European smart cities business models

Avoid the trap: from piloting projects to upscaling

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European Climate, Infrastructure and Environment Executive Agency (CINEA)
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1. Executive summary

The European Smart Cities and Communities (SCC) initiative stands as a pioneering and expansive research and development endeavour in the realm of Smart Cities. Launched in 2015, it has brought together 120 cities and 515 partners across 18 innovative partnerships, dedicated to trialling, assessing, and ultimately expanding over 550 smart solutions in real-life settings. The programme's scope is impressive, creating a significant and enduring influence on the development of the smart cities market.

The Horizon 2020 programme has invested €381 million in SCC projects, with the total value of supported projects, including additional funding, reaching €446 million. In 2022, Horizon Europe further bolstered this initiative with two new projects centred on Positive and Clean Energy Districts (PCED). The accumulated expertise from eight years of SCC execution has notably contributed to the EU's current ‘Climate-Neutral and Smart Cities’ mission under the Horizon Europe framework (2021-27), with 53 of the 120 ‘Climate Neutral and Smart Cities’ having previously engaged in the SCC Initiative.

This report aims to pinpoint, comprehend, and highlight viable business cases and financing models, with a special focus on Positive Energy Districts (PEDs). It delves into value and service chains, hurdles, prerequisites, and potential strategies and mechanisms for scaling and commercialisation.

The report evaluated 12 Lighthouse Consortia and selected 13 business models as exemplary models that have contributed to expansion and upscaling of projects.

The **key insights** of the report are as follows:

1) Avoiding the piloting trap: Cities are guided by public good, value generation, and operational effectiveness rather than profit-centric business models. The research consortia that were evaluated, encountered challenges in escalating innovative solutions from the district to the city scale due to a lack of emphasis on expansion and business modelling. Several essential elements are involved in taking solutions from a controlled pilot phase to commercial viability, such as alternative financing that does not rely on grants, established operational models, robust ownership structures, and integration into local ecosystems.

The term 'piloting trap' encapsulates the challenges of broadly implementing solutions that have been successful in pilot projects. To bridge the gap from pilot projects to commercial scale effectively and ensure market readiness, innovative business models and financing strategies must be developed. In addition, cities should advocate for innovation and procurement processes that support the shift to operations and scaling. To surmount these barriers, it is imperative to address scalability, integration issues, and expertise at the onset of the project lifecycle. Crafting effective pathways and mechanisms for successful continuation is vital (refer to Figure 1).

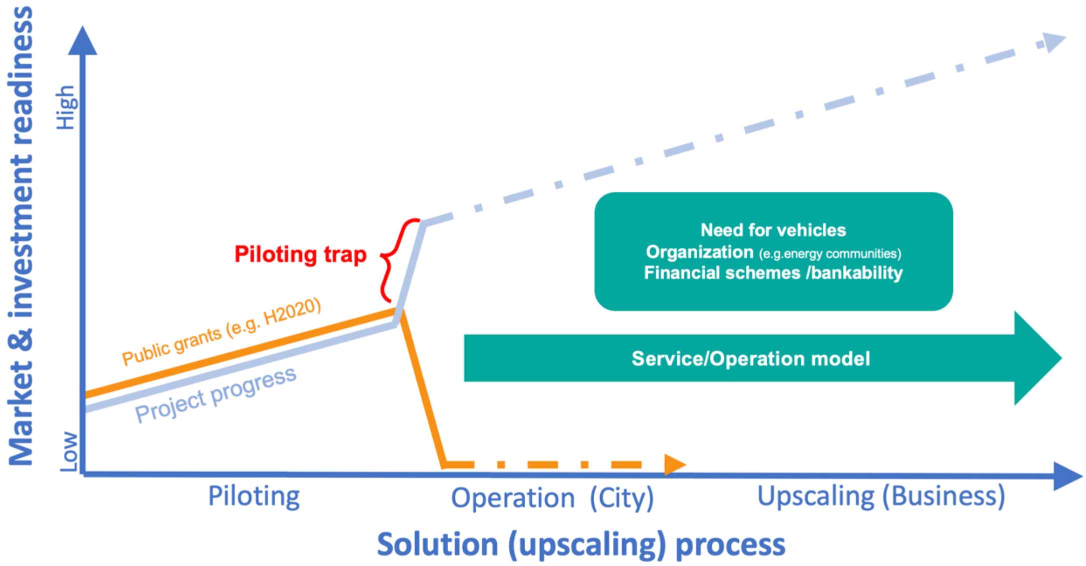

Figure 1: Grant-based piloting needs to transfer towards successful operation and (commercial) upscaling. This requires innovative models and processes to address the tendering, operation, financing, and long-term organisational anchoring. Graph: Scalable Cities.

2) Integrating technologies, infrastructure, and services: For the optimal functioning and advancement of Positive Energy Districts (PEDs), it is crucial to ensure that deployed technologies are interoperable. Cities should integrate these districts into their overarching plans and emphasis technologies that guarantee seamless connectivity while dismantling barriers within technology usage and city administrations to encourage innovation and ownership.

Businesses are also encouraged to implement management systems and customer-focused service models to establish stable revenue streams and enhance operational efficiency. While current projects predominantly leverage ICT and AI for these purposes, they often overlook the essential aspect of behavioural change, particularly in energy management and efficiency.

3) Navigating the innovation landscape: The transformative potential within the SCC initiative's research-centric approach has yet to be fully tapped. Though, it has already created value and yielded positive outcomes. Entrepreneurs and businesses that have integrated piloting into their business development strategies emerge as the most effective proponents for innovation dissemination. Cities should strive to foster and sustain an environment conducive to the success and scaling of enterprises and urban ecosystems.

The solutions and processes showcased in the pilot projects have made an impact on the districts and are promising for broader urban application, while simultaneously mitigating business risks. Nevertheless, the path to extensive commercialisation presents a specific set of challenges.

4) The evolution of Positive Energy Districts: A Positive Energy District (PED) is not an off-the-shelf product but a dynamic and evolving process to develop a combination of solutions and service offerings that match the requirements of a site. A PED, like any smart district, is an amalgamation of diverse solutions, collaborations, and intricate stakeholder networks. The construction of a PED should be viewed as a continuous learning process, requiring the collective creativity and co-operation of various stakeholders, along with robust engagement and synergy with the local environment.

5) Forging a unified vision with stakeholders: Cities must cultivate a shared understanding with businesses and investors to bolster their expertise and capabilities. Indeed, the upscaling of PED solutions necessitates substantial investment. Financial backers are essential in accelerating and enlarging the scope of promising solutions and processes, as exemplified by the 13 cases. This may lead to the creation of innovative public-private partnerships as traditionally investors have not been sufficiently involved in innovative projects. It is imperative to develop trust and understanding across stakeholders.

The **recommendations** are the following:

1) Fostering market readiness through strategic frameworks: It is essential to establish financial and organisational frameworks and service models through a collaborative and unified approach. This is particularly crucial as cities navigate the substantial costs associated with climate mitigation and adaptation in their journey towards climate neutrality. Cities must proactively develop early-stage business cases, operational strategies, and financial models for their forthcoming initiatives. This entails the early integration of financial expertise to ensure robust planning and execution.

2) Cultivating an innovation ecosystem and defining municipal roles: Municipalities are increasingly charged with integrating cutting-edge digital innovations to address pressing urban challenges and bolster competitiveness and resilience. Success hinges on nurturing an ecosystem in which experimentation, adaptation, and engagement in dynamic collaborations is nurtured. This requires a transformation of conventional, risk-averse municipal processes to embrace innovative procurement which helps to avoid inefficient tendering and expenditure.

Cities must articulate their roles within this ecosystem. There is a significant amount of trust in a city's capacity to develop and enforce regulations and governance, whereas the private sector is often relied upon for infrastructure projects. In fulfilling this role, cities can focus on fostering innovation through cutting-edge regulatory frameworks, such as 'regulatory sandboxes'. These experimental spaces provide a protected environment without regulatory constraints to develop technologies and business models that are not market ready.

For smaller cities that often lack the necessary capacity and expertise, access to standardized toolkits, blueprints, and processes for collaboration is vital to incorporate innovation, operationalise it and maintain their future-proofness.

3) Realising untapped potential through cross-platform collaboration: To fully harness the potential and assets of smart city projects, a significant increase in the exchange of learnings and cases across national, European, and international programmes is essential. The most substantial untapped potential lies in the opportunity to disseminate these hard-won solutions, vast expertise, and dynamic collaborations, which have been cultivated over years. Programmes like Germany's 'Smart Cities Made in Germany' (MPSC), encompassing roughly 70 cities, and the Net Zero Cities Programme, including about 120 cities, could benefit from such knowledge sharing.

The report explores the 13 exemplar business models that have been selected at varying stages of the PED value-chain to highlight the significance of smart city prototyping, implementation and the opportunities to upscale products and services.

	Lighthouse case	Brief description	Project, city & owner
1	**Smart energy management and infrastructure (heat)**	Smart infrastructure and management in private buildings using automated thermostats and smart valves and applications for (end) users	**SPARCS 2020-2025** Leipzig, DE Partner: CENERO Energy GmbH
2	**Financial risk sharing model**	Financial scheme to reduce risk for investors or building and neighbourhood measures	**+CityxChange 2018-2023** Trondheim, NO Partner: Officinae Verdi Spa
3	**V2G EV charging network**	Smart energy infrastructure management system that integrates bi-directional charging infrastructure, rooftop PV and load management	**IRIS 2017-2023** Utrecht, NL Partner: LomboXnet
4	**Smart infrastructure, energy management and local trading platform**	Smart infrastructure/microgrid and management and local trading platform linking PED and national energy market	**Atelier 2019-2024** Amsterdam, NL Partner: Banlieu BV
5	**E-Bus charging system full-service model**	Full-service model for public e-bus charging including infrastructure, software, maintenance	**SPARCS 2020-2025** Espoo, FIN Partner: Plugit Finland Oy
6	**PED energy management toolbox and AI based optimisation**	Smart infrastructure and management including AI based prediction and optimisation, energy community for renewable energy self-consumption	**RESPONSE 2020-2025** Dijon, FR Partner: EDF France
7	**Heat as a service model including storage in buildings**	Renewable energy generation within student village from heat pump upcycling district cooling flows, thermal storage and smart energy management development of a full-service model	**RESPONSE 2020-2025** Turku, FI Partner: Turku Student Village Foundation
8	**Open urban data platform and service marketplace**	City provides a data platform and portal (BIM & 3D models, real-time data) and marketplace for urban data services and applications offered by providers; city sets and enforces governance framework	**Ruggedised 2016- 2022** Rotterdam, NL Partner: FutureInsight
9	**Urban digital innovation executive leadership programme**	The training programme managed by a university introduces the building blocks for successful digitalisation and innovation strategies for communities, cities and regions	**Ruggedised 2016- 2022** Rotterdam, NL Partner: Erasmus University Rotterdam

10	**2nd life battery storage**	Refurbished batteries from heavy duty vehicles (buses) are assembled into electric storage units in buildings and are operated in connection with PV systems	**IRIS 2017-2023** Gothenburg, SE Partner: Volvo Buses
11	**Floating river turbine**	Hydroelectric floating river turbine generates power at low flow speeds, compliant with environmental regulation	**+CityxChange 2019-2024** Limerick, IRE Partner: GKinetic Energy
12	**Crowd-funded solar plant**	The City of Valencia financed a solar plant for self-consumption on a city owned building with crowdfunding from citizens	**Match-up** 2017- 2023 Valencia, ES
13	**Tenant electricity model**	A 'Tenant Electricity Model' (TEM) enables the consumption of locally generated energy from a photovoltaic (PV) system. The model focuses on shared consumption	**MatchUP 2017-2023** Dresden, DE

Table 1: Lighthouse cases

2. Glossary

Business models

Business models describe the creation, delivery and capture of value provided by a product or a service and are mostly associated with enterprises. They cover the focus and purpose of the respective enterprise and help to provide better experiences and services. Complementary business cases can be integrated into value chains. Aside from economic value (profit), societal, environmental and cultural values are also covered. Business models are bound to innovation processes. They transfer proven processes and components to another environment, striving to move beyond established framework conditions by defining novel settings. They focus on value generation and profit rather than cost efficiency.

Operating model

An operating model is a blueprint for delivering value to target customers/beneficiaries. An operating model brings the business model to life and executes it. An enterprise operating model describes how the enterprise configures its capabilities to execute actions to deliver business outcomes as defined in the business model[1]. The scope is efficiently delivering (public) services in established framework conditions e.g., regulatory, capacities and costs.

Ecosystem

A (digital) ecosystem is a distributed, adaptive, open socio-technical system with properties of self-organisation, scalability and sustainability inspired from natural ecosystems[2]. The (digital) ecosystem is extended to the societal and economic context, emphasising interrelations and changeability. An ecosystem is more than a network.

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[1] https://www.gartner.com/en/information-technology/glossary/operating-model

[2] https://en.wikipedia.org/wiki/Digital_ecosystem. This site is a suitable access point by providing references for further exploration of the topic

3. Introduction: The Smart Cities and Communities initiative

The Smart Cities and Communities (SCC) initiative is one of the largest and most comprehensive Smart Cities research and development programmes to date. The SCC has been funded by the EU's research and innovation programmes under Horizon 2020. The initiative aims to develop, pilot, and replicate innovative and impactful solutions for smart, low-carbon districts. The first focus areas of the programme are mobility, energy, ICT and data, and citizen participation, encouraging the urban low-carbon transition and the development of a European city-needs-led smart city market. From 2019 onwards, the focus shifted to Positive Energy Districts (PED).

120 European cities and 515 partners have **implemented and piloted more than 550 solutions** within the Lighthouse Projects

Since 2015, 120 cities and 515 project partners have developed, tested, and implemented more than 550 solutions across 18 SCC projects. 'The overall Horizon 2020 funding granted to Lighthouse projects amounts to €381 million. The value of supported projects, including co-funding, amounts to €446 million. On average, each Lighthouse city plans to invest approximately €1.1 billion and each Fellow city €400 million to carry out such projects'.[3]

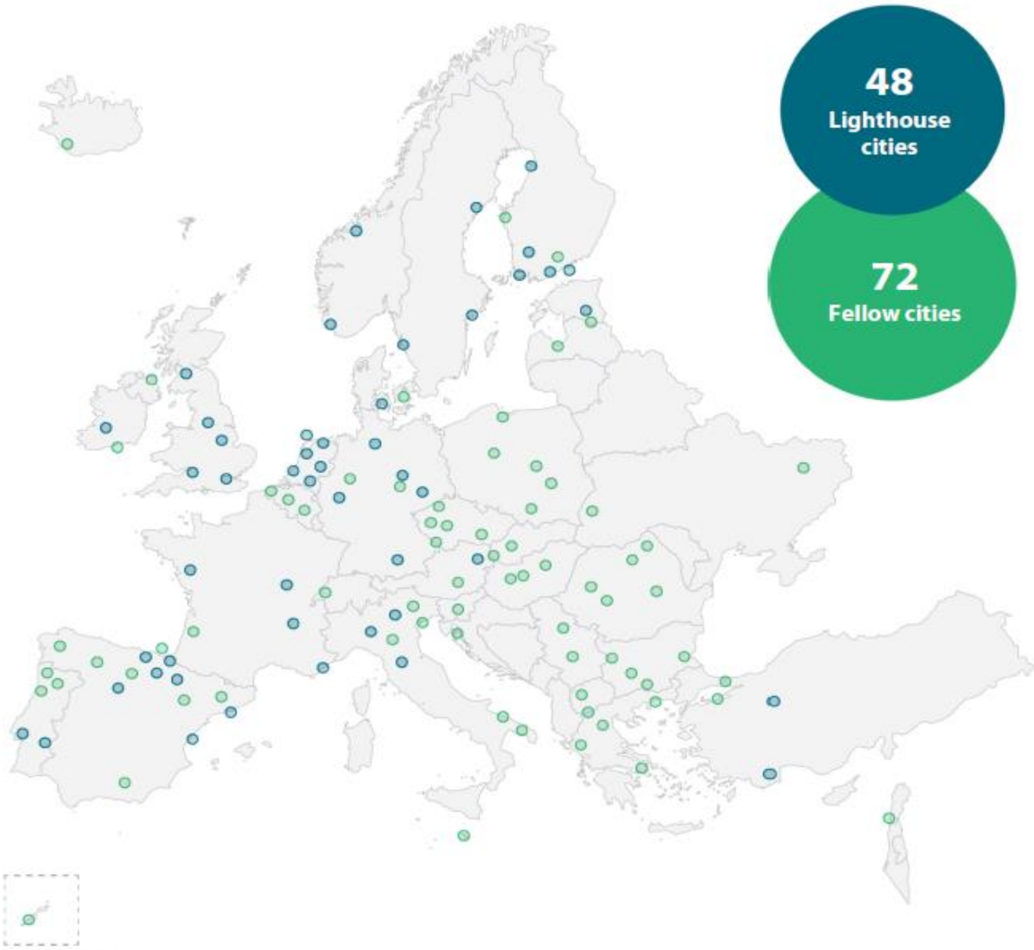
The SCC initiative has a noticeable impact on cities, including through the installation of over 17,500 smart meters, the refurbishment of over 1 million m^2 of floor space, the introduction of more than 5,270 electric vehicles, the installation of nearly 500 e-charging stations and the involvement of over 260,000 European citizens.

Additionally, significant value is generated from the expertise built within public and private organisations through the lessons learned and improvements discovered while piloting and implementing hundreds of projects. Moreover, cultural and organisational changes have led to new policies and frameworks and the implementation of new cross-sectoral processes and collaborations.

53 of the 120 "Climate Neutral and Smart Cities" had already participated in the SCC Lighthouse Programme.

The know-how and "process learning" from eight years of SCC programme implementation have also made a noticeable contribution to the current 'Climate-Neutral and Smart Cities Mission' programme under the EU's new work programme Horizon Europe (2021-27). Of 120 mission cities, 53 have already participated in the SCC initiative. This demonstrates the significant value of knowledge transfer towards new programmes and the successful upscaling of know-how, lessons learnt and collaborations from the smart districts of the SCC projects to the city-wide approach of the current 'Climate-Neutral and Smart Cities Mission'.

3 Special Report "Smart cities Tangible solutions, but fragmentation challenges their wider adoption European" Court of Auditors, 2023



Source: ECA.

Figure 2: Since 2015, 120 cities, 48 Lighthouse Cities and 72 for Fellow Cities have implemented and replicated smart city projects

4. Methodology

The aspiration for market readiness, upscaling, and the appeal to private investors has been a persistent ambition and challenge since the launch of the programme in 2014. The purpose of the work undertaken in the context of this report was to identify, understand, and showcase potential business cases and financing schemes within the programme. Emphasis was placed on comprehending the value chain, challenges, processes, and potential avenues and vehicles for upscaling and commercialisation, particularly within the ten latest consortia and their Positive Energy Districts (PEDs). However, based on the level of financial data provided by the assessed projects, detailed description of cases and solutions will be emphasised rather than business cases.

The results are built on direct input from 12 SCC projects, discussions with the Business Models and Finance Task Group (BMF TG), the Board of Coordinators, as well as the Smart City Marketplace, the European City Facility (EUCF) and experts from the European smart cities community. The active engagement of these stakeholders ensures a holistic understanding of innovative business models and financing schemes, reflecting the diverse experiences and challenges encountered in upscaling and financing Smart Cities projects.

The assessment must be considered as a hands-on examination of PED implementation and possible pathways for upscaling but does not intend to deliver broader research and in-depth descriptions of PEDs or technologies. The data collection and analysis took place from June to November 2023 and followed three major steps based on a questionnaire, structured interviews, and secondary literature, such as deliverables or reports. The report focuses on SCC projects between 2016 - 2020.

This report includes data from the White Paper on 'PED Reference Framework for Positive Energy Districts and Neighbourhoods'[4] and the 'Special report: Smart cities - Tangible solutions, but fragmentation challenges their wider adoption', European Court of Auditors (2023).

The following projects have been included and contributed to the assessment: SPARCS, +CityxChange, MAKING-CITY, IRIS, ATELIER, POCITYF, RESPONSE, MAtchUP, Stardust, Ruggedised and the Scalable Cities initiative.

4 https://jpi-urbaneurope.eu/wp-content/uploads/2020/04/White-Paper-PED-Framework-Definition-2020323-final.pdf

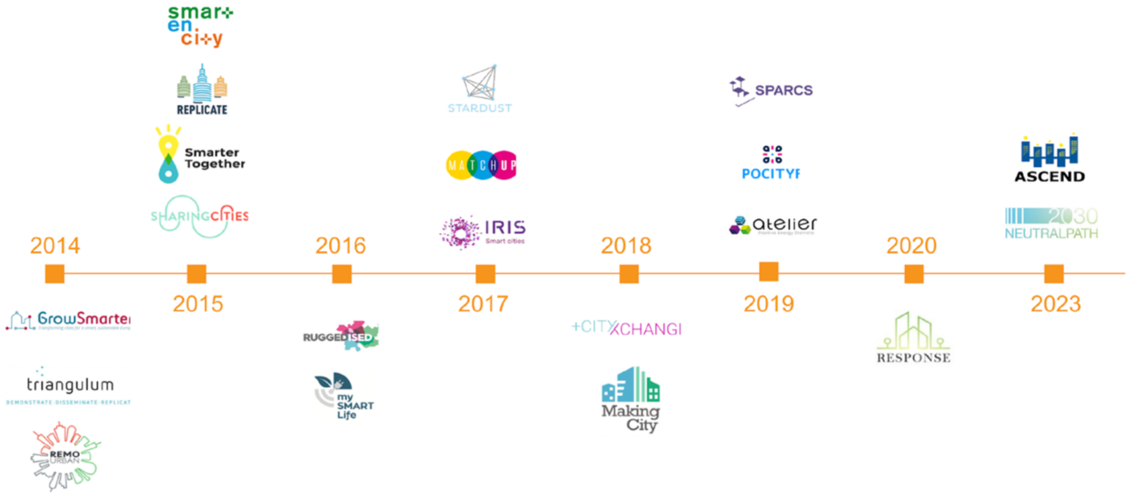


Figure 3: The assessment focused on the latest 10 projects emphasising energy measures and Positive Energy Districts (PEDs)

Step 1: Comprehensive questionnaires

The Scalable Cities Secretariat and the Task Group Business Models and Finance (TG BMF) designed and provided a questionnaire on innovative business models and financing schemes, which was sent to 12 consortia in June 2023 out of which 10 had responded within the given timeframe and could be considered in further evaluation. The evaluators had no influence on this questionnaire.

Each project was asked to describe its two best "Lighthouse" business models and financing schemes. The respective partners of the projects responsible for business models and financial schemes curated the selection of the business model cases and the collection of information from cities and other concerned project partners. Seven projects responded with data on 13 cases.

However, more data and discussions with the case owners were required to deep-dive into the cases and to select the 13 Lighthouse cases to be described in the report and showcased at the Scalable Cities roadshow.

Step 2: Structured interviews and follow-up discussions

The assessment of the survey data was followed by a series of structured interviews to clarify remaining questions and data gaps, to understand challenges, perceived value chains, lessons learned and upscaling potential.

The interviews were conducted with the owners of the business cases, who were usually experts from private companies and representatives from cities that implement PEDs. Thirteen interviews were conducted with eight projects.

The structured interviews and follow-up discussions took place via video call and face-to-face at the Final Conference of the SCC Project +CityxChange in Trondheim, Norway in September 2023 and at the Smart City World Congress 2023 in Barcelona, where the team participated in various working groups and panel discussions. Face-to-face exchange proved to be a valuable source of information, often reaching beyond the information provided in the case or in the questionnaire.

The questionnaires and structured interviews built the backbone of the study. Discussions with experts from the European smart cities community and the Climate Neutral and Smart Cities mission that focused on financing aspects and vehicles for a larger scale uptake helped to clarify context and improve the policy framework.

Figure 4: Workshop on business models and financing schemes in Trondheim. Photo: Scalable Cities

Step 3: Secondary literature and project documents

The assessment was limited to the sources mentioned above. However, in some cases, the experts referred to selected public project deliverables, reports, presentations and project websites to acquire the required information.

Step 4: Comprehensive review

Ultimately, the report was presented to the interviewees and case owners for verification and was reviewed and supplemented by several experts and the Scalable Cities secretariat and approved by CINEA. The contributing experts, cities and organisations are listed in the attachment to this report.

5. Evolution of smart and positive energy districts

This chapter provides an overview of infrastructure components and services for interconnection and interoperability that constitute a PED. The overview is based on input and appraisal from city representatives and research partners from the assessed projects. The selected 13 Lighthouse cases provided examples of solutions deployed to deliver infrastructures or services addressing challenges and trying to meet PED objectives.

The essence of a "smart" Positive Energy District (PED) lies in tailoring it to a specific city framework condition, "local fabric", and the needs of diverse stakeholder groups. It requires a meticulous process rather than an off-the-shelf solution. It requires collaboration amongst stakeholders, such as citizens and end users, who are pivotal in shaping the district's identity and customer journey.

A PED will involve diverse stakeholders, including citizens - inhabitants of the district and individuals coming to the district for work, education, recreation, and other activities. Every PED has essential elements consisting of infrastructure and intelligence.

One of the main principles of the PED concept is to produce as much energy as possible in the neighbourhood for its consumption needs. A PED's core elements encompass infrastructure and intelligence, focusing on energy generation, storage, efficient buildings, mobility, and - critically - connectivity and interoperability. This report considers only technology that has demonstrated a technology readiness level (TRL), allowing for timely market uptake and roll out, i.e. TRL 7-9.

Building blocks of a PED

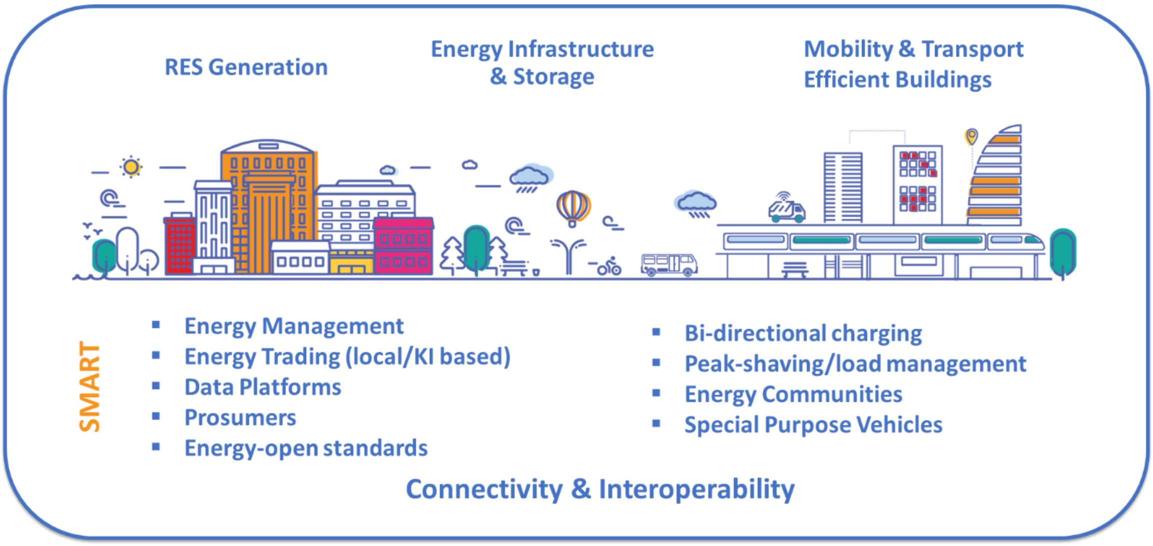


Figure 5: Smart districts require connectivity and interoperability between PED components

A PED is composed of diverse building blocks consisting of components, digital tools and services that are connected. Figure 4 shows the main elements of a PED.

Renewable energy generation and sources

Energy generation must consider electric power and a high share of renewable energy and renewable heating and cooling sources. There is a need for overall electrification of processes not only in buildings, e.g. by a broad roll-out of heat pumps for heating and cooling buildings, but in all sectors, including manufacturing and transport. Electric power will be generated from renewable energy plants. The increasing demand for electricity must be mitigated by higher overall energy efficiency, for example in building envelopes, all appliances and vehicles.

For most cities, solar power is the main source of renewable electric energy. Therefore, photovoltaic (PV) panels could be widely distributed. However, the organisation and management of installed panels are crucial for them to be effective within each district. If they are intended to be installed on already existing roofs, the structural analysis of the buildings needs to be considered and could hinder the wider deployment of decentralised PV "plants". Additionally, restrictions related to cultural heritage can be a barrier to the wider roll-out of PV plants at the district level (e.g. in Limerick, project +CityxChange).

In urban environments, wind turbines are mostly not feasible at large scale. Large wind turbines are out of the question, and small wind turbines are experimental and less efficient and may provide unwanted side effects like increased noise levels. Therefore, no case related to wind power is presented in this report.

However, cities have other resources to consider for integration into the energy chain. Waste incineration (e.g. in Dijon, project RESPOND) can be a source of district heating (DH) networks. Waste heat from manufacturing processes or wastewater 2dtreatment plants (e.g. in Turku, project RESPOND) or by utilisation of lost heat from wastewater can also be heating sources.

Other avenues to explore for efficient renewable energy generation depend on geographical conditions, like the feasibility of exploiting geothermal energy or the availability of novel technical solutions. An example of this is the usage of hydropower for electricity production with efficient and scalable tidal turbines that operate at slow river speeds without impacting the environment or riverbed (e.g. Trondheim, Limerick, project +CityxChange).

Energy infrastructure and storage (Grid)

The aim of smart and energy-efficient infrastructure is self and on-site consumption. A PED concept encourages self-consumption within a building and a neighbourhood organised, for example, as an energy community. An emerging piece of energy infrastructure is charging stations for electric vehicles (EV), both light vehicles like e-bikes and cars, as well as heavy vehicles like buses and (utility) trucks in municipalities (e.g. in Espoo, project SPARCS or Trondheim, project +CityxChange). Stations should allow bi-directional charging to support grid stabilisation and enable electric vehicles to act as "roaming batteries", which is an interesting feature (e.g. in Utrecht, project IRIS).

Energy storage in a PED is crucial for balancing the production and consumption of renewable energy and fostering self-consumption. Batteries are the main storage medium for electricity; the development speed for new battery technology is high. However, recycling batteries from EVs gives them a "2nd life" as local electricity storage is a market-ready service (e.g. in Gothenburg, project IRIS). Aside from electricity, heat could be stored on the building and block/district levels depending on the energetic and economic efficiency and scalability of the technology used, such as PCM (phase change materials, e.g. in Turku, RESPOND).

For a PED, a micro-grid can provide important benefits (e.g. in Turku, project RESPOND) since the technology for renewable energy production builds on it.

Efficient buildings

Crucial elements of a PED are efficient buildings. Buildings are long-term assets, and a life-cycle approach shall be considered to assess their impact on climate, environment, society, and economic value using a LCA (Life Cycle Assessment) approach.

Transforming an existing neighbourhood into a PED is a challenging task in which strategies for speeding up retrofitting play a major role. Thermal renovation is crucial to improve energy efficiency and facilitate the building infrastructure for future-proof technology (e.g., renewable energy, fit for low-temperature heating systems, smart metering, etc.). It may also provide an opportunity for "upgrading" neighbourhoods towards higher levels of comfort, for example with the integration of green roofs and facades helping to create urban microclimates and mitigate heat islands.

Mobility and transport

Establishing a PED provides an excellent opportunity to rethink the use of public space and develop new solutions and digital tools for the mobility and transport of goods within the PED and in connection with other districts. Mobility hubs facilitate modal shifts for persons and support organising goods logistics for (small) enterprises and individuals. Additionally, they can be enriched with service offerings like co-working spaces, long-term parking, and services for vehicles.

Even though mobility and transport are important elements of smart and positive energy districts that have been addressed in earlier SCC projects, since 2016, the focus of the projects has shifted away from mobility towards energy and subsequently as of 2019 towards PEDs, including e-charging infrastructure as part of a smart grid.

Connectivity and interoperability

A smart, positive energy district requires connecting, managing and thereby "smartening" the different building blocks and solutions. At the same time, intelligence rules and algorithms for interoperability should be applied to allow for trading, controlling, monitoring, and optimisation. Additionally, the corresponding digital interfaces are necessary.

Advanced energy management systems algorithms and artificial intelligence (AI) tools facilitate predictions, operate the billing for demand and supply, and model pathways towards decreased overall energy consumption.

Crucial data can be obtained from smart metres. Intelligent valves and thermostats are devices used to optimise energy supply and demand. Furthermore, these devices help to detect the required level of comfort and the least input of energy.

Suitable data sets and access to data via data stores or platforms featuring for example IoT applications (IoT = Internet of Things) or data from sensor networks, are enablers for connectivity and interoperability. This requires developing and implementing sound data governance and management policies respecting data sovereignty of entities – such as individuals but also enterprises and public administrations. Urban data platforms should facilitate the principles of open and FAIR (Findable, Accessible, Interoperable, Reusable) data fostered by the European Commission data management requirements and help to mitigate vendor lock-in.

As the assessment has shown, connectivity and interoperability tools play a crucial role in enhancing grid flexibility and enabling local energy trading, thereby fostering the growth of energy communities and prosumers. Notable examples include energy management systems like those implemented in Leipzig under the SPARCS project and in Dijon through the IRIS consortium. These systems significantly contribute to the efficiency, sustainability and stability of the energy infrastructure.

6. The Lighthouse cases

The project consortia were asked to provide two business cases. The assessed cases indicate a high level of innovation, value creation and up-scaling potential. However, due to the nature of the research focused piloting projects, the financial data are insufficient to describe them as mature business cases. Not surprisingly, private sector partners owned and implemented the most developed cases towards market readiness.

The report describes thirteen "Lighthouse cases" that have been selected along the PED value-chain to highlight the significance of smart city prototyping, implementation and the opportunities towards upscaling potential products and services. Although the cases are all aligned with the aforementioned elements of a PED they are diverse in relation to actors, stakeholders, regulations, framework conditions and regional fabric of cities all over Europe.

Overview of Lighthouse cases

The table below contains the list of the 13 Lighthouse cases marked in dark grey, which will be described in more detail. The cases in light grey have not provided enough details to be analysed. Their impact on bridging the piloting gap was not yet foreseeable due to their maturity level. They could be added at a later stage when their maturity will be higher.

	Case	**Brief Description**	**Project & City**
1	**Smart energy management and infrastructure (heat)**	Smart infrastructure and management in private buildings using automated thermostats and smart valves and applications for (end) users	**SPARCS 2020-2025** Leipzig, DE Partner: CENERO Energy GmbH
2	**Financial risk sharing model**	Financial scheme to reduce risk for investors or building and neighbourhood measures	+CityxChange 2018-2023 Trondheim, NOR Partner: Officinae Verdi Spa

3	**V2G EV charging network**	Smart energy infrastructure management system that integrates bidirectional charging infrastructure, rooftop PV and load management	**IRIS 2017-2023** Utrecht, NL Partner: LomboXnet
4	**Smart infrastructure, energy management and local trading platform**	Smart infrastructure/microgrid and management and local trading platform linking PED and national energy market	**Atelier 2019-2024** Amsterdam, NL Partner: Banlieu BV
5	**E-bus charging system full-service model**	Full-service model for public e-bus charging, including infrastructure, software, maintenance	**SPARCS 2020-2025** Espoo, FIN Partner: Plugit Finland Oy
6	**PED energy management toolbox and AI-based optimisation**	Smart infrastructure and management, including AI-based prediction and optimisation and energy community for renewable energy self-consumption	**RESPONSE 2020-2025** Dijon, FRA Partner: EDF France
7	**Heat as a service model, including storage in buildings**	Renewable energy generation within student village from heat pump upcycling district cooling flows, thermal storage and smart energy management development of a full-service model	**RESPONSE 2020-2025** Turku, FIN Partner: Turku Student Village Foundation
8	**Open urban data platform and service marketplace**	City provides a data platform and portal (BIM & 3D models, real-time data) and marketplace for urban data services and applications offered by providers; city sets and enforces governance framework.	**Ruggedised 2016- 2022** Rotterdam, NL Partner: FutureInsight
9	**Urban digital innovation executive leadership programme**	The training programme managed by a university introduces the building blocks for successful digitalisation and innovation strategies for communities, cities, and regions	**Ruggedised 2016- 2022** Rotterdam, NL Partner: Erasmus University Rotterdam
10	**2nd Life battery storage**	Refurbished batteries from heavy-duty vehicles (buses) get assembled into electric storage units in buildings, and are operated in connection with PV systems	**IRIS 2017-2023** Gothenburg, SWE Partner: Volvo Buses
11	**Floating river turbine**	Hydroelectric floating river turbines generate power at low flow speeds, eligible with environmental regulations	**+CityxChange 2019-2024** Limerick, IRE Partner: GKinetic Energy

12	**Crowd-funded solar plant**	The City of Valencia financed a solar plant for self-consumption on a city owned building with crowdfunding from citizens	**MatchUP** 2017- 2023 Valencia, ES
13	**Tenant electricity model**	A 'Tenant Electricity Model' (TEM) enables the consumption of locally generated energy from a photovoltaic (PV) system. The model focuses on shared consumption	**MatchUP 2017-2023** Dresden, DE
14	Feasibility study climate neutral district and revenue models	The Follower City Riga elaborates four scenarios that shall be considered for the implementation of a climate-neutral district, including prosuming, storage, management business management and revenue models.	**Atelier 2019-2024** Riga, LV (Follower-City)
15	Smart infrastructure and PED business canvas	Bidirectional smart inverters, power electronics energy routers, advanced buildings management systems and energy management systems for private buildings reduce costs and address energy poverty	**POCITYF 2019-2024** Evora, PT
16	Flexible electricity grid	Flexible and sustainable electricity grid networks with innovative storage solutions, and flexible and sustainable district heating/cooling with innovative heat storage focusing on public buildings	**POCITYF 2019-2024** Alkmaar, NL
17	Air quality sensor	Assessment of air quality sensors as well as value and use cases of the data	**RESPONSE 2020-2025** Turku, FIN
18	Integrated planning process BM development	The city of Oulu uses an integrated spatial and energy planning model for the PED; Business models are under development by a consultancy	**MAKING-CITY 2018-23** Oulu, FIN

Table 2: Overview of 18 Lighthouse cases

Detailed description of Lighthouse cases

1. Smart energy management (Heat)	**SPARCS 2020-2025** **Leipzig, DE (Lighthouse City)** **Lead partner:** CENERO Energy GmbH	**Classification:** Service model & energy management. **Corporate**	**Status:** Ongoing **Upscaling potential:** High
More efficient management of the heat demand using smart devices and applications. (1) Improving the efficiency of energy-generating plants by implementing smart infrastructure using smart thermostats and an automated valve in the heating system from a combined heat and power plant, and (2) Usability and accessibility by user-app and energy-management software. (3) Reducing required generation and costs by more efficient peak /load management.			

Development, innovation and operation	**Business-/service model & value creation**	**Lessons learned**
Innovation Communication of sensors and valves, shutting down of water circulation - more efficient than heat pumps; comprehensive energy monitoring. **One stop shop** for heat demand control. **Operation by a private service provider.**	**Customers** Corporate users such as industrial/commercial property owners, corporate tenants, RE developers. **Business model** Software as a Service: monthly fee (per intelligent thermostat connected to the energy management platform). **Job to be done** Reducing peak load and a more efficient energy management reducing costs. **Options** Additional sensors like air quality, CO_2 and temperature for additional monthly fees; data analytics as consulting service. Straightforward case with robust upscaling potential.	Better data on demand for energy. To connect "loose ends", e.g. energy management systems from other companies in other buildings, it requires rules of collaboration between the different energy providers and users for the PED in order to achieve the best possible joint success. Go straight for a whole-service model for a connected approach and greatest benefit to customer and end-user. Private company - faster implementation, better upscaling potential.

Table 3: Smart energy management (SPARCS)

<table>
<tr><td>2. Financial risk sharing model</td><td>+CityxChange 2018-2023

Trondheim, NO (Lighthouse City)

Lead partner: Officinae Verdi Spa</td><td>Classification: Financial Scheme

Corporate</td><td>Status: Completed

Upscaling potential: Medium</td></tr>
<tr><td colspan="4">Assessment and calculation of potential benefits and/or financial and investment risks for retrofits and local renewable generation for positive energy districts, distributed amongst a cluster of stakeholders reaching a common goal, guidance on avoiding potential investment losses and reducing financial exposure to risks. The analysis of risks and potential revenues is put in relation to each stakeholder with local market assets and flexibility and measures the financial value of each asset of the project. The sharing of the risk-benefit constructs involved in such projects can attract investors and stakeholders because a larger number of institutions share the individual risk.</td></tr>
<tr><td>Development, innovation and operation</td><td colspan="2">Business-/service model & value creation</td><td>Lessons learned</td></tr>
<tr><td>Innovation
The Financial Risk is an indicator that measures how much each player/investor, in terms of percentage, risks losing money on its own business or investment decision. The total value is a product of summing up and integrating all assets and interventions in a single economic, financial, environmental, and social assessment process based on indicators suitable to measure the investment against its global direct and indirect impacts.

Applicable for all PED-related infrastructure investments (including ICT systems).

The City of Trondheim leads and coordinates all the PED implementation phases involving all the stakeholders and asset owners participating in the process. Each stakeholder can share and operate within this tool.</td><td colspan="2">Customers
Cities, financial investors, developers.

Business model and revenues stream
Consultancy to build a PED model, financial assessment including environmental, social and governance sustainability (ESG) assessment.
This approach allows to capture total value both across linear PED development (i.e. from implementation to impact generation) and across themes (economic-financial aspects + ESG).

Job to be done
Decreasing risk investment by a broader understanding and more transparent approach to costs and risks involved between the different participants in a project.

Good upscaling/replication potential for service.</td><td>Method and its results have been applied to various business cases and energy investments within the PEDs.

Rationale: sharing of financial risks reduces the potential total loss for everyone, especially important in the energy sector, where (market) risks are increasingly hard to foresee and benefits might take a certain time to unfold.</td></tr>
</table>

Table 4: Financial risk sharing model (+CityxChange)

<table>
<tr><td>3. V2G EV charging network</td><td>IRIS 2017-2023

Utrecht, NL (Lighthouse City)

Lead partner: LomboXnet</td><td>Classification: Smart Infrastructure (EV-Charging)

Corporate</td><td>Status: Completed

Upscaling potential: High</td></tr>
<tr><td colspan="4">Vehicle-to-Grid (V2G) applications serve as storage units, often called 'roaming batteries,' integrated within the electric grid. Their purpose is to store surplus energy generated from sources such as rooftop PV and redistribute it, for instance, to power street lighting. V2G applications are already market-ready and have been successfully commercialised in the Netherlands.

Utrecht holds the distinction of being the first city worldwide to implement vehicle-to-grid (V2G) technology extensively. The initiative for the 'Public Vehicle Charging' tender commenced in November 2018 for Utrecht City.

Electric vehicles (EVs) also play a role in managing peak load capacities, especially in peripheral sections of the grid. In a bidirectional application, EVs can feed power back into the grid, contributing to its stabilisation.</td></tr>
</table>

<table>
<tr><th>Development, innovation and operation</th><th>Business-/service model & value creation</th><th>Lessons learned</th></tr>
<tr><td>Innovation
Solar power is integrated to a district-wide power storage system for maximum grid flexibility. Primary storage: V2G batteries of e-cars and public transport e-buses; secondary storage in stationary batteries in buildings.

Operation
Required Infrastructure:
bi-directional charging stations; energy management.
The entire value chain is in place with several stakeholders.
In the City of Utrecht, the service is operated by a procured contractor.

1st V2G innovation ecosystem built in Utrecht with the support of the city, We Drive Solar, Renault, Hyundai and other partners.</td><td>Customers
Fleet operators, charging solutions, storage, solar power (smart charging), grid operator.

Business models
Combination of several use cases and business cases. Paying customers: fleet operators, charging solutions, storage, solar power (smart charging), grid operator
Value chain: fleet operators (starting point), PV operators (energy communities), grid operators.

Job to be done
Powering urban car fleets and buses with solar energy.

Sound upscaling and replication potential; promising segments logistic centres, industrial parks.</td><td>Private company (kick-started by an entrepreneur!) - faster implementation, better-upscaling potential.

City sets the framework, industrial development policy.

Countries have different regulatory frameworks.</td></tr>
</table>

Table 5: V2G EV charging network (IRIS)

4. PED energy management and local trading platform	**Atelier 2019-2024** **Amsterdam, NL (Lighthouse City)** **Lead partner:** Banlieu BV	**Classification:** Energy Management & Trading **Corporate**	**Status:** Ongoing **Upscaling potential:** Feasible Assessment
The positive energy district *Buiksloterham* in Amsterdam strives to create a mixed area for tertiary and new residential buildings. Car access will be restricted, and an EV/bike/Biro sharing scheme will be provided. RES (PV, geothermal, waste) is produced within the district. An intelligent microgrid will manage supply further, integrating energy storage and linking to the public grid. A local energy market platform enables energy and flexibility trading both locally within the positive energy district and on the wholesale energy and balancing markets, leading to integration between the local energy market and the national / EU energy markets. New market paradigms and governance models are supported by the establishment of local energy markets.			

Development, innovation and operation	**Business-/service model & value creation**	**Lessons learned**
Innovation New, high-energy efficiency building groups concentrated on newly developed plots. **Local renewable energy production**, from PV, ground heat, and waste streams, contributes to the positive energy balance. **Smart microgrids** that enable intelligent coordination of local renewable energy supply, storage and (flexible) demand, and exchange of energy between the demonstrator plots and with the public grid. Testing and establishing a local energy market, which interacts with the grid and residents acting as prosumers. The operation of energy management and trading is in corporate hands, but in assignment of the owners and users of the buildings (cooperatives).	**Customers** Residents, energy communities, grid operator. **Business model and revenues streams** Testing a local energy trading platform for developing prosumer services. **Value capture through prosumers;** any surplus of energy will be sold to the grid operator, generating a revenue stream. **Private investors** cover 98,5% of total investment cost. **Job to be done** Local energy markets and (smart) energy communities, empowering citizens, and local businesses as customers to take an active role in the transition. Upscaling potential linked to the actual demonstration.	Dependent on national regulations such as the Dutch 'project-net', which allows cooperatives and associations to develop a network that combines both operating the grid and production, delivery and management for a maximum of 500 connections. Feasibility requires comprehensive testing. An energy autonomous district is independent from conventional energy (gas) providers except for occasional maintenance or refurbishment.

Table 6: PED energy management and local trading platform (ATELIER)

5. E-bus charging system full-service model	**SPARCS 2020-2025** **Espoo, FI (Lighthouse City)** **Lead partner:** Plugit Finland Oy	**Classification:** Service Model (including infrastructure) **Corporate**	**Status:** Ongoing **Upscaling potential:** High

The project is set to become Finland's largest public electric bus charging system and serves as a testbed for Helsinki Region Transport (HSL). The charging system is powered by RES. At first, the layout was designed with Espoo City and offered as charging as a (full) service to be upscaled to other areas and regions in Finland.

Development, innovation and operation	**Business-/service model & value creation**	**Lessons learned**
Innovation First full-service model for public transport charging to be developed, tested, customised and upscaled (hardware & software). Operator provides managing software/APIs connecting to existing fleet management. Renewable energy as the primary source for charging stations requires the negotiation of contracts with energy providers. 30 electric buses to be operated. Fully operated by a corporation.	**Customers** Cities, public transportation authorities, private fleets. **Business models and revenues streams** Charging as a service against monthly fee for operation and energy costs with small invoicing fee. Value chain includes research and development to installation, operation, and maintenance also providing charging hardware and managing software. Charging infrastructure owned by the provider and requires initial investment (loan). Data use cases are under exploration. Existing public demand and upscaling potential to other public and private fleets.	Within these complex public sector projects, intense stakeholder management and testing of the system at the early phase. Due to high investment in grid /infrastructure, a long duration of service contract is desirable (ca. 10 years), as well as durable equipment. Buses with long routes or smaller batteries need the described service. Upscaling might enable "large-scale" contracts with RES-suppliers which reduces costs. Communication of significant contribution/benefits to climate neutrality goals of the city/sector is important. Dealing with the existing grid connection is a challenge.

Table 7: E-bus charging system full-service model (SPARCS)

<table>
<tr><td>6. PED energy management toolbox and AI-based optimisation</td><td>RESPONSE 2020-2025

Dijon, FR (Lighthouse City)

Lead partner: EDF France</td><td>Classification: Energy management

Corporate</td><td>Status: Ongoing

Upscaling potential: Medium</td></tr>
<tr><td colspan="4">The energy managing solution (covering electricity and district heating) aims to drive the fuel switch towards RES and reduce energy demand through local energy production, energy storage and smart thermostats (developed by a start-up) combined with energy management. An AI-based demand prediction seeks to optimise the system. Additionally, energy communities shall help to increase the self-consumption ratio of electricity in the concerned public buildings.</td></tr>
<tr><td colspan="2">Development, innovation and operation</td><td>Business-/service model & value creation</td><td>Lessons learned</td></tr>
<tr><td colspan="2">Innovation
Thermostats crucial front end:
- Reduce energy consumption in the apartments,
- 15% of energy saving targeted,
- Reduce peak demand of district heating network, reducing gas consumption.

Prediction system ‘Cleverly’ at TRL 8-9; APIs developed within Response. Cleverly collects real-time data from sensors but also AI modelling from which further business models will be developed.

System to contribute to grid flexibility, test peak shaving and optimised operating command to storage equipment for higher self-consumption ratio.

PV panels on the roofs for energy production, linked to the batteries.

Storage solutions.

EDF will operate the system during the project</td><td>Customers
B2B: Public bodies, housing associations, facility management businesses.

User: Inhabitant/tenant with installed smart thermostats (costs: ca 800-1000€ per flat).

Business models
Saving energy as a service costs but also income from surplus energy sales will be passed on to building owners/inhabitants.

Retail business: panels, tools for energy communities, toolbox for building owners.

Project addresses energy poverty in buildings operated by Dijon Social Housing Company.

Possible additional case: storage as a service.

Job to be done

Better energy management for residents.

Upscaling potential linked to the actual demonstration.</td><td>Building flexibility is the next elephant in the room.

Importance of resident onboarding, acceptance of generalised use, nudges (e.g. adopting the out of home switch), prudent data sovereignty concept.

ECs huge market demand for energy flexibility and stability for 20 years; turning passive users into active prosumers.

Embrace innovation more – co-operation with start-ups, research.

Also used to pilot wind power plants, operation model.</td></tr>
</table>

Table 8: PED energy management toolbox and AI-based optimisation (RESPONSE)

7. Heat as a service model, including storage in buildings	**RESPONSE 2020-2025** **Turku, FI (Lighthouse City)** **Lead partner:** Turku Student Village Foundation TYS)	**Classification:** Heat as a service **Corporate**	**Status:** Ongoing **Upscaling potential:** Medium

Within a student village, the project seeks to increase local renewable energy production, including upcycling waste heat from district cooling flows and reducing energy consumption. The selected case provides 'Heat as a Service' for public buildings/student homes.

Development, innovation and operation	**Business-/service model & value creation**	**Lessons learned**
Innovation Principal technology challenge: improving the overall operational efficiency of heat networks by balancing their demand-driven peaks and troughs to improve the efficiency of the heat generation plant and enable the capture or any zero-carbon surplus electricity generation from intermittent renewable sources. **Product innovation** Phase Change Material (PCM) thermal storage can store between 4 to 10 times as much energy by volume as compared to the counterfactual, e.g. hot water tanks, glycol etc.; increased storage can be placed onto the district heating network with minimal visual or land value impact. Technology allows the up-scaling of aggregates - building level, district level. Technology allows for low water temperature (e.g. from district cooling or wastewater). **Operational innovation:** Integration with heat pumps, RES, wastewater plant. PCM technology as enabler; patented, TRL 7-8. **Facility owner:** TYS (Turku Student Village Foundation) in co-operation with storage provider and municipal energy company Turku Energia.	**Customers** Property owners; facility management companies; heat generation/distribution companies **Business models** • **Heat as a service** (HaaS): allows arbitrage between the cost of heat generation at different times of the day to provide the end consumer and heat generators financial benefits while paying back the CAPEX. • **Model for tenants**: cost for heating/cooling; if integration with electrical energy - whole energy bill, extend depending on contract for the rent (all in etc.). • **HaaS model:** finance would be provided by a manufacturing company or asset-backed finance company; CAPEX. **Revenue stream** monthly standing charge to pay for the upkeep and availability of the infrastructure plus variable €/kWh unit price for the supply of kWh of heat. This would vary according to the heating season at a minimum or different price for the summer as well for the winter. Carbon cost/savings can be a potential account to consider.	Start small, looking for a meaningful focus to scale up potential. Heating/cooling is the biggest energy consumption, sustainability is important - go for it. Data use cases - also non-profit, not monetarily driven; prove for calculation of KPIs. Good replication potential compared to the winter.

Table 9: Heat as a service model, including storage in buildings (RESPONSE)

<table>
<tr><td>8. Open urban data platform and service marketplace</td><td colspan="2">Ruggedised 2016-2022

Rotterdam, NL (Lighthouse City)

Lead partner: FutureInsight (NL)</td><td>Classification: Data Platform & Service

Corporate</td><td>Status: Roll-out

Upscaling potential: High</td></tr>
<tr><td colspan="5">The City of Rotterdam provides a data platform as a portal (BIM & 3D Models, real-time data) and marketplace for urban data services and applications offered by trusted private and public providers. The entire infrastructure and operation are outsourced to a corporate partner. The city sets the data governance framework, rules and regulations and observes and enforces them on an operational and strategic level.</td></tr>
<tr><td colspan="2">Development, innovation and operation</td><td colspan="2">Business-/service model & value creation</td><td>Lessons learned</td></tr>
<tr><td colspan="2">Innovation
Platform and infrastructure operated by private provider independently from any specific software.

Platform is a portal that helps to make data and applications accessible, but the city does not store it.

Data collection, sensor networks, etc. done by service providers not the city.Data-centric approach (tendering software, according to data formats).

Governance Board with external mixed members to set and observe the rules and framework with the right to intervene, thereby also filling the gap of missing legislation.

Operational body to assist with and ensure governance. Public launch platform and infrastructure in 2024 but still exploring since little best practise available.</td><td colspan="2">Customers
The platform is a marketplace and intermediator for business cases, services, and applications offered by providers.

Business model and revenues streams
Revenue stream from pay-per-use models, possible licensing etc.

Revenue stream to private platform operator through upscaling to other cities
Initial Investment by City for the development: 30% of 2.5 Mio EUR.

Private provider covers maintenance and storage costs also beyond the project framework.

Job to be done
Trustworthy data platform for developing applications.</td><td>Developed in the course of various projects (Expresso, Ruggedised).

Corporates are trusted infrastructure partners, and governments are trusted partners for governance and ethical frameworks (not infrastructure).

Share the "data reality" and communicate with the outside, e.g., Housing cooperation BIMs are compatible with the city platform.

The city needs to ensure data sovereignty, maintain public control, and make sure it is an open data standard (more important than open source).

Open data platform to citizens using open data standards but some data beyond paywalls.

Seek for the energy, 'coalition of the willing' over silos and build an innovation ecosystem.

Innovation is 25% technique /content and 75% organisational and cultural change.

Demand-driven as well as supply-driven.

Importance of generic, scalable, and maintainable data sources (FAIR principles).</td></tr>
</table>

Table 10: Open urban data platform and service marketplace (Ruggedised)

9. Urban digital innovation executive leadership programme	**Ruggedised 2016- 2022** **Rotterdam, NL (Lighthouse City)** **Lead Partner:** Erasmus University Rotterdam	**Classification:** Replication **Corporate / public**	**Status:** ongoing **Upscaling potential:** Medium-high
The training program which is managed by a university, introduces the building blocks for successful digitalisation and innovation strategies for communities, cities, and regions. The course consists of 8 modules, including peer-to-peer coaching and reflection and "reflect and connect" in e-learning format; The target market is Benelux, but the aim is to expand to other European countries.			

Development, innovation and operation	**Business-/service model & Value Creation**	**Lessons learned**
Innovation First of its kind five-day training program with a fee: 'Urban Digital Innovation Executive Leadership Program – Working towards Climate Neutral Cities' Modules focus on innovation-centric leadership, agile governance, cyber resilience, innovation for scale, citizen engagement, digital inclusion, agile regulations, ethical frameworks, digital fundamental and emerging technologies. Collaboration with partner networks (e.g. Eurocities), frameworks, connections; in the Netherlands organisation of cities	**Customers** Municipalities but also semi-public organisations **Business model and revenue streams** Programme fee: 50% of development costs were covered by the project, effort from the university, enthusiastic consultants. The goal is to break even not to generate profits. **Job to be done** Bridge a competency gap, reinforce skills, building a Network and sharing the learning curve between past and current smart city programs	After the trial to be launched in spring 2024 University as host is a "neutral space" - no business interest in technology.[5]

Table 11: Urban digital innovation executive leadership programme (Ruggedised)

[5] More Information: https://ecda.eur.nl/education/urban-innovation-executive-leadership-programme/

10. 2nd life battery storage	**IRIS 2017-2023** **Gothenburg, SE (Lighthouse City)** **Lead partner:** Volvo Busses+ Property Mgt	**Classification:** Smart Energy Infrastructure & Storage **Corporate / public**	**Status:** Completed **Upscaling potential:** High
Batteries refurbished from heavy-duty vehicle (bus) applications are assembled into electric storage units within buildings. These batteries are intended to boost the self-consumption rate of renewable electricity generated from rooftop PV systems, reducing peak consumption and lowering overall power demand. These batteries form part of a microgrid that covers multiple residential properties and includes several e-charging stations. The interconnected buildings are linked to the grid and managed by a smart energy system.			

Development, innovation and operation	**Business-/service model & value creation**	**Lessons learned**
Innovation Storage made from > 200 kWh electricity storage in 2nd life automotive (bus) batteries powered by 140kW local PV and as an enabler for decentralised RES integration. Comprehensive value chain from battery recycling via integration in EMS to grid flexibility. **Operation** The role of utilities is unchanged. A property management company operates the microgrid as an energy service. The property management company develops standards and interfaces for interoperability with Energy Management Systems (EMS). Business opportunity for battery recycling companies - renting out batteries. Business opportunity for property management to operate and enhance flexibility of grid.	**Customers** Residents, property owners, facility managers. **Business models and revenues streams** 2nd life battery as an energy service. Energy savings; reimbursement for peak shaving on the sub-grid level (district or block) and the possibility of selling electricity to the grid. **Job to be done** Positive Energy Buildings and peak shaving. Incremental upscaling opportunities towards district level and other districts by the facility manager.	Shift in regulation concerning energy and grids impacted the process; energy communities are strong partners but also competing with utilities. Both are needed, so diplomacy is necessary. Perceive energy as a problem (need and cost) - things happened faster than expected and was launched by the private sector. Making a city an innovation space! Not invent but adapt solutions; orchestrate and foster collaboration; build trust through governance. Viable potential for upscaling in a district and municipality; replication to other municipalities is possible.

Table 12: 2nd life battery storage (IRIS)

11. Floating river turbine	**+CityxChange 2019-2024** **Limerick, IRE (Lighthouse City)** **Lead partner:** GKinetic Energy	**Classification:** Renewable energy generation **Corporate / public**	**Status:** Commercial Pilot Projects, Roll-Out **Upscaling potential:** High
The space and potential for urban renewable energy generation is limited. A dedicated district-level renewable generation was planned and prototyped within the project as a river turbine. Hydroelectric tidal energy converter technology has been developed so it may generate power at low flow speeds and naturally deflect debris with its counter-rotating turbines. Reduces fossil fuel dependency and increases energy security and decentralised power generation.			

Development, innovation and operation	**Business-/service model & value creation**	**Lessons learned**
Innovation Iterative design and testing at an open water test site focused on minimising negative ecological, societal, and environmental impacts. The initial 60kW design was adapted to resource availability at the site, resulting in multiple smaller 12kW floating devices upstream of an existing weir/bridge structure. Generator unit requires no land space. Design refinement in the +CityxChange project has resulted in a very robust, affordable product that is 97% recyclable at the end of life. Fixed 6kW model for canals now in development. The later stage blade pitching design has a patent pending for EU & UK and a global patent. **Development** Earlier engagement with river stakeholders led to refinements in turbine design and a change in the proposed location. Hydrology studies and geographical assessment to understand the characteristics of the available resources and select a site. Planning permission for 3 devices granted in an EU Natura 2000 Special Area of Conservation which entailed full environmental assessment.	**Customers** Residents, property owners, companies. **Business models and revenues streams** Sales of local renewable electricity or consumption within the district contributing to a Positive Energy District (PED) model. Due to the predictability of hydrokinetic resources, it serves as an ideal base load supply and an ideal complement to more intermittent sources such as solar and wind. One 12kW device can supply forecastable baseload energy compared to 84kW of solar with 1/50th the footprint. **Job to be done** Powering district with hydro energy source.	Regulatory authorities are under-resourced and processing times are far too long at 24-48 months. Early contact with stakeholders and regulatory authorities is important to ease acceptance of the technology. This deployment and the performance data generated has hugely increased the marketability of the device proving it to be a viable solution for European cities aiming to reach zero CO_2 emissions.

Table 13: Floating river turbine (+CityxChange)

<table>
<tr><td>12. Socialised solar photovoltaic plant</td><td>MAtchUP 2017-2023

Valencia, ES (Lighthouse City)</td><td>Classification: Financial scheme

Corporate / Public</td><td>Status: Ongoing

Upscaling potential: Medium-high</td></tr>
<tr><td colspan="4">Public-private collective financing model to promote the installation of a 100kWh photovoltaic plant on the roof of a public building – 'Las Naves Brillen'. The project aims to promote citizens' active participation in the energy transition, creating a sense of ownership and belonging to a community, and demonstrate an innovative approach to support investments in energy transition based on crowdfunding. It combines economic/financial objectives (giving citizens the option of receiving financial returns thanks to the investment in this project) with social and environmental ones (contributing to the energy transition). The project enables faster deployment of RE in public buildings, opens investment opportunities for small investors and promotes the quality and security of investments through the municipality.</td></tr>
<tr><td>Development, innovation and operation</td><td colspan="2">Business-/service model & value creation</td><td>Lessons learned</td></tr>
<tr><td>Innovation
Innovation relies on the social model deployed to associate citizens and residents to the operation and provide them energy and return on investment.

Development
The preparatory phase involved several actions to reduce energy consumption, such as awareness raising towards employees on energy saving and efficient behaviours, energy audits, and workshops.
The business model, its underlying conditions, main elements and performance were studied and defined, with the support of a consultancy.
The collective financing campaign was launched and promoted through several means (e.g., street and bus advertisements; website, video, promotional materials, presentations).
The campaign was launched in November 2021 and aimed to raise 80,000 euros to finance the PV installation. 100% of the financing was raised through the investments of more than 100 people. The initiative was managed by Las Naves, innovation agency of Valencia City Council.</td><td colspan="2">Customers
Citizens, public administration.

Business models and revenues streams
The public actor invests in the PV plant. Citizens participate in financing through loans with annual returns (bilateral contracts between the administration and citizens) (crowdfunding model).

The model's financial sustainability is obtained through the economic savings of Las Naves enabled by the self-consumption of energy and the sale of excess energy to the grid (feed-in tariff).

Job to be done
Develop and maintain an energy model. Combining economic value, environmental and social values.
Economic value: economic savings for Las Naves due to energy self-consumption, financial return for citizens.
Environmental value: Renewable Energy generation, CO2 emissions savings.
Social value: Citizens participate and link their investment (and its profitability) to the success of a renewable energy project. Citizens participate in the energy transition as active actors.</td><td>Internal procedures to prepare the project were quite long due to bureaucracy (e.g. for roof lending). Still, the pilot project provided an opportunity to solve the administrative issues (this learning can be capitalised on when this action is upscaled on other public buildings).

Administrative and bureaucratic management is complex, particularly if many participants are involved in the financing.

Political leadership and commitment to the project were key.

Continuous communication campaign was very important, to promote the initiative and then during the project to maintain participant engagement.</td></tr>
</table>

Table 14: Socialised solar photovoltaic plant (MAtchUP)

<table>
<tr><td>13. Tenant electricity model</td><td>MAtchUP 2017-2023

Dresden, DE (Lighthouse City)</td><td>Classification: Financial scheme

Corporate / Public</td><td>Status: Completed

Upscaling potential: Medium</td></tr>
<tr><td colspan="4">A 'Tenant Electricity Model' (TEM) enables the consumption of locally generated energy from a photovoltaic (PV) system by tenants of an apartment building. It applies the principle of shared consumption to the supply of green electricity. By participating in the TEM, the tenants get a fixed discount on their electricity price. Additionally, the green electricity coming from the PV system is discounted in three phases of time, weather and surplus feed-in (load-variable tariffs), encouraging the tenants to schedule electricity consumption at low price times and high availability of RES. The model helps reduce energy consumption from the grid and the feed-in of PV power into the grid, contributing to grid relief. The technical system is equipped with battery storage, which increases the self-consumption rate and the autonomy of the system. Within the MAtchUP project, the model was implemented within an existing building and within the newly constructed 'District Future House' building.</td></tr>
</table>

Development, innovation and operation	**Business-/service model & value creation**	**Lessons learned**
Innovation Tenant Electricity Model (TEM) **Development** SachsenEnergie (energy utility provider) was responsible for the design and approval planning of the energetic components (PV system with storage), construction supervision of the PV system, as well as calculation of the TEM and acquisition of the participating tenants. EA Systems Dresden, a company specialised in planning, optimisations, and evaluations of energy systems, developed a simulation model to evaluate the system layout and to test suitable smart tariffs in advance. VONOVIA (housing company) and WGJ (housing cooperative) provided roof areas for the existing building and the new building, 'District Future House' respectively; a roof usage contract was put in place between the building owner and the energy utility to implement this model.	**Customers** Tenants and property owners. The model is tailored to customers and must be adapted for new apartment buildings considering roof size, orientation and statics, shading and the number of users. **Business models and revenues streams** The economic and business case varies from case to case. The ratio of the roof area to the number of tenants must be favourable to provide economic feasibility. **Economic value:** Grid relief; Grid transmission with its associated fees is saved, and these savings are passed on to customers, Financial benefits for tenants. **Environmental value:** Locally generated Renewable Energy, CO2 emissions savings, more efficient energy consumption (users have access to real-time information on their energy consumption and automated billing). **Social value:** Tenants participate in the urban energy market and contribute to the Energy Transition.	The tariff 'Mein Mieterstrom smart' (My smart tenant electricity) was tested comprehensively in the 'District Future House' to expand the knowledge and develop tools for the implementation of the tenant electricity model. The billing system has been designed, and its limits have been identified. The model is now fully implemented and is working properly, offering two price discount rates. A high percentage of the tenants in the test buildings are participating and benefitting from the price discount. Most users utilise electricity specifically during the time slots of price discounts, as emerged from a survey about the model performance. The main reasons to participate in the TEM are the lower price compared to the normal tariff, the innovative usage of RES in its energy consumption and the regionality.

Table 15: Tenant electricity model (MAtchUP)

7. Key insights of the report

This chapter delves into the core findings of the current paradigm where city administrations focus on the broader aspects of operational efficiency and value delivery financed with public funds and grants. However, a strong emphasis on business modelling and bankable business cases is essential to successfully up-scale and roll out the piloted solutions and attract private enterprises and private investment to enable viable long-term operations.

Avoid the piloting trap

Cities focus on public interest, value creation, and operations, rather than on profits and business models. In the research programme, the primary focus of the projects was not on upscaling and business modelling, nor on the necessary inclusion of relevant experts. Consequently, most consortia encountered significant challenges in transitioning their solutions towards operational scalability, moving from the district level up to the city level and beyond.

Additionally, socially oriented business models are being implemented, as seen in Valencia with the "socialized power plant" and in Dresden with the 'Tenant Energy Model'. These models aim to integrate economic, social, and environmental values, potentially leading to significant value creation. However, the pathway to scaling these models at a city-wide level remains unclear.

While many of the tested solutions and applications were developed within the "protected environment" of the pilot phase, transitioning to the commercial upscaling phase brings critical aspects to the forefront. These include market readiness, non-grant financing, integration into an operational ecosystem, and incorporation into comprehensive service models.

The report defines the "piloting trap" as the challenge of broadly deploying a solution that was successfully tested during the pilot phase. Several factors contribute to this difficulty including the absence of (non-grant-based) financing for rollout, the lack of established operation models and ownership structures, and the deficiency in innovation and procurement processes essential to proceed with the upscaling within the value chain. Consequently, it is crucial to focus on developing upscaling pathways, mechanisms, and processes during the pilot project deployment and to tackle this barrier early in the project lifecycle.

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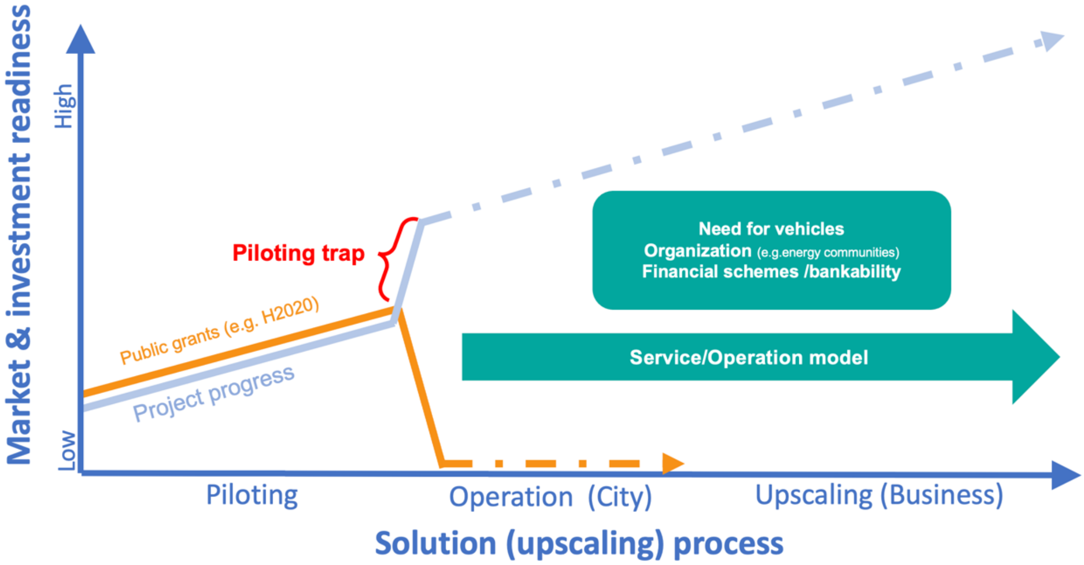

Figure 6: Grant-based piloting of solutions needs to master the gap towards the (commercial) upscaling and successful operation

The assessed cases highlight several critical trends towards business models.

- There is no one-size-fits-all business model or blueprint for Positive Energy Districts (PEDs) that an organisation can adopt. Instead, a PED is developed through the collaboration of various stakeholders who bring together different components, solutions, and value chains. The exemplary 'Lighthouse' cases focus on specific components, without purporting to offer a comprehensive PED solution. These cases break down the PED concept to focus on the most profitable and feasible components. As a result, it is essential for a public organisation to coordinate these varied elements and value chains, ensuring their alignment with broader urban master plans and strategies.
- For most of the innovations the cases demonstrated focus predominately on the integration of technology rather than building business models. They require a public or private entity to bring together the different elements of the value chain and deliver a seamless service to the customer. Good examples are the V2G Grid in Utrecht or the second life battery in Gothenburg, where the facility manager plays the crucial role of value chain orchestrator. Further examples are cases in Dijon, Turku and Amsterdam.
- Cities can serve as reliable and trustworthy moderators to convene stakeholders, setting the right frameworks and facilitating the testing and deployment of solutions. This presupposes a clear definition of the role of the city administration at an early stage. Notable examples include: Rotterdam’s data governance and marketplace enforcement, Utrecht’s vehicle-to-grid systems, Dijon’s ‘Energy as a Service’ project, and Valencia’s socialized power plant.

Integrating technologies, infrastructure, & services

To maximise the effectiveness of Positive Energy Districts (PEDs), it is crucial to develop tools that enhance interoperability within PEDs and their seamless integration into broader city master plans. Central to the success of a PED is technology that ensures reliable connectivity and interoperability.

From a municipal standpoint, early project phases need to tackle the operations, maintenance, and securing of financing for solutions beyond the initial project scope, as well as cultivate widespread acceptance and ownership within city administrations. This approach helps to surmount innovation barriers and break down silo thinking.

For businesses, it is essential to manage and operate various solutions efficiently via platforms and management systems. Service models that present a streamlined, customer-centric interface are vital; they not only create stable revenue streams but also create optimization opportunities for providers.

The current solutions and business models are predominantly focused on technologies and services that facilitate functionality and integration, driven notably by information and communication technology (ICT) and artificial intelligence (AI). While these projects often overlook the role of behavioural change and the business models that support such shifts, there are significant overlaps in areas related to energy management and efficiency. Additionally, end-user applications provide valuable insights and encourage more energy-conscious behaviour.

The following business models may be envisioned from the data and information provided by the projects:

- **Services for renewable energy production** from solar, wind, hydropower, and geothermal sources, and considering circular economy streams (e.g., waste heat, biogas, residual waste treatment, etc.) and storage components. Numerous cases include energy-as-a-service models.
- **Planning, engineering/procurement, and maintenance** of renewable energy appliances - technical services, possible as a full-service model.
- **Renting of remodelled bus batteries** to building facility management companies - storage-as-a-service, load and peak balancing.
- Operation of PV plants, heat pumps, and batteries for self-consumption as an additional **value stream for facility management companies** possibly in combination with bi-directional charging of e-vehicles.
- **Services and operations for energy communities, including billing**
- **Digital and data analysis services** including data operation, privacy, security, intellectual property (IP) issues.
- **Prediction-as-a-service for** energy service providers, grid operators for balancing supply and demand, energy efficiency.

Navigating the innovation landscape

The case analysis and interviews reveal a trend toward a significant reduction of risk towards innovation. By advancing the understanding of customer journeys and value chains, these projects have paved the way for identifying potential business models and the partners needed to execute them. A key achievement of the Smart City and Community (SCC) projects is notably the reduced risk in both project and product development circles, adding substantial value to the business development of the partners. Pilot projects have clearly demonstrated their worth by establishing scalable pathways, being implemented in initiatives such as the IRIS Lighthouse cases, with similar strategies soon expected from the Atelier and Response projects.

Nonetheless, assessing the long-term sustainability of these business models poses challenges. Firstly, earlier SCC projects are closed now which limits access to data outside the project scope. Secondly, private sector partners often withhold detailed information on potential business cases to safeguard future products and possible competitive advantage. Lastly, some projects are still running, with their final outcomes still pending.

Furthermore, the research-centric nature of the projects often results in the creation of business cases and the involvement of relevant expertise being deprioritised at early stages. Consequently, transitioning to a focus on 'business cases and architecture' during later phases of the project proves to be complex and time-consuming.

The list below showcases various examples of the impact and value generated by the Lighthouse cases:

- Increasing **grid flexibility** with RES, for example: Amsterdam's Buiksloterham district uses smart microgrids to balance energy supply and demand, contributing to increased grid flexibility despite a higher share of renewable energy sources (RES).

- Better **peak load management** through Bi-directional charging, for example: Utrecht's V2G project demonstrates how an EV fleet remains productive even when parked through bi-directional charging, contributing to grid stability and energy efficiency.

- **Increase self-Consumption from local RES**, for example: Turku's Heat as a Service model focuses on increasing local renewable energy production, aligning to raise self-consumption rates from nearby RES.

- **Optimising energy** efficiency measures from **AI-based optimisation of management systems**, for example: Dijon's AI-driven energy management system learns from real-time data, contributing to reduced energy consumption and improved grid flexibility.

- **Alignment of energy production and consumption.** There are multiple examples from cities, such as Valencia, Amsterdam, and Turku.

- Addressing **energy poverty** in public residential buildings, for example: Turku's Heat as a Service model addresses energy poverty by providing an efficient and cost-effective approach to heat generation for public residential buildings and student homes.

- **Recycling of used automotive batteries**, for example: Gothenburg's Second Life Battery Storage repurposes batteries from heavy-duty vehicles, addressing the challenge of recycling the rapidly increasing number of old batteries.

- **Sandboxing for legal framework development**, for example: Rotterdam's Open Urban Data Platform uses sandboxing as a feature to develop legal framework conditions, fostering innovation and driving the upscale of smart city initiatives.

- **Reducing GHG emissions** by increased RES and efficiency rates, for example: Amsterdam's Buiksloterham and Utrecht's V2G network, showcase mitigating greenhouse gas emissions through increased energy efficiency and RES utilisation.

Evolution of a positive energy district

A PED – and any smart district- comprises various solutions, applications and complex stakeholder constellations. Building a PED must be considered as a (learning) process that requires the co-creation and collaboration of diverse stakeholders and a strong acceptance and interaction with the local ecosystem.

The **role of municipalities** is to create favourable conditions and to enable and moderate the process for proper implementation, alignment and integration into the respective city urban development frameworks. An example of favourable conditions and frameworks for exploring scaling-up potential is facilitating legal and organisational sandboxes within their city authority.

A positive energy district, along with its diverse use cases, is not merely a goal but a means to deliver tailor-made services that align perfectly with the needs of end-users and the city context. Consequently, it is essential to introduce service models that are both understandable and efficient, specifically designed to cater to these needs effectively and ensure a positive overall impact.

Forging a unified vision with stakeholders

It is essential to emphasise that the **city's financial experts have on rare occasions, been part of designing the Lighthouse cases.** Scaling up some solutions will likely require more involvement from them to schedule better financing needs (operating expenditure, Opex; mid- and long-term capital expenditure, Capex) and how innovative financing schemes can help to bridge potential financing gaps.

Focusing on **value creation and operation, financial expertise, and capacity to assess, develop or apply innovative financial vehicles, investment schemes**, etc., has yet to be established inhouse within European municipalities. Especially the earlier generations of the research-focused projects and initiatives have not incorporated business modelling and investment expertise from the outset, which has shown to be crucial for building and integrating an architecture, tools, and understanding needed to address financial instruments and business cases during the scaling phase. Presumably, the roll-out of products and scaling efforts occur, but most likely outside the scope of these projects. One of the reasons might be the protection of business interests.

After all, it is **vital to showcase best practices and elucidate their impact on regional economic, financial, or environmental progress.** Furthermore, this could significantly expedite the **revision of national regulations**, as seen in the evolving status of energy communities across various regions. By spotlighting successful models, cities can influence policy changes, foster broader, sustainable urban development, and understand how to attract private investment.

8. Recommendations: connect the dots and make them count!

Fostering market readiness through strategic frameworks

When operating a pilot project, a major challenge is bridging the gap between pilot initiatives and full-scale, long-term operation, while tapping into the existing potential for upscaling and replication. This transition is crucial for the success of smart city and urban transition projects like those focusing on the development and implementation of Positive Energy Districts (PED), which still need to prove their viability beyond public grant funding and subsidies.

A survey by the European Court of Auditors revealed that, on average, each Lighthouse city plans to invest approximately €1.1 billion, and each Fellow city about €400 million. However, cities often face constraints such as regulatory frameworks, static procurement processes, or a lack of financial expertise. On the other hand, investors may lack an understanding of the cities' needs.

Municipalities are subject to strict public funding regulations, whereas market forces and shareholder expectations drive private or semi-public entities. Both groups are fundamental stakeholders within innovation frameworks and must find common ground, shared values and a mutual language. While public grants, such as those from Horizon 2020 or Horizon Europe, are pivotal in the piloting phase for developing and demonstrating bankable cases of PEDs, it is crucial to assess and develop sustainable and robust financial models to ensure their long-term sustainability.

Moreover, it is essential to evaluate how to meet the financial stakeholders' requirements and expectations, and how to build up municipal structures to apply these standards and attract private investment.

Testing new pathways to upscale

There is a clear need to develop interconnected service models and mechanisms to operate and secure their financing. A Special Purpose Vehicle (SPV) is a legal entity created for specific, clearly defined purposes, often used to isolate financial risk. It may be owned by more than one entity and is typically used to own assets like power plants, along with associated permits and contract rights. SPVs are crucial in public-private partnerships, facilitating the operation and financing of projects.

This endeavour will require clear interface definitions and extensive interdisciplinary support covering governance, finance, technology, and legal issues, including intellectual property rights management and public procurement regulations.

Establishing innovative financial mechanisms such as revolving funds, green bonds, or citizen-involved investment vehicles (e.g., crowdfunding, crowd-lending, asset tokenization) demands sophisticated expertise within city administrations, the involvement of reliable partners and intermediaries, and robust portfolios of projects. It also requires the capacity to build an aggregated portfolio of projects at various maturity levels beyond single municipalities.

Alongside external support, the transfer of knowledge and experiences between cities and public servants on a peer-to-peer level will be crucial for building relevant expertise and steering public grant projects from their pilot stages to scalable, market-ready operations.

Involvement of the public in financial schemes

Fostering citizen participation in financial terms should also be considered by municipalities, along with regional financial institutions, as several benefits can be expected.

Financial assets with regional references enhance local involvement and unlock funds for projects. Trust and sound risk assessment are paramount and highlight the importance of engaging reputable trustees in pilot projects and processes.

While economic earnings are fundamental, factors like security and perceivable regional impact (e.g., supporting local employment, products, enhanced local energy autonomy, liveable public spaces, etc.) will be significant for private savings and investment schemes. Local and regional financing and investment instruments should be integrated into trans-regional schemes for better scalability and harmonisation with European instruments like innovation funds and guarantee programmes.

Various surveys within the community have shown that municipalities need to be willing to explore innovative financing vehicles outside their "public grant" comfort zone and rethink their approach to public service provision.

Cultivating an innovation ecosystem and defining municipal roles

Municipalities face a critical challenge: they must seamlessly integrate cutting-edge innovations into their ecosystems and administrative frameworks to address pressing urban issues. The key to this integration is adopting groundbreaking digital solutions in mobility, energy, and climate protection, often pioneered by startups. These innovations are essential for ensuring cities' future readiness and competitive edge. However, their successful integration requires establishing dynamic collaboration and new innovative procurement processes that move beyond conventional, risk-averse municipal approaches, enabling new financing and investment vehicles.

The Smart Cities and Communities projects have set a new direction for urban development, positioning cities in pivotal roles. These pilot projects act as incubators, developing innovative solutions through a blend of technological integration and a user-centric approach. Success hinges not solely on city budgets or interventions but on a vibrant ecosystem willing to test, fail, learn, and iterate. This exploratory method proves more effective for developing innovative urban solutions within PEDs than traditional approaches, saving public budgets by avoiding costly misdirected tenders.

Cities must define their roles within this ecosystem by moderating and acting as intermediaries for local stakeholders. Cities and the public sector are deeply trusted to develop and enforce regulations and governance, while infrastructure projects are confidently entrusted to the private sector.

Possible roles of cities include:

- **Setting project objectives for PEDs** that align with the overall urban strategy framework and ensuring that solutions contribute to these objectives.
- **Coordinating and moderating stakeholder and partner management** as a neutral, trustworthy intermediary.
- **Developing and establishing innovative procurement and tendering processes** that allow for experimentation while ensuring a seamless transition from piloting to implementation and larger-scale rollout.
- **Developing governance and regulatory frameworks to support prototyping and innovation,** including data governance strategies and regulatory sandboxes that encourage new policy development.

10. Experts and contributions

This assessment builds on the contribution of representatives from numerous cities, enterprises, research institutions and consultancies. We would like to express our thanks to all of you and to the Scalable Cities secretariat for their support.

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Please find below a list of **cities and organisations** that have contributed to this assessment:

Alba Julia (RO)	https://www.apulum.ro/index.php/primaria_en
Amsterdam (NL)	https://www.amsterdam.nl/en/
Dublin (IE)	https://www.dublincity.ie/residential
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Turku (FI)	https://www.turku.fi/en/frontpage
Utrecht	https://www.utrecht.nl/city-of-utrecht/
Valencia (ES)	https://www.valencia.es/

The exchange with representatives from the following **Organisations** contributed to better understand roles and objectives for **enterprises, consultants and research institutes**:

Enterprises	
Cenero Energy GmbH	https://www.cenero.de/
EDF France	https://www.edf.fr/

Ferroamp	https://ferroamp.com/en/
FutureInsight	https://www.futureinsight.nl/
GKinetic Energy	https://gkinetic.com/
IES - Integrated Environmental Solutions Ltd.	https://www.iesve.com/
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Cleantech Scandinavia (Cluster Organization)	https://cleantechscandinavia.com/
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GNE Finance	https://gnefinance.com/
Green Building Council Espana	https://worldgbc.org/gbc/green-building-council-espana/
Officina Verdi Spa	https://www.ovaerdi.com/
R2M - Research2Market	https://www.r2msolution.com/
TNO	https://www.tno.nl/en/
Urban DNA	https://urbandna.eu/

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