NIVALIS Smart Solar City

The concept of positive energy buildings (PEBs) emerges as a transformative solution to respond to the urgent need to combat carbon emissions and reduce our environmental impact. With their highly efficient design, renewable energy sources, and cutting-edge technologies, they overcome their energy needs by producing surplus energy, which can be fed back into the grid or stored for later use. By upgrading the current building stock into positive energy buildings and districts, we can significantly reduce greenhouse gas emissions and the reliance on fossil fuels while enhancing our built environment's comfort and efficiency.

In addition to their contribution to a sustainable future, PEBs offer numerous benefits, such as improved air quality, thermal comfort, and overall building resilience. In addition, lower energy consumption and the ability to sell excess energy back to the grid results in significant cost savings over time, thus making PEBs highly attractive to building owners and buyers and offering a competitive edge in the real estate market. The EXCESS demo case in Spain showed that PEBs can be only achieved in the cases where there is sufficient roof area for PV that could cover the energy demand of the building. This is typically only the case for buildings with limited amount of floors and high roof areas.

This replication case of NIVALIS Smart Solar City is located in the municipalities of Gójar and Dílar in Granada. It constitutes the first ecologically sustainable and intelligent urban development project in Spain and is an example on the international stage. The project aims to create a positive energy district, with a pollution-free space that generates energy by harnessing available renewable resources and an E-Mobility system.

Capable of integrating diverse and complementary uses, NIVALIS fosters interactions between residents and visitors, creating a balanced model of coexistence through the dissemination of knowledge and the induction of positive behaviours among its inhabitants.

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1 Baseline Assessment of the Implementation Environment

1.1 Building description

The building of this replication plan is part of an urban and sustainable development district called "NIVALIS Smart Solar City." It is located in the southern metropolitan area of Granada, between the municipalities of Gójar and Dílar. NIVALIS aims to create a 100% renewable self-supplying energy system and a sustainable mobility with zero carbon emissions. It is conceived as a place to live in harmony with nature and a healthy space to live, work, enjoy, learn, and share knowledge.

It is a residential building of approximately 30 units, which share a commercial use on the ground floor, where shops and restaurants will offer products grown in Nivalis' area. The design is developed in response to the growing demand for efficient, sustainable, and healthy housing, with large terraces and community spaces designed to promote cohabitation. On the ground floor, the central area of the building opens up from the square towards the private common spaces, the green areas, and the street behind.

1.2 Regulatory Aspects and Public Support Schemes

Local Regulation

The Justification Memorandum[1] document of this project's Intermunicipal Planning Plan is normative. The plan states that it aims to achieve an urban development with a zero or neutral balance in CO2 emissions associated with building uses and a positive energy balance through the use of renewable energy.

To achieve this objective, the Urban Plan proposes several passive measures to reduce the energy demand, specially focused on reducing solar gains during hot seasons through shading elements and vegetative barriers. All shading elements should be able to mantain a good solar exposure during winter, and therefore species with deciduous leaves should be promoted.

Additionally, solar-exposed opaque surfaces should have sufficient thermal inertia to delay the effect of overheating towardin interior spaces. In this sense, the ideal solutions are ventilated façade systems, with insulation outside and mass inside.

Apart from the energy eficiency requirements, some other local regulations apply enforcing natural lighting or minimum ceiling heights that have to be taken into account.

Spanish Law

Article 15 of the Spanish Technical Building Code of Energy Savings (DB-HE) sets out the basic rules for making buildings more energy-efficient in the Spanish territory. These regulations are designed to promote a rational use of energy, reduce consumption to sustainable levels, and encourage the use of renewable energy sources. It includes limitations on energy consumption based on location and building use, requirements for thermal envelope characteristics, specifications for thermal and lighting installations, and mandates for the use of renewable energy hot water and electricity generation.[2]

The provisions in this code are basic and correspond to the competencies attributed to the State in the Spanish Constitution. For their implementation, they will have to be further complemented with provisions from the regional building codes.

EU Level

At the EU level, new constructions must ensure the building meets high energy performance standards per the EPBD. The directive also mandates optimising health, indoor air quality, and comfort levels in building energy calculations and highlights the IEQ impacts on the health, productivity, and overall well-being of building occupants.

Suelo NS-01_Dílar / NS-02_Gójar

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1.3 Social Dimension

NIVALIS has been designed as a positive energy district. The building will serve as a modern, sustainable living model, and all the surrounding buildings will follow the same idea. Currently, there are no residents as the urban plan is under development, allowing for implementing innovative design and environmental strategies from the ground up. The NIVALIS area's key focus is energy sharing and achieving CO2 neutrality, ensuring that the development aligns with the latest environmental standards and contributes to a greener future. This emphasis on sustainability includes a comprehensive approach to energy efficiency, incorporating renewable energy sources and innovative grid technologies that promote resource sharing among residents.

Furthermore, 30% of the NIVALIS area will be allocated to social housing, demonstrating a commitment to inclusivity and community welfare. This provision ensures that affordable housing options are available, fostering a diverse and vibrant community. By integrating these elements, the NIVALIS area aims to create a harmonious living environment that balances ecological responsibility with social sustainability. This forward-thinking approach addresses current housing needs and sets a benchmark for future developments in the surrounding area, showcasing how urban planning can effectively combine sustainability and social responsibility.

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1.4 Assessing Strengths, Weaknesses, Opportunities and Threats in Relation to a PEB Upgrade

This building is a new construction, presenting different opportunities, benefits, and disadvantages. In terms of climate, the Mediterranean Climate is very favourable for achieving PEB standards, as it is characterised by mild temperatures and high solar irradiation. Compared to colder climates, the energy challenges in southern Spain arise from the need to cool buildings rather than heating them. However, the Spanish building code has been adapted to EU directives, and the current insulation and efficiency requirements are close to the level required to reduce demand to the level needed to meet more easily the PEB standard.

Strengths

- New urbanised area: easy to include geothermal heat pumps and PV or PVT
- New building: easy to adapt the insulation requirements to PEB level

Weaknesses

- Poor knowledge about installing new technologies and innovative building solutions that improve energy efficiency
- Costs of non-standardised and innovative solutions are higher and there are not enough subsidies
- Installation of PVs limits the use of the roof as a terrace area

Opportunities

- The level of isolation from the grid, incentives to reach self-sufficiency via flexibility
- Incentives to trade energy with electric mobility
- As a new urban development, it could be transformed into a PED

Threats

- As a new urbanised area, licenses and connection of services (electricity, water) take time to receive

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2 Technical Information / Design Specifications

Mild temperatures and high solar irradiance characterise the local climate conditions in Dilar (Granada). To take advantage of these conditions, the plan for this building relies on maximising the electricity production provided by PV panels integrated into the building's roof, minimising the building thermal demand (space heating/cooling and DHW) with both passive (high-efficient envelope) and active solutions (such as motorised blinds and heat recovery systems), and optimising the sizing and working of the thermal generation system.

The building envelope for all the buildings from this district was defined in a previous project developed by CENER, called the "Nivalis Smart Solar City" project. CENER developed a guide with the technical descriptions that should be taken into account by the project's developers for all the buildings located in the Solar City Nivalis. The envelope properties are:

Surface	U-value
Exterior wall	0.17
Roof	0.16
Ground floor	0.22
Windows	1.1

The heating system will be water-based floor heating with very low water design temperatures (supply 35 °C / return 30 °C). On the other hand, the cooling system will be Fan Coil Units (FCUs) with high water design temperatures (supply 10 ºC/ return 15 ºC). These temperatures will ensure a better COP (EER) of the ground-coupled heat pump.

The thermal generation will consist of a geothermal source heat pump for space conditioning and DHW with an aerothermal heat pump specially dedicated to DHW production during summer. The expected COP of the system will be around 4, achieving high efficiency in the building's thermal generation.

PVs will generate local electricity on the roof of the building. Approximately a total of 100kWp could be easily installed on the building roof. Shading effects in the PV panels are not considered for this building, as he has yet to be build that will surround this one in the future has not yet been defined. This PV facility will generate electricity mainly during summer, when the solar irradiation is more intense, producing a significant energy surplus. Therefore, to increase the ability of the building to manage such an overproduction, a lithium-ion battery will be installed in the building with an energy management system (EMS) that contains different control strategies to optimise self-consumption or energy cost.

A critical actuation in these climates is using shading devices to reduce solar gains during summer. The dwellings' control systems will automatically activate these devices based on the measured solar irradiation.

Sensors and meters must be placed in the dwellings and thermal systems to manage and coordinate all these systems together.

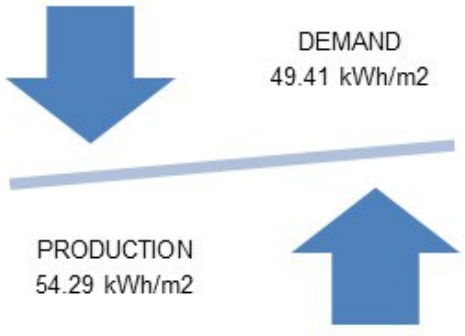

Figure. 1 Building Energy Balance (kWh/m2)

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3 Business Model Details & Possible Financing Arrangements

PEBs generate more energy than they consume, offering significant environmental, economic, and social benefits. A PEB business model revolves around creating value through energy efficiency, sustainability, and financial viability. By leveraging advanced technologies, strategic partnerships, and customer engagement, PEBs can offer significant benefits to owners, tenants, and the broader community, while also contributing to environmental sustainability and energy independence. The building in the NIVALIS area will achieve the highest possible building certification standard in Spain, resulting in lower interest rates on mortgage loans.

Furthermore, the building in NIVALIS area is a new construction, and therefore no subsidies or grants are available. The developer company, land owner, and/or construction company have to cover the extra costs compared to a standard construction. However, the NIVALIS area can share or exchange energy with neighbouring buildings and EV chargers, allowing extra revenues as it has been designed as a positive energy district. The idea is to be totally independent from the grid.

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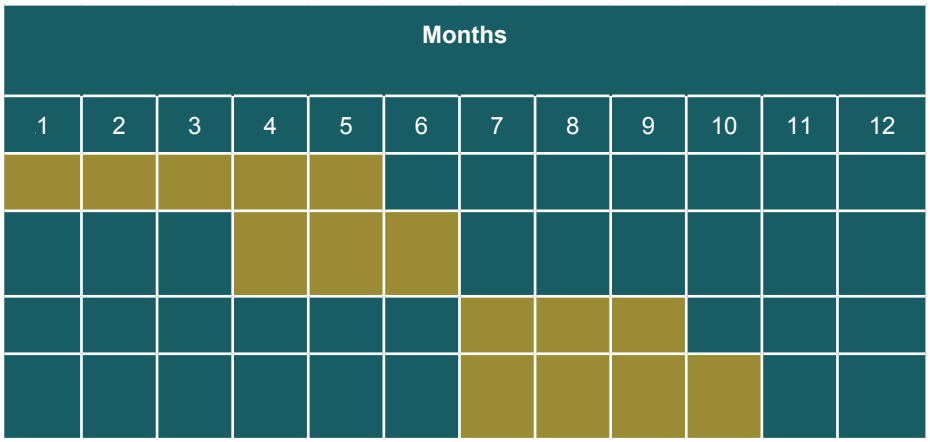
4 Possible PEB Upgrade Timeline

The project is already in the design phase and needs to be completed by adapting the proposed solutions. Once the construction package is finished, it could be presented to the City Council to obtain the building permits, and at the same time, the property would select the construction company. The construction works are estimated to take 20 months. During the final months, sensors and meters programming could overlap.

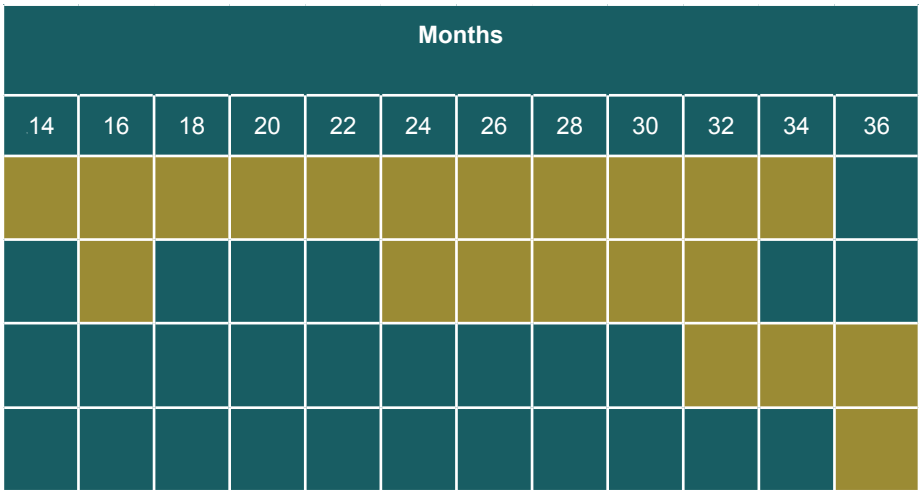
PEB Upgrade Activities in M01 to M12

- Activity A – Project Design
- Activity B – Implementation of PEB Solutions into the Plan
- Activity C – Building Permits
- Activity D – Contractor Selection



PEB Upgrade Activities in M12 to M36

- Activity E – Construction Works
- Activity F – PEB Implementation
- Activity G - Sensors and Meters Programming
- Activity H – Project Conclusion



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5 Local Government Recommendations

To accelerate energy efficiency, maximise the integration and use of renewable energy sources, and roll-out PEBs through financial incentives such as subsidies and grants, local governments could make PEB retrofits more attractive in various ways:

For green city projects, such as NIVALIS, a fast-track permitting system should be created to accelerate applications without causing excessive and unnecessary waiting times.

In addition to regional and national grant or subsidy schemes, local governments could consider establishing a special fund for PEB support and/or acting as a guarantor for banks to offer low-interest loans for PEB projects.

Local governments should create lighthouse projects using non-standardised and innovative PEB solutions. Despite their high cost, putting a series of small public projects out to tender improves demand and helps create a local market. This pushes the private sector to develop skills while reducing costs and creating market awareness.

Lastly, local governments should enhance technical advisory services (One-Stop-Shops) so that building owners can approach public officers to support them with decision-making on which measures, subsidies, or grants to apply for to enhance buildings & energy performance.

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