The Path from Pilot to Scale

collaborating with European smart cities to accelerate the smart cities market.

Co-funded by the Horizon 2020 Programme of the European Union

SMARTER TOGETHER

SHARINGCITIES

REPLICATE

smarter city

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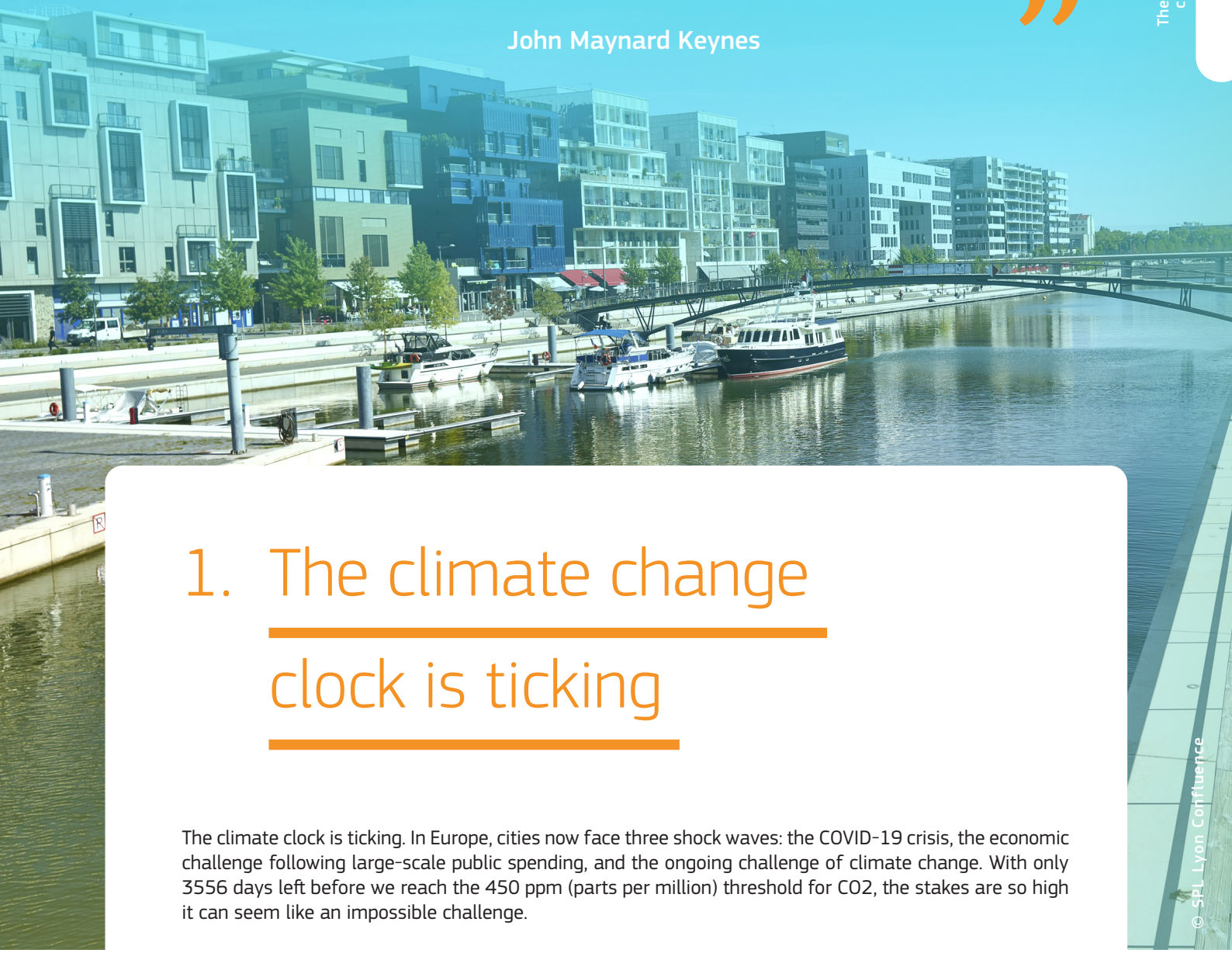
> The difficulty lies not so much in developing new ideas as in escaping from old ones.
>
> John Maynard Keynes



1. The climate change clock is ticking

The climate clock is ticking. In Europe, cities now face three shock waves: the COVID-19 crisis, the economic challenge following large-scale public spending, and the ongoing challenge of climate change. With only 3556 days left before we reach the 450 ppm (parts per million) threshold for CO2, the stakes are so high it can seem like an impossible challenge.

However, we do not believe the solution is impossible. Europe is financing the most extensive smart city research and development programme[1] in the world, in which European values are firmly embedded. Through this programme we have tested a range of concrete solutions that can help us to achieve our ambitious climate goals. Four Smart Cities projects that started in 2016 are about to deliver their results. They demonstrate clearly how addressing the challenges presented by COVID-19 and the climate crisis requires a change of mindset, and there is a need to realise smart, green, and resilient investments on a much larger scale than what we currently deliver. The issue with this is not strictly financial; the financing is available, but it needs to be channelled in a more impactful way.

This short paper summarises our main findings.

1 Smart Cities and Community (SCC01) programme: The programme combines Lighthouse cities who are paving the way with integrative urban demonstrators, combining mobility, energy and infrastructures to develop sustainable districts, and Fellow Cities that are here to learn from the experience of the Lighthouses and replicate successful actions on their own level.

PHOTO: Place nautique et îlots ABC (September 2014) by Thierry Bazin

2. Four Projects, 24 cities engaged in successful energy transition

Our four projects draw together an impressive pool of European cities of all sizes (see map):

Sharing Cities includes some of Europe's largest urban areas (London, Milan, and Lisbon as Lighthouse cities (LHCs) and Warsaw, Bordeaux, and Burgas as Fellow cities). These are thriving cities, three of which are capital cities, considered growth engines for their countries.

In **Smarter Together** (Lyon, Munich, and Vienna and the Fellow cities of Santiago de Compostela, Sofia, and Venice) the project brings together large cities which represent significant economic development in their region.

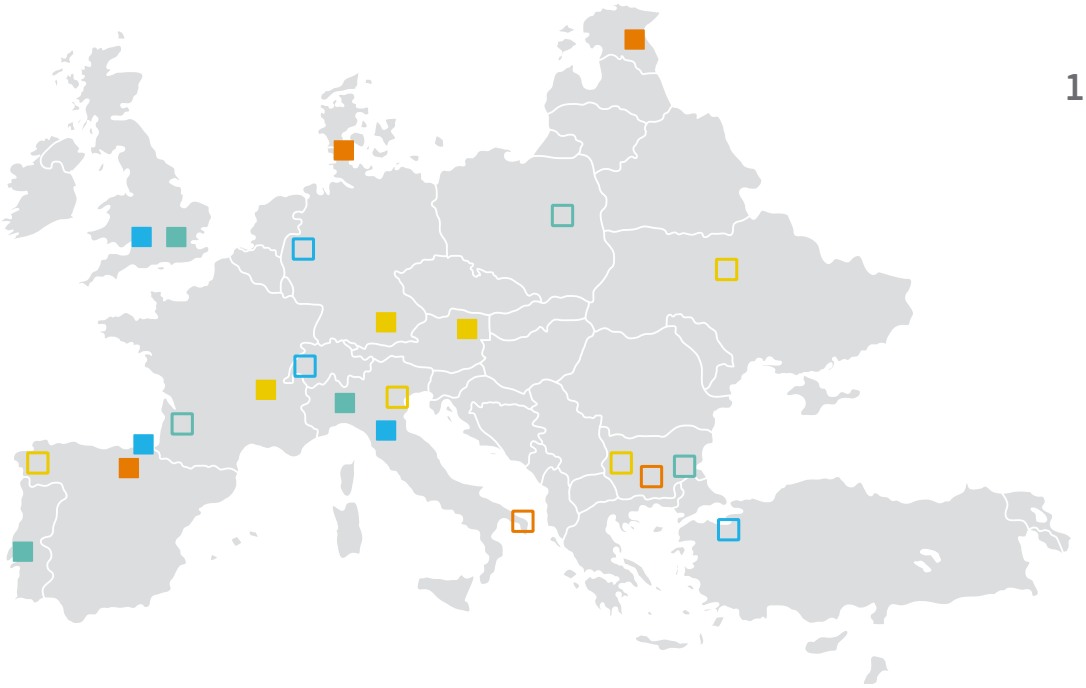
Replicate covers smaller mid-sized cities (San Sebastián, Florence and Bristol, plus Fellow cities Essen, Lausanne, and Nilüfer) that are references for economic development and test beds for their regions.

SmartEnCity is made up of small cities (Vitoria-Gasteiz, Sonderborg and Tartu, with Fellow cities Lecce and Asenovgrad) that are close to their citizens and want to become better places to live.

Our projects address critical urban challenges such as energy use and the need to move towards low-carbon transport systems, with the common objective of increasing citizens' quality of life. The geographical coverage ensures a large diversity of urban and climate contexts.

We also have significant variety in the way the projects are administered. All projects are a partnership of between 20-40 partners from public, private, and academic backgrounds. Sharing Cities and Replicate are led by city authorities, SmartEnCity is led by a private company and Smarter Together is led by a city-owned development agency in Lyon. All these organisations have one shared common challenge – to orchestrate an ecosystem of partners with different strategies, horizons, rationales to deliver a complex portfolio of projects that make the case for smart, low-energy solutions. For cities, it is an important change: rather than simply delivering or operating services, the emphasis is on designing and building them with differing levels of involvement from a wide range of stakeholders.

Project	REPLICATE	SHARINGCITIES	SMARTER TOGETHER	smarter city
Lighthouse Cities	Donostia / San Sebastian - ES Florence - IT Bristol - UK	London - UK Milano - IT Lisboa - PT	Lyon -FR München - DE Wien - AT	Vitoria /Gasteiz - ES Sonderborg - DK Tartu - EE
Fellow Cities	Nilüfer - TR Essen - DE Lausanne - CH	Burgas - BG Bordeaux - FR Warszawa - PL	Santiago de Compostela -ES Venezia - IT Sofia - BG Kiev - UA	Asenovgrad - BG Leece - IT



Total Budget
118 842 739,63 €

Total Funding
68,10 %

The four projects share a vision of what a smart city is or should be

– a city that:

i) is driven by the needs of the city and the quality of life of its citizens, rather than just technology for its own sake;

ii) embeds sound governance based on a PPPP (Public/Private/Partnership/People) approach, not a top-down one; citizens are not just passive recipients but active and key players;

iii) builds on open frameworks and supports ecosystems of innovation bringing together coalitions of companies of all sizes with associations and citizens;

iv) is trustworthy, respecting data privacy and avoiding bias;

v) breaks siloes and is empowered to act in a more agile, innovative, and coordinated way.

3. The Four collective impacts

3.1. Joint impacts and lessons learned

Notes:

- The indicators chosen are measured, not calculated. We have not compared the amount of energy saved, or the reduction of CO2 emissions thanks to the different implementations of the various LHCs. The models for calculating these indicators may differ from one city to another, and the comparison between cities is therefore biased.
- Each LHC completed a template to show one of their projects within Replicate, Sharing Cities, SmartEnCity, or Smarter Together. These templates are available in the Annex section.

3.1.1 Retrofitting and Eco-refurbishment

To achieve ambitious carbon reduction targets, a key area that cities will need to focus on is retrofitting large numbers of buildings that do not use energy efficiently. To address this challenge, eco-refurbishment has been a significant area of action across the Lighthouse cities.

Deep energy eco-renovation projects have a clear environmental benefit in reducing energy use and carbon emissions. They can also lead to consistent economic savings for both tenants and the municipality.

The renovation of buildings of different types in cities and neighbourhoods with distinct social, economic, meteorological, and cultural characteristics has led to a wealth of replication information. Smart systems have also been developed to maximise the efficiency of eco-renovation measures. Across the eco-renovation activities of the four projects, we can draw three main common conclusions.

Conclusion 1: Fragmentation of the value chain can be minimised by providing services such as a 'one-stop shop' for refurbishment activities

Eco-renovation is central to developing neutral or positive energy districts, but the value chain can be fragmented. This means that business models are hard to define and the benefits hard to quantify. However, the complexity can be decreased by providing renovation on demand.

The four projects have tried to develop this approach by from the start involving the various technical specialists, housing union leaders and residents, and by continuing this engagement throughout the project and post-retrofit. The constant exchange of information and a bottom-up approach are critical to implementing eco-refurbishment projects successfully. It is particularly important to collect information about residents' needs, to co-design solutions, and to gain their support from the design stage and throughout the process.

Supporting residents to address all the financial, legal, technical, and human issues they may encounter is also important. In terms of human factors, residents' changing habits and how they use energy is critical to a building retrofit's long-term success. The post-retrofit stage plays a crucial role in making retrofit interventions effective beyond their limitations in time and resources.

Conclusion 2: Developing in-house structures to achieve large eco-renovation projects successfully

Lyon (Smarter Together) and Vitoria-Gasteiz (SmartEnCity) have used specific entities to coordinate successful eco-refurbishment projects. These structures have been relevant to maintaining good relationships with different stakeholders, especially the residents.

SPL Lyon Confluence (SPL) is an agile special-purpose public company dedicated solely to the Confluence district's redevelopment. SPL can form close relationships with residents and local businesses, easing the creation of public-private collaborations and producing more ambitious operations in partnership with many stakeholder groups. SPL, in partnership with the Hespul non-profit association, coordinates deep thermal building refurbishment projects and distributes subsidies to private groups of building owners.

In Vitoria-Gasteiz, VISESA (VIS) is a public company with an innovative role. It acts as a 'delegate promoter' of the retrofitting actions on behalf of the communities of homeowners. Through agreements signed between both parties, VIS manages, contracts, supervises, and finances the correct design and execution of the refurbishment works, delivering the final product 'turnkey' to its owners and charging them the total cost minus subsidies received. VIS also manages the different administrative tasks to receive the subsidies (application, justification, etc.) as a one-stop-shop agency.

Conclusion 3: Keeping a holistic vision for implementing eco-refurbishment projects

Considering a city district as a whole complex ecosystem with multiple stakeholders, each with complementary objectives and priorities, is critical before implementing district-level and eco-refurbishment projects. Interventions need to be planned from a holistic vision aligning the public-private stakeholders' goals in a way that can only be achieved through collaboration. Each building could also be considered as an ecosystem, having its own architecture, conditions, use, population, and context. Thus, it requires significant preliminary work in the design phase (identification of all the building's main sources of energy loss, development of tailor-made technical solutions, etc.) to reach an agreed common solution that will fulfil all the stakeholders' objectives and expectations.

Best practice: the example of Tartu

In Tartu, the average energy consumption of the lighthouse district buildings is currently about 270 kWh/m² annually. The target level is 90 kWh/m², reducing energy consumption by more than 66%. This ambitious goal is not achievable by only using standard insulation technologies. A combination of different measures is needed, including ventilation with heat exchangers and consuming local photovoltaic production. All the technical solutions will be accompanied by modern digital technologies for the best outcome. Intelligence has been conferred on the buildings via a Smart Home system to regulate indoor climate and monitor energy consumption. Smart home solutions have been installed in all renovated houses, and the systems are currently being adjusted. Also, a socially innovative ambassador programme has been set up whereby representatives of apartment associations teach residents how to use modern technical systems to ensure a healthy indoor climate in their apartments. This demonstration project has significant potential to replicate in Eastern Europe, particularly for the numerous Soviet-era apartment buildings.

3.1.2 Energy transition

Renewable energy production is essential to improving the energy balance of a building and in achieving zero-energy-emissions districts. All four projects have increased energy production (heating and electricity) from local renewable sources: biomass, geothermal, waste-to-energy cogeneration, and photovoltaic systems.

Some of the Lighthouse cities have also used IT to efficiently manage energy flows, by developing energy management systems. The implementation of these measures produced the following lessons:

Conclusion 1: District heating is one of the most promising methods for achieving carbon neutrality.

Supplying a district with heating and cooling is usually done by three competitive grids: electricity (which also powers most of the building and housing appliances), gas, and district heating. The district heating market share is extremely diverse across various European cities and depends on many different factors. However, a district heating network powered by renewable energy seems promising in relation to positive energy districts, and there is certainly room for progress in terms of market share.

Developing more sustainable districts requires establishing a strategy to define the proper balance between a set of objectives: sustainability, security of supply, and price control to limit increases in energy poverty.

In terms of achieving low prices to avoid energy poverty, connecting a group of buildings to a single heating network makes it possible to reduce maintenance that needs to be carried out by specialist staff, and also primary energy procurement costs. Fewer technical incidents are typically observed, which also reduces corrective maintenance costs. Finally, the investment required in each building is reduced, since much of the central heating system is removed. There is no need to invest in the building's gas network, and this contributes to better use of floor space.

Conclusion 2: Reaching a critical mass is crucial.

The scale of a district is significant in establishing energy sharing, mutualisation between buildings and benefiting from smart building management systems and technologies such as blockchain management of a district's energy consumption – even allowing some financial trading of surplus energy.

Technical innovations and IT solutions must be supported by citizen participation, stakeholder involvement, or governance learning. When planning for such developments it should be noted that it can be very time-consuming and complicated to implement photovoltaic system installations, cogeneration and other renewable heating generation sources.

Conclusion 3: Energy effective solutions

To achieve better operational performance, public private partnerships (PPPs) have often been introduced in relation to the management of clean coal district heating, as a value for money (VfM) solution.

In San Sebastián, Fomento San Sebastián has worked in a close public-private collaboration with the technical lead partner of the intervention. In this business model, property and responsibility for the service are public, while technical work is private. The public driver has been crucial to the success of the activities, providing greater security and confidence for residents, and setting the rates to be paid by users. Consequently, the policies that govern the operation of the systems are also public. The district heating covers not only the demands of the new houses that have been constructed, but also the retrofitted ones that are part of the integrated action through a public-private model.

Best practice: sustainable energy management systems in London

In the London demonstrator area, deep retrofits include installing renewable generation combined with the latest energy management control technologies including connected monitoring and control, the Internet of Things (IoT) and sustainable energy management systems (SEMS). This is on top of standard retrofit measures to boost energy efficiency.

SEMS is an integrated energy management system that links a whole ecosystem of energy assets, allowing energy managers to control and optimise energy use. Energy assets can include:

- energy producers like solar panels and heat pumps/heating networks,
- energy consumers like lamp posts,
- electric vehicle charging points,
- household appliances like washing machines and dryers.

The SEMS works by collecting data from a range of energy assets, combining it with external data such as weather and market pricing, and applying advanced processing. Predictive controls provide suggestions for how best to operate this energy asset network and what is most optimal. The 'optimal' solution depends on the policy goal of the city or authority, which could include minimising carbon emissions or costs. Analysing and visualising multiple energy assets and uses also helps energy managers understand existing energy production and use patterns to forecast future energy use.

Best practice: community engagement for designing smart and energy efficient houses in Bristol

Bristol has created a successful model placing power within communities around project design and decision making in its smart homes delivery. This represented a new approach for the city council creating the co-design of the 'mobile future home' which engaged communities in an innovative and interesting way to help educate about the benefits of energy efficiency and smart measures being installed in their homes. Co-designing and co-creating solutions with citizens and has also been used in the demand side response interfaces to ensure there is a better understanding of financial and energy savings that can be made and is helping to tackle fuel poverty issues.

3.1.3 Innovative mobility solutions

Traditionally, urban mobility has been viewed through the lens of competition between private vehicles and public transport. The levers that enhance the public transportation modes were mostly public transport growth, constraints on personal vehicles (parking, traffic, etc.) and financial incentives. COVID-19 has served to intensify the conflict between private vehicles and public transport, and increased the need for innovative and alternative low-carbon transport options. In this sense, the cities have among other things deployed electric buses, charging stations and various car-sharing systems.

The future of mobility will be soft, electric, and personalised, combining micro-mobility (bikes, scooters) and macro-mobility (shared vehicles, public transport) to give users an on-demand experience. The new mobility measures developed by the four projects have been invaluable in identifying common barriers and challenges to achieving this.

Conclusion 1: Developing Mobility as a Service (MaaS) models and thinking 'end-user experience'

Implementing efficient mobility solutions requires a massive change of mindset from public transport operators, shifting towards a Mobility as a Service (MaaS) model. We have seen this model arise in cities such as Munich and Vienna, where mobility stations are located near to large public transport nodes complemented by a portfolio of mobility services (e-bikes, shared e-cars, e-vans, and multimodal information). The competition element between cars and public transport is also shifting and the end-user experience is now critical. Competition in the micro-mobility field is thriving. Nimble and agile companies can pop up with solutions that, whilst not always sustainable, present a good option for the end-user. Cities can continue to regulate, but must also be agile to develop micro-mobility services successfully. A new way of thinking and a new skill set is required to provide this deployment.

Conclusion 2: Electricity is not the only alternative to gasoline and diesel

Electricity is not the only energy alternative to gasoline or diesel. Indeed, in Sonderborg two new biogas plants will fuel buses and other heavy transport vehicles. The idea is to establish a positive closed-loop effect, much like that of a circular economy. The biogas comes from a local pig farm, and the waste material is used as fertiliser.

Conclusion 3: Match mobility solutions to a city's characteristics

Lisbon's hilly landscape meant a traditional bike scheme would not be sufficient. The city's topography also makes it expensive to redistribute bikes. Therefore, using e-bikes that could assist with cycling uphill and the construction of safe cycling infrastructure was an effective method to increase bike use and build a cycling culture in the city.

Lisbon's bike share scheme is station-based. The docks can receive both conventional and e-bikes. However, Lisbon's docking stations are innovative as they provide enough power to charge batteries, as the scheme was built from scratch – unlike many other docked bike schemes where recharging must be retrofitted and batteries swapped out manually. The demand for the Lisbon bikes has been impressive. Starting with 500, the scheme has now expanded to over 2,000 and is still growing.

Best practice: A holistic technology approach for smart mobility in Florence

The transport sector in Florence required substantial, integrated action to achieve a significant level of financial saving. The priority was to deploy measures around infrastructure to achieve the city's 2030 targets. The municipality and its partners had developed smart grids to increase the number of public charging stations and satisfy the requirements of the new e-taxi fleet (+100 e-vehicles with a 25% discount on licence fees); implement six reserved very fast recharging points (20 minutes for a full charge, with an app for booking); and promote agreements with e-vehicle providers. New taxi services for night-time use and vulnerable people were promoted. The city also improved its Electric Mobility Management (EMM) system, managing the charging network and equipping its smart lighting infrastructure with cameras to control traffic and access to limited traffic zones. The traffic management platform underwent cybersecurity testing and was linked to the public information system (web, app, and street panels) and the smart city control room, enabling it to collect and process real-time information from many different sources.

3.1.4 Urban data platforms

Bristol, Florence, London, Lyon, Milan, Munich, San Sebastian, Sonderborg, Tartu, Vienna, and Vitoria-Gasteiz have their own operational data platforms, while Lisbon has already developed a prototype to procure a city-wide platform. The urban data platforms implemented by the four projects may have different aims, but even so, we can draw common conclusions:

Conclusion 1: The data platform strategy deployed must be 'data-informed' and not 'data-driven'.

Smart cities have been frequently portrayed as technology- and data-driven. It started with IBM and other technology providers, and can be seen today, for instance, in experimental AI smart cities in China.

As said, this project has taken another position. The technology is not an end, but a means to reach a more informed decision that can help optimise the city's public services management and enhance the ecosystem's involvement to co-create, design, build and run better services and applications. Projects have striven to demonstrate the relevance of this approach to testing and learning new cooperation models between public, private, and people.

Conclusion 2: We need to shift from experimentation to scaling.

Urban data platforms often appear to be still in their infancy, which is surprising given the seemingly rapid and profound changes in the digital economy and the potential of their uptake.

Several barriers were encountered and overcome, including:

- **Slowness in collecting, sharing, and processing the data.** This work is handled by IT experts, and so the operational departments are totally dependent on their efficiency.
- **It is not a problem of privacy:** Privacy and ethics are vital pillars that require addressing.
- **Urban data platforms need a business model:** we can expect excellent outcomes from this new infrastructure, through improving city management systems; achieving energy efficiency goals; providing the local ecosystems with a factory floor to build better services; stimulating social interactions; and contributing to more prosperity and well-being. However, business models are challenging to establish for urban infrastructure such as electricity and roads.
- **Urban data platforms as public infrastructure or common goods require a different approach from buying a digital platform from a provider,** even in a platform-as-a-service model:
  - *First, in positioning the added value of the platform and explaining why we need it: for instance, to improve the efficiency of utilities, or to target personal interactions and improve the quality of life.*
  - *Second, designing the platform on open-source components and through open innovation.*
  - *Thirdly, guaranteeing citizens the ownership of their data without allowing them to trade this data. The idea is to share data in the public interest and for missions that have a real impact on quality of life, such as tackling the COVID-19 pandemic.*

The pilots developed below have taken this learning into consideration. They have not started from a 'grand and theoretical vision' but have focused on concrete use cases to build a response that can later be extended to other smart cities.

Best practice 1: A smart data platform to accompany renovation activities in Munich

Munich authorities tracked and measured renovation activities using a data platform to collect and analyse data. GDPR-compliant contracts were made with the apartment owners to allow energy data collection and analysis for individual flats and whole buildings.

Implementing the smart data platform created experience around the end-to-end collection and treatment of smart city data and the required architecture for such a platform. These now serve as replication blueprints to design and implement an operative Munich Digital Twin and an urban data platform to support a multitude of current and future smart city use cases around traffic, climate change, innovative city development, and others.

Best practice 2: Digital citizen engagement – Milan's SharingMi platform

SharingMi is a social media platform which brings together Milanese citizens, encouraging them to share stories, experiences and ideas, to grow awareness, stimulate action around urban challenges, reframe and normalise sustainability, and encourage them to make positive changes. It has proven very popular in Milan, with a thriving community and over 3,000 downloads to date.

On the platform users can find lots of different ways to get involved, from volunteering to eco events, tips to reduce waste, etc. They can also post questions or direct other members to sustainable projects happening in Milan, and celebrate their actions with the SharingMi community.

To encourage users to participate, the system has a reward system and a 'challenges' section. Citizens earn 'claps' that can be boosted by connecting their SharingMi account to third-party apps that measure activities like walking, cycling, and in-home energy management. Claps are then converted into points redeemable at various businesses, both local and global, via the app. Users also receive sustainable goods and services from 'reward partners' of the app.

3.2. Lessons learned by the four projects

The four projects addressed similar challenges. Below are lessons that were collectively learned about building smart cities because of our programmes:

3.2.1 The challenges affecting our smart city projects.

The four projects addressed the same barriers, ranging from governance and management issues to sustainable business models and financing. We can identify the following:

1. **Mindset and working habits of cities can prove unsuitable;** smart city projects challenge orthodox ways of working. Cities are organised to deliver services traditionally. They are democratically accountable and have their own organisational histories and cultures. Some have intensive human resource development and structures that are change agents; others have been weakened through decades of privatisation and budget reductions. All are working in a specific societal environment with citizens who have a range of expectations. Creating holistic, collaborative and interconnected smart cities that can address the urgency of climate goals requires a change of mindset for public administrations, strong leadership, and a genuine commitment to new ways of working.

2. **Our consortia are composed of different and complementary entities with a common objective.** Even if we share the same goals, project implementation requires soft skills to deal with differences. Cities are, as far as the European tradition shows, subject to ethical norms and are accountable to voters, whereas companies answer to their shareholders as long as they operate within the law. Citizens balance their shared common values with the immediate needs of their daily lives. Those might be either objective (poverty, exclusion, unemployment, housing crises, etc.) or subjective (habits of life, mobility, or housing). There is a need to merge a long-term vision with short-term expectations and capacities.

3. **The four projects have built and demonstrated pilots in a living environment.** By testing in a real-world environment, we have been able to see how this technology would work if it were to be scaled up. The challenge is to shift from the pilot stage to wider adoption, extending, for instance, the lessons learned to the 33 boroughs of London, the Lyon Metropole, or San Sebastián as a whole. This requires sound business models, scale, and acceleration. Politicians' engagement is also of the utmost importance. But it will not occur if the changes mentioned above do not happen rapidly. Business models – not a tool often used by city officials – describe the value chain to deliver a value proposition to customers or citizens, and how the value can be created and captured. Most of the business models we have implemented show value creation. Cities seem to face a kind of innovator dilemma. When faced with disruption, cities are torn between two options that are equally unfavourable. On one hand they can protect legacy activities, at the risk of jeopardising the city's future by dismissing potential disruption. Alternatively they can bet on disruption, without being certain that this will ever create a market, and at the risk of jeopardising legacy activities.

4. **Different economic reasoning and language between public officials (budget) and the investment community (business model) can hinder replication goals.** The funding gap paradox is still there! On the one hand, cities have a portfolio and pipeline of projects that require funding. Even large cities cannot commit to finance everything. On the other hand, money is abundant and in dire need of finding secure investments. Smart cities projects represent valuable investments as they can be certified as secure and green.

5. **Uncertainty and risks are inherent to experimentation, creating a challenge for risk-averse cities.** Even if cities are risk-averse, the pilot projects' value relies on experimentation to test new concepts on a small scale for future scalability. Smart cities combine traditional infrastructure with disruptive technologies that transform relationships between people and the urban environment. These technologies include automated and autonomous vehicles; cloud-based management services to improve delivery of municipal services; and lighting systems with embedded sensors. Innovation frequently happens not following a linear approach but by making mistakes or learning from mistakes. As David Bowie, one of our great 20th century innovators, said: *"I don't know where I'm going from here, but I promise it won't be boring."*

3.2.2 Does city size matter?

Each programme is quite different in terms of the size of the cities involved, from London, with a population of nearly 10 million, to Sønderborg, with a population of 25,000. Size impacts how easy or difficult it is to build a smart district and scale up what works. On the surface, London, with its unrivalled access to finance, should be able to implement technology and scale it up easily. This is true up to a point, but sometimes it is more effective to be medium-sized or small.

Small cities
(up to 100,000 people)

Smaller cities often have less easy access to the resources needed to transform into a smart city. Those resources include access to finance, local expertise to design and implement innovative technologies and complex projects, and the confidence to engage with a new and emerging sector. Furthermore, small cities may not have leaders who readily embrace innovation and may struggle to act autonomously if they are part of a broader region.

However, despite these hurdles, small cities do possess some significant advantages over their larger neighbours. Firstly, the cost of deploying technology city-wide is much lower. Large cities will need private investment. Small cities can sometimes use grants or small pots of private investment that are easier to obtain, and less risky. Secondly, interventions delivered in a small city can have a much more visible impact on the citizens. It is also simpler for small cities to engage with their citizens and maintain meaningful engagement, especially when population churn is low. Indeed, on a smaller scale, the concept of a smart ecosystem, combined with a circular economy approach, is much more viable than it is in a large city.

Medium cities
(100,000 - 500,000 people)

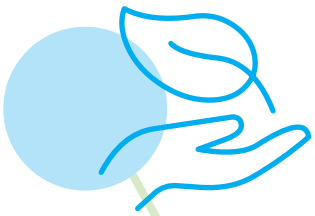
There are still potential issues with access to finance in medium-sized cities, and the development of solutions locally, but these problems are less pronounced than in small cities. Often, local businesses will be able to engage in the design and implementation of solutions, though the market will be limited and skills may still need to be sought elsewhere. Cities at this size will find themselves in competition for resources with lots of other similar cities, as well as larger ones, and need to identify their strengths to compete. On the other hand, medium-sized cities must achieve the transition to becoming smarter and more sustainable as this is where most Europeans live. Making upgrades to transport networks and buildings should be possible at a scale where investors and governments are interested, and the lessons learned can be replicated in multiple other locations.

Large cities
(over 500,000 people)

Large cities have the advantages of critical mass and scale. Most will have important financial centres and access to private investment. They will enjoy access to a range of skills and expertise locally, and have the capacity to engage with the marketplace with some confidence. In many instances they will be businesses' largest customers, and thus will shape the market. Due to their size, they will have piloted multiple types of technology and understand what works most effectively. However, being a large city is not always an advantage, particularly in the larger cities with fragmented administrative systems. For example, there are 33 boroughs in London who each have a population of over 300,000 and an autonomy to match. This means that scaling up involves multiple stakeholders and cross-cutting political consensus, which is often difficult to achieve when working with innovation. Also, the impact of pilot projects in a large city is almost impossible to measure effectively, as there is so much 'background noise'.

3.2.3 Main levers to use in smart city projects

Regardless of the city's size, there are some common aspects of delivering smart city interventions that impact all municipalities. Through our SCC01 programmes we have experienced these factors, and we have captured our learnings here.

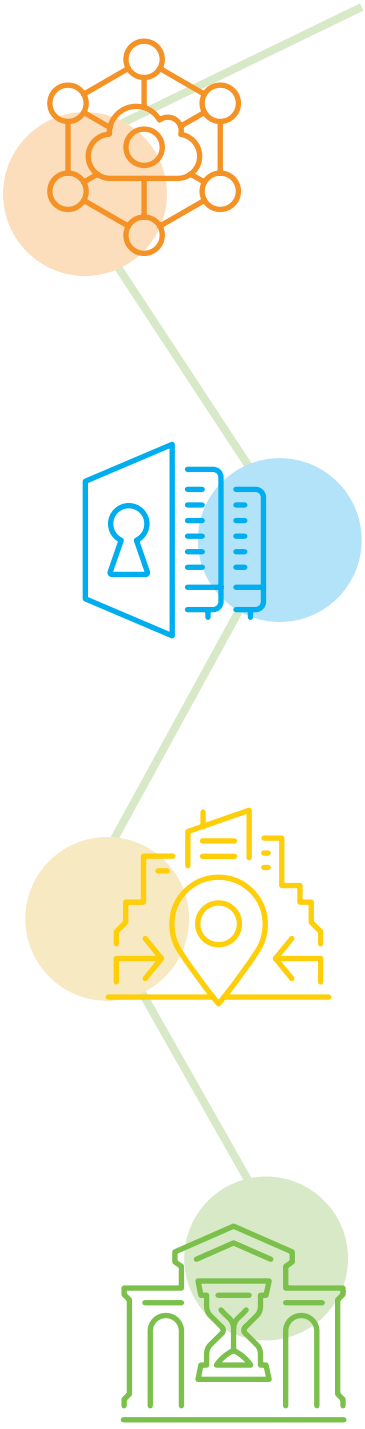


Ecosystem approach - the smart city marketplace suffers from a solution-first approach. Solutions are often designed and then retrofitted to different cities. This sometimes works, but often it does not, leading to interventions that do not make it past the pilot phase. The SCC01 programmes have adopted an outcome-led approach to designing, testing, and implementing smart city solutions, and this has resulted in better solutions adopted by the cities.

Collaborative partnerships - Alongside an outcome-led approach, the 2016 SCC01s also demonstrated the power of collaborative partnerships between public, private, and academic organisations. By working together from the beginning, these cross-sector partnerships have delivered effective technical solutions to city challenges. They have helped build up technical capabilities and capacities in our cities that will continue once the grant funding finishes. This approach should be central to a smart city, since smart collaboration is just as important as smart tech.

Leadership and governance – Project management, leadership, and transversality are strongly needed to simplify the complexity behind the city machine and allow stakeholders to understand and overcome differences in regulatory frameworks and social, economic, and geographical features of cities. Creating a sound governance for each project was the first step of the 'Four'. It appeared critical for the projects' success and their roll-out to convince decision-makers. Social scientists, designers, anthropologists – and social skills generally – are as essential as engineers.

Citizen engagement -The Lighthouse programme has increased our understanding of how to engage with citizens. The subject of smart cities can be a difficult one on which to engage with citizens. There are understandable concerns regarding privacy, surveillance, and health-related issues regarding new and innovative technology, not helped by a large amount of false information that can be found online. When making any intervention, it is essential to engage with citizens from the very beginning. Involve them in the design, testing, and implementation, and make sure you take the time to explain what you are aiming to do and how their data will be used.



Data standardisation - The generation and analysis of data make the infrastructure that we test 'smart', and we have all learned several lessons regarding data collection and use. The need for standardisation is one of the most important lessons. To unleash the value of big data, you need to analyse multiple data sets over various areas. It is tough to do this when data is collected in different ways against different measurements. Indeed, when writing this report, it became apparent that all the programmes had collected information on their impact in different ways! Several cities have used the opportunity of the Lighthouse programmes to standardise the way they collect data in their cities, and have used this as the basis of data sharing agreements locally.

Data security and privacy - GDPR was introduced in the middle of our projects, so we have explored how we ensure that we honour this regulation. A few of us have tested privacy impact assessments, which have worked well, and have found that smart infrastructure needs careful consideration, particularly when collecting data on people's location. With the rise of cyberattacks, we must also ensure that this technology is as secure as it can be.

Replication and additional funding - The four stories show the ambitious replication plan needed to help cities tap into both their own funding and private investment. This is the only way to avoid the pilot trap of failing to connect successful innovation and pilot schemes to large-scale investments and purchasing decisions. The objective is close: some projects have already succeeded in raising private and public investment at a rate of ten times their own budgets. Sharing Cities has recently announced that the project will raise 250 million euros of additional funding.

Investment and financing - Through designing and testing technology, we have created multiple business models for different smart technologies in different regulatory scenarios. This has shown that there is a clear return on investment for many kinds of technology, and that these technologies also deliver substantial environmental and social benefits. In conversations with the investment community, they have signalled a willingness to invest. From the supply side, there is a need to make projects more bankable for decision-makers such as city representatives and investors. They need investable business models in place. This suggests that more work is required to improve how we create business models for innovation to unlock investment. There is also a need for scale, which can be fulfilled through various means:

- Accelerate project deployment by 'packaging' the main components and leaving a place to tailor differentiation according to the particular needs of individual cities or districts. All things being equal, this is a similar approach to that of the automotive industry.
- Pool or bundle projects at different phases until they reach a critical scale. This can be a way to attract more financing in cities where the scale of individual projects is not large enough to interest external investors.

4. What's next: scaling up SMART solutions across Europe and internationally

Through collective effort and demonstrating our experiences, the four projects and, more broadly, the Smart Cities and Communities projects are paving the way for widespread implementation of smart city technologies and contributing to change the way cities address future challenges. Capturing and spreading this knowledge is also at the core of our projects' ambitions. Our collective experience is meant to be used in cities throughout Europe and beyond to set their path towards decarbonisation and improved quality of life.

The challenge is now to shift from pilots to broader adoption. The four projects represent 24 cities. The Smart Cities and Communities network covers more than 116 cities, and the movement is growing. Next should come the upscaling and acceleration phase, but how to do this in a concise time frame?

We believe it can be done by leveraging our experience around the seven recommendations below:

Being pragmatic and bold.

We hear many bright speeches and read many inspiring reports regarding decarbonisation. Who knows? Maybe the pace of technology will allow us to achieve dramatic improvements. But at the city level we should be pragmatic, implementing at a broader scale the lessons learned in pilot phases to replicate within metropolitan boundaries and beyond. Cities are the only living things that do not die, but they are extremely slow to move, and they tend to forget. We have accumulated an impressive set of competences and methodologies; and we have a pool of talented people that can be used in areas in dire need of energy transition.

Change the ways of working.

Cities are here to exploit and deliver fully functional daily services with economies of scale. With digital transformation, this is becoming less and less true. Citizens are critical players to mobilise (see the rise of the on-demand and sharing economy). Dealing with these complexities requires more agility, design thinking, multidisciplinary tools, and more community innovation schemes or approaches. To make an analogy, what could happen if we harness the pandemic mindset that has delivered us COVID-19 vaccines in less than a year? Creating and distributing vaccines is a complex coordination problem, though not as difficult as creating a climate-neutral city, and would not have happened without substantial public backing, open science, and innovation. The power of necessity can mainstream new ways of working and help to accelerate a systematic transition for cities to more sustainable models.

Bridging the gap between innovation and scaling to the market.

We need ambitious plans at each metropolitan level, but it takes time. Meanwhile, money is there, and can find good projects: but according to investors they are often too slow, too small, or not packaged well enough. We can see another echo from the cities, of course. But they are somewhat reluctant to explore new financing paths by leveraging their assets or pooling projects in portfolios.

Accelerate the completion of the project by creating in-house companies or purpose-driven vehicles.

Public administrations/municipalities are too slow to implement a massive transformation at the required speed. Therefore, the role is given to private actors, which exploit the territory. We know that public developers, for instance, or specific in-house public companies can work with more agility, recruit the right talents and resources, and more efficiently find deals with private partners or investors.

Simplify everything.

This is the first principle for a designer: products and services should be easy to use and easy to sell. We must do the same thing and adopt an on-demand approach to deliver services. The same goes for providing information to decision-makers; we live in an attention economy!

Deploy new urban data platforms that are more focused on open source and components, with new forms to share and use data with citizens.

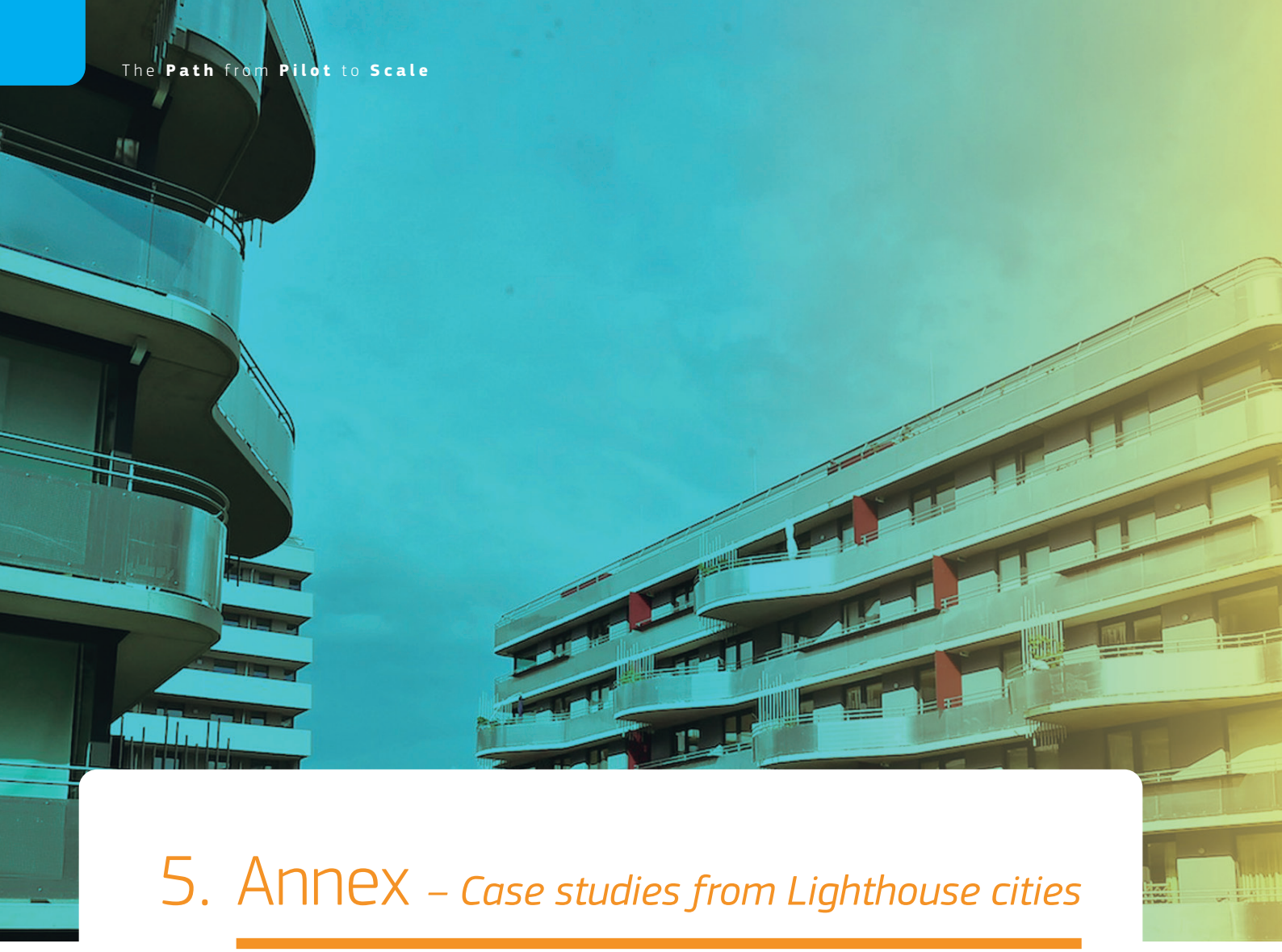
This is essential as the uptake of artificial intelligence increases.

Focus not on energy transformation but on well-being and resilience.

What we have learned from our projects is that the need for energy transition is not an appealing message. Well-being and resilience, which have more resonance, are certainly concepts better able to capture the attention of citizens and encourage their involvement.

The Four and the 18 Smart Cities projects have built up an impressive bank of knowledge. At the moment, however, this looks more like a bazaar rather than a cathedral. It is intuitive, use-case driven, and adapted to cities. But it does not yet solve the investor's dilemma: how to reach scale. What works in Paris may not work in Berlin or in Prague for an investor or a venture capitalist.

Solving the investor's dilemma involves dramatically accelerating knowledge transfer and significantly developing a packaged approach. By transforming this SCC-01 common knowledge into practical building blocks, and addressing the main challenges a city can face in developing and deploying smart solutions (business model procurement, technical specification), we will help other cities in Europe and elsewhere not to have to reinvent the wheel, and allow them instead to focus on the needs of their citizens. This will help the transition to scale by reducing the time needed to develop the projects and provide visibility to investors.



5. Annex – *Case studies from Lighthouse cities*

Each Lighthouse city has chosen to present one successful project within its respective H2020 project.

This section synthetises the different successful projects, in the following order:

- REPLICATE — *Replicate*
- SHARINGCITIES — *Sharing Cities*
- smarter city — *SmartEnCity*
- SMARTER TOGETHER — *Smarter Together*

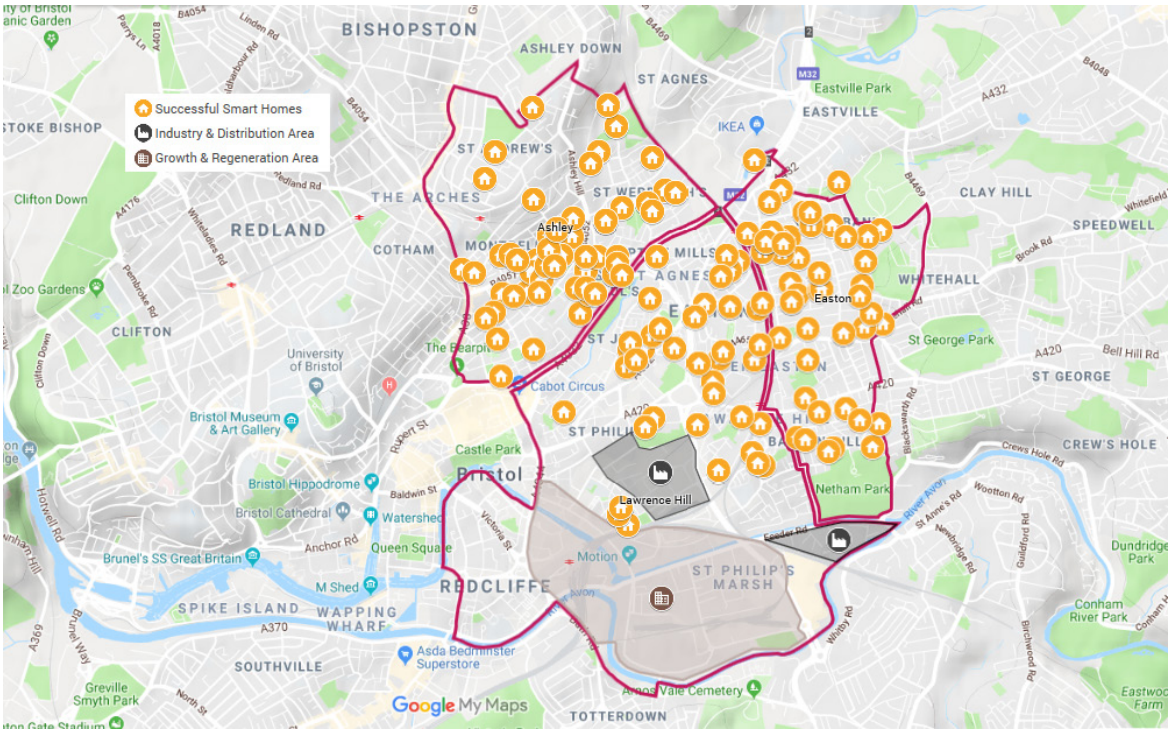
Bristol (UK), Replicate

CITIZEN AND STAKEHOLDERS' ENGAGEMENT WITHIN SMART HOME PROJECTS

Description of the urban context of the district and the project

General description

Bristol has an extremely diverse population. Many of those who would stand to benefit most from what a smart city can offer are furthest from engaging in it. For example, in future if you do not know how your home appliances work with dynamic tariffs, you may end up paying even more for your household bills. In the Bristol pilot areas of Ashley, Easton and Lawrence Hill, the population provides a true representation of the city. It is a culturally diverse area with a mix of housing stocks, and with two areas in the top 10% affected by fuel poverty.



Description through the prism of the thematic action carried out

The Replicate Smart Homes project was co-created with a community engagement approach that has empowered community organisations and individuals to take the lead on engaging citizens.

The smart homes team working with community organisations led by Bristol Energy Network engaged 151 homes to become 'smart connected homes' trialling smart appliances and energy management systems. This project also worked with an energy demand management system to test how Bristol can balance the local grid in future through a smart city platform.

Co-design and asset-based community development approaches were used wherever possible, which led to strong community ownership of the project. Energy champions were recruited and supported to aid the project delivery. A demonstration space at the 'Eco-Home' was also created to encourage sponsorship from a range of companies and other organisations.

Impacts and results of the project

- Installation of smart appliances and monitoring equipment in 151 homes has saved individual households up to an estimated £150 per year.
- The project reached people who would not normally get involved: 29% of participants live in social housing, 31% are from Black, Asian, or minority ethnic (BAME) backgrounds.
- A co-designed 'mobile future home' was created to engage citizens.
- Relationships with community organisations have been strengthened and have led to further collaborative work in the field of home energy.

Keys, essential message, or lessons learned

- Co-design approaches are essential to effectively engage communities in smart city projects.
- Devolving power to community groups to lead elements of the project yielded great success in terms of reaching a wide audience and informing decision-making.

Impactful and innovative solutions

- Placing power within communities around project design and decision-making represented a new approach for the city council.
- The co-design of the mobile future home engaged communities in an innovative and interesting way.
- Co-design of demand-side response interfaces.

Donostia/San Sebastián (Spain), Replicate

LOW-ENERGY DISTRICT

Description of the urban context of the district and the project

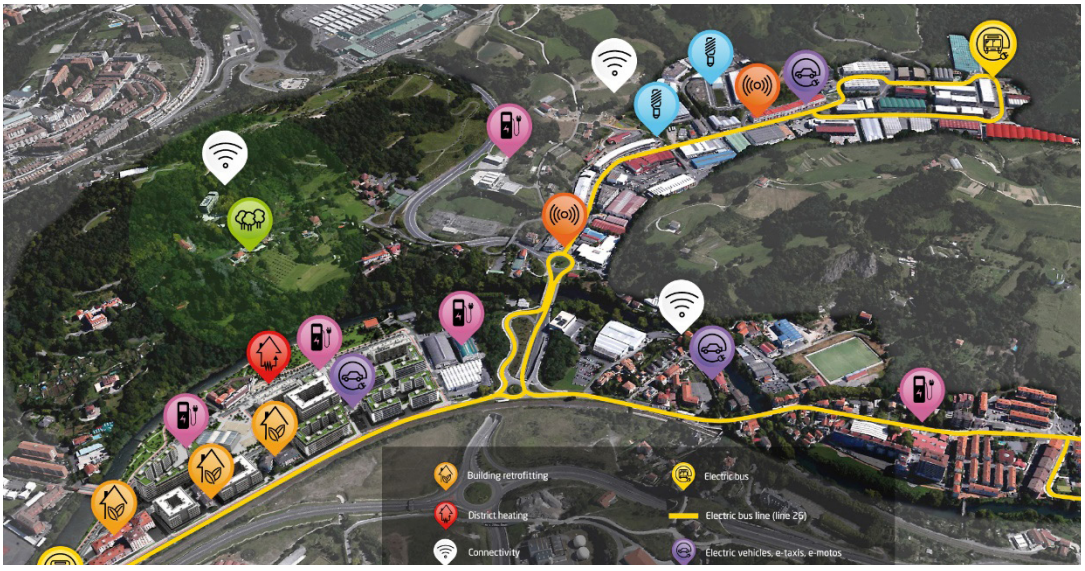
General description

This Replicate Lighthouse project took place in the Urumea riverside district of San Sebastián (the residential neighbourhood of Txomin, Poligono 27 industrial park, and Ametzagaina natural park).

The Urumea river characterises the neighbourhood of Txomin and forms the main axis of the district, yet also represents a barrier and a cause of flooding. This area was urbanised during the first half of the 20th century. The old buildings were energy-inefficient, while poor connections with the city centre created a risk of social exclusion. To address this problem, in 2008 San Sebastián City Council defined a special urban plan to regenerate the district, respond to the flooding problems, regenerate the residential area, improve connections with the city centre, and foster the transformation of the area's economic activity from traditional industries to service-oriented activities. Almost 1,500 households are planned to be built in the neighbourhood (approximately 1,000 have already been built), turning Txomin into a new residential neighbourhood.

There is also a city-wide Smart Plan, developed through a dedicated company, Fomento de San Sebastián, that has established some actions in Txomin. Apart from the new houses that are being built, 156 households have been retrofitted within the Replicate project framework.

The actions carried out within the framework of the Replicate project in San Sebastián include energy efficiency, sustainable mobility, and ICT-infrastructure. Other specific projects have also been carried out in the district, following the neighbourhood positioning strategy. These actions are enabling the Urumea Riverside District to position itself as a smart district with nearly zero emissions.



Description through the prism of the thematic action carried out

The actions deployed in the Urumea Riverside District aimed to turn the district into a smart district with close to zero emissions, creating a district brand in terms of sustainability. The Replicate project sought to improve the transition process towards the development of smart cities in the fields of energy efficiency, sustainable mobility, ICT and infrastructure, accelerating the rollout of innovative technologies and improving residents' quality of life.

In the residential neighbourhood of Txomin, 156 homes and 34 commercial establishments distributed in ten blocks with a total surface area of 18,350 m^2 have been retrofitted. The scope of the intervention covered the rehabilitation of the façades, windows, and roofs. These homes are also connected to the neighbourhood's centralised heating and hot water system. The district heating system covers the area known as Txomin Enea (160,000 m^2). Heat generated in a central location is distributed through insulated pipes to provide domestic hot water and central heating to homes and public buildings. The district heating scheme is sized to meet the needs of 1458 dwellings, including 156 retrofitted houses. The system is owned by the city council, through Fomento de San Sebastián. The central has 7,400 kW of power, with two 1,400 kW biomass boilers (renewable energy). A demand side platform will provide information to district heating users about their thermal energy consumption with the aim of fostering social awareness and saving energy.

The Txomin neighbourhood also has a new social housing block promoted by San Sebastián city council with a total of 162 homes served by 11 entrances. A comprehensive monitoring system has been deployed for this smart building and two homes have been equipped with several smart solutions and appliances. This block was built according to passive house and other energy efficiency principles, and all demand for heating and hot water is met by the district heating system. The SmartHomes building integrates technological solutions both for building managers (to optimise management and maintenance) and for residents (to optimise use of resources, increase awareness and save money). SmartHomes is a knowledge generator to transfer positive results and success stories to the neighbourhood, other districts and other cities.

Apart from energy, other complementary schemes have been developed in the district under the Replicate framework. These relate to sustainable mobility, ICT, and infrastructure: two electric buses to connect the district with the city centre, electric vehicle deployment (e-taxis, e-motorbikes, etc.), smart public lighting and related IP services, and a high-speed mobile network. A smart city platform with a linked open data portal has also been developed.

A participatory process funded by Replicate and promoted by Fomento San Sebastián has been carried out in the neighbourhood, encouraging stakeholders to reflect on their neighbourhood and their interest in implementing actions in energy efficiency, sustainable mobility, ICT, infrastructure and cooperative services. The objective was to work with the different agents (citizens, local businesses and Fomento San Sebastián) to build collaborative proposals for the future of the smart neighbourhood.

Impacts and results of the project

The various actions are contributing to Txomin becoming a low-energy district.

The retrofits created several important benefits for the neighbours:

- Improved comfort in the houses in terms of inside temperature, humidity and noise reduction, and reduction of energy consumption, energy bills and CO_2 emissions.
- Exponential revaluation of homes and, in turn, an improvement in the energy rating of homes.
- Retrofitted buildings have been connected to the district heating network, gas appliances removed, and overall energy efficiency improved thanks to the benefits of district heating.
- The retrofits and conversion to district heating have improved the buildings' performance, comfort, energy efficiency and greenhouse gas emissions.

- The first analysis of monitoring results from the retrofitted buildings shows a considerable reduction in their energy demand with respect to the base measurements from 2017.
- Improved energy rating.

The district heating has environmental and economic benefits for both users and developers:

- Sustainability is guaranteed by the use of renewable energy in the form of biomass from nearby forests.
- Lower primary energy consumption and reduced CO_2 emissions.
- Lower spending on preventive maintenance (which is carried out by specialist staff) and primary energy procurement.
- Lower risks, as there is no combustion equipment in the building.
- Improved comfort for tenants.
- 365×24 availability and better guarantees of service quality.
- Reduction of investment required in each building. Individual central heating systems are removed and there is no need to invest in the building's gas network, which contributes to better use of floor space in each building.
- User-friendly monitoring platform for citizens.

Keys, essential message, or lessons learned

- The Txomin neighbourhood is becoming a smart district with close to zero emissions that has created a district brand in terms of sustainability.
- Citizen engagement has been key to the success of the implementations.
- Several stakeholders have been involved in the co-creation process, with citizens at the core of the process.
- Environmental, social, and economic impacts have been achieved and innovative solutions deployed, improving residents' quality of life.
- The successful deployment of the actions as a pilot project will contribute to the scale-up and replication process.
- The business model behind each action has been analysed and is also a key aspect to consider.

Impactful and innovative solutions

The neighbourhood of Txomin is the first low-energy district in the city of San Sebastián. The retro-fitting and district heating interventions in Txomin- are part of a comprehensive transformation of the Urumea riverside district towards a smart city model through several actions in the energy field, sustainable mobility, ICT, and infrastructure. The actions deployed have been designed as part of an integrated vision to position the district as a nearly zero-emission district as part of an integrated planning process.

The district heating system that is in operation is extremely innovative because of the business model implemented. The management model defined was one of public-private collaboration. Fomento de San Sebastián would be the owner and proprietor of the district heating system, while the contracted

company would rent the installations from Fomento and operate and maintain the service. The district heating development project is also highly innovative for the city and region, as it is the first publicly owned district heating system in the Basque Country.

The district heating plant was designed to integrate visually into the urban environment. It is covered with vegetation and its curved form creates continuity with surrounding natural spaces to reduce the visual impact. Facilities are installed in a large semi-basement glazed building. The use of renewable energy in the form of local forest biomass contributes to the scheme's sustainability.

Txomin is the first district-level building retrofit to be done in San Sebastián, so it is an innovative project for the city and the citizens. The retrofitted homes in Txomin are privately owned. It is an important step for Fomento San Sebastián and the city council, since the district-level retrofit could be replicated in other parts of the city. It must be said that citizen engagement is one of the key factors in the success of this intervention. The neighbourhood association was involved in the project from the very beginning, and this facilitated the engagement and agreement of all the residents. The replication potential in privately owned houses in other districts of the city is being analysed with the aim of promoting further retrofitting actions in San Sebastián.

Florence (Italy), Replicate

SMART MOBILITY INFRASTRUCTURE

Description of the urban context of the district and the project

The main purpose of Replicate in Florence was to put into practice the mobility policies adopted in 2015 through a co-creation process with the Florence Smart City Plan to yield a complete and real test of the vision for smart mobility: electric, green, sustainable, inclusive, active, and resilient.

Florence chose the Novoli district, which occupies the north-western quarter of the city and forms one of its main gateways including the airport, the highway exit and the main train station.

The transport sector, which has huge influence on the urban area of Florence, required a substantial, integrated action to achieve significant savings. Priority interventions have been identified, including mainly infrastructure plus supporting measures. To achieve its 2030 targets the municipality and its partners (e-distribuzione, Enel X, SILFI, UNIFI, CNR, Thales, Mathema, SPES) created a smart electric grid that performs better and is more resilient than before. The partners analysed the development plan for the charging network to satisfy the requirements of the taxi fleet (+100 e-vehicles with a 25% discount on licence fees). They increased the number of public charging stations (+40 in Novoli, +200 across the city) and added six very fast charging points (20 minutes for a full charge, with an app for booking). They promoted agreements with e-vehicle providers, added new taxi services for vulnerable people and night-time use, and improved the EMM that manages the charging network. They created a smart lighting infrastructure with cameras to control traffic and access to low-traffic zones (LTZs). The traffic management platform was also improved through cybersecurity testing, and links to public information systems (web, app and street panels) plus the smart city control room, which collects and processes real-time information from many different sources as set out in a digital manifesto signed with city service providers and stakeholders.

The study visit web app (http://replicate.mathema.com)

Impacts and results of the project

The main result is a 'coordinated mobility package' that is now being studied for replication in different cities and for extension to the metropolitan area of Florence, as stated in the recently adopted Sustainable Urban Mobility Plan. The impacts of several infrastructural enablers (smart grid, smart lighting, smart city platform) cannot be evaluated directly, but by 2018 the charging network had already achieved ambitious results, with about 110/tCO_2 avoided per year by the new e-taxi fleet and more than 180/tCO_2 per year thanks to the provision for charging private electric vehicles. Florence's recovery from the pandemic will gain more and more advantage from these new infrastructure measures, which allow greater flexibility and control in the mobility sector while reducing environmental impact.

Keys, essential message, or lessons learned

- Technology implementation in a city should always aim to provide useful services and not just test innovation – this is what 'smart' means for Florence. From this point of view a single implementation must be part of a vision or a plan: adapted to the context, tailored to the boundary conditions, and coordinated with other actions to discover and exploit synergies.
- The final aim of any innovative implementation should be always clear to all stakeholders, and monitored to ensure good performance that improves citizens' quality of life.
- Wide stakeholder participation, starting from the original decision-making process, is a cross-cutting basic condition. The process should include infrastructure managers, service and technology providers, data managers, and users.
- As innovative technologies evolve faster and faster they often also become cheaper, to the extent that in a few years the associated business models may change completely. These innovative technologies support the diffusion of the smart mobility approach, and this diffusion has led to changes in the internal organisation of the municipality (increased ability to manage new challenges an integrated vision, and openness to innovation), the local legal supporting framework, the evaluation of impacts and externalities (health, social inclusion, poverty), and co-creative processes that multiply ideas and create consensus.

Impactful and innovative solutions

- **Smart grid:** thanks to the development of new protective systems in the substations and the use of advanced automation, it is now possible to reconfigure the grid more quickly, so as to improve service quality and reduce power outages. The smart grid is the key to developing further smart services: it should be included in planning tools as an enabler, in collaboration with the distribution system operator (DSO). The technology is quickly evolving and improving, and this must be considered while designing future extensions.
- **E-taxi model:** Florence's support for e-taxis has shown good results and has already been replicated elsewhere. The municipality has driven the transition to an e-fleet through cheaper licences for e-vehicles, a dedicated fast charging infrastructure, innovative services such as the booking app, agreements with e-vehicle producers, and priority for e-services.
- **New governance models:** the Smart City Control Room including the traffic management platform has a unique multi-level governance model (Firenze Digitale) which is paving the way for a successful collaboration among utility companies, fire brigades, the 118 rescue agency and the municipality – a win-win solution for all.
- **Cybersecurity issues:** analysis of the Florence pilot scheme in terms of GDPR and cybersecurity highlighted vulnerabilities and defined a remediation plan for the existing architecture. As new systems are added, they will adopt a cybersecure-by-design approach that will minimise future risks.
- **Smart lighting support:** public lighting is the backbone of the city and the existing lighting infrastructure can easily support additional services to reduce land use and costs. Besides its improved energy efficiency, the new smart lighting system integrates equipment such as video cameras for security and LTZ enforcement, Wi-Fi hotspots, and environmental sensors.

Milan (Italy), Sharing Cities

RETROFITS FOR LOW-ENERGY BUILDINGS

Description of the urban context of the district and the project

Urban areas not only produce a considerable portion of human-made emissions, they are also particularly vulnerable to the negative effects of climate change. Both local decision-making and strategic approaches have a part to play in finding opportunities and pursuing more sustainable pathways.

Through Sharing Cities, this project explored how to retrofit older buildings in the three Lighthouse cities with energy efficiency measures and smart controls. The aim is to reduce energy consumption through tailored energy measure packages in public and private housing.

In Milan, the demonstration area known as Porta Romana/Vettabbia is under complete redevelopment. Its renewal will connect the historic centre of the city to the surrounding green belt by 'stitching together' two areas of the city that are now geographically, economically, and socially separated. Porta Romana in the north of Milan is a former railway yard, a brownfield area of 216,000 m^2 owned by Sistemi Urbani SpA. Post recovery, this area has the opportunity to become a functional mix of private and social housing, with multi-modal integration around a new station, and a large park of at least 74,000 m^2.

In the demonstration area of Milan, five private residential buildings were retrofitted – a total of 24,670 m^2. The successful creation and rollout of the co-design process is already being scaled up in other multi-property buildings in the city. Technical and co-design meetings with owners allows each intervention to be tailor-made, so as to address the real needs of the buildings' residents. In a consecutive set of participative sessions, residents were coached on the technical and financial implications of the solutions that best suited their needs, a process that also increased their literacy in energy-related topics. Overall, the package of solutions included insulating external walls, integrating renewable energy sources, and updating heating and lighting systems to more energy-efficient technologies. At the end, the residents were more aware of the expected impacts, understood the process better, and added value to the interventions.

Impacts and results of the project

Deep energy renovation projects have a clear environmental benefit in reducing energy use and carbon emissions. They can also lead to consistent economic savings, both for tenants and for the municipality, according to the cost accounting scheme used in public housing.

Within the Sharing Cities programme, the retrofit scheme implemented in the demonstrator area of Milan will save 589 t CO_2 per year (more than 2,000,000 kWh per year). If the same improvements were made to all the public housing stock in Milan, the city could save more than 250 kt of CO_2 annually.

Site	Original building energy class	Post-retrofit building energy class
Via Passeroni 6	F	C
Via Tito Livio 7	F	C
Via Verro 78 B/C	D	B
Via Fiamma 15/1	E	C
Via Benaco 26	G	D

Environmental and economic benefits include:

- reduced air pollution
- carbon savings
- waste reduction from avoidance of demolition and construction
- new business opportunities
- job creation
- increased GDP

Keys, essential message, or lessons learned

- **Engagement with residents is critical and must start before work begins and continue post-retrofit.** The people affected must be involved from the start, to collect information about their needs and to co-design solutions. Milan's co-design process in multi-owner buildings is a great example of pre-retrofit engagement and how this can lead to innovative results.

- **The co-design process in multi-owner, residential buildings has proved to be key to success.** Every building is different, distinguished by its architecture, conditions, use, population (for housing) and context. To make sure this works, you need your residents to be supportive. That means including them at the design stage and throughout the process.

- **Changing the habits of residents and how they use energy is critical to the long-term success of a building retrofit.** Post-retrofit plays a crucial role in making retrofit interventions effective. Both the private and the public sector need to communicate better with citizens about the importance of post-retrofit actions. The three cities have devised different ways and means to promote take-up of energy efficiency behaviours by raising people's awareness.

Impactful and innovative solutions

Building retrofits are not a new idea. However, there are three major innovations in the Sharing Cities approach:

- **Deep retrofits that include the installation of renewable generation combined with the latest energy management control technologies.** This is on top of standard retrofit measures to boost energy efficiency. An example of a deep retrofit includes connected monitoring and control, the Internet of Things (IoT), and sustainable energy management systems (SEMS) working together. Combining these technologies has enabled greater efficiencies through supply and demand balancing and peak shaving. The impact of such an approach shows how smart cities can benefit communities, over and above standard building retrofit works.

- **A co-design approach** developed by partners Politecnico di Milano, Legambiente, Poliedra, TEICOS and Future Cities Catapult. Housing residents were actively engaged and contributed to the design and choice of interventions. This engagement carried on once the works finished to ensure continued support, the effective use of upgrades, and improved wellbeing.

- **Retrofitting protected heritage buildings.** Most building stock in our cities, especially in major European cities like Milan, is old. Many buildings are significant in terms of culture and heritage. As such, they are protected by regulation. This can make retrofits hard, especially for things like renewable generation that often do not fit with the historic building aesthetic. However, Sharing Cities has shown how this can be done effectively.

Lisbon (Portugal), Sharing Cities

E-BIKE SCHEME FOR SMART E-MOBILITY

Description of the urban context of the district and the project

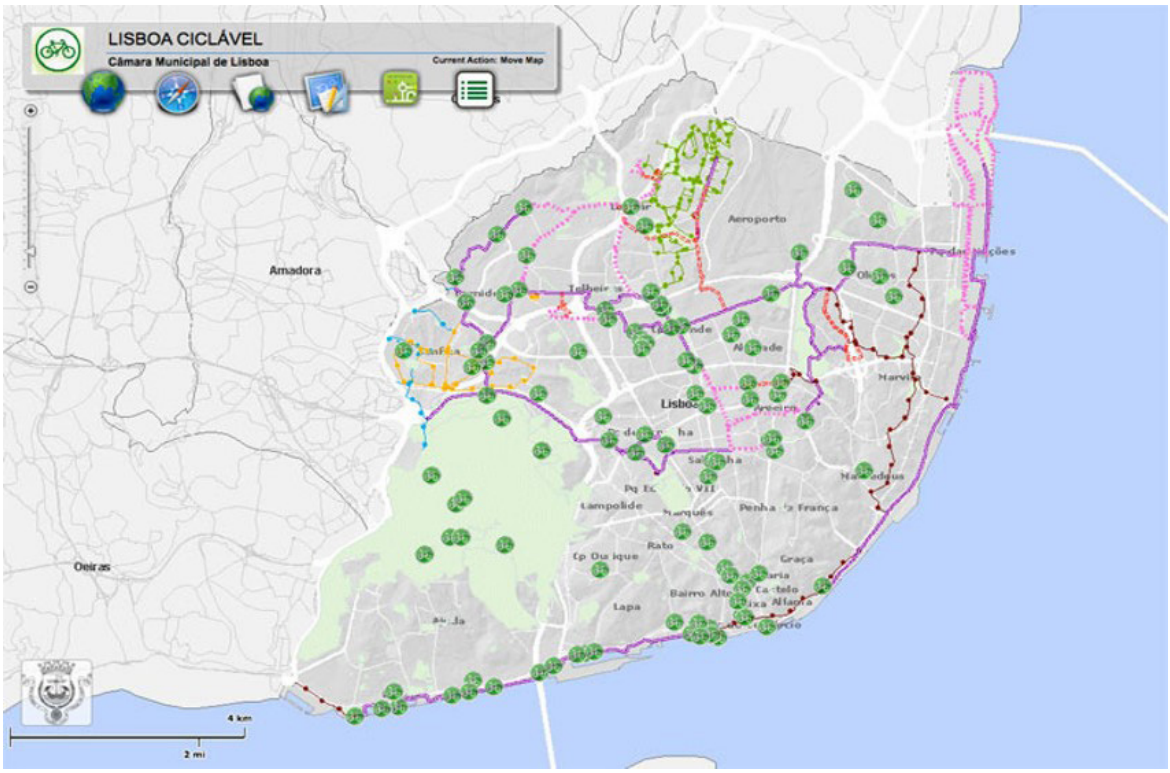
General description

Portugal has one of Europe's lowest rates of cycling, and car ownership is very high. In Lisbon, this posed problems in terms of traffic congestion, air quality, safety, and noise.

Lisbon is also an old city with many historic districts. This makes it difficult to create high-quality cycling infrastructure. It is very hilly, so a traditional bike scheme was not likely to be popular. The city's topography also makes it expensive to redistribute bikes. E-bikes were therefore the best option to address these constraints.

E-bikes offer a range of environmental and social benefits such as:

- reducing traffic congestion by encouraging people to cycle instead of drive;
- improving air quality by providing people with a sustainable way to travel;
- encouraging uptake by providing e-bikes which make it easier to manage the city's challenging topography;
- reducing reliance on fossil fuels by encouraging people to switch from driving to e-bikes.



Description through the prism of the thematic action carried out

Despite the challenges, the Portuguese capital rolled out its first bike sharing scheme in 2017 through Sharing Cities to launch its new city strategy for mobility. The pilots proved a big success, so the scheme, called GIRA, was rapidly expanded across the entire city. It is owned and run by EMEL, the municipal mobility company that also manages the city's parking infrastructure.

The scheme now has 810 bikes, around 50% of which are e-bikes, and 81 docking stations. Lisbon plans to expand the scheme further, especially in the residential suburbs – recently tenders have been issued to procure an additional 1500 bikes and 30 additional stations.

The city has increased bike lanes too. Cycling infrastructure is expected to increase from just 10 km of bike lanes 10 years ago, to 210 km by 2021. Legally, apart from the dedicated paths, bicycles now have the same rights as other vehicles on public roads. Better infrastructure, more availability of e-bikes and low cost of use have encouraged people to take up cycling, alongside other low-carbon transport modes.

Lisbon's bike share schemes are station-based. This means that a user can pick up and drop off the bikes at a dedicated station. The docks can receive both conventional and e-bikes. The stations provide enough power to charge batteries, as the scheme was built from scratch with e-bikes in mind.

Lisbon has developed its own app to provide users with this service, with three main features:

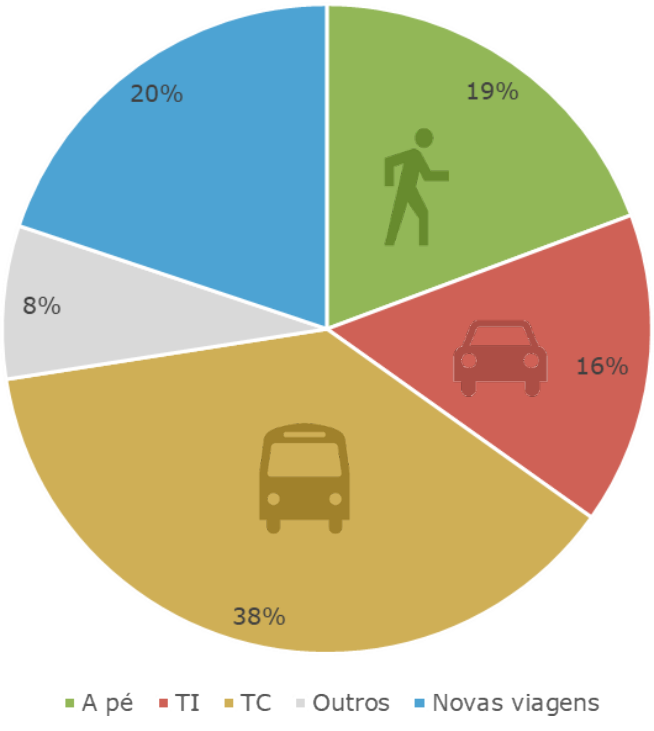
1. People can find and look for available bikes nearby. This is a must-have and should be as easy as possible, so users can always find a bike.

2. The bike can be unlocked automatically. Unlocking the bike should be simple and take only a few seconds. Current solutions range from scanning a QR code on the bike to tapping the 'unlock' button in the app.

3. Payment is simple and secure. This is vital for a user-friendly experience. You must also consider security issues such as personal credit/debit card data.

Impacts and results of the project.

- 3 million journeys made by 16,000 users since 2017
- 26% use the bikes daily
- 38% switched from the bus
- 16% switched from cars
- 20% new journeys created
- 486 tonnes of CO^2 emissions saved during the project.



Keys, essential message, or lessons learned

Choosing the right business model is vital to ensure the smooth operation of an e-bike scheme. It is crucial to think long-term while defining your business model: in Lisbon, the costs of running and managing the scheme represented 70% of the total costs. Having a high-level strategy from the start will help you determine whether the scheme is commercially viable. It will also help you work out the value proposition. Consider making the scheme cheaper to use during the colder months and off-peak, when demand fluctuates.

Engaging political leaders and local communities is key to getting support for an e-bike project. Political leaders can act as catalysts to achieve your goals. They can help speed up decision-making, make funding available, sort land rights use issues and ensure that different city departments work together. Understanding the community's needs and interests can help you define the strategy for rollout. The service must be user-friendly and offer, for example, different ways to pay.

Impactful and innovative

Lisbon's hilly landscape meant a traditional bike scheme would not be effective. The city's topography also makes it expensive to redistribute bikes. Using e-bikes that could assist with cycling uphill, as well as the construction of safe cycling infrastructure, was therefore an effective way to increase the use of bikes and build a cycling culture in the city.

Lisbon's bike share scheme is station-based. This means that users pick up and drop off their bikes at dedicated stations. The docks can receive both conventional and e-bikes. However, Lisbon's docking stations were innovative in that they provide enough power to charge batteries, as the scheme was built from scratch – unlike many other docked bike schemes where recharging must be retrofitted, or where batteries need to be swapped out manually.

The innovative e-bikes are proving to be very popular with citizens, with data showing that each e-bike makes ten or more times the number of trips compared to its conventional counterpart:

- e-bikes are used 10 times a day (4 during COVID)
- classic bikes are used once a day (0.2 during COVID).

Data also shows that people are using e-bikes to travel longer distances:

- e-bike journeys average approximately 2–2.4 km,
  while classic bikes travel on average 1 km per journey.

London (UK), Sharing Cities

LOW-ENERGY BUILDINGS AND SMART INFRASTRUCTURE

Description of the urban context of the district and the project

Royal Borough of Greenwich

The Royal Borough of Greenwich (RBG) forms a distinct district in London. RBG is one of London's 33 local authorities and is one of the six designated 'growth' Boroughs of East London.

The Royal Borough is faced with the challenge of facilitating economic growth while managing the consequences of that growth. Through the implementation of its Smart City Strategy, the Borough seeks to become a resource-efficient, low-carbon, healthy and liveable district within the capital: a district where its citizens enjoy social and economic opportunities, while feeling integrated and part of the decision-making processes affecting the environments and communities they live in, and where services are delivered efficiently and reflect the needs and desires of its citizens.

The Greenwich demonstrator area is one of the most strategic locations in London. It stretches along the riverfront – from the UNESCO World Heritage Site to the Greenwich Peninsula – and occupies 516 ha. The site combines visitor attractions including the O2 entertainment district, a new business start-up district, and residential buildings both existing and new.

Sustainable energy management system

In the London demonstrator area, deep retrofits include the installation of renewable generation combined with the latest energy management control technologies. This is on top of standard retrofit measures to boost energy efficiency, for example through connected monitoring and control, the Internet of Things (IoT), and sustainable energy management systems (SEMS) together.

SEMS is an integrated energy management system that links a whole ecosystem of energy assets, allowing energy managers to control and optimise use. Energy assets can include:

- energy producers like solar panels and heat pumps/heating networks
- energy consumers like lamp posts
- electric vehicle charging points
- household appliances like washing machines and dryers.

The SEMS works by collecting data from a range of energy assets, combining this with external data such as weather and market pricing, and applying advance process and predictive controls to provide suggestions for how best to operate this network of energy assets. What counts as the optimal solution depends on the policy goal of the city or local authority, but would typically target either minimum carbon emissions or minimum cost. Analysing and visualising multiple energy assets and uses also helps energy managers to understand energy production and use patterns and hence to forecast future energy use.

Combining these technologies alongside retrofit, renewable energy assets and other IoT solutions has enabled greater efficiencies through supply and demand balancing and peak shaving. The impact of such an approach shows how smart cities can benefit communities, over and above standard

building retrofit works.

Integrated low-carbon technologies in public housing

Building retrofit in London focuses on two large social housing estates in Greenwich's Peninsula ward. Both were built between the wars. They consist of 267 council-owned flats of varying sizes and provide social housing for residents.

A SEMS has been developed for the heating system at Ernest Dence Estate. This system optimises the running of its heating/energy system by taking in data from the different energy assets, including a water source heat pump supplied by boreholes that draw water from the Thames basin. This will provide heating and hot water to the building.

Data will then be combined with external factors such as weather and energy pricing, and an advanced process control approach will be applied.

Impacts and results of the project

- Retrofit impact to date: 527 tCO^2 per year saved; 2,404,295 kWh per year of energy saved.
- Savings are equivalent to the energy usage of 667 average UK homes. This is based on an average consumption of 3,600 kWh per year for standard electricity (as per the latest gov.uk data set).
- The average London household spends £1,171 a year on energy. In our trials, the SEMS is helping residents reduce their energy bills by 10%.

Keys, essential message, or lessons learned

- **Understand your existing energy assets, including the available data and control functionalities that they provide.** This will inform the scope and scale of SEMS. Older assets will have limited control functionality and may require new sensors and meters to enable data connections. In some cases, assets may need to be replaced or upgraded. It is best to know as soon as possible, since this can take time.
- **Using a modular system architecture allows you to introduce new features over time.** Anticipating further innovation in the energy system and planning your solution to accommodate this helps future-proof SEMS and hence free the city from technological lock-in. Designing a system to accommodate future developments will also help you assess and choose the right ownership model.
- **Integrate your delivery plan with other planned activity in your city – the scope of this activity should align with your SEMS goals.** This might include building upgrades and retrofits, e-mobility infrastructure and vehicle deployment, and renewable energy installations. Understanding planned activity will inform the scope of SEMS in your city. This will allow you to smoothly integrate new functionalities, assets, and systems. Being aware of timescales for delivery will also improve project planning. This will enable you to anticipate key periods of rollout and allow for suitable resourcing.

Impactful and innovative solutions

1. In the process of creating the SEMS, a team at Imperial College London developed a simulation of the building, also known as a Digital Twin. By modelling the estate and the energy assets being introduced, the digital twin aided assessment of the impact of the retrofit and energy efficiency measures planned for the estate. This showed how the SEMS might be able to optimise energy use once the retrofit measures are completed. In addition, real-time field data was integrated into the London Datastore data platform. This can then support data flow into the digital twin, alongside external data sets such as weather and pricing. The results from the SEMS so far are impressive, showing a 10% energy reduction on top of the building retrofit action.

2. Deep retrofit in Greenwich included ambitious energy efficiency fabric improvements. These include loft and external wall insulation, window refurbishment, and upgrades to communal lighting and individual gas boilers. The project also trialled IoT technologies like smart thermostats, in-house temperature and humidity sensors, boiler sensors and connected smoke alarms. These can help reduce energy use and save residents money on their energy bills, while also alerting them to environmental conditions such as damp and mould. They are also being used to monitor the impact of the retrofit and provide an improved and proactive maintenance service.

Sønderborg (Denmark), SmartEnCity

NEW LOCAL BIOGAS INFRASTRUCTURE FEEDING 44 BUSES

Description of the urban context of the district and the project

Sønderborg's energy and climate transition is driven by its ProjectZero vision, which targets zero carbon by 2029. The project was approved by a united city council (31 members) in 2007 and anchored in a public-private partnership. The focus is on the energy system (buildings, industry/manufacturing, renewable energy production and green transportation). The ambition is to improve overall energy efficiency by 44% using smart solutions, and to replace fossil fuels 100% with renewables.

The SmartEnCity project has accelerated the transition and added several core demonstration projects. One of these is the replacement of all diesel buses by 44 buses fuelled by locally produced biogas, including new gas filling infrastructure. The bus and gas filling projects were implemented in early summer 2017 and have been in operation since.

In summer 2020 the scheduled production of local biogas started by building the first of two new biogas production plants. This is scheduled to feed not only the biogas buses but also other heavy transport vehicles and industrial processes.

In October 2020, the company Sonfor (a partner in SmartEnCity) launched 10 new waste management vehicles driven by biogas. The new vehicles are important components in creating a new circular economy around waste management (separation of organic waste, plastics etc.), the new biogas plant and the collection vehicles.

Impacts and results of the project

- 44 biogas buses with electronic/smart information systems
- new biogas fuelling infrastructure
- two new biogas production plants – one already in operation
- 10 new biogas-driven waste collection vehicles
- waste separation into 10 fractions

Keys, essential message, or lessons learned

Ambitious climate goals, committed city council members and integrated energy planning, all supported by citizen engagement, will boost your climate actions.

Green transport is a core challenge in medium-sized cities and municipalities, but integrated energy planning can help you speed the transition.

Impactful and innovative solutions

Roadmap2025 will help Sønderborg achieve 75% carbon reductions by 2025 and inspire other cities to create integrated energy plans (IEPs).

Battery solutions will improve energy efficiency in housing associations.

Tartu (Estonia), SmartEnCity

RETROFITTING SOVIET-ERA APARTMENT BUILDINGS INTO VERY-LOW-ENERGY BUILDINGS

Description of the urban context of the district and the project

General description

Tartu is the second-largest city in Estonia and the main hub in the south of the country. The population of the city proper is around 95,000, while the Tartu urban area including neighbouring municipalities has about 130,000 citizens. Tartu is Estonia's education centre, with over 15 higher education institutions. Around 7,000 people live in the city centre, making up 7% of all citizens. The pilot area includes a part of the city centre with about 4,000 residents. The population density of the city centre is about 3,600 people/km^2. There are around 1,600 multi-apartment buildings in the City of Tartu. 50% of these were built between 1960 and 1990.

In the city centre are 42 ' *hrustsovka*' style apartment buildings which were mostly built in the 1960s. Their inhabitants are socially mixed and diverse. The apartments are privately owned, and in many cases rented out, often to students. The renovation activities will directly affect around 2,100 inhabitants of the pilot area. A total of 18 residential buildings (about 680 apartments and about 35,200 m^2 of heated space in the buildings) will be renovated. The objective of the retrofit plan is to drastically reduce the energy usage of the *hrustsovkas*. The average annual energy consumption of these buildings is currently about 270 kWh/m^2, and the target is to reduce this by more than 66%, to 90 kWh/m^2. This ambitious goal cannot be achieved by using regular insulation technologies alone. A combination of different measures is needed, including ventilation with heat exchangers and local energy production from solar panels. All the technical solutions will be accompanied by modern ICT technologies for the best outcome.

A smart home platform enables residents to regulate the indoor climate of their apartments and monitor their energy consumption. The retrofit model is widely replicable, since Eastern Europe has an estimated 1,000,000 *hrustsovka*-type apartment buildings in need of renovation.

Impacts and results of the project

During the project, 18 apartment buildings will be renovated. To date, all renovations have been completed at 17 buildings and the last one will be completed by July 2021 at the latest. Smart home solutions have been installed in all the renovated apartments and the systems are currently being adjusted. Data on the energy consumption of houses can already be seen on CIOP, an important part of the smart city platform.

Keys, essential message, or lessons learned

- Renovation of this type of residential building to dramatically improve energy efficiency requires significant preliminary work in the design phase and especially in the technical solutions (ventilation, heating, etc.).
- The involvement of various technical specialists, housing union leaders and residents, as well as the constant exchange of information, have been crucial to the successful implementation of the project.
- As a rule, the integration of different IT solutions is more complicated and time-consuming than planned. This should be considered when planning activities and obtaining solutions.

Impactful and innovative solutions

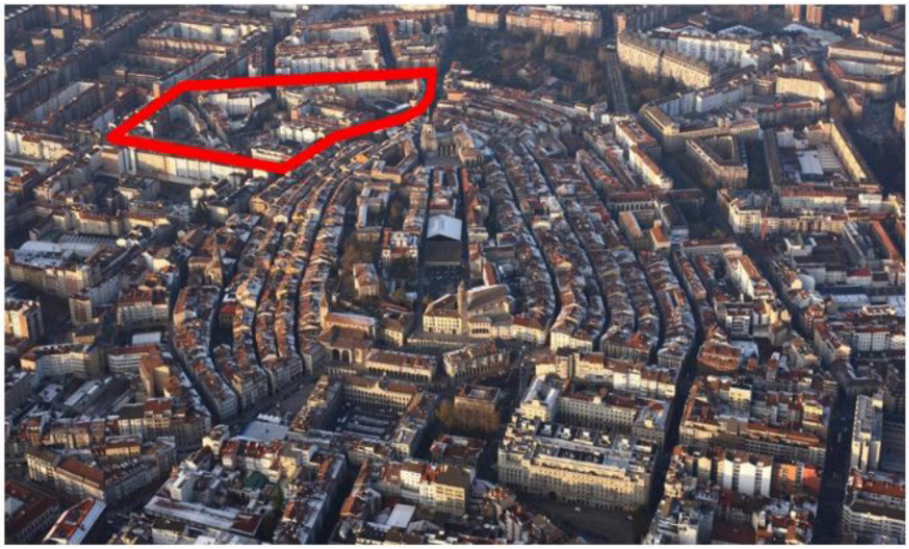
- Smart home system for regulating the indoor climate and monitoring energy consumption.
- Social innovation through an ambassador programme, in which representatives of apartment associations help other residents to learn how modern technology can help to maintain a healthy indoor climate.
- Technical approach needed to retrofit Soviet-era apartment buildings into energy-efficient near-zero-energy class buildings, for the first time in Estonia. This has great replication potential in Eastern Europe.

Vitoria-Gasteiz (Spain), SmartEnCity

CORONACIÓN DISTRICT

Description of the urban context of the district and the project

General description



RESIDENTIAL buildings: 27 (312 dwellings)
Heated area > 22,700 m²
\+ GYM & SPA
BINGO
CIVIC CENTRE
ASSOCIATIONS CENTRE
CHURCH
TOTAL EQUIVALENT DWELLINGS: 655

PROPERTY:
- PRIVATE: dwellings, gym & spa, bingo and church
- PUBLIC: Civic Centre and Associations Centre (Municipal property)

Vitoria-Gasteiz is the capital of the Basque Country in the north of Spain. With 240,000 inhabitants the city is a Europe-leading municipality that is investing in the green economy (Green Capital 2012).

The Coronación district lies at the north-west edge of the old town of Vitoria-Gasteiz. The district was built to accommodate mainly migrants from rural areas in other parts of Spain, who moved to work in the city's factories during the 1950s and 1960s. Coronación can be considered the first neighbourhood of the first city ring built before 1980. Most of the buildings were constructed during the 1960s and 1970s (85% of dwellings were built before 1970), and the district has changed little since that time.

A thorough field study by the project partners revealed that:

- In terms of building accessibility, 68% of the buildings have an elevator (vertical accessibility), and 49% of buildings have an accessible entrance (horizontal accessibility).
- Regarding building types and energy efficiency, 51% of the buildings have individual heating per apartment and double-layer facades without insulation. Between 50% and 70% of their windows have been replaced.
- In terms of structural security, most of the buildings are in good condition.

Description through the prism of the thematic action carried out

The building renovation consists mainly of envelope retrofitting, which involves insulating the facade and roof, improving airtightness and installing new low energy windows, if needed. Coronación was chosen for this intervention as it was identified as the city's most vulnerable neighbourhood in terms of social aspects, stability, habitability, accessibility, and energy efficiency.

Impacts and results of the project

- 26 buildings joined the project. By October 2020 retrofits of 11 buildings were complete. 11 more buildings were in progress, and work on the remaining four was due to start before the end of 2020.
- District heating network deployment work had already started and was expected to finish in July 2021.

Keys, essential message, or lessons learned

- Communication with the citizens is crucial, and engagement of the district residents' associations is very beneficial.
- Starting with a single bottom-to-top retrofit project could be more efficient than running multiple jobs in parallel.
- To engage your target audience, results must appear from the very beginning of the project. Success in medium- and large-scale projects requires a 'demo inside the demo'.

Impactful and innovative solutions

- Innovative business model to foster the renovation of buildings.
- Innovative role of the public company VISESA (VIS) as delegate promoter of the retrofitting actions, on behalf of the communities of homeowners.
- Through agreements signed between both parties, VIS manages, contracts, supervises and finances the design and execution of the refurbishment works, delivering a turnkey final product to its owners and charging them the total cost minus subsidies received.
- VIS also manages the various administrative tasks required to receive the subsidies (application, justification, etc.) as a one-stop agency, relieving the social housing landlords residents of these cumbersome tasks.

Lyon (France), Smarter Together

LYON CONFLUENCE

Description of the urban context of the district and the project

The Lyon-Confluence urban project will double the size of Lyon city centre in 30 years. Overall, the Lyon-Confluence area is 150 hectares, made up of equal parts existing and new neighbourhoods. The new housing will replace old factories and warehouses; 1 million m^2 is to be built by 2030, of which half is already complete.

Urban challenges:

- refurbishment of the historic part of the neighbourhood
- mixed-use new blocks (office space, housing, shops, public facilities)
- construction of new public spaces
- environmental performance of the urban project (new and existing area)

Impacts and results of the project

- 500,000 m^2 of new buildings finished (half of the planned new construction)
- 70,000 m^2 of energy-saving retrofits for old buildings
  (works finished, in progress or confirmed)

Keys, essential message, or lessons learned

For the building energy retrofits there is a need to address all types of buildings, including social housing, private housing, offices and public facilities.

To set up and carry out building energy retrofit projects, funding is not the only key. Such projects need to include support for building owners to address all aspects, including financial, legal, technical, and human factors.

Data collection must begin early – before starting the feasibility studies – and carried on before and after the refurbishment work.

Data on all the buildings refurbished should be collected in a consistent format and stored in a suitable data repository that avoids vendor lock-in.

Impactful and innovative solutions

Setting up a club for stakeholders in the energy renovation industry in the Greater Lyon area, and also elsewhere in France.

Mobilisation of this club to improve the lessons learned from energy retrofit projects, and to provide inputs for the Greater Lyon area energy master plan (and the future framework for energy renovation of buildings).

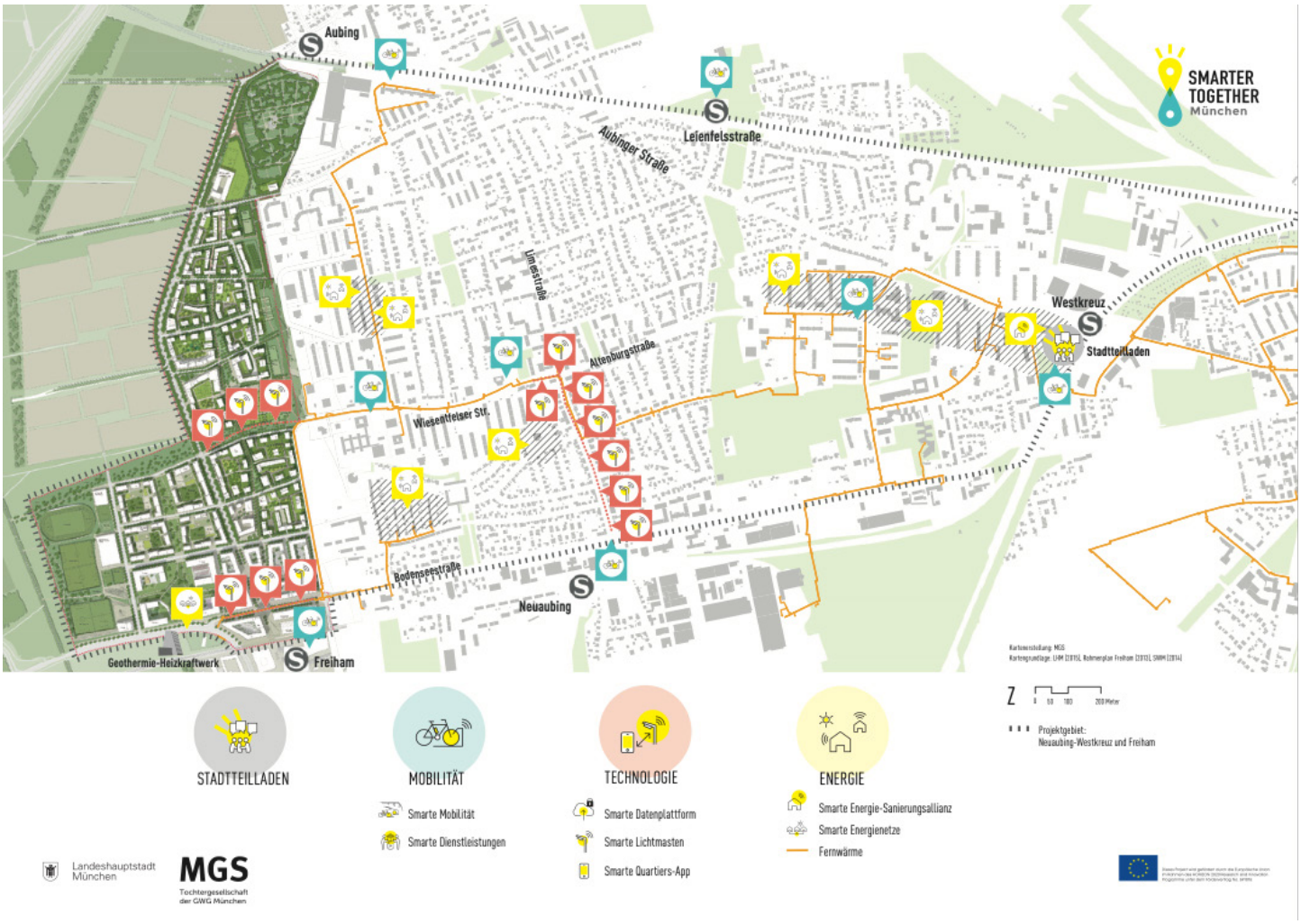
Munich (Germany), Smarter Together

RETROFITTING AND DIGITISATION

Description of the urban context of the district and the project

Munich is implementing its pioneering smart city solutions within Smarter Together in the project area of Neuaubing-Westkreuz/Freiham. This district is located on the western edge of the city and houses approximately 30,000 people. The project area includes the new Freiham housing area, as well as Neuaubing-Westkreuz where many of the residential properties were built in the 1960s and 1970s to comparatively low standards of energy efficiency.

Pilot projects such as Smarter Together are part of Munich's larger effort to foster future-oriented sustainable urban development, contribute to climate goals and reduce CO_2 emissions. The solutions are designed to improve energy efficiency, energy infrastructure and energy supply, to offer easy access to green mobility, and to promote solutions for digital and organisational innovation. With the aid of cutting-edge technology and the intelligent use of data, the aim is to reduce fossil fuel consumption and improve residents' quality of life. Munich has the ambitious goal of becoming climate-neutral by 2035.



Impacts and results of the project

The solutions developed and piloted within Smarter Together have led to many future-oriented developments within the City of Munich. These include a digitisation strategy for the city, the development of a digital twin, and a city-wide resolution on 'Sharing Mobility' with input from the project. In terms of refurbishment, Smarter Together was able to demonstrate that in-depth consultation with homeowners can lead to better refurbishment rates:

- 42,100 m^2 of building retrofits achieved thanks to intense consultation with homeowners' associations before and during refurbishments.
- 3.6 % refurbishment rate in 2020 within the Smarter Together project.

Keys, essential message, or lessons learned

Working on the smart city of tomorrow is never an undertaking that can be approached in isolation, because the work mostly concerns people's homes and their immediate living areas. An integrated approach is needed, combining clear city governance with steady and clear communication with the citizens involved. Implementing smart solutions can never just be about new technologies; it needs to put the citizen in the centre.

Impactful and innovative solutions

In the case of Smarter Together Munich this can be seen most clearly when talking about the refurbishment in the project area. Renovations within a community of homeowners are demanding in terms of organisation, technology, legal aspects and finance. Due to their decision-making structures, owner associations also require longer lead times. Intensive consultation with, and support for, the (private) owners before and during the construction phase is necessary, as explained above. Paying attention to these factors, however, yielded 42,100 m^2 of energy efficient refurbishments and a renovation rate of 3.6 % in 2020. (A rate of 2% annually is the officially expected number for refurbishment in Munich).

We tracked and measured the renovation activities using appropriate IT tools. In Smarter Together a data platform was installed to collect this data and analyse it. GDPR-compliant contracts with the flat owners were put in place to allow data collection and analysis of energy data relating to individual flats and complete buildings.

Implementing the smart data platform yielded experience around the end-to-end collection and treatment of smart city data and the architecture required for such a platform. These now serve as a replication blueprint for the design and implementation of a Munich digital twin and an urban data platform that will support a multitude of current and future smart city use cases around traffic, climate change, innovative city development and more.

Vienna (Austria), Smarter Together

HOLISTIC URBAN RENEWAL

Description of the urban context of the district and the project

The Viennese Smarter Together project area is in the southeast of Vienna. Simmering, Vienna's 11th district, is characterised by its working-class history and a diverse building stock with a high share of municipal and subsidised housing. With a higher-than-average percentage of citizens with migrant backgrounds and lower than average levels of education and income, the project area is a perfect testbed for a real-life implementation of innovative solutions that are relevant for replication. In total, Simmering has 21,000 inhabitants as well as some larger industrial sites such as Siemens Mobility, where the metro trains for Vienna are produced.

Urban challenges:

- Adaptation of the area to reduce climate change and mitigate its effects
- Massive population increase
- Peripheral location encourages car-oriented transport (e. g. higher than average car ownership)
- Consider the diversity of the population when planning refurbishment measures and communication activities
- Upscaling of technical innovation potential in social/subsidised housing as well as public buildings under the current legislation

Impacts and results of the project

The interdisciplinary and cross-thematic approach of Smarter Together in Vienna is already being replicated. In the next 10 years, six other neighbourhoods are planned to be developed similarly. In addition, a series of thematic follow-up projects have been launched by both the City of Vienna and the project partners.

- EUR 7 million of funding has triggered EUR 80 million of total investment
- 66,000 m^2 of buildings refurbished and 8,600 m^2 newly constructed (housing + zero-energy gyms at a school building)
- 29 e-vehicles put into operation
- 450 kW_p PV installed
- 38,000 people reached and/or involved throughout the project.

Keys, essential message, or lessons learned

New demonstration projects need time for testing, but more importantly they need on-site support for the people that are supposed to use them, so that they can understand the personal benefits of the project and make good use of any technologies involved. An interdisciplinary approach activates more synergies.

Innovation projects need to be embedded in a governance process to ensure their sustainability beyond their limitation in time and resources.

Technical innovation has always to be backed by human resource development, whether this is through citizen participation, stakeholder involvement or public administration support.

A holistic refurbishment should also include improvements in the building services required to achieve the previously calculated energy savings.

Impactful and innovative solutions

Next to the existing school in Simmering, a newly constructed school annex incorporates four zero-energy gyms and 15 classrooms. Its energy is supplied by ground-source heat pumps, PV, and solar thermal energy. The latter is either used to help meet the building's heat demand or fed into the secondary district heating grid. Diverse energy systems are thus interlinked and managed thanks to an integrated data platform developed within the project itself.

In addition, due to climate change, tempering of school buildings is becoming necessary over a greater part of the year. According to current Austrian legislation, active cooling of school buildings is forbidden. However, the use of geothermal energy via heat pumps, besides being eco-friendly and renewable, makes tempering of the building technically necessary. In this case the current strict legal provisions do not apply, making heat pumps even more attractive for the future.

All the solutions are tailor-made, and their merging represents a substantial innovation in the context of public buildings, since cooling of schools is an issue that was not previously foreseen.

Next to the technical aspects vital for its success, the project benefited from the involvement of the school pupils. This was done via workshops, in-house as well as external, and more specifically through a mobile urban living lab (SIMmobile) in front of the school at various stages of the process. The pupils' involvement added specific value to the renovation process in the form of a sustainable social dimension. The SIMmobile, which was managed by the Urban Renewal Office, served as a hub where pupils' needs and wishes for their future school could be identified and handed over to the planners, who then included several of the ideas in their planning (such as a boulder wall in the gym).

As a result, the combination of technical improvements and the broad participation process not only increased the satisfaction of teachers, pupils, and other stakeholders, but also ensured that the technical solutions serve broader societal goals within an integrated Smart City.

NOTE

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