oPEN Lab
TARTU PAMPLONA GENK
LEADING THE TRANSITION TO POSITIVE ENERGY NEIGHBOURHOODS

Towards a regulatory framework for positive energy neighbourhoods

Outline of the oPEN-Lab policy roadmap

SPAIN

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Abbreviations and acronyms

Acronym	Description
BAPV	Building applied photovoltaic
BIPV	Building integrated photovoltaic
CEC	Citizen energy community
CSC	Collective self-consumption
DSO	Distribution System Operator
CTE	Technical Building Code
EED	Energy Efficiency Directive
EMD	Electricity Market Design
EPBD	Energy Performance of Buildings Directive
EV	Electric vehicle
GHG	Greenhouse gases
MEPS	Minimum energy performance standards
NZEB	Nearly zero-energy building
PEN	Positive energy neighbourhood
PV	Photovoltaic
REC	Renewable energy community
RED	Renewable Energy Directive
ZEB	Zero emission building

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Executive summary

The positive energy neighbourhood (PEN) approach can contribute to scaling up renovations while engaging local communities in the energy transition. A PEN is characterised by a group of buildings and public spaces with connected infrastructure, within a geographical area. A PEN aims for energy-efficient and energy-flexible groups of connected buildings and urban areas which produce net zero greenhouse gas (GHG) emissions from energy use on an annual basis and actively manage an annual local or regional surplus production of renewable energy. This report includes an analysis of national and regional implementation of the EU policies which underpin the PEN approach to building renovations.

oPEN Lab draws from the experience of Pamplona oPEN Living Lab in Spain, in which the PEN approach is being piloted. An analysis of regulatory barriers for energy performance, collective energy production and sharing, demand-side flexibility, and whole-life carbon and circularity have given insights as to where the current policy framework is hampering the roll-out of PEN. Despite not being explicitly encouraged by current policies, elements of the PEN approach are nevertheless already supported through various incentives and initiatives across these regions. These provide a base for the development of 'solution packages' in consecutive steps in close collaboration with Living Lab stakeholders.

Spain demonstrates a more proactive approach to integrating PEN features, supported by national funding programmes focusing on renovation and local energy production. The expansion of collective self-consumption to up to 2 km makes sharing energy from a neighbourhood perspective easier. Recent regulatory changes such as dynamic tariffs facilitate demand-side flexibility, which is a key element of the PEN business case. Despite these advances, confusion around the terminology and specifics of energy sharing, and a lack of expertise in whole-life carbon approaches and material reuse, remain significant barriers.

While local initiatives and EU funding aid the integration of PENs, consistent challenges such as the complexity of energy sharing regulations, limited financial incentives for energy storage, and the need for enhanced expertise in sustainable building practices highlight the need for a unified EU-wide strategy to fully realise the potential of PENs. Policymakers are encouraged to address these barriers through integrated, clear and supportive regulations that align with the EU's climate-neutrality goals, fostering an environment where PENs can thrive as sustainable energy solutions.

Harmonised definitions and frameworks for PENs are necessary for assessing progress and ensuring consistency across Member States. More tailored financing solutions are required to protect vulnerable households and mitigate energy poverty, aligning with the directives' focus on social equity. Assessing the social and environmental co-benefits of PENs is critical for maximising their impact. By addressing these challenges and leveraging the opportunities presented by the ongoing implementation of the Energy Performance of Buildings Directive, Renewable Energy Directive III and Energy Efficiency Directive, PENs can emerge as a cornerstone of sustainable urban development within the EU, contributing significantly to energy efficiency, renewable energy deployment, and social goals.

Introduction

The decarbonisation of the EU building stock requires renovation at scale. The Renovation Wave aims to at least double renovation rates across EU Member States by 2030 in order to achieve a decarbonised building stock by 2050.

> 'The necessary decarbonisation of the Union building stock requires energy renovation at a large scale: almost 75% of that building stock is inefficient according to current building standards, and 85-95% of the buildings that exist today will still be standing in 2050. However, the weighted annual energy renovation rate is persistently low at around 1%. At the current pace, the decarbonisation of the building sector would require centuries.'
>
> **2024 EPBD recast**

The neighbourhood/district approach is recognised in the 2024 EPBD recast as a cost-efficient way to scale up renovations while taking into account social and environmental aspects.

Within the oPEN Lab project, a positive energy neighbourhood (PEN) is an approach which aims to decarbonise a neighbourhood, while the Living Lab is a network of stakeholders which enables co-creation with the local community for testing of technological, process and social innovations in a real-life environment (see Figure 1). A PEN includes a cluster of buildings together with public space and shared services and facilities, and it includes specific technological and financial solutions, adapted to the local context. A PEN aims for energy-efficient and energy-flexible groups of connected buildings and urban areas which produce net zero greenhouse gas (GHG) emissions from energy use on an annual basis and actively manage an annual local or regional surplus production of renewable energy. The PEN project is enabled by a Living Lab which gathers groups of local stakeholders from the public, NGO and private sectors who will scale up PEN projects and other initiatives in the district/city. oPEN Lab Living Labs have a strong focus on engagement, consultation and co-creation processes, and trusting relations with local stakeholders and communities.

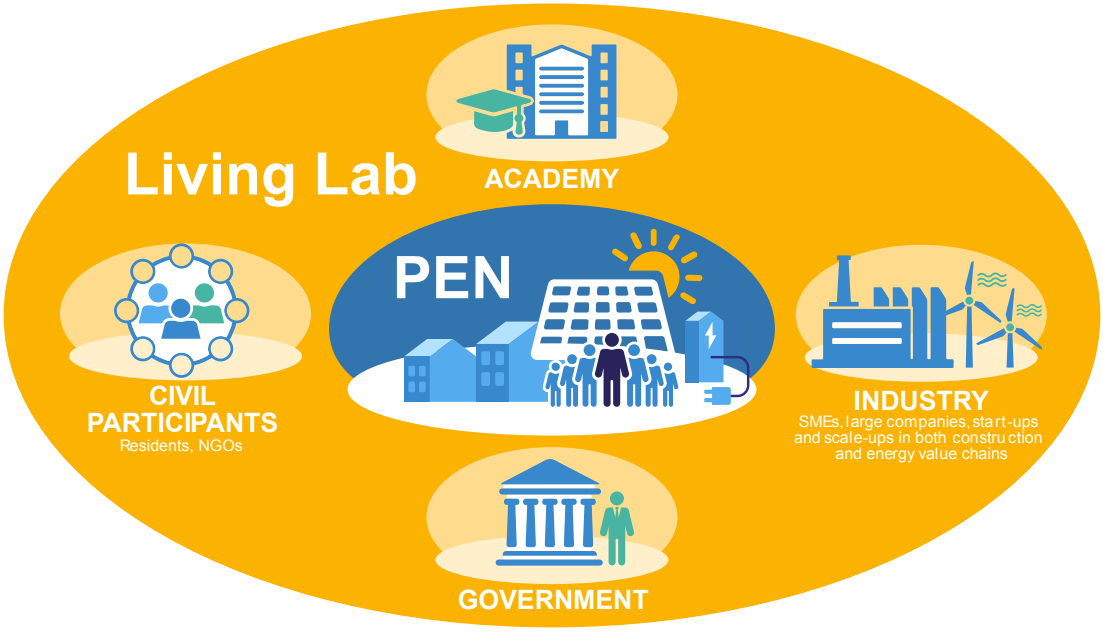

Figure 1 Conceptual difference between PEN and Living Lab

The 2024 EPBD recast for the first time considers the neighbourhood/district approach to renovations, shifting from an individual building approach to a building embedded in the urban infrastructure. Even though other directives and national, regional and local policies do not yet incorporate the neighbourhood approach, they relate to other relevant aspects for PENs, such as:

- Energy performance
- Collective production, sharing and selling of energy
- Demand-side flexibility
- Whole-life carbon and circularity

This analysis provides a base for tailored policy recommendations to facilitate PEN uptake in Spain, Flanders and Estonia. It is based on extensive desktop research, including the transposition of the 2018 Clean Energy Package in each pilot country, and a series of interviews and focus group sessions with key stakeholders of the three Living Labs, such as architects, developers, municipalities, energy agencies, and research institutions. The interviews helped to identify regulatory barriers and best practices for Livings Labs, and complemented the key national, regional and local policies relevant for PEN which were identified with the desktop research.

Experience from the Living Labs' local stakeholder ecosystems provides valuable feedback on the issues and best practices in transposing the EU Directives, ensuring a bidirectional exchange within different levels of local, regional and national governance.
Besides policy mapping, barriers and best practices were identified in the following areas:

- Financial barriers on how to ensure deep levels of renovation and engage vulnerable homeowners.
- Legal barriers regarding collective production of renewable energy linked with electricity market regulations, procurement processes and public tenders which do not encourage prefabrication or re-use of building elements, data privacy, etc.
- Lessons learnt from the Living Labs, adjusted and interpreted based on real-life conditions of current regulations.
- Possible solutions to identified policy gaps and barriers offered by best practices from other countries.

The goal of this Outline of the oPEN-Lab policy roadmap is to map the main policies and barriers for having a discussion with key stakeholders about working together to build the final policy roadmap. This first analysis will be used for stakeholder engagement sessions to co-create a non-technical solutions package with a view to overcoming PEN barriers. The goal of the final policy roadmap, due in 2026, is to embed the PEN approach into policies at all levels to work towards achieving local energy, environmental, housing and social goals.

2. The positive energy neighbourhood concept

2.1 Added value of neighbourhood approaches in building policies

PEN are at the pinnacle of the energy transition in urban environments. PENs can contribute to the decarbonisation of the building stock, while providing additional benefits for residents both at the building and neighbourhood level, enhancing wellbeing and social cohesion. Besides the deep renovation of individual buildings, PENs can encompass a range of shared spaces, services and facilities, such as shared heat pumps, photovoltaic panels, electric vehicles (EVs), EV charging stations, bicycles, and common spaces with greenery, water and biodiversity. Neighbourhood approaches provide additional benefits to demand-side flexibility compared to single apartments or buildings through the aggregation of energy assets and stacking of revenue streams – and thus generate greater energy savings and economic benefits for homeowners. **PENs go beyond the mere combination of individual positive energy buildings: they are the integration of buildings and neighbourhood infrastructure, creating a dynamic interaction with energy, mobility and industry.** This approach aligns seamlessly with the Renovation Wave's call for an integrated, participatory and neighbourhood-centred approach.

Renovations are a key requirement for the successful decarbonisation of the European building sector.[1] As recognised in the Renovation Wave,[2] deep renovations currently only occur in 0.2% of the building stock per year. The advantages of neighbourhood approaches to renovations as opposed to individual building approaches are acknowledged in the 2024 EPBD recast, and Member States are required to implement and report on the 'district and neighbourhood approaches' in their national building renovation plans.

> *(j) the promotion of district and neighbourhood approaches and integrated renovation programmes at the district level, which may address issues such as energy, mobility, green infrastructure, waste and water treatment and other aspects of urban planning and may take into account local and regional resources, circularity and sufficiency;*
>
> **2024 EPBD recast**

2.2 The positive energy neighbourhood concept in relation to policy

PEN as an enabler to achieve policy goals at local level

This section will detail the oPEN Lab concept and definition of PEN, in relation to decarbonisation policies for the building stock. PENs can contribute to achieving the following policy goals:

- Climate mitigation: reduce GHG emissions
- Climate adaptation
- Increase renovation rates
- Increase share of renewable energy

[1] https://www.european-calculator.eu/wp-content/uploads/2020/04/EUCalc_PB_no3_Buildings.pdf
[2] https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1603122220757&uri=CELEX:52020DC0662

- Smart electricity grid, demand-side flexibility
- Reduce fuel poverty
- Sufficiency policies at city, neighbourhood and building scale
- Improve social cohesion and community engagement

The right scale to adapt to the local context

In summary, PENs are projects which implement renovations enabled by the Living Lab network of stakeholders to achieve social, climate and environmental policy goals, by adapting the array of available technical, process and financial solutions to the local context. The Dutch government has used a similar neighbourhood-level approach to implement the phase-out of fossil fuel heating systems in residential buildings (OECD, 2023). It used a multi-level approach for vertical and horizontal policy co-ordination:

- Plan a heat transition vision and implementation
- Lead natural gas-free pilot projects
- Engage a broad array of stakeholders, citizens and local businesses to take action

The neighbourhood is the right scale for public authorities to engage with local communities to collectively find technical solutions for renewable energy heating systems, depending on the renewable energy production and storage potential. For example, if there is a lake in the neighbourhood there is the potential for seasonal water heat storage. The neighbourhood is also the right scale to find solutions to overcome technical, social, regulatory and financial challenges. For example, a neighbourhood is likely to have similar heritage protection of buildings.

Integration with urban infrastructure

PENs consider the interaction of the building with the electrical and district heating and cooling grids. Smart systems, heat and electricity storage maximise self-consumption within PENs, allowing an excess of renewable energy which can be shared with the wider district or renewable energy community. The sharing of energy between a PEN and a renewable energy community can contribute to a sense of community, energy security and sufficiency, as well as empower citizens for active participation in the energy market and energy transition. This can contribute to getting citizens on board and leaving no one behind, and can contribute to the acceptance of climate policies.

Implementing sufficiency principles

Finally, PENs can contribute to the incorporation of the sufficiency principle in energy and environmental policies. Sufficiency is one of the key pillars in building policies to deliver decarbonisation while tackling inequalities in access to energy services (Figure 5). According to the 6th Assessment Report of Working Group III of the IPCC, ‘sufficiency policies are a set of policy measures and daily practices that avoid demand for energy, materials, land and water while delivering human well-being-for-all within planetary boundaries’ (Shukla et al., 2022). The main goal is to meet human needs and provide services required for human well-being (e.g. housing including thermal comfort, nutrition and mobility), which implies an economy that stays within planetary boundaries. The PEN approach can untap a series of sufficiency design strategies, with shared spaces, services, renewable energy systems and heating systems which can provide added community well-being while reducing material and land use. For example, this could be as simple as having one heat pump instead of individual heat pumps in each flat. Another example is having shared rental EVs or better access to public transport instead of personal cars, which would cut down on parking lots and pollution alike.

oPEN Lab PEN definition

Districts and neighbourhoods are frequently differentiated according to their scale and social connotations. The term ‘district’ is usually related to large-scale urban areas, while ‘neighbourhood’ typically refers to smaller interconnected urban zones. There are several reasons why a neighbourhood approach is important for developing urban renovation projects. First and foremost, a sense of community identity will enhance renovation efforts towards a better urban environment that will improve the welfare of the inhabitants: PENs aim for community well-being, supported by instruments for economic, social and environmental development.

oPEN Lab definition of PEN

According to the oPEN Lab project, a positive energy neighbourhood (PEN) is characterised by a group of buildings and public spaces with connected infrastructure, within a geographical area. A PEN aims for energy-efficient and energy-flexible groups of connected buildings and urban areas which produce net zero greenhouse gas emissions from energy use on an annual basis and actively manage an annual local or regional surplus production of renewable energy.

A PEN should focus on several key concepts:

- PENs seek an integrated, participatory, neighbourhood-based approach to maximise the benefits of innovative energy systems.
- The benefits of a PEN extend to providing affordable living, enhancing indoor environments, and promoting well-being among its residents.
- A PEN is linked to an urban energy system and it is driven by renewable energies, which provide optimised and flexible supply.
- Buildings within a PEN environment are energy efficient, and their reduced heat requirements allow for low-temperature and decarbonised heating systems like heat pumps and novel generation from district heating.
- A PEN facilitates increased utilisation of renewable energy within the local energy system by providing optimal flexibility and by managing consumption and storage capacities according to demand.
- A PEN features the sufficiency principle of energy, environmental and social strategies.
- A PEN supports the circular economy and residual value, by embracing lifecycle analysis of embodied energy and embodied carbon considerations.

3. Policy mapping framework

PENs represent a cross-sectoral approach to renovations, energy provision and urban planning whose value propositions rest on the synergies between these. As a result, PENs are impacted by various policy fields, and there is no dedicated policy initiative that regulates and supports them.

For the purpose of mapping PEN-relevant policy, the central sub-themes and PEN aspects are presented below. Each theme is listed and described in the following subsections. The results of the mapping of EU policy and the Fit for 55 package are presented in Section 4.

Energy performance of buildings

At the EU level, the previously implemented versions of the EPBD introduced minimum performance requirements for new constructions and major renovations. These also included minimum shares of renewable energy produced on-site. The minimum requirements for major renovations have been transposed into national building regulations with different levels of ambition, considering also climate differences.

For neighbourhoods to achieve a yearly net positive energy balance, policies need to encourage individual buildings or whole districts to go beyond minimum energy performance requirements and generate a surplus of renewable energy where possible. This needs to be coupled with the financial and non-financial incentives to do so, such as subsidies to renovate and facilitation services.

Collective production, sharing and selling of renewable energy

At EU level, REDII[3] and EMD[4] contain important provisions and definitions for a legal framework enabling the production, storage, sharing and selling of energy. REDIII, approved in November 2023, keeps the same definitions for collective self-consumption and renewable energy communities (Table 1).

Renewables self-consumers	**Article 21, REDII**	'A final customer […] who generates renewable electricity for its own consumption, and who may store or sell self-generated renewable electricity, provided that, for a non-household renewables self-consumer, those activities do not constitute its primary commercial or professional activity.'
Jointly acting renewables self-consumers (collective self-consumption)	**Article 21, REDII**	A group of at least two cooperating 'renewables self-consumers […] who are located in the same building or multi-apartment block' or, where permitted by a Member State, within other premises.
Renewable energy community	**Article 2 (16), REDII**	A **legal entity**, based on open and voluntary participation, autonomously controlled by shareholders or members in proximity to renewable energy projects, **consisting of natural persons, SMEs, or local authorities**, with the primary goal of delivering environmental, economic, or social community benefits rather than financial profits. They are limited to renewable energy systems (heat and electricity) and rooted in the local community.
Citizen energy community	**Article 2 (11), EMD**	A **legal entity**, also based on open and voluntary participation that is value-driven rather than by financial profits. **There is no geographical limitation and electricity only is being produced and shared.**

Table 1 Overview of different energy-sharing possibilities in EU directives.

[3] Directive (EU) 2018/2001
[4] Directive (EU) 2019/944

PENs rely on an enabling framework for sharing energy among individuals and groups – sharing and thus reaching a net balance is at the core of the PEN concept. Thus, for this section, the degree to which regulations encourage or inhibit energy production, sharing and trading and the functioning of renewable energy communities or collective self-consumption is explored.

Demand-side flexibility

With the electrification of heating and mobility, electricity will become the core of the energy system in the next few decades – and the IEA[5] emphasises the huge role that flexibility will play. The EPBD recast, REDIII and EED include important provisions to encourage energy storage, smart heating, integration with sustainable mobility, and energy management systems. Demand-side flexibility is a key service of PENs which aims to maximise self-consumption at neighbourhood level and provide flexibility services to the grid. To exploit this potential it is key that regulations promote demand-side flexibility and smart technologies.

Whole-life carbon and circularity

Previous EU legislation did not mandate Member States to implement regulations that promote the use of secondary construction materials, their circularity, or life-cycle assessment methodologies. Thus, for this section any relevant national policies that have emerged on the initiative of a Member State will be listed. Going forward, the Council Conclusions on the Circular Economy in the Construction Sector from 28 November 2019 urged the Commission to facilitate the circularity of construction products when revising the Construction Products Regulation (EU) No 305/2011. The Commission's proposal for the construction products regulation currently under revision includes clarity on reused pre-fabricated houses. Several provisions of the 2024 EPBD recast make the shift from operational GHG to embodied carbon, among them the introduction of global warming potential over a building's whole life cycle. However, at this stage, no minimum requirements regarding the whole life-cycle emissions are being introduced.

With the PEN approach, renovations are a key measure to improve energy performance and make the most of collective renewable energy assets. Ideally, sustainable material choices (e.g. also secondary construction materials) are facilitated by a coherent whole-life carbon perspective and methodology.

[5] https://www.iea.org/reports/net-zero-by-2050

4. Local, regional and national policies for Pamplona (Spain) Living Lab

4.1 Introduction

Pamplona is the capital of the Navarre region in northern Spain. The Pamplona oPEN Living Lab aims to set up one of the few operational PEN pilots in Spain and demonstrate a new urban energy concept bringing together social, technical and process innovations. PENs can make essential contributions to achieving not only GHG emissions and renewable energy targets but also to reaching renovation targets, creating more social cohesion in neighbourhoods and addressing the housing crisis by reducing long-term energy costs. However, to make PENs a scalable concept in Spain it is important to investigate any regulatory barriers in the current policy framework that could hamper their uptake.

The purpose of the following analysis is twofold:

1. Through policy mapping and analysis, the current readiness of the Spanish regulatory ecosystem for PENs is assessed. Based on extensive desktop research, the transposition of PEN-relevant EU directives in Spain and other key policies were scrutinised. This will provide a first analysis of the key areas of policy recommendations to be further developed in subsequent stages of the project to identify non-technical 'solution packages'. Four aspects of policies were identified as relevant for PEN:

- Energy performance of buildings
- Collective production, sharing and selling of energy
- Demand-side flexibility and smartness
- Whole-life carbon and circularity

2. Based on a **series of interviews and focus group sessions** with key stakeholders of the Pamplona oPEN Living Lab – such as architects, developers, the municipality, and research institutions – **regulatory barriers and best practices** for Pamplona oPEN Living Lab were identified. **This provides a base for tailored policy recommendations to facilitate PEN uptake in Spain.**

The background section below provides key information about the Pamplona oPEN Living Lab and the current state of Spanish and Pamplona policies of relevance to PENs.

4.2 Background

Pamplona Living Lab

Pamplona is a city of 203,418 inhabitants[6] and the capital of Navarre, a regional leader in the renewable energy sector in Spain. The city joined the Covenant of Mayors in 2009, and is a Smart Cities and Communities Lighthouse City under the Horizon 2020 STARDUST project. Under the Urban Agenda 2030, Pamplona aspires to be:

1. Green, ecological and committed to the climate
2. Socially inclusive
3. Innovative with a knowledge economy

Its ambition is to be a European frontrunner city, so it is running various pilot projects in the Pamplona oPEN Living Lab, situated in the Rochapea district with around 25,000 residents. This is one of the most vulnerable areas of Navarre with a poverty rate of 11.3%.[7] oPEN Lab focuses on two pilot sites within the Living Lab: the IWER complex (a former industrial building in private ownership) currently used for a variety of functions, such as business premises and offices, and two housing blocks from the San Pedro group owned by Pamplona City Council.

Table 2 Overview pilot sites in oPEN Living Lab Pamplona.

San Pedro	IWER complex
42 independent buildings with a total of 235 apartments, each 60 m^2 before renovation.	33,000 m^2
They were last retrofitted in 1985, and have an energy usage of 250-350 kWh/m^2. In the context of oPEN Lab, two of the buildings will be fully refurbished.	Its energy performance is poor (350 kWh/m^2), despite being renovated in the early 2000s. Façades are listed for heritage protection.
Residents in the San Pedro building founded a REC in June 2023.	IWER complex will operate as a private REC created in January 2023.
Foresees the use of lightweight roof retrofitting with BIPV, and lithium battery storage capacity of 40 kWh for shared use in each building. Combined with high efficiency heat pumps, this will meet domestic hot water and heating needs.	Planning for a capacity of 910 kWp of building integrated photovoltaic (BIPV) and building applied photovoltaic (BAPV). However, the ownership of photovoltaic (PV) assets and the financing is yet to be clarified, because of the low potential return on investment. The goal for this part of the project is to have a significant amount of BIPV and BAPV, a lithium second-life battery, a review of the HVAC system with efficient aerothermal heat pumps and low global-warming-potential refrigerants, an underground water tank, and water mines for thermal accumulation (ATES).

[6] https://www.pamplona.es/la-ciudad/observatorio-urbano/poblacion-y-demografia/pamplona/poblacion
[7] https://portalsalud.navarra.es/documents/11746728/14305293/Rochapea_InformeZBS.pdf/f0e04c38-051a-5d6d-26f4-103a924541b3?t=1643723179163

The two sites for oPEN Lab will operate independently, implementing a 'day ahead matching strategy'[8] as part of two independent renewable energy communities (RECs). Virtual energy balance will link both sites as part of the neighbourhood approach, which will also explore virtual joint operational strategies. As is the case in many Spanish cities, Pamplona is densely populated with six to eight storey buildings and highly concentrated energy consumption; given that renovations are planned to a nearly zero-emission building (NZEB) standard, additional energy supply is required. In the San Pedro condominiums, the energy agency previously tried to install rooftop PV and to promote CSC; however, currently there is no renewable generation and storage present – residents were not 'energy-active' until the establishment of the REC in recent months

Climate and energy landscape

National – Spain

The 'Sustainability and Climate Change' chapter of the 'España 2050' strategy confirms Spain's commitment to achieve carbon neutrality by 2050 and envisions radical change in how to produce energy, boost green taxation, and reduce dependence on foreign energy sources. In 2021, the national government released Law 7/2021, of 20 May, on climate change and energy transition,[9] which makes climate neutrality in 2050 a legal obligation. **This law is a centrepiece of PEN-relevant legislation: it encourages the use of materials with the lowest possible carbon footprint in buildings, improvements in building accessibility, and the integration of renewable energy in housing renovations.** It increases the minimum requirements for PV installations for self-consumption in property owner communities, and promotes zero-emission heating and cooling systems. Finally, it introduces a mandate for EV recharging infrastructure in buildings with parking areas of more than 20 spaces, effective as of 1 January 2023. The Long-Term Decarbonisation Strategy (ELP 2050) already mentions the electrification of heat, demand reduction and thermal renewables for the building sector specifically; and importantly for PENs, it puts the consumer and demand-side management at the centre of its focus.

The National Integrated Energy and Climate Plan (PNIEC) 2021-2030 is also relevant for PENs. After a period of public consultation in autumn 2023, the PNIEC will be finalised by summer 2024. This draft raises the 2030 target for PV from 37 GW to over 76 GW, and the national share of renewable energy to 48% of final energy consumption (electricity 81%). It also reduces final energy demand by 44% through energy efficiency measures by 2030 compared to 1990.[10] Finally, it includes a large variety of PEN-relevant measures such as the promotion of an Energy Storage Strategy (under Measures 1.4 Development of innovative renewable energy installations, and 1.5 Energy storage) and flexibility (Measure 1.6 Demand management and flexibility) and reiterates measures from the 2021 Road Map for Self-Consumption to improve self-consumption and citizen participation (1.8. Development of self-consumption with renewables and distributed generation). While PENs are not explicitly mentioned, the neighbourhood level is mentioned several times, also in relation to the development of risk capital as a channel for business financing (5.6 Strengthening public venture capital for technology transfer in energy and climate).

[8] A day-ahead matching strategy is a method used in electricity markets where buyers and sellers trade electricity for delivery the next day. This strategy helps balance supply and demand, and sets the price for each hour of the upcoming day.
[9] Ley 7/2021, de 20 de mayo, de cambio climático y transición energética
[10] https://www.lamoncloa.gob.es/serviciosdeprensa/notasprensa/transicion-ecologica/Paginas/2023/280623-gobierno-consulta-publica-plan-energia.aspx

Regional – Navarre

Under Article 148.1 of the Spanish Constitution, regional governments have exclusive responsibilities concerning urban planning and housing. They are also mainly responsible for allocating national public funds to final users. Regions (Comunidades Autónomas) can regulate renewable projects and impose additional requirements in their areas; however, the Secretary of State for Energy is responsible for the national energy strategy, and for granting authorisations for facilities with an installed capacity of more than 50 MW when they affect the territorial scope of more than one autonomous community or are offshore in the territorial sea.[11] This means that while regions can regulate projects and set additional requirements, the final approval for a project to proceed comes from government ministries at national level, with significant projects or policy changes also requiring parliamentary approval.

The region of Navarre approved the Energy Plan of Navarre last year, which establishes ambitious targets for the energy transition and the creation of a regional energy agency. **The plan outlines a strategy to mobilise EUR 2,300 million between 2023 and 2027 to transform the Navarre energy landscape.** The revised plan focuses on a significant increase in solar and wind energy capacity, with the aim of multiplying installed solar capacity eight-fold from 178 MW to 1,505 MW, and doubling the installed wind power capacity from 1,305 MW to 2,023 MW within seven years. The document underscores the crucial role of the private sector in financing these initiatives, with 88% of the total funds (EUR 2,040 million) expected to come from companies and consumers. Currently, 25% of the energy consumed in Navarre is renewable, and the plan envisions doubling this figure to 50% by 2030.

There is also a goal to achieve 100% renewable elcyectricity in Navarre by 2030, compared to the current 85%. In addition, it aims to reduce primary energy consumption by 30% compared to the figures originally projected for 2020, solely through energy-efficiency measures. The region of Navarre recently approved its own Foral Law on Climate Change and Energy Transition, which targets a 23% reduction in GHG emissions from 1990 levels by 2030 and the creation of a regional energy agen.

Local – Pamplona

The municipality of Pamplona has an ambitious 2030 Energy Transition and Climate Change Strategy for Pamplona (SECAP), developed under the European Covenant of Mayors. It includes an action mainly targeting the rehabilitation of façades and roofs of 60% of dwellings built prior to 1979 (30,274 dwellings), before the first energy regulation code was introduced in Spain. The aim of SECAP is to promote a just energy transition, mitigating and adapting to climate change, and to achieve the eradication of energy poverty.

The city aims to increase renewable energy generation by 37% and energy efficiency by 39%, reducing carbon emissions by 64% by 2030 compared to 1990 levels. Currently, only 9.5% of final energy consumption in Pamplona comes from renewable sources, and of that only 18% is locally produced. These numbers indicate that PENs have the clear potential to help achieve set targets.

[11] https://www.trade.gov/country-commercial-guides/spain-energy

4.3 Analysis of the regulatory framework

Energy performance in buildings

Policy mapping

Reducing energy demand and increasing renewable energy production in buildings in a PEN are key to achieving a positive energy balance. In practice this means that existing buildings will need a deep renovation beyond minimum energy performance requirements.

The EPBD is largely transposed in Spain in the Technical Building Code (CTE), which defines energy performance requirements. This is a core regulation that establishes the technical legislative framework for the safety and habitability of building construction. **NZEB standards have been mandatory for the construction of new buildings or major renovations since 2020.** The minimum requirements for total primary energy consumption for renovations in the residential sector vary according to the climatic zone from 75 kWh/m^2 to 115 kWh/m^2 per year. This is relevant for the Pamplona oPEN Living Lab, which aims to bring more than 20,000m^2 to NZEB standards through renovation. However, there are currently no public incentives to go beyond NZEB standards in Spain and reach energy-positive building standards. Instead, the Spanish oPEN Living Lab stands out from business as usual due to its use of high-performance vacuum insulation and industrialised elements, as well as for the inclusion of a significant renewable energy generation capacity and advanced energy management systems.

To support the effort to reach NZEB standards, the national government created a framework for a group of incentive programmes financed by NextGenerationEU under the 'Plan for Housing Renovation and Urban Regeneration'.[12] Energy renovations are thus subsidised in line with the Spanish Long-term Renovation Strategy (LTRS) and Plan Nacional Integrado de Energía y Clima (PNIEC). Particularly relevant is the Programa de Rehabilitación Energética de Edificios (PREE) with a budget EUR 300 million, which promotes actions carried out by individuals and communities of owners as well as RECs, CECs and those affected by energy poverty. It focuses on interventions in the building envelope and improvements in the energy efficiency of thermal systems and lighting, and aims to support the energy renovation of an equivalent of at least 40,000 residential buildings. It builds on Royal Decree Law 15/2018 on urgent measures for energy transition and consumer protection, which laid out the base for fiscal measures for energy efficiency and a greater integration of renewables.

Best practice

With a budget of EUR 1 billion, Component 2.I2 of Spain's Recovery and Resilience Plan aims to build at least 20,000 new social housing dwellings. Their primary energy consumption is guaranteed to be at least 20% lower than that required for almost zero-energy buildings in Spanish regulations.[13] This is paving the way to making social housing a key part of the PEN approach, which includes new builds.

[12] NextGenerationEU is a temporary recovery instrument of €800 billion to help repair the immediate economic and social damage brought about by the coronavirus pandemic and to build a post-COVID-19 Europe that is greener, more digital, and more resilient. https://next-generation-eu.europa.eu/index_en

[13] https://www.navarra.es/es/tramites/on/-/line/ayudas-para-mejorar-la-eficiencia-energetica-de-las-viviendas

Policy	Level implementation	Key provisions	Relevance for PEN
Technical Building Code: CTE-DB HE Energy Saving	National	The CTE DB-HE regulates energy use and demand in buildings. It applies to new and retrofitted buildings. It also establishes the minimum requirements for renewable electricity generation. The latest update in 2019 made NZEB building codes mandatory from 28 January 2020 for new or significantly renovated buildings.	An ambition level of minimum requirements for major renovations contributes to achieving a positive energy balance at neighbourhood level. After the transposition of NZEB, Spain will soon implement the zero-emission buildings standards of the 2023 EPBD recast.
Royal decree 178/2021 Regulation on Thermal Installations in Buildings (RITE)	National	RITE establishes the minimum conditions that must be met by thermal installations for energy efficiency and safety. It contributes to the PNIEC goal to reduce primary energy consumption by 39.5% by 2030.	It promotes more sustainable heating systems and makes it more difficult to justify having fossil fuel heating.
Royal Decree 853/2021	National	This regulates aid programmes in the field of residential rehabilitation and social housing as part of the Recovery, Transformation and Resilience Plan.	Renovation programmes for private residential and social housing can be implemented more easily with the PEN approach, thanks to economies of scale and community engagement.
Law 10/2022, of June 14, on urgent measures to promote the activity of building rehabilitation in the context of the Recovery, Transformation and Resilience Plan	National	Aims at strengthening the capacity of homeowners associations to improve energy efficiency in buildings. It lowers the majority requirement for approving renovation and accessing financing and public support. It facilitates access to loans granted by private financial institutions through a new line of guarantees. It includes income tax incentives for renovations.	Improving access to private finance and capacity-building for homeowners associations are important aspects of PEN implementation in the private residential sector.
Special Protection Plan and Interior Reform of the Old Town (Plan Especial de Protección y Reforma Interior (PEPRI) del Casco Antiguo)	National	In view of the declaration of the Old Town as an Asset of Cultural Interest with the category of Historic-Artistic Site (BOE 29/04/1968), the PEPRI plan complies with the requirements of the Spanish Historic Heritage Law (Title II) and the LFOTU (Art. 92). It is not permitted to install PV panels on roofs in the old town.	The PEPRI of the Old Town of Pamplona hampers PV systems because it stipulates that roofs cannot be flat and that tiles of a specific colour must be used. However, the PEN approach promotes technological solutions which can be adjusted to local neighbourhood conditions, including heritage protection.

Table 3 Overview of national and local policies for energy performance in Spain.

In Navarre, there are additional funding sources under the Biziberri Plan, an initiative by the regional government to combine EU funds with regional funds. Grants under the plan cover the 'permanent aid' which can also be accessed by homeowners' associations or developers. They also cover 'MRR Housing' (aid to improve the energy efficiency of homes, focused on heating and cooling) which can be accessed by individuals or public administrations, and MRR Buildings (aid for the energy rehabilitation of buildings, focused on building envelop) aimed at houseowner associations in buildings that are at least 20 years old. For the two latter it is a requirement – regardless of NZEB standards – to prove there is a reduction of non-renewable energy consumption and energy efficiency improvement to fixed percentage rates. There is also a tax deduction for investments in renewable energy installations for natural or legal persons paying taxes in Navarre.[14] To access private funding and potentially achieve energy performance levels beyond NZEB standards, Spain has established a special financing arrangement between the Ministry of Transport, Mobility, and Urban Agenda and the Official Credit Institute. This initiative is designed to provide preferential financing to communities of property owners, with the goal of encouraging the renovation of their buildings.

PENs can use renewable heating systems such as heat pumps with low global warming potential to further improve the energy performance of buildings. In Pamplona, these will be used in the IWER pilot complex and combined with BIPV, which will be designed to increase the efficiency of the heat system by using heat recovery systems. The Regulation on Thermal Installations in Buildings (RITE)[15] transposes the 2018 EPBD and EED and encourages this technology. It makes it necessary to justify using conventional thermal systems instead of sustainable or more efficient heat systems, and promotes the use of the latter. The latest update from 2021 also promotes the incorporation of renewables in general, mandating technicians and installers to propose the replacement of fossil fuel equipment. In addition, users of all administrative or commercial buildings above 1,000 m^2 are now required to be informed about the energy consumption of the building – and thus behaviour change is encouraged.

Furthermore, the revision of the DB HE Energy Saving regulation mentioned above lifted barriers to using alternative technologies in PENs. The CTE now requires, for example, mandatory solar thermal installations for new constructions and major renovations. However, it was found that residents often choose to not connect the installation because of high maintenance costs. Under the revision, buildings can use aerothermal heat pumps as an alternative solution.

Regulatory barriers

While Spain has set regulations and incentives that support the PEN concept implicitly, the practical case of the Pamplona oPEN Living Lab has revealed some remaining policy barriers. It was for example noted that for the installation of PV systems within a PEN, permission needs to be granted by the distribution system operator (DSO), which can determine the technical requirements for access to the electricity grid. However, these conditions can become very strict and hamper the investment. The approval process and the registration of the installation can sometimes take a year or longer. These delays impact investment decisions and make it harder for the PEN to predict how the installation will need to run. **The revised REDIII incorporates provisions with a view to accelerate the permit-granting procedure for RES, which should thus enable smoother implementation for PEN projects.**

[14] https://www.navarra.es/es/tramites/on/-/line/Informe-de-inversiones-en-instalaciones-de-energias-renovables-y-en-sistemas-de-recarga
[15] Royal Decree 178/2021

Existing building regulations in Spain require NZEB as a minimum standard for major renovations, and the Pamplona oPEN Living Lab buildings will comply with NZEB standards. Currently there are no public incentives which encourage deep renovations beyond minimum requirements. However, where feasible, renovations should go beyond minimum requirements, aiming for positive energy buildings which will contribute to lowering energy demand and achieving a positive energy balance at the neighbourhood level. The EPBD recast introduces a shift to Zero-emission buildings (ZEB) levels, and incentives should encourage projects to go beyond even that.

The existing NZEB definition includes a minimum share of renewable energy generated on-site or nearby, which is in line with the PEN approach of maximising local production and self-consumption. However, the upcoming implementation of the ZEB definition in the EPBD recast will extend the renewable energy sources to RECs and 'decarbonised energy sources', an approach which discourages the deployment of renewable energy source at the building and neighbourhood level.

Originally, buildings used to have coal boilers, with a shift to oil heating systems taking place some 40 to 50 years ago. Since then, around 2,000 households in the pilot area have moved to individual gas boilers, which are better – but still less efficient – than heat pump thermal installation for heating and hot water for the whole building. However, many buildings are technically not adjusted to having a collective heating system such as a collective heat pump.

Barriers	Policy recommendations	Stakeholder
Long permitting processes and strict technical requirements for installation of renewable energy sources pose difficulties for PEN planning and investments.	Implement REDIII provisions on accelerating permit-granting procedure for RES. Implement previous provisions on the obligation of DSOs to publicise information on grid capacity.	National government
Lack of incentive to go beyond NZEB level and implement deep renovation.	Transpose ZEB requirements of the EPBD recast. Provide public incentives to go beyond minimum requirements.	National and regional government
Existing buildings rely on individual HVAC systems for each apartment and are not equipped with collective systems.	Use building codes and subsidies to promote collective systems for heating, storage and RES.	Local government

Collective energy production and sharing

Policy mapping

A precondition for PENs to unfold their potential is a regulatory framework that enables collective energy production and storage. In practice, inhabitants and citizens share the investment costs but also the benefits from collective production. If well enabled by the regulatory framework, energy sharing can allow communities of owners to bypass high grid tariffs and become prosumers that are more closely connected to their own energy production and consumption. To reduce reliance on additional cables or infrastructure, energy is shared virtually with concrete shares allocated per living unit.

Spain has recently made regulatory changes to better enable energy sharing, going beyond the requirements of REDII Article 21 on 'jointly acting renewable self-consumers', which allowed CSC within an apartment building. Spain first extended this to a range of 500 m, and later of 2 km. CSC was first legalised through Royal Decree-Law 15/2018 which also grants the right to self-consume energy without charge and with a simplified administrative procedure. The so called 'sun tax'[16] was eliminated, and a mechanism for compensating surpluses was introduced. Previously, only individual self-consumption connected to an internal network was possible. Under the changes, several consumers could be associated with the same generation plan, which could also be nearby.[17] In Royal Decree 244/2019 the administrative, technical and economic conditions for self-consumption of electricity were further spelt out. The law mentioned 'Autoconsumo colectivo en red interior' (within a single building) or 'Autoconsumo colectivo a través de red' (for energy sharing through the public grid). Power surplus can now be shared with consumers in proximity feeding into the grid as long as participating entities comply with at least one of the following conditions:

- They operate within the low voltage grid and are connected to the same transformer.
- They are located in the same cadastral area.[18]
- The location of production and consumption points is within a radius of 2,000.

In Navarre, the plan for self-consumption and electric storage is part of the Navarre Energy Plan 2030.[19] The Foral Law 4/2022 on the Climate Change and Energy Transition of Navarre promotes the generation of renewable energy. This law requires newly constructed residential, industrial, commercial and service buildings with a roof area of more than 500 m² undergoing major renovation or change of use, or those renovating their roof, to install individual or shared-use PV systems. These must cover at least 35% of the roof area in the south, southeast and southwest orientations; which in practical terms increases the minimum required previously by the CTE.[20]

In Royal Decree 23/2020, the definition for REC from REDII is adopted and RECs are recognised as legal entities that are part of the electrical system. The law elaborates further on the types of activities involved. The law also introduced a national register for self-consumption with free access in order to monitor its impact.[21]

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[16] 'Impuesto al sol': a controversial toll applied to self-consumed energy in Spain implemented in 2015 for the costs of distribution and maintenance of the Spanish electricity network.
[17] https://www.lamoncloa.gob.es/consejodeministros/Paginas/enlaces/050419-enlaceautoconsumo.aspx
[18] https://www.rescoop.eu/uploads/rescoop/downloads/Collective-self-consumption-and-energy-communities.-Trends-and-challenges-in-the-transposition-of-the-EU-framework.pdf
[19] https://www.navarra.es/documents/48192/0/PresentacionPlanAutoconsumo.pdf/700a1bd6-cf2a-c7b6-b545-da71fa-7af086?t=1576841617751
[20] Previously, the CTE foresaw the amount of electricity capacity to be calculated based on the size of building and its roof. This resulted in buildings being required to use between 2.5-25% of their rooftops. These rules were simplified, but mostly require more solar rooftop than previously.
[21] ECR_MSfiche_Spain_final.pdf (europa.eu)

Table 4 Transposition of EU directives in Spain.

EU concept	Transposition into Spanish regulations	Key provisions	Relevance for PEN
CSC	Royal Decree 244/2019 (energy sharing distance amended in Royal Decree 20/2022)	Sets a definition for CSC. It also specifies that production installation should be close to and associated with those of consumption. (The user needs to be within 2,000 m of the renewable energy source (as per amendment).	CSC allows PEN residents to invest collectively in renewable energy sources without setting up a legal entity.
REC	Royal Decree 23/2020	Article 4 sets out definition, requirements and activities. RECs need to be legal entities.	No taxes are paid on shared energy, and grid fees are set to zero. However, setting up a legal entity may be a barrier.
CEC	Mentioned in RD 23/2020, no direct transposition	N/A	Since CEC only focuses on electricity and has no geographic limits, it is not ideal for PENs.

Besides recent changes in regulation to better support CSC and REC concepts, there are also a variety of incentives and programmes in place in support of PEN: they include 'CE-OFICINAS,' a programme specifically designed to provide funding to Community Transformation Offices for the promotion and revitalisation of energy communities. Other programmes developed by the Institute for the Diversification and Saving of Energy are:[22]

- CE-APRENDE: has the objective of creating the concept of the energy community, and of identifying future partners and users.
- CE-PLANIFICA: aims to plan and create energy communities.
- CE-IMPLEMENTA: is part of component 7, 'Deployment and integration of renewable energies', of the Recovery, Transformation and Resilience Plan. It promotes over 40 REC initiatives (and covers up to 60% of costs). Priority is given to innovative multi-component installations, and projects with social and gender importance. The participation of vulnerable households is particularly prioritised.

To promote an increase in self-consumption, Royal Decree 19/2021 modified the 'horizontal property law'. This allows PV or other energy installations to be put in place without the agreement of all the units in a multiapartment building. A majority of owners must still approve for installations to be permitted in common spaces. A one-third majority of the community board is required to approve PV on the common roof for private use.[23]

[22] NetZeroCities
[23] https://energanova.es/ley-de-propiedad-horizontal-de-placas-solares-en-comunidades-lo-que-tienes-que-saber/#:~:text=La%20Ley%20para%20instalaciones%20de,de%20las%20cuotas%20de%20participaci%C3%B3n.%E2%80%9D

Table 5 Overview of energy sharing policies in Spain.

Policy	Level implementation	Key provisions	Impact for PENs
Royal Decree-Law 15/2018	National	Introduces three fundamental principles that will regulate self-consumption activity: (i) self-consumed energy from renewable sources, co-generation or waste will be exempt from all types of charges and tolls; (ii) it recognises the right to self-consumption shared by one or various consumers to take advantage of economies of scale; and (iii) simplification of the administrative process (for facilities up to 100 kW).	The set-up of PENs is facilitated with a regulatory framework to allow CSC and simplified administrative procedures, and it provides financial incentives to encourage PEN business models.
Royal Decree 244/2019 an amendment Royal Decree 20/2022 (on measures to respond to the economic and social consequences of the war in Ukraine and to support the reconstruction of the island of La Palma and other situations of vulnerability).	National	Created the CSC framework that allows several consumers within the same community, such as a neighbourhood or residents' association, to share ownership and access to generation facilities located within the community. Users of solar panels are exempt from paying any related tax for their PV installation. Users can access CSC if they are within a distance of 2 km (using the grid) or if they share the 14 digits of the cadastre. The installation can be licensed with a simple notification to the municipality, and it must also be registered with the DSO.	Facilitated rules and the removal of barriers to CSC among PEN residents.
Royal Degree Law 23/2020 Amendment of Energy Sector Act	National	Definition of new ways to take part in energy transition, i.e. REC, storage. The REC definition is taken from REDII (Directive (EU) 2018/2001). This law ensures that RECs will be considered fairly in competitive processes, allowing them to compete on an equal footing with other participants for access to the payment system.	Consumers and owners are now able to earn income, no additional permit is needed for selling excess energy. However, REC participants are not allowed to sell energy between themselves, only to share. This is a first step to allow smaller actors such as RECs or PENs to enter the market.

Royal Decree 19/2021 on urgent measures to promote building rehabilitation activity in the context of the Recovery, Transformation and Resilience Plan.	National	Modifies the 'horizontal property law' to facilitate the installation of renewable energy sources on the roof with a one-third majority of the community board. For CSC, variable coefficients must be established before consumption occurs and energy is generated, to avoid billing complications. The coefficients must be defined for each hour of the year.	The change in the condominium regulations may enable the installation of renewable energy sources on the roof by third parties or by a group of residents; however, to have the majority on board for collective investments in RES, community engagement, feasible business models and access to low-interest loans are all required.
Foral Law 4/2022 on Climate Change and Energy Transition	Regional	Sets requirements to encourage the production of clean energy, with a focus on reducing environmental harm and optimising existing energy sites. It also emphasises the importance of engaging citizens, organisations and local players through collaborative initiatives like CSC and REC at the local or regional level. The law's goal is, among others, to promote energy cooperatives by incorporating them into RECs.	Promotes CSC and RECs – which can be part of a PEN, or a PEN can be part of a bigger REC/ energy cooperative and provide excess energy or aggregated flexibility services.

Regulatory barriers

A key barrier to collective energy – and thus to PENs – is persistent confusion over the distinction between RECs, CECs, and CSC, commonly summarised as 'autoconsumo compatido'. Current fragmentation across levels and policies on RECs and CSC creates confusion about the various energy sharing models and the terminology of 'self-consumption'. CEC is not transposed, and the term 'local energy community' is frequently used without a clear definition of what it refers to. The existing CSC regime enables bottom-up PEN initiatives since it allows energy sharing within a 2 km range without the need to be registered as a legal entity, which can be a significant burden for communities of residents. However, repeated changes such as the extension of the 500 m boundary to 1 km and later 2 km do not create a predictable environment for investments. The transposition of the CEC framework could potentially allow PENs to be part of it, and sell excess energy and flexibility services.

Barriers	Policy recommendations	Stakeholder
No transposition of CEC framework into Spanish legislation which could prevent PENs from selling excess energy and flexibility services to CECs.	Transposition of CEC and revision of Royal Decree 244/2019.	National government
Confusion around energy sharing models and terminology.	Establishment of one-stop-shops for EPBD recast guidelines and set-up of information campaigns regarding PEN, CSC and REC opportunities.	Regional and local government
Frequently changing regulatory context does not allow long-term investment and business model planning.	Make regulatory changes in collaboration with stakeholders from the construction sector and NGOs to accompany PEN stakeholders in their projects, create a supportive framework, and gather feedback for policies.	Regional and local government
Inability to share energy within a PEN or REC, with only the possibility to share energy and sell excess energy to the grid at a lower price.	Ensure sound compliance with updated Energy Market Design (EMD) Directive currently under revision which aims to simplify energy sharing.	National government
Risk of corporate capture of RECs.	Establish an implementation mechanism – such as a supervising authority – to ensure compliance with the REDII and REDIII requirement that RECs are limited to natural persons, SMEs and municipalities.	National and regional government
Risk of prioritising big renewable energy power plants in natural, agricultural areas instead of within the city.	Implement Article 15 of REDIII on 'renewable acceleration areas', prioritising *'artificial and built surfaces, such as rooftops and facades of buildings, transport infrastructure and their direct surroundings, parking areas, farms, waste sites, industrial sites, mines, artificial inland water bodies, lakes or reservoirs, and, where appropriate, urban waste water treatment sites, as well as degraded land not usable for agriculture.'*	National and regional government

Demand-side flexibility

Policy mapping

PENs can play a central part in the transformation of the energy system as they maximise local self-consumption and can even provide flexibility services to the grid. Smart technologies and automation play a key role in enabling flexibility of consumption. The latest modelling for the district of Rochapea showed that if all roofs are used, only parts of the actual energy demand can be covered. Spain has a special need for flexibility because of its energy grid's dependence on imports from neighbouring countries and its interconnectivity security supply. The particular need for flexibility will increase with the roll-out of PV installations in the Navarre region. In September 2022, a group of companies published a manifesto for a national strategy for demand-side flexibility in Spain, proposing a 5% reduction of domestic electricity consumption in peak hours.[24] In 2022, a roadmap for demand-side flexibility in Spain was published,[25] and in 2023 several priority actions were identified in this regard:[26]

- Participation of demand flexibility in all wholesale markets
- Aggregation of distributed energy resources
- Development of the independent aggregator in line with Directive (EU) 2019/944

First attempts to integrate the topics are notable in measure '1.2. Demand management, storage and flexibility' under chapter 3 of the National Energy and Climate Plan. One of its objectives is the promotion of citizen participation in demand management, and the neighbourhood scale may provide advantages in aggregation of flexibility, as well as citizen engagement in finding storage and energy management solutions.
With the oPEN Living Lab Pamplona project, the city wants to demonstrate innovative digital methods, industrial workflows for design and construction, and monitoring with integrated life-cycle assessments. Building and local energy system operations are optimised through dynamic balancing of renewable energy sources, flexibility aggregation and trading. Spain has been using dynamic tariff systems since 2014. The Voluntary Price for the Small Consumer (PVPC), regulated in Royal Decree 216/2014, reflects the hourly variation of the price of energy in the daily and intraday market and the adjustment markets. Therefore, consumers directly experience wholesale electricity price variations in their electricity bills, encouraging energy-saving behaviour in peak times.

Royal Decree 20/2020 (mentioned above) introduced new regulations for the renumeration regime. For example, it approved a new auction-based mechanism for renewable energy. According to this mechanism, renewable energy producers can participate in auctions organised by the Spanish Energy Market Operator (OMIE), which will determine the prices and volumes of electricity to be traded in the wholesale market. The auctions take place every quarter and last for one year. PENs can protect residents from electricity price fluctuations. With the right energy storage and management system, residents can avoid buying from the grid at high prices, and share energy between themselves instead of selling cheap to the grid.

[24] Spain manifesto demand side flexibility
[25] Roadmap for demand flexibility in Spain | ENTRA association
[26] CEEC |clusterenergia.cat

In oPEN Living Lab Pamplona, the plan is to have one meter for the St Pedro building and then different meters for each unit. In Royal Decree 1027/2007, Spain had already introduced digitalisation in non-residential buildings with high energy consumption, requiring them to become smart buildings. All of the analogue electricity meters were replaced with digital, remotely-operated versions in 2018 following a government mandate, with Spain outperforming most other Member States.[27] To ensure that momentum is maintained, Resolution 247/2019 requires energy meters to be installed in all new buildings as well as existing buildings that undergo major renovations or extensions. Royal Decree 736/2020 made it mandatory in buildings with central heating or cooling systems built before the approval of the RITE (Regulation of Thermal Installations in Buildings) of 1998 and located in climatic zones **C, D and E** of the Technical Building Code (CTE) to install a 'Repartidores de costes de calefacción' [heating cost allocator]. These can detect heat differences between the radiator and the room, and provide a very accurate indication of how much heat a consumer is using.

Table 6 Overview of demand-side flexibility policies in Spain.

Policy	Level implementation	Key provisions	Impact for PENs
Royal Decree 736/2020	National	Regulates the requirements for installations in buildings equipped with central heating and cooling systems, and guarantees individual meters for each consumer. Implementing this regulation is expected to lead to average savings of 24% on household energy bills.	This will empower users with greater autonomy in determining how to optimise their consumption and enhance the comfort of their homes.
Resolution 247/2019 Technical and Metrological Regulations for Alternating Current Electrical Energy Meters	National	Regulates the installation and operation of energy meters in buildings, following the technical standards and specifications established by the Spanish energy market operator (EMCO). The energy meters must be connected to a reliable power supply and a local or national communication network.	Deployment of meters is a necessary condition for PENs.

[27] https://www.engerati.com/smart-infrastructure/10-experts-on-getting-smart-spain-leads-the-way/

Regulatory barriers

The change towards dynamic tariffs has been a big step in opening up the potential for PENs; however, barriers remain, especially around the use of data. Access to less aggregated data would allow better planning for interventions at a district level. Key barriers are the monopolies in the electricity sector, administrative barriers, and limited access to data managed by DSOs.

There is also an obligation for thermal networks to have a meter for each housing unit to encourage energy savings. Collective thermal units (for domestic hot water) need separate meters so units can be charged for their real consumption. The demand-side flexibility regulation framework is currently being developed. The independent aggregator is expected to be implemented in 2025, according to Red Eléctrica de España.

Barriers	Policy recommendations	Stakeholder
Aggregated or lack of availability of data for energy optimisation. Lack of individual metering in housing units for domestic hot water and thermal energy.	Transposition of CEC and revision of Royal Decree 244/2019.	National government
Lack of individual metering in housing units for domestic hot water and thermal energy.	Enforce the obligation for thermal networks to have a meter for each housing unit.	National government
PENs can work in practice as aggregators; however, the legal framework does not allow them to sell flexibility without an aggregator.	Enable small actors such as PENs or RECs to enter the electricity market to provide flexibility services.	National government

Whole-life carbon and circularity

Policy mapping

PENs can contain buildings of varying types and use a large variety and combination of technological systems. This allows for some flexibility with the materials used in renovation processes and in choices of technology. oPEN Living Lab Pamplona is integrating life-cycle thinking from early design stages to ensure that embodied energy and emissions targets are met, as well as driving a reduction in pollutants. In the case of IWER, efforts are being made to reduce demolition waste. Project partners are developing a user-friendly label for the environmental impacts that are outputted from life-cycle analysis of materials used, to enable stakeholders to better interpret the results.

Changes in requirements for green public procurement have been made. Companies which apply for public funding can get more points in the offer evaluation if they execute an life-cycle assessment on their internal operations and projects. However, the outcome of the life-cycle assessment does not hold any weight in the selection process.

From a regulatory perspective, no direct regulation encourages consideration of embodied emissions. While there have been different reports and studies highlighting the whole-life carbon approach in Spain, no method has been specified on a legal policy level. The Green Building Council España (GBCE) published a Whole Life Carbon Roadmap for Spain in 2022.

In autumn 2023, the public-private circular economy partnership 'Navarra Zirkular' had its first forum. It aims to promote circular practices in companies, and has created the first Circular Navarre Catalogue showcasing 20 organisations in the region which use circular business models. The Navarrese Circular Economy Agenda 2030 has a key working programme on promoting sustainable construction, such as through valorisation of inert industrial waste and construction and demolition waste.

oPEN Living Lab Pamplona aims to use a prefabricated indoor insulation system for energy renovation. An optimised process based on digitalisation of the workflow through building information models is being tested to reduce costs and environmental impacts. A modular concept for façades and prefabricated elements is expected to leverage the renovation process by shortening the retrofitting time, improving air quality and reducing dust, noise and other disturbances for users. The National Energy Efficiency Fund (NFEE) is aimed at reducing energy consumption in the production and installation sector, and could potentially support green retrofitting with prefabricated renovation – which, due to its low market share, is still expensive.

Table 7 Overview of whole-life carbon and circularity policies in Spain.

Policy	Level implementation	Key provisions	Impact for PENs
Spanish Urban Agenda	National	*'Improving the quality and sustainability of buildings (Strategic Goal 2.6)'*: Using efficient building techniques that guarantee the use of suitable materials for buildings and dwellings and facilitate reuse. This would form part of a 'build to last' approach.	Built new or retrofit with lasting and reusable materials to reduce the whole-life carbon impact.

Regulatory barriers

A key barrier to using secondary materials and reducing whole-life carbon impact is the absence of certification to ensure a certain quality standard. Spain has not introduced a calculation method and does not have a calendar for introducing minimum thresholds for embodied carbon, unlike other frontrunner countries. This inhibits the incorporation of reused elements and sustainable materials, and is a more widespread barrier for the reuse of construction materials. Planning is difficult and time-consuming, as not only the quality but also the availability of second hand material can be uncertain, making it expensive. However, the EPBD recast introduces the calculation of life-cycle global warming potential for ZEB, which can be a first step towards a calculation method that will enable the implementation of thresholds.

Furthermore, the use of more sustainable, recycled or reused materials is reportedly very time- and cost-intensive, as recycling from demolition sites requires a high level of coordination between the different actors involved.

Best practice

Madaster, the **Dutch marketplace** for construction material, provides online access to available or required inventory on demolition, renovation or construction sites.

Construction professionals still have little expertise with digital tools to optimise the workflow, which would reduce time, environmental and cost impacts.

Barriers	Policy recommendations	Stakeholder
There is little expertise on this topic among construction professionals.	Improve capacity-building.	Regional government
Time and cost issues from using sustainable, recycled or reused materials.	Mainstream a marketplace and registries for secondary materials and mandate planning. Develop material passports.	National government
No national-level methodology or certification for whole-life carbon.	Implement 2023 EPBD recast provision on life-cycle global warming potential calculation for ZEB.	National government

5. Conclusion

The current Spanish policy landscape does not explicitly encourage the PEN approach. However, various policies, incentives and initiatives encourage the deployment of important elements for PENs. Spain has developed a comprehensive incentive programme with funds from NextGenerationEU to channel finance towards renovation and local energy production, with special attention to energy-poor and social housing. Recent changes in the tariff structure towards dynamic tariffs discourage peak energy consumption, creating a more favourable regulatory environment for demand-side flexibility in PENs. The country has incorporated changes to better facilitate self-consumption, by extending CSC to a 2 km range. This allows PENs to collectively produce and share energy between residents without being registered as a legal entity. The role of RECs is also strengthened with the IMPLEMENTA funding scheme. Yet key barriers remain. There is confusion around the terminology of 'local energy communities' and details of energy sharing, the definition of CEC from the EMD has not been transposed, and key expertise for including a whole-life carbon perspective or reusing construction materials is lacking.

PEN is a promising approach for achieving EU energy objectives, but its success depends on national governments including it in their own policies and programmes. The explicit mention of neighbourhood and district approaches for renovations and the requirement to report on progress within national building renovation plans in the new EPBD is an important milestone for the PEN approach. To further foster the uptake of PENs there is a need for a common definition and framework. The definition must leave enough flexibility to enable local adjustments, depending on limitations such as heritage regulations, renewable energy potential, and electricity grid capacity. However, the concept, approach and calculation method should be harmonised to allow for comparison between projects. In addition, such a definition is critical to enable meaningful follow-up on the policy goals related to the progress of district and neighbourhood approaches in the national building renovation plans.

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