Journal of Physics:
Conference Series

PAPER • OPEN ACCESS

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To cite this article: A Kalms *et al* 2023 *J. Phys.: Conf. Ser.* **2600** 082029

"oPEN Lab" project as an underpin innovation for Positive Energy District solutions in Pamplona

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Abstract. With the EU's goal of climate neutrality by 2050, urban areas should move towards Positive Energy Districts (PEDs) as powerful ecosystems of balanced energy. The aim of this research is to present the methodology that facilitates the implementation of technical and social innovations, designed and implemented through co-creation, specifically for the neighbourhoods of Pamplona (Spain) in the framework of the project "oPEN Lab" on the way to PEN and based on a local Living Lab (LL). This project is a positive consequence of the evolution and achievements in urban, energy and mobility city planning made possible by the methodology, solutions and actions presented in the context of research and innovation projects such as STARDUST and Efidistrict Fwd.

1. Introduction

With 75% of Europeans living in urban areas and an increasing focus on existing buildings to achieve full decarbonisation by 2050, it is crucial to design, adapt and retrofit our neighbourhoods to zero emission standards, supporting a holistic and human-centred view. Within this challenge, PEDs are emerging as powerful ecosystems to transform the urban fabric into balanced areas where energy production is higher than energy consumption on an annual basis. Specifically, the city of Pamplona indeed follows its 2030 Agenda [1] as a city strategy which objectives, among others, are the production of affordable and non-polluting energy and sustainable cities and communities, for which some commitments were made for 2030 to reduce at least 55% greenhouse gas emissions (GHG) compared to 1990, 32% renewable energy in energy consumption, and 32.5% improvement in energy efficiency. These objectives were also aligned in the climate change and energy transition strategy of the Pamplona City Council.

In order to reach these objectives and aligned with this Agenda, several European projects have been developed or are currently under development, such as:

1) **Efidistrict Fwd** [2] (2014-2017) is focused on Chantrea neighbourhood in Pamplona that contemplates the energetic rehabilitation of buildings, the reforms of old district heating (DH) systems to supply renewable thermal energy to the renovated homes;

2) **STARDUST** [3] (2017-2024) has deployed for testing in the North District of Pamplona lighthouse a set of technical innovative solutions, integrating the domains of buildings, energy, and e-mobility, using the latest ICT tools as sewing thread to effectively integrate the different actions that will contribute to the energy transition of cities;
3) **"oPEN Lab"** project [4] (2021-2026) builds upon its predecessors' ambition and challenges to kick-start the transformation of districts with a history of economic decline so as to become areas of development, testing and demonstration of innovative technologies, social experimentation and the emergence of new business models that contribute towards PED implementation. In this sense, a Positive Energy Neighbourhood (PEN) could be understood as an incipient PED and therefore borrows from its requirements although on a nearest geographical area, according to JPI Urban Europe definition of PED [5].

This work is structured firstly into a section on scientific methodology, followed by a presentation of the results obtained, and finally a section on conclusions.

2. Scientific methodology

This section provides an overview of the methodology used, which follows a three-phase process (see figure 1), starting with very focused actions of limited scope in the first phase, gradually increasing in scope to well defined areas of the city, which raises complexity including new actors in an holistic approach in the second phase, and culminating with all actors under a very general LL approach [6] related to a district and its decision making planning complexity in the third phase.

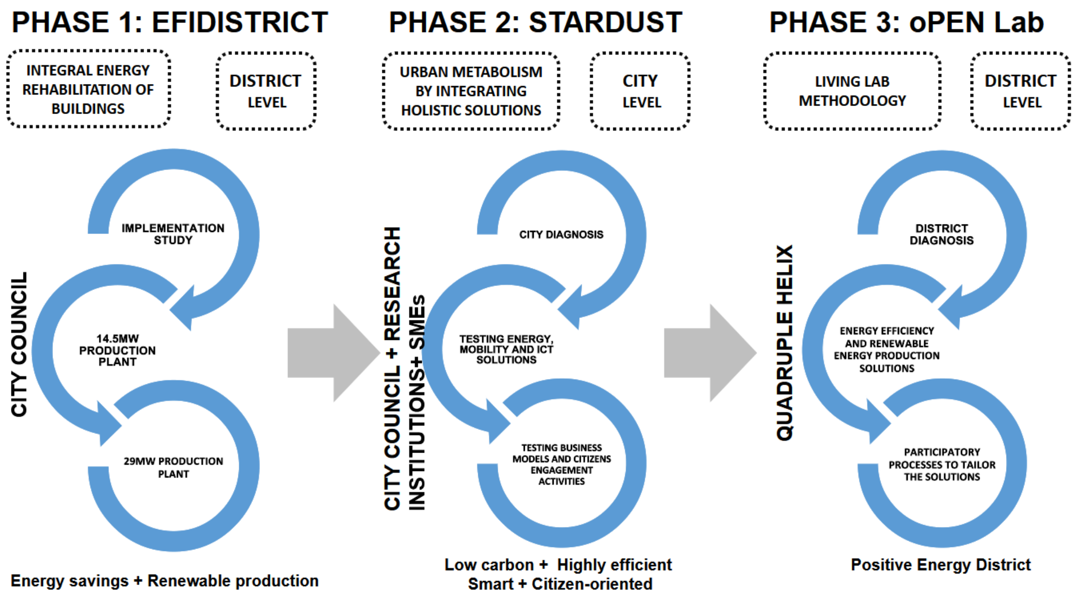

Figure 1. The three phases followed in the methodology.

In the **first phase** (March 2014-March 2017), a methodology based on the integral energy rehabilitation of buildings at the neighborhood level has been used, by creating the centralized production of thermal energy (biomass is the main source of energy and natural gas the secondary). It allows the use of innovative technologies and smarter use of energy and resources that would not be possible with conventional configurations. This phase is settled in three stages: 1) execution study of the Efidistrict power plant; 2) installation of a 14.5 MW production plant; 3) installation of a 29 MW production plant. The main objective was to enhance energy saving and to increase renewable energy sources (RES). In this first phase, the only entities involved were institutional.

In the **second phase** (October 2017- March 2024), a broader implementation methodology has been proceeded with at the city level, redefining Urban Metabolism by integrating holistic solutions as "islands of innovation" with smart ecosystems with open city information platforms. This phase is also divided into 3 stages: 1) city diagnosis to identify the main urban challenges of the three lighthouse cities (LCs) considering the diverse dimensions of the city (social, environmental, energy, economic and mobility); 2) testing of technical solutions at the level of energy, mobility and ICT through the Smart Pamplona Lab program; 3) testing of non-technical solutions in the form of business models and citizens engagement activities. The main objective is to introduce low carbon footprint, highly efficient, smart and citizen-oriented cities. The agents involved in this phase were the City Council and the local innovation system, formed by research institutions, the University and local SMEs.

In the **last phase** (October 2021-March 2025), after the lessons learned in the first two phases, a holistic LL methodology is being implemented at the neighborhood level. In this way, innovative solutions are currently experimented and implemented at the neighborhood and building level, taking into account the final users and all the agents involved in the neighborhood, with special emphasis on the citizens. This goal implies the next stages: 1) study of the context and needs of the neighborhood, 2) proposal of technological solutions to improve the energy efficiency of buildings and RES, and 3) execution of participatory processes to tailor the solutions to the needs of end users. Here, the main objective is to advance in the transformation of the neighborhood towards a PEN by applying LL methodology adapted to local conditions in a warm and temperate climate. The actors involved are the whole quadruple helix of the innovation helix framework.

3. Achieved results embracing Pamplona's 2030 Agenda

This section provides an outline of the results of the projects mentioned in section 2 already carried out and still in progress, in the city of Pamplona contributing to support the reported methodology.

3.1. Contributions from finished or nearly finished projects

3.1.1. Smart and low carbon buildings

The key achievement was to move from stand-alone refurbished or newly constructed smart demonstration buildings to a district scale action, by taking advantage of synergies and optimization opportunities. See figure 2 with monitored data such as consumption and CO2 reduction, RES contribution and total net energy use, disaggregated for the different locations, such as:

- Chantrea: Deep renovation to nZEB standard of 35 buildings, 58,000 m^2, as a result of Efidistrict Fwd project for the promotion of refurbishment works (877 dwellings). More than 2,200 homes in an environment which required the prevention of the degradation of the neighbourhood as a whole. As a result, residents have improved their quality of life and comfort in their homes, reducing the consumption of 65% of non-renewable primary energy consumption, and decreasing an average of 63% emitted CO_2 (92 dwelling reach 76 %). Foreseen energy savings: 5.05 GWh/year.
- Navarra Social Housing Plan: this plan provided for 524 social housing units in Pamplona and surroundings, 138 of which (10,638 m^2) were already occupied and monitored as part of STARDUST. The buildings are built to nZEB standards to minimise energy costs for tenants. Indoor air quality of each dwelling are ensured by continuous automatically monitoring the CO_2 concentration and relative humidity percentage. The overall aim is to combat energy poverty and provide a healthy indoor environment. Foreseen energy savings: 0.46 GWh/year.

3.1.2. Energy networks: district heating (DH)

In the North District of Pamplona, 8 existing and inefficient DH grids were integrated into a single highly efficient ring. This integrative process made feasible the creation of a new centralized Smart Energy Plant (SEP) based on biomass, to supply heating and DHW to 2,200 private dwellings, the Psychogeriatric Center (see in figure 2), and 5 public buildings with 16 MWth power. The whole regulation of the SEP relies on neighbourhood Energy Management System (EMS).

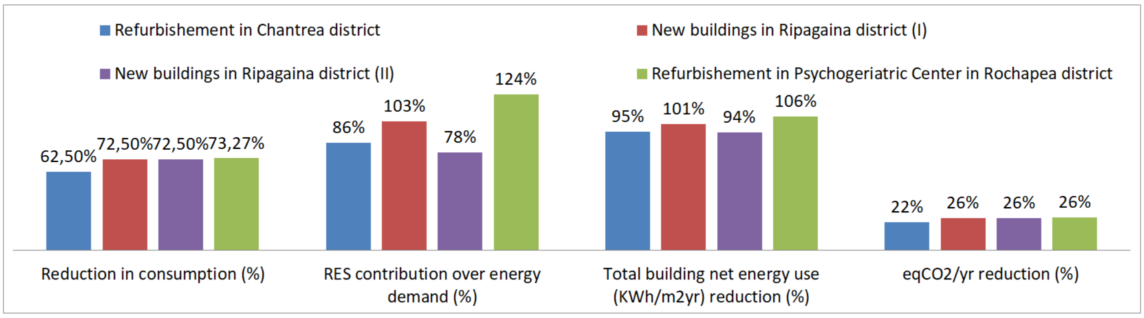

Figure 2. The results of monitoring of STARDUST actions at four locations.

3.1.3. Smart electric mobility

In Pamplona, to pave the way to a more sustainable clean and smart mobility multiple actions were implemented by the LC: 30 e-taxis, 20 electric vehicles (EVs) + 2 vehicle to grid (V2G) adapted cars for public fleets, 150 EVs private cars, 100 public e-bikes, 5 hybrid public buses, 5 fast chargers for taxis, 2 V2G chargers, 60 charging points in streets and parking public and 30 e-chargers in communal garages, and 1 e-bus line with 6 e-buses and 2 pantographs of 350 kWe grid-connected.

3.1.4. The importance of the One-stop information office (OSIO)

As an active link between stakeholders (dwellers, technicians and the Efidistrict management team) was created an OSIO in the Chantrea district, during Efidistrict Fwd project. Information was provided to residents, through meetings and information sessions, on the housing rehabilitation project and the construction of the biomass plant, as well as the subsidies available for the renovation of the houses. As a result, the number of household rehabilitations exceeded those in other areas of the city.

3.1.5. Overall integrator: Open City Platforms

In the smart cities' context, each LC has developed its own customized city platform, sharing the same objectives, architecture and services, based on the trend of open ICT tools. Therefore, the huge amount of data sets from monitored sources, such as refurbishment data or citizen control operating feedback, which need to be processed and analysed to enable the creation of new products and services that optimize the city functioning and the quality of life of its citizens.

3.2. Contributions from "oPEN Lab", an initiated project

3.2.1. "oPEN Lab" methodology

The oPEN LL Pamplona is considered as a structure where the local agents define, experiment, and implement innovative solutions and projects related to energy issues, renaturalization, building rehabilitation, sustainable mobility, urban and social regeneration of the environment. In this framework, achieving an active commitment of citizens and other local social agents is fundamental to move towards the PEN. The adaptation to the specific context of the Rochapea district (see in detail in figure 3) involved working in defining: (I) the Mapping Canvas to the LL Integrative process (design thinking), (II) an own LL strategy plan (based on gamification techniques between the 5 LL partners representing the quadruple helix and members of the consortium), and (III) actions roadmap accepted by the stakeholders and the governance model (still on process). Therefore, the five main challenges identified to be addressed were: (1) to regain the trust of the citizens in the usefulness and interest of the project by designing enhancements in the participatory processes, (2) align social and economic interests so that the LL methodology is valuable for co-creating with end-users the new technologies and innovative solutions to be implemented in the neighbourhood, (3) learning to work between the different organizations of the 4-helix involved in the project, being able to design a map of the stakeholders, their relationships, needs and interests in order to adapt their contributions. (4) To be able to translate technical information as well as what a LL is and its processes into a simple language. (5) Reaching out to minorities, such as the younger adults or families experiencing energy poverty.

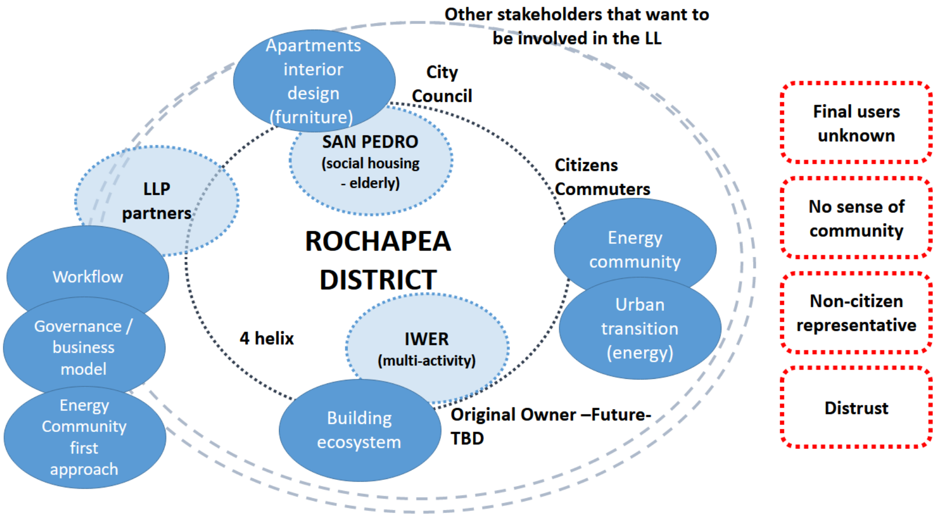

Figure 3. The Rochapea district is the centre of application of the Living Lab methodology.

3.2.2. Going social

Getting the commitment of the different agents involved in the neighborhood, and especially of the citizens, is one of the major challenges of the project. For this reason, a strategic action plan at urban, building and personal level was created to gain the confidence and interest of the users. In this way, the scope of action covered from awareness-raising activities to better understand the district context, to co-design processes to adapt technical and social solutions to the needs of end users, and training to understand the new concepts that emerge within the local LL. Also, as the OSIO, what involved citizens and stakeholders in the neighbourhood was the creation of a local Energy Community (EC) and an Energy Information Office (EIS). The EC's operation model was based on citizen participation, through specific informative sessions (e.g. Assembly of Agents with 38 participants) and training sessions on topics such as energy, governance and business model (e.g. with 3D visor of the future district or the 3D refurbishment choice in advised groups), with the final control of decision-making directly falling to the citizens themselves. The EIS informed citizens about the ECs, RES and available subsidies to encourage their participation (% of cumulated consultation is in figure 4).

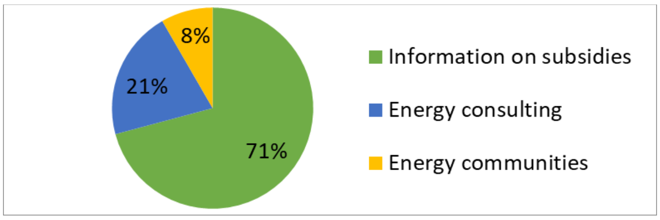

Figure 4. The results of Energy Information Office on reasons for consultation.

3.2.3. Solutions towards PEN objectives

In the PED framework, the ambition was to bring more than 20,000 m^2 up to nZEB standards, focused in two sites in the Rochapea district: (I) San Pedro (SP), with two blocks of flats (over 180 dwellings) owned by Pamplona City Council. The entire building envelope, as well as all building thermal system (BTS), balconies, building-integrated PV (BIPV) production were designed and an additional fast charging point. The renovation of the building's façade is intended to proceed from the inside, improving previous projects by an innovative technique based on vacuum insulation panels, allowing a thickness reduction in the insulation while preserving the external appearance. At building level, the selected technologies included low GWP heat pumps with a high seasonal COP, a microgrid with 30 kWp PV generation, a 40 kWp Li-ion battery per building allowing to exchange energy. And for optimal management of all systems, a micro-grid approach was defined, with a dedicated EMS able to introduce price signals and controls, interfacing with a BMS which interacted through innovative smart interfaces with elderly residents in their new active role as prosumers, offering flexibility of consumption. (II) IWER complex, a former industrial site underused, despite being a landmark of the district. The first phase of renovation targets an area of 7,500 sqm to become a nursing home. As it is a listed building, the refurbishment projected involved a thermal envelope of the building retrofitting from the inside for the façade. 2 MWp BIPV potential, EV chargers of e-mobility, 120 kWh Li-ion battery controlled by a Smart Converter and an EMS to monitor and optimize operation at a building and district level were included as energy solutions. All this implied 1580 MWh/year primary energy demand and 23,921 teqCO2/year GHG emission reductions in 2021.

4. Discussion and conclusions

"oPEN Lab" actions in coordination with complementary initiatives promoted by Pamplona City Council across Rochapea aims to be a replicable model of PEN in other districts in the future. The methodology adopted and the results briefly illustrated tend to place the citizen at the center of the changes leadership, assisted by the local authorities, while incorporating the other members of the quadruple helix that enable social and technical innovation. However, technology innovations and energy efficiency improvement solutions based on capacity building or even incorporating energy flexibility solutions have limited impact if public acceptance, understanding and participation, and, in this way, citizen engagement is low. In addition, some legal and administrative barriers also take time. In this way, LL methodology is a very attractive solution, with many operational opportunities to local decarbonisation improving living life quality, but with some governance challenges, that learning by doing should be optimally mastered. Anyhow, persistent questions arises to the table: will these innovations be enough to dynamise in time to meet the Local Agenda targets? What will be the main barriers to achieve complete decarbonisation in the coming years?

The ambitious goal implies involving all actors in transdisciplinary collaboration through a local and scalable LL. The main conclusion is that the previous projects sharing the same objective have empirically collaborated to identify the most suitable local methodology. This way, the technological and social solutions at local level function as catalysts to bring positive energy to the neighbourhoods. In this paper, a synthesis of the importance of the holistic approach of LLs has been exposed, and well justified by the specific cases presented in the city of Pamplona.

Acknowledgments

"oPEN Lab" is a project funded under the European Union's Horizon 2020 Research and Innovation Programme under grant agreement (GA) No. 101037080, and STARDUST under GA No. 774094.

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