Co-Creating Local Energy Transitions Through Smart Cities: Piloting a Prosumer-Oriented Approach

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Aerial photo of award-winning positive-energy complex 'Gardens International' in Limerick

A key future challenge is to provide decentralized and sustainable energy (Rifkin 2011). Given that challenge, the theme of Post-Oil City asks how this can be accomplished for cities and regions which evolved using fossil fuels.

The Horizon 2020 innovation project Positive City ExChange (+CityxChange) responds to this challenge and to the Sustainable Development Goals (SDGs), New Urban Agenda, Paris Agreement, as well as the Sustainable Energy Transition Plan and Green Deal of the European Union. It implements an innovative demonstration-driven approach in the context of smart cities by enabling participatory innovation environments and opening energy markets to decentralize and prosumer-oriented models. It focuses on strong integration within the public sector and co-creation across stakeholders and citizens.

Positive City ExChange is one of 17 ongoing or completed European Smart Cities and Communities Lighthouse projects to develop and implement solutions for: 1). secure, affordable and clean energy; 2). smart electro-mobility; and, 3) smart tools and services in over 100 cities. The +CityxChange consortium unites the two lighthouse cities Trondheim (Norway) and Limerick (Republic of Ireland) with the five follower cities Alba Iulia (Romania), Písek (Czech Republic), Sestao (Spain), Smolyan (Bulgaria), and Võru (Estonia) to achieve sustainable urban ecosystems that establish 100% renewable energy city-regions by 2050 as part of the European energy transition. The project enables the co-creation of the 'future we want to live in'. It develops frameworks and supporting tools to enable a common energy market supported by a connected community and integrated with cities' urban planning, as well as new policy intervention, market (de)regulation and business models that deliver positive energy communities and integrate e-Mobility as a Service (eMaaS).

This article discusses how the +CityxChange project creates an enabling environment for the societal and technical innovations that are required to transition towards positive energy blocks, districts and cities, for, with and by citizens. Eighteen months into the project, the portfolio includes, amongst others, instruments for novel policy intervention, community engagements, market (de-)regulation and business models that enable scaling-up and replicating Positive Energy Blocks and Districts across cities in and outside the European Union. The solutions include data and technology-centered projects as well as urban planning and citizen-focused elements, such as co-creating city visions and accelerating change and disruptive solutions through open innovation playgrounds and participatory governance.

The article focuses on the implementation, achieved results, learnings, replicability and impact on the urban planning sector – providing a practical course of action for the Post-Oil City.

BACKGROUND

To reach the goals of the European Energy Transition, massive decarbonization and energy production alternatives need to be rolled out. Such ambitions are part of major 'top-down' European climate and energy strategies, such as the European Green Deal, many national strategies, and also ambitious municipal plans, such as C40 initiatives, Covenant of Mayors, individual Sustainable Energy Action Plans and many more. These energy transitions need to take place within the broad and ambitious framework of the UN Sustainable Development Goals (SDGs).

The question is how do we get there? What are promising approaches for such complex challenges? Who are the relevant stakeholders and what are the structures, and barriers related to implementation, piloting, and scaling? How can cities and citizens adapt and rise to the challenge?

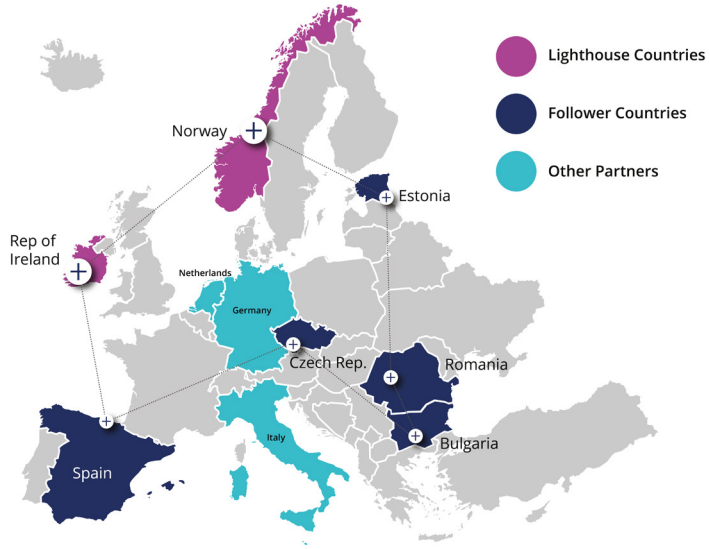

Figure 1: Lighthouse, Follower and Partner countries and cities of +CityxChange

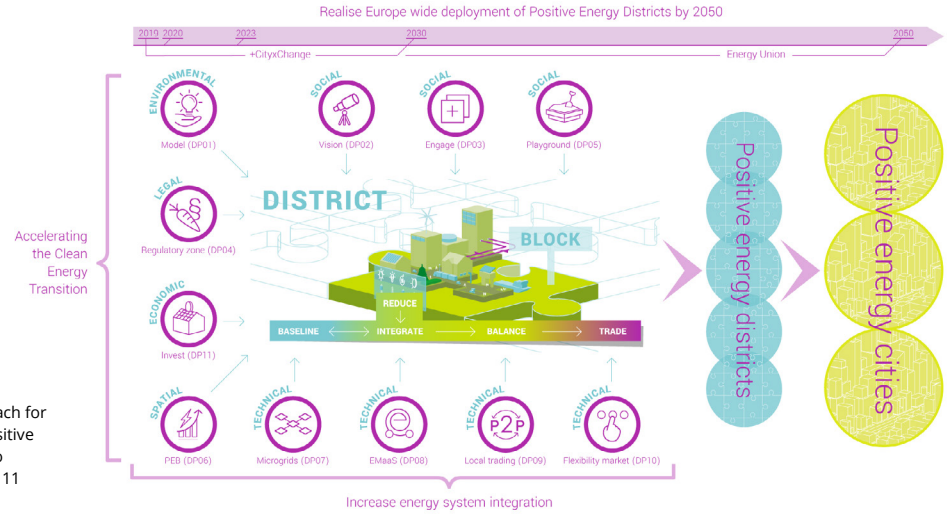

Figure 2: Approach for scaling from Positive Energy Blocks to Cities, based on 11 demonstrations

Experiences of the other European Smart Cities and Communities projects have shown that discipline-specific approaches are not capable of handling complex urban and societal challenges. However, common barriers and solutions exist and are being identified (Vandevyvere 2018, Borsboom-van Beurden 2019). Cross-disciplinary and sectoral co-creation is a better way to develop transition pathways for cities and communities to becoming energy positive. However, such high-impact approaches are challenging to implement.

As one complementary 'bottom-up' approach, the European Horizon 2020 Research and Innovation program has, for six years, been running the funding scheme of 'Smart Cities and Communities' Lighthouse projects for large scale demonstrations. Currently there are 17 projects in this scheme.[1] It focuses on topics of energy systems integration and urban energy transition with a city perspective and fosters innovation and replication.

+CityxChange is part of this project family. It started in November 2018 with a project duration of five years, including three years of development and deployment of demonstrations, and two years monitoring and replication to verify the validity and applicability of results. The project follows a very

local approach for each city and a cross-cutting approach between the cities for learning and knowledge exchange. The program works with cities as main partners, supported by local and international solution providers and universities. These partners collectively plan, implement and monitor physical, digital and social demonstration projects at the urban block and district level. The main goal is to develop and deploy Positive Energy Blocks and Districts, and ultimately Positive Energy Cities.

Eleven demonstration projects are arranged around this goal covering environmental, spatial, social, technical, economic, and regulatory aspects. The main aspects of the project are people, technology, and environment needed to develop Positive Energy Blocks and Districts and to foster replication.

How to handle the complexity of the challenge

In +CityxChange, we set out to develop a multi-disciplinary, multi-actor, and multi-country approach of co-creation and open innovation (Curley and Salmelin 2018). Already during the proposal stage, we built a consortium of 32 partners with experience and competency in co-creation and open urban innovation, as key drivers towards being able to develop Positive Energy Districts and Cities.

Our approach was to achieve local energy transitions by viewing and examining various municipalities, as well as research, industry, and citizens aspects, using a quadruple helix innovation approach (Carayannis and Campbell 2009). This ensures that cities' and citizens' needs are front and center, that solutions can be integrated across city domains, and research and industry can support the transition.

One key element to support this integration was setting up innovation testbeds in the city. These living labs (ENOLL 2020) facilitate experimental research in a real-world setting. The experiments are planned, implemented and monitored by a cooperation of public and private sector partners, academia, citizens and other stakeholders. The outcomes can be new or improved services, data, technologies or processes. Shared value can be created when the stakeholders – professional ones as well as citizens – organize themselves into open innovation ecosystems (Curley and Salmelin 2018). In the +CityxChange project, such ecosystems, called 'Innovation Playgrounds' (Mee and Crowe 2020), facilitate the development of new solutions and processes through physical, digital, and social support.

Mee and Crowe (2020) explain the difference between an Innovation Playground and an Innovation Lab. The former is a dedicated area in the city which provides a testbed and experimental environment open for citizens and stakeholders to pilot innovations in de-regulated conditions. The latter is the physical manifestation, comparably to urban labs or fab labs/makerspace, which provides a space to hold workshops, inform, engage, share, test, collaborate and co-create. The Innovation Labs provide an exchange point between stakeholders and give citizens a space to learn, ask, and experiment themselves. Furthermore, they serve as a physical and conceptual environment of the Citizen Observatory, which enables the distributed collection of scientifically verifiable data by citizens to contribute to transparent local decision making and policy development.

To create the enabling open innovation environment, our project focuses on three crucial dimensions. The first is the social dimension – the people or next-generation citizens who must be a part of co-creating and visioning and who must participate actively for the transition to succeed. Secondly, the technological dimension is essential, for example, encompassing a novel e-Mobil-

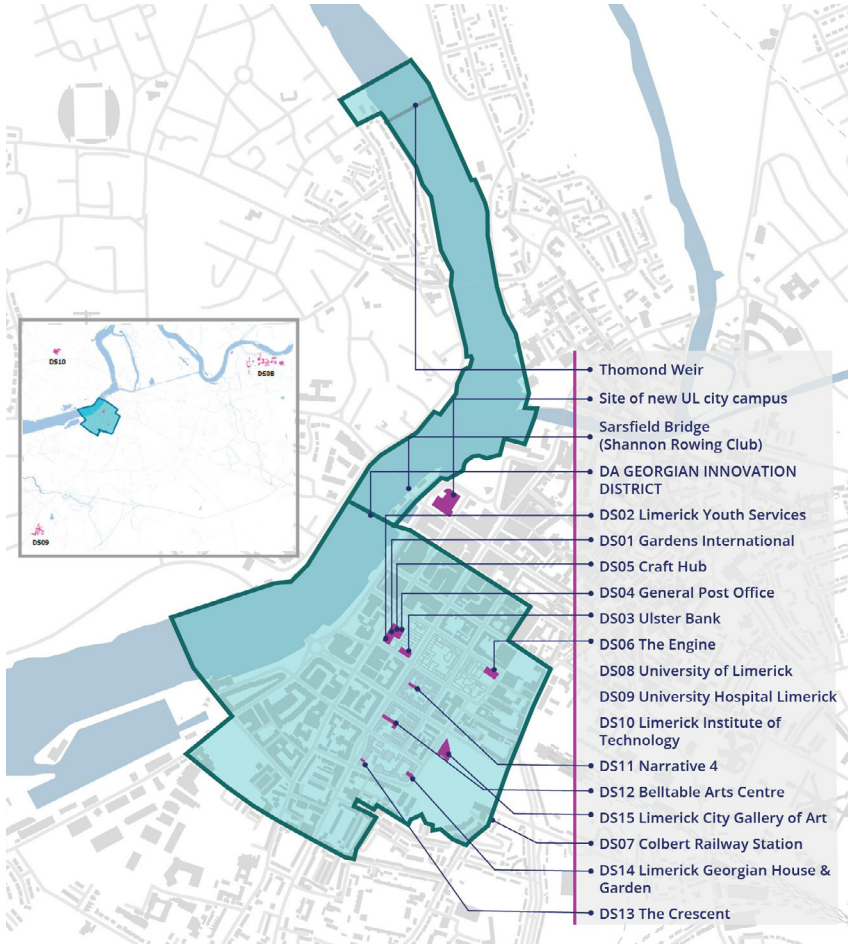

Figure 3: Project demonstration area and sites in Limerick, Ireland

ity as a service scheme or a local peer-to-peer approach for energy trading. The final key ingredient is establishing an environment of innovation through policies, regulations, as well as business models. While many more elements could be listed, these three should be the starting point, and everything else should be built upon as well as aligned with these as much as possible.

Smart city initiatives must emphasize co-creation and open innovation through active citizen engagement and participation to be successful in the long term (García and Mora 2020). In the past, and even today, many smart city approaches primarily focused on new technologies and view people only as users. However, active 'next-generation smart citizens' are critical to ensure the alignment of technological innovation with society's interests, to scale the work outside the projects, and instigate behavioral change. Therefore, strengthening the collaboration between the public and private sector, our primary focus is on citizen involvement. However, genuine participation that does not only 'tick the boxes' is challenging, resulting in the creation of an integrated system of different frameworks and concepts which are jointly working towards a citizen-led process.

How do we get people interested in and contributing to the project? We follow two specific approaches. First, Local Energy Champions are identified, trained and supported by the municipalities and project partners to distribute

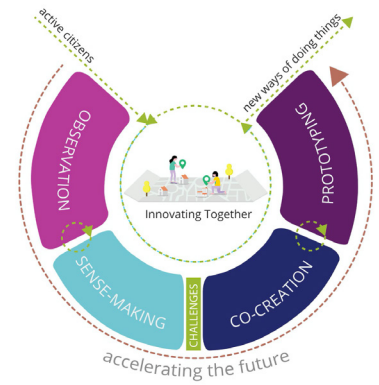

Figure 4: Innovation Playground journey

	Engage	Design	Activate	Accelerate	Support
Standardisation	Evaluation	Visualisation	Simulation	Funding	Sharing
Policy development	Review	Revision	Planning	Budgeting	Analysis
Innovation partnerships	Appointment	Linking	Collaborating	Prioritising	Portfolio management
Organisational development	Idenification	Leadership	Intrapreneurship	Self organisation	Twinning
Citizen engagement	Acknowledgement	Deliberation	Localisation	Connection	Amplification
Project development	Pitching	Prototyping	Delivering	Capitalising	Storytelling

BOLD CITY VISION FRAMEWORK FOR 2050

Figure 5: Bold City Vision Framework for 2050

knowledge, advocate for change, activate residents – acting both as 'voice' for the project and representative of the community. Second, Next Generation Smart Citizens are guided to enable and ensure long-term, sustainable societal transformation, for example, through campaigns at schools and educational facilities and gamification of concepts and technologies.

Establishing the places and enabling stakeholders is essential, but eventually, the generated knowledge must be injected into the work of public and private stakeholders. Additional to the ongoing exchange in the Citizen Observatories, Innovation Labs and Playgrounds, the broader public is involved through concrete activities such as Climathons as well as Citizen Engagement Weeks. These activities link the project work with ongoing activities in the city and guarantee broad support of society while embedding it into ongoing project work. The results and learnings of these activities are continuously fed into the cities' Bold City Visions for 2050. They create a shared vision and strategy, aligned with other local, national and European Union policies, as well as global goals such as the SDGs or New Urban Agenda (Tanum et al. 2019). This mainstreaming ensures that all departments are working jointly towards a politically backed goal as well as providing an overarching vision document which guides other plans and policies beyond the project duration.

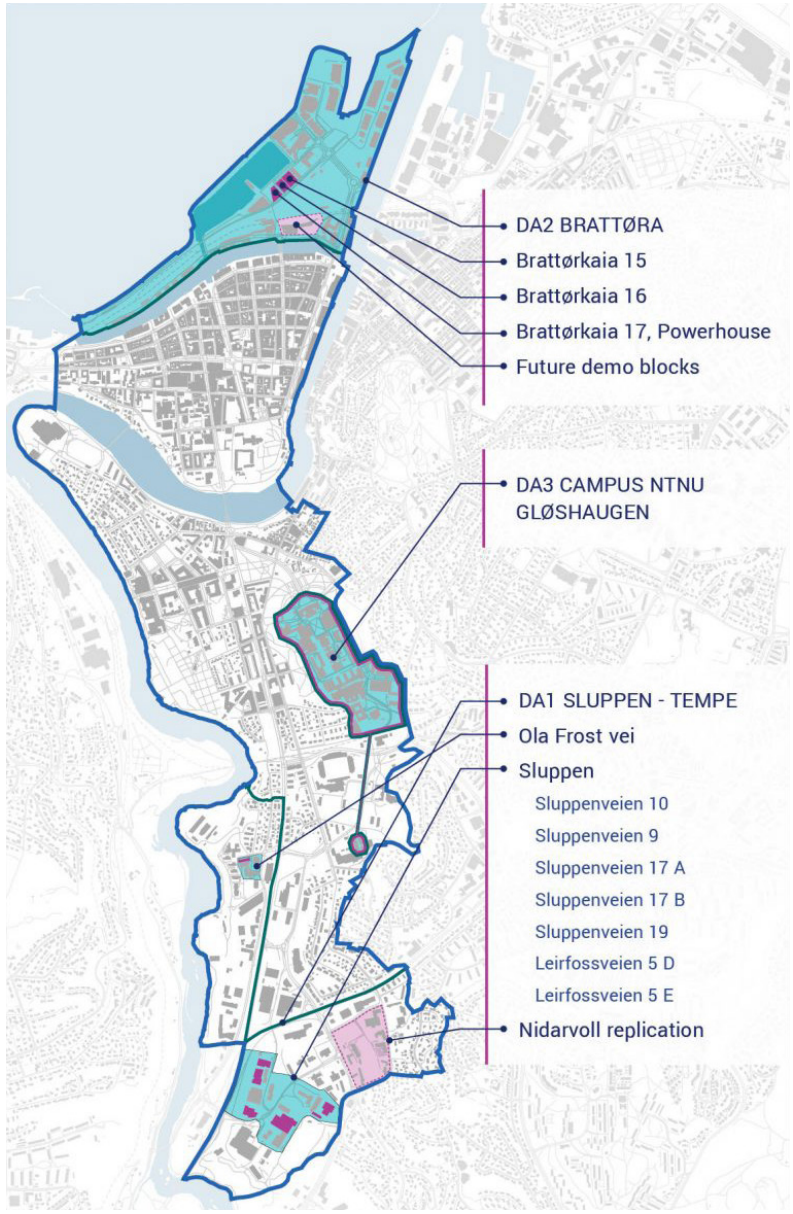

Figure 6: Project demonstration area and sites in Trondheim, Norway

FROM THEORY TO PRACTICE

The developed concepts are being translated and localized into actions within all seven project cities. We give a brief overview of the implemented actions so far in the two Lighthouse Cities.

Trondheim selected four physical spaces throughout the city to serve as Innovation Playgrounds for citizen engagement. The first one was set up at the municipal administrative offices. Here, public outreach and co-creation are co-located with a shared project office for the project and a number of other related city initiatives called *Innovasjonstorget*, including the University-City co-operation and the United Nations Centre of Excellence on SDG City Transition in Trondheim.

Figure 7: Official opening of the Powerhouse in Trondheim, a plus energy building and an anchor building in the project, owned by Entra, an associated partner, and designed by Snøhetta

Figure 8: Storytelling workshop in Innovation Lab Limerick

Figure 9: Climathon 2019 in Trondheim, Norway

Figure 10: Gamification. City Energy Game, Limerick's 2019 CityEngage Week

In Limerick a previously existing Fab Lab has been repurposed as an Innovation Lab which hosts regular events between the citizens, public and private sector. The University of Limerick operates the lab and currently plans the relocation and enlargement of the space together with other stakeholders of Limerick. This allows even more and diverse activities to take place while becoming a prominent public front of the positive energy movement.

At this Limerick innovation lab, a learning framework for Positive Energy Champions and Next-Generation Smart Citizen is in development and currently being tested. The learning framework consists of a 20 weeks period with a range of events, including the city engagement weeks, training, workshops, Climathons, and more. The latter is initiated by collaborating with schoolteachers from Smolyan and the University of Limerick, collaboratively setting up a learning environment in times of online education due to the COVID-19 pandemic.

The framework for the Bold City Vision 2050 resulted in a variety of visioning workshops as well as a scaling effect in Norway with other cities taking over the approach. Additionally, the generated knowledge is exchanged with the newly established United Nations Centre for Excellence in Trondheim which works towards the localized assessment of the Sustainable Development Goal achievement as well as the U4SCC[2] indicators (Tanum et al. 2019).

Mainstreaming the project activities into ongoing work of the municipal administrations and anchoring it within the community is crucial to ensure the project's success, as well as to scale from Positive Energy Blocks to Cities over time and after the completion of the project.

Innovative Technology in Positive Energy Blocks and Districts

The technical core of the +CityxChange concept for Positive Energy Blocks and Districts revolves around developing and upgrading paths and toolboxes for different aspects that can be adapted to different cities. It contains systems for local trading of energy, the integration of local storage, the integration of electric vehicles and their use, integrating energy and mobility needs and markets, sustainable investments into refurbishments and new buildings, tools for modeling, urban planning, and operations, an underlying ICT layer that integrated city systems and open data portals, and a pathway of how to include these aspects.

Spatially, a Positive Energy Block consists of at least three buildings, with a combination of old and new buildings in close proximity (with a minimum viable size) where concepts can be demonstrated. While it is possible to reach a Positive Energy Blocks with only new state-of-the-art buildings, such a development would not demonstrate how to integrate existing building stock to actually reach the energy goals within short timelines. Buildings of a zero or plus energy standard can serve as anchor buildings, enabling a Positive Energy Block together with their neighbors. As part of the urban concept, Positive Energy Blocks can be scaled up by plugging additional buildings, energy assets, and other measures into the system, allowing a growth path with increased local energy production and reduction measures, to grow towards a Positive Energy District.

To reach a net zero or positive block or district, not all buildings need to contribute equally. For example, for some older buildings full upgrades are not feasible, and the concept includes balancing between different types of buildings with different demand profiles, for example business and residential, coupled with short-term storage.

To bring the demand side down, building upgrades and refurbishments are needed along with changed energy behavior. On the other side, local generation in the form of photovoltaics, heat pumps, wind or water turbines raise the local supply and allow customers to move into prosumer roles. In addition, local storage in the form of electrical batteries is included, while the district heating system in small areas can be its own buffer, and some advanced buildings already have their own storage tanks to disconnect from the grid on demand.

A key component to connect energy and mobility needs is the inclusion of electromobility as a service, connected to the Positive Energy Blocks. This is a twofold contribution. The first aspect is an integration of people's mobility needs of electric car sharing, public transport, city bikes, etc. The second aspect is to use the energy from the residential or the work areas of the Positive Energy Blocks to charge the electric vehicles needed for this scheme. To make electric vehicles first class assets in the energy system, we pilot vehicle-to-grid technology. Instead of only optimizing the charging of electric vehicles, this enables the batteries of the electric vehicles to be used as storage for the Positive Energy Blocks. Despite rising electric vehicle use and shared car ownership there is a lot of downtime on these cars. Vehicle-to-grid technology utilizes car batteries, when the car is not being driven, to reduce overall needed stationary battery capacity.

All this is tied together with a local grid control system that integrates these assets as a local or community grid or as part of a larger grid. The grid control system actively manages these resources, enables peer-to-peer trading between buildings in a prosumer-enabled system, facilitates a flexible market for local grid operators, and aims to enable local data verification and market settlements through next-generation zero-fee blockchain systems.

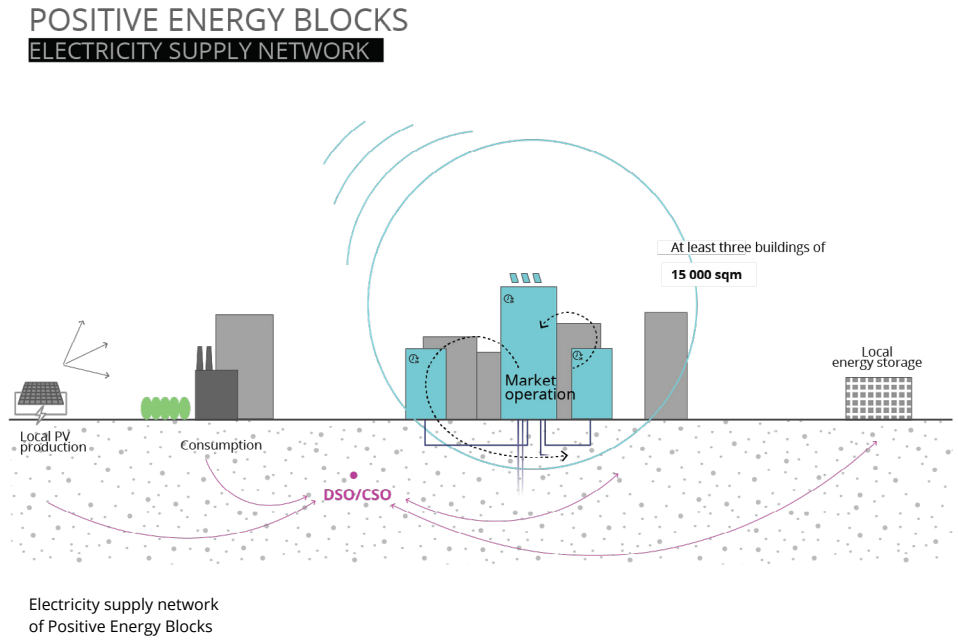

Figure 11: Transformation from traditional distribution network operators (DNOs) to active system management

In the current project phase, first smart meters and control systems are deployed and vehicle-to-grid chargers and batteries are being finalized. Various Positive Energy Block modeling and operating tools and decision support tools are in final development or testing stages. Market and flexibility models are developed and are being adapted for local implementation. Building owners are well integrated into the Positive Energy Blocks and investment models and replication are well underway.

Regulatory Frameworks and Investment Models

The development of Positive Energy Blocks or Districts needs to happen within the local/national regulatory boundaries. At the level of the European Union, the Electricity Regulation and Electricity Directive set the basis for flexible and connected markets whilst the Intelligent Transport System (ITS) directive (2010/40/EU) regulates the deployment of intelligent transport systems. However, the definition of the requirements related to these directives is delegated to the single nations, making the international scenario fragmented.

Smart cities innovations challenge the status quo and therefore require changes to existing regulations and financing models to support demonstration activities and piloting. To avoid regulations as bottleneck for the development, collaboration with regulators is therefore crucial. Single dispensations or dedicated permissions can be requested for specific requirements. This can make it possible to foster innovation and conduct live experiments in a controlled environment (European Commission 2018) through the Regulatory Sandbox framework (also called Regulatory Innovation Zones).

The purpose of a Regulatory Sandbox is twofold: to enable prototyping, testing and piloting of new technologies and approaches and to develop new guidelines and increase regulatory clarity in collaboration with the regulators.

The heterogeneous approach of each country does not allow the development of a turnkey solution. Disaggregated energy markets and industries limit the development of approaches easily replicable cross-country. Alignment between regulation and technology would lead to the development of new business models. Investments are required for the development of Positive Energy Blocks and sourcing financial resources is critical to the success functioning and implementation of a sustainable business model. Alongside national and local funding sources, innovative business models can include new funds and players that will work alongside traditional ones like crowdfunding and green bonds, small and medium-sized enterprises, technologies providers, energy service companies.

The +CityxChange approach is to develop an integrated investment model which can be adapted to different socio-economic contexts for the identification of a bespoke mix of financial products. In the models developed for the lighthouse cities the public authorities maintain a central role in the investment model supported by public private partnership and private investors, including building residents and commercial activities within the pilot sites.

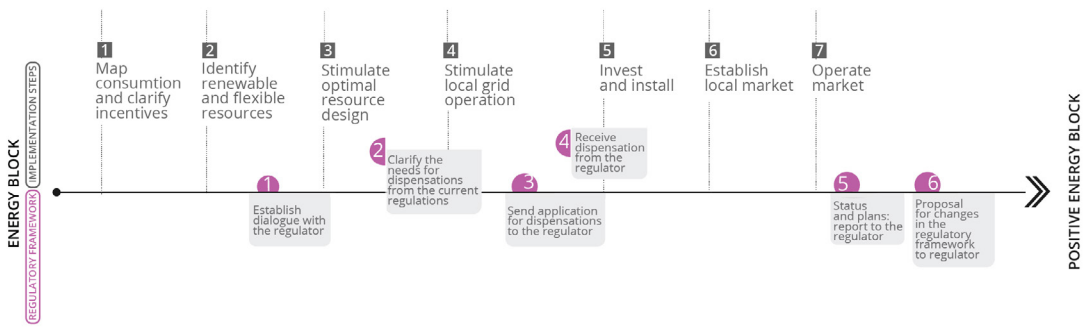

Figure 12: The +CityxChange regulatory sandbox approach

LESSONS LEARNED

Although replication is one of the aims of the European Commission Horizon 2020 Smart City program and it is encouraged within the projects, achieving it has been compared to the quest for the Holy Grail (Vandevyvere 2018). The combination of parties, interests, technologies, business models, legal context, social aspects, etc. requires a fine balance of different elements that can be hard to achieve.

In +CityxChange the lessons learned by the lighthouse cities in the first implementation phase are used to start the replication process in the follower cities. These lessons and the experiences in follower cities in turn are used to facilitate replication across at least 20 European cities. Since every environment and city is different, we do not offer a cookbook, but rather guidance documents and processes that support adaptation.

A replicable starting point is the creation of the Bold City Vision, combining existing city planning and management processes with goals, key opportunities and actions for becoming a smarter and more sustainable city. A clear vision, aligned with the existing conditions and developed in collaboration with stakeholders and not simply imposed, has proved to be the first step towards successful implementation for the lighthouse cities. Moreover, stakeholder engagement should not be considered a check-box exercise but instead should continue as their support is a discriminating factor for successful implementation of the solutions/innovations.

To enable and achieve change there has to be commitment from all levels. To promote success in the communities, the activation of citizens through, for example, Positive Energy Champions[3] is critical. It is also important to have a point of contact for the project who liaises with all the parties involved and promotes the change message linked with the implementation.

The adoption of open innovation as a guiding principle (Wyckmans et al. 2019) enabled: balanced individual concrete budgeting; risk management and investments with social innovation; shared value creation and the long-term, high-impact mission of contributing to positive energy cities; and, ultimately a climate-neutral Europe (European Commission 2020). After 18 months, this principle has also proven valuable to make room for the sometimes serendipitous (Mazzucato 2013) contributions of citizens, alternative processes, new technologies or opportunities for cooperation within a detailed, 5-year Description of Action.

To identify and document new learnings, dedicated learning sessions are organized between partners, to discuss and compare experiences from various cities, and then feed them back into the project for improved activities. While not originally planned for, the project is now developing metrics that are able to monitor the impact of these learning effects within the project and with others.

+CityxChange has a wide, targeted range of interactions with other projects and networks, both within Europe and beyond. In addition to dedicated cooperation with the other 16 Smart City Lighthouse projects, +CityxChange engages in cooperation with the members of the European Innovation Partnership (EIP SCC 2020) on Smart Cities and Communities to promote learning and replication, with the European Strategic Energy Technology Plan Action 3.2 (European Commission 2018a) Smart Cities and Communities in order to contribute to the creation of 100 Positive Energy Districts by 2025, and with the research organizations of the Joint Programme on Smart Cities of the European Energy Research Alliance (EERA JPSC 2020), to create a strategic research agenda able to support the development of positive energy cities and communities.

THE WAY FORWARD

Positive-energy cities that generate more energy than they consume, with net zero greenhouse gas emissions and a surplus production of renewable energy, can become the batteries of a climate-neutral society. However, this is not simply a technological question. Ensuring that such cities are, first and foremost, sustainable, resilient, safe and inclusive, as well as positive-energy, requires robust open innovation ecosystems of small, medium and large companies, public sector, academia, citizens, the arts, cultural and creative industries, media, non-for-profit foundations, and many more. For these stakeholders to cooperate, requires a solid framework – a safe space – in which they can come together, discuss, test, fail, try again and eventually find good solutions for their local environment. As such, the +CityxChange project aims to be the bridge that helps experts and citizens to come together and innovate.

We hope to join forces with similar projects across the world, to be able to expand the cooperation to other countries and regions and learn how the project's experiences may help transform existing urban environments in China, India, or Africa, into positive-energy cities and communities. We also look forward to what we can learn from them.

Acknowledgements

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Endnotes

1 For more information, see https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/topic-details/lc-sc3-scc-1-2018-2019-2020 and https://smartcities-infosystem.eu/scc-lighthouse-projects.

2 United for Smart Cities and Communities (U4SCC) is an initiative by ITU and UNECE and supported by several UN agencies. It is a global platform to strengthen the use of ICT in the transition towards smart sustainable cities. https://www.itu.int/en/ITU-T/ssc/united/

3 individual participants who will incorporate the positive energy concepts into their daily life and promote it by encouraging and helping fellow citizens to do the same.

4 The full consortium and more information on the project are available at https://cityxchange.eu/team

Figure 13: Project representatives during project meeting in 2019

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