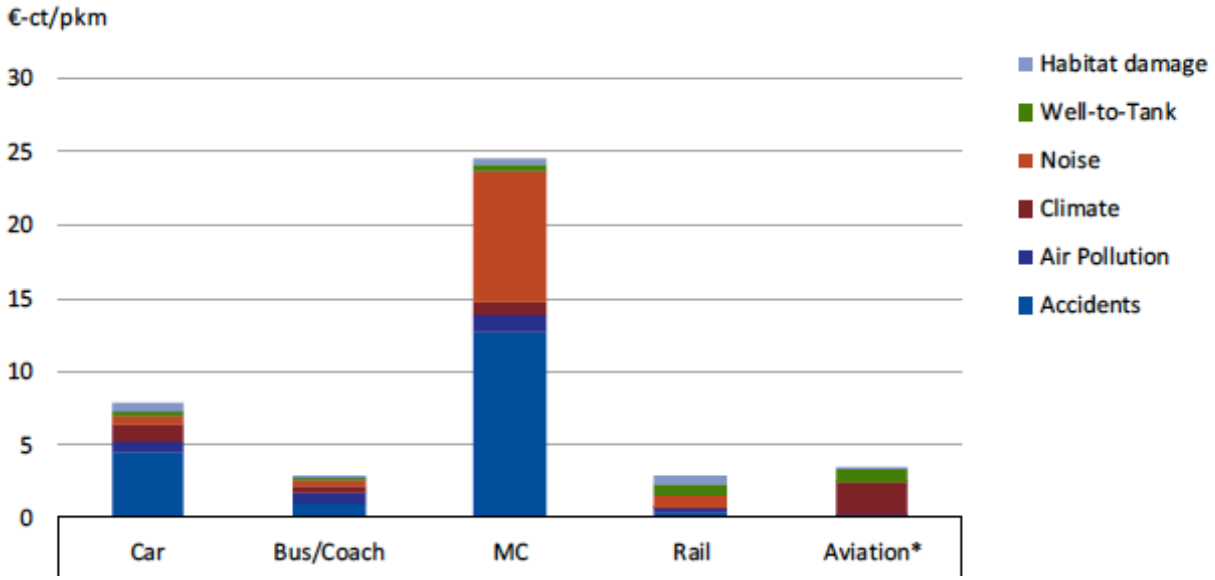

Figure 4 – average impact for passengers' transport mode at EU28 level (without congestion costs)

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Vehicle category	Fuel type	Fuel efficiency (average real-world CO_2 emissions in g/km)	Motor-ways	Urban roads	Other roads	Average all roads
Passenger transport (€-cent per pkm)						
Passenger car	Petrol	2016 fuel efficient car: 99 g/km	0.33	0.38	0.30	0.34
		2016 fuel inefficient car: 180 g/km	0.60	0.69	0.55	0.61
		2000 fuel efficient car: 161 g/km	0.41	0.48	0.37	0.42
		2000 fuel inefficient car: 233 g/km	0.57	0.67	0.51	0.58
	Diesel	2016 fuel efficient car: 89 g/km	0.19	0.21	0.16	0.19
		2016 fuel inefficient car: 119 g/km	0.25	0.28	0.22	0.25
		2000 fuel efficient car: 135 g/km	0.22	0.24	0.19	0.22
		2000 fuel inefficient car: 176 g/km	0.29	0.32	0.25	0.28
	LPG	119 g/km	0.16	0.18	0.14	0.16
	CNG	196 g/km	0.27	0.30	0.23	0.27
	Full electric	0 g/km	0.84	0.84	0.84	0.84
	PHEV - petrol	39 g/km	0.10	0.08	0.08	0.09
Motorcycle	Petrol	Fuel efficient motorcycle: 100 g/km	0.42	0.35	0.31	0.36
		Fuel inefficient motorcycle: 128 g/km	0.51	0.48	0.40	0.46
Moped	Petrol	46 g/km	0.17	0.17	0.17	0.17
Motorcycle	Electric	0 g/vkm	0.10	0.10	0.10	0.10
Bus (18 t)	Diesel	Fuel efficient bus: 954 g/km	0.11	0.18	0.11	0.13
		Fuel inefficient bus: 1,155 g/km	0.13	0.20	0.13	0.15
	CNG	1,007 g/km	0.01	0.01	0.01	0.01
	Electric	0 g/km	0.63	0.63	0.63	0.63
Coach	Diesel	Fuel efficient coach: 583 g/km	0.07	0.13	0.08	0.09
		Fuel inefficient coach: 742 g/km	0.08	0.16	0.09	0.11

Table 16 – Marginal well-to-tank costs for reference vehicles

For the calculation of the external costs, the following table has been developed on the basis of the handbook data.

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	Passenger transport											
	Road									Rail		
	Car petrol	Car diesel	Car hybrid (PHEV)	Car electric	Cars total	Bus	Electric bus	Motor bike	Electric motor bike	High speed train	Electric pax	Diesel pax
Cost category	c€/pkm	c€/pkm	c€/pkm	c€/pkm		c€/pkm	c€/pkm	c€/pkm	c€/pkm	c€/pkm	c€/pkm	c€/pkm
Accidents	4,5	4,5	4,5	4,5	4,5	1	1	12,7	12,7	0,1	0,5	0,5
Air pollution	0,3	1,2	0,06	0,05	0,7	0,8	0,05	1,1	0,02	0	0,01	0,8
Climate	1,2	1,1	0,44	0	1,2	0,5	0	0,9	0	0	0	0,3
Noise	0,5	0,6	0,3	0	0,6	0,4	0	9	0	0,3	0,8	1,4
Congestion	4,2	4,2	4,2	4,2	4,2	0,8	0,8	0	0	0	0	0
Well-to-tank	0,4	0,4	0,15	0,8	0,4	0,2	0,6	0,5	0,16	0,3	0,8	0,1
Habitat damage	0,5	0,6	0,5	0,5	0,5	0,1	0,1	0,3	0,3	0,6	0,6	0,8
Total	11,6	12,6	10,15	10,05	12,1	3,8	2,55	24,5	13,18	1,3	2,71	3,9

Table 17 – Average external costs for EU28 passenger transport by cost category and transport mode

3 REFERENCES:

- NEEDS (New Energy Externalities Developments for Sustainability) project results (FP6 2008)
- Guide to Cost-Benefit Analysis of Investment Projects (2014) – European Commission–DG for Regional and Urban Policy
- INNOVHUB STAZIONI SPERIMENTALI PER L'INDUSRIA: "Studio comparativo sulle emissioni di apparecchi a gas, GPL, gasolio e pellet"
- European Environmental Agency: "Overview of electricity production and use in Europe" https://www.eea.europa.eu/data-and-maps/indicators/overview-of-the-electricity-production-2/assessment-4
- Environmental Prices Handbook EU28 version (by CE Delft)
- EC–DG MOVE "Update of the Handbook on External Costs of Transport", version 2014 (by Ricardo AEA) and version 2019 (by CE Delft)