Master Thesis

Analysis of the Competitiveness of Energetic Communities in Spain

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Abstract: Energy communities in Spain are expanding but remain early-stage and often subsidy-dependent; this study assesses their techno-economic competitiveness and social value and outlines a practical path toward a mature 2050 scenario. Two archetypes are modeled 39 kWp rooftop PV system serving 20 households under collective self-consumption and the same PV coupled to a 47.2 kWh community battery operated to raise self-consumption. Hourly energy flows are obtained with PVSyst; a 25-year project cash-flow model (WACC 5%) evaluates four financing cases; social cost–benefit is estimated with a 3% real social discount rate. Results show IRR above WACC in all cases: PV without subsidy 5.98% (payback 13 years), PV with subsidy 18.31% (5 years); PV+BESS without subsidy 9.60% (9 years), PV+BESS with subsidy 17.85% (5 years). Storage increases self-consumption and lowers peaks, improving readiness for future flexibility revenues; the social appraisal yields positive net social value from lower bills for vulnerable households, avoided emissions and reduced arrears. We conclude ECs are technically and economically viable with meaningful social benefits; scaling requires completing the specific Royal Decree with data access for dynamic sharing and hourly settlement, a stable incentive for shared energy, DSO flexibility procurement, OTC support and mobilization of citizen finance.

Keywords: Energy communities; Self-consumption; Photovoltaics; Storage; Flexibility; Energy poverty; Social WACC; 2050 Strategy.

0. Introduction

0.1 PROJECT MOTIVATION

Since I began my career as an engineer, I have been interested in how the energy model is evolving, above all because of its implications for society. What strikes me most is that, although there is much talk about energy transition, people are often forgotten. Energy Communities seem to me to be a way to bring that transition closer to people, to make it more tangible and participatory.

As I have learned how Energy Communities operate, I have seen that they offer something different: they allow citizens, municipalities or small businesses to work together to generate and manage their own energy. This not only has technical or economic advantages, but can also help reduce inequalities, tackle energy poverty or revitalize rural areas.

One of the reasons I decided to focus on this topic is that I feel it has a direct impact on people. It is not only a matter of efficiency or technological innovation, but also of social justice. In addition, it is a field with great potential that still needs a lot of analysis, especially so that initiatives can grow without relying so heavily on subsidies or public aid.

With this work I want to better understand how Energy Communities are functioning in Spain today, what barriers they are encountering, what role support schemes play, and what can be done to make their development more stable and accessible to more people. In short, it interests me because it connects technology with society, and because it can be part of a broader solution for the energy model of the future.

0.2 PROJECT OBJECTIVES

The main objective of this work is to propose recommendations that will allow Energy Communities in Spain to move from being an emerging solution—still largely dependent on subsidies—to becoming a widely implemented, structured and viable alternative within the national energy system.

To get there, this work sets out a series of specific objectives, all closely aligned with what is included in Annex B of the thesis.

The specific objectives of the project are:

• **Characterize the current status of Energy Communities in Spain.** This includes analyzing how many exist, which technologies they use, how they are legally organized (associations, cooperatives, etc.), who takes part (citizens, municipalities, companies, etc.), where they are most present and what role public support plays. This part is essential to understand our starting point.

• **Differentiate Energy Communities from the shared self-consumption model.** Although they may look similar technically, there are many legal, organizational and social differences worth studying. The aim is to understand why an Energy Community can deliver greater community value and whether that value justifies the greater organizational effort involved.

• **Analyze the technologies currently used in Energy Communities.** Although most communities are based on photovoltaics, the analysis also reviews the use of batteries, charging points for electric mobility and, to a lesser extent, thermal technologies such as solar thermal or heat pumps. This is key to assessing the technical and economic feasibility of each type of project.

• **Study international trends.** In many European countries, Energy Communities are far more advanced than in Spain. An important part of the work is therefore to examine what has been done in countries such as Germany, Denmark or the Netherlands, which barriers they have overcome, which support policies have worked and which lessons we can apply here.

• **Propose a realistic future scenario for Spain.** The aim is to imagine how Energy Communities could develop by 2030, taking into account current support schemes, the observed growth rate, social interest and technical potential. The idea is to outline a reasonable, non-idealized scenario that can serve as a basis for concrete recommendations.

In addition to these general objectives, the work also has a practical focus that includes a techno-economic comparative analysis between an Energy Community (with solar PV generation) and a shared self-consumption project. This will make it possible to see in which cases one option or the other makes more sense, and how factors such as support schemes, cost-sharing or project size influence outcomes.

0.3 ALIGNMENT WITH THE SDGs

One of the reasons this topic is so interesting is that it directly touches many of the social and environmental concerns that shape the international agenda. Energy Communities are directly connected with several of the United Nations' 2030 Agenda Sustainable Development Goals (SDGs). This not only reinforces the relevance of the topic from an academic standpoint, but also from a practical and policy perspective.

From the moment I began researching Energy Communities, I realized it is not just a technical or energy issue. On the contrary, it is a tool that can have a real impact on people's quality of life, on the local environment, and on the way, citizens participate in the ecological transition. In that sense, Energy Communities are especially aligned with the following SDGs:

SDG 7: Affordable and Clean Energy

This is the most evident link. Energy Communities promote the use of small-scale renewables, usually photovoltaics, with a local, distributed approach. This helps reduce costs, avoid intermediaries and ensure that the energy generated remains in the area. In addition, many Energy Communities focus on vulnerable groups or rural areas, making access to energy fairer and more equitable.

SDG 11: Sustainable Cities and Communities

By fostering citizen participation, improving the energy resilience of neighborhoods and towns, and driving local projects, Energy Communities help build more cohesive, sustainable and self-sufficient communities. Many Energy Communities also arise in response to specific territorial challenges such as depopulation, unemployment or energy poverty.

SDG 13: Climate Action

Distributed renewable generation, combined with self-consumption and storage, reduces greenhouse gas emissions. At the same time, Energy Communities play a role in climate awareness, as participants typically gain greater knowledge of sustainability, energy savings and responsible resource management.

SDG 12: Responsible Consumption and Production

Energy Communities promote a model in which citizens not only consume, but also produce, manage and share energy. This fundamentally changes the relationship with energy resources, leading to more efficient and mindful use. In many cases, Energy Communities also promote sustainable habits, electric mobility or energy retrofits.

SDG 17: Partnerships for the Goals

An Energy Community works thanks to collaboration. It is common for municipalities, cooperatives, local companies, citizens and social entities to take part. This partnership logic is key to achieving structural changes in the energy system. Many communities also access public support, which shows the need for public–private collaboration to make these projects happen.

In short, Energy Communities are a very useful lever for meeting the climate and social goals set by Spain and the EU. Their participatory approach, adaptability and scalability make them a solution that fits well with the sustainability principles of the 2030 Agenda.

This alignment with the SDGs is not just a reference for this work. It is also a guide for action so that, in the future, public policies, business models and citizen involvement are structured around principles of resilience and sustainability.

1. Actual state of Energy Communities

1.1 FOUNDATIONS AND DESCRIPTION OF CCEEs IN SPAIN

Energy communities were created in the European Union so that neighbors, SMEs and municipalities can take an active role in the energy transition. It is not only about consuming electricity. They can also produce it, store it, share it and sell it. The idea is that management is democratic and that the main goal is to generate benefits for the area where they operate.

This approach appears in two European directives, one on renewables (2018) and another on the electricity market (2019). The first refers to renewable energy communities. The second introduces citizen energy communities. In Spain, all this is captured in a draft Royal Decree that states who can take part, what rights they have and what support exists to get them up and running.

From a legal standpoint, an energy community is a legal entity. Participation is open and voluntary, and the real decision-makers are its members. They are usually individuals, municipalities and small companies. The aim is not to make money at any cost. The goal is to generate environmental, social and economic value for members and the local area.

There are nuances between the two types: renewable energy communities are based on renewable sources and usually operate close to their users. Citizen energy communities are framed more within the electricity system, with the idea of empowering consumers and enabling their entry into markets on fair terms.

The draft Royal Decree translates these ideas to the Spanish context, asks public authorities to remove unnecessary barriers and streamline procedures, and requires cooperation from the distribution system operator in energy exchanges within the community. It includes a prior responsible declaration before starting activity and the option to publish public lists of active communities. This helps provide visibility and order. It also allows facilities owned by these communities to enter the renewable energy economic regime and apply for subsidies where applicable. The logic is to recognize their special character and ensure they can compete on equal terms with other sector agents.

Basic rights are clear: to produce, consume, store and sell renewable energy; to share the energy generated; and to access markets without discriminatory treatment. The 2019 European rule adds that communities may organize the internal allocation of their electricity and use digital tools to manage it among members, respecting system rules. A community may generate, supply and consume; it may also store energy, offer efficiency services and manage electric vehicle charging. This opens the door to local projects that go beyond the purely electrical side. Thermal solutions, mobility and demand-side management can be included.

In Spain, the draft Royal Decree connects these possibilities with existing figures. For example, it allows a community to represent a group of self-consumers under Royal Decree 244/2019. This means shared self-consumption is not the opposite of a community but a practical way to operate within one. The EU asks countries to create a framework that facilitates these initiatives. This involves access to financing, removing barriers, enabling the entry of lower-income households and real cooperation from the distributor. It also asks that all this be reflected in energy planning and monitoring reports.

In practical terms, communities bring generation closer to consumption, which reduces losses and can provide flexibility to the grid. This view fits with the European trend of accelerating permits for small installations and digitalizing the management of distributed resources. The renewables rule points in that direction and encourages stronger demand response and bidirectional charging.

The draft Royal Decree provides for the periodic publication of a list of communities that have filed the responsible declaration, in addition to those that may be issued by the autonomous communities. With this framework, it is normal for many projects to start with shared PV self-consumption and, over time, add storage, efficiency measures, electric mobility and flexibility services. This is the logical path opened by the European directives and their adaptation in Spain.

1.2 CCEEs IN SPAIN: THE DATA

According to the latest report from the Observatory Energía Común, 659 energy communities have been identified in Spain and 200 were created in 2024 alone, which means the phenomenon is advancing rapidly and that the ecosystem—although still young—is consolidating a high pace of launches. Looking at territorial rollout, 8.10% of municipalities have at least one community and the country reports 1.4 communities per 100,000 inhabitants, while more than 27,000 people and entities are already members, a volume that confirms a broad and growing social base.

Geographical distribution is not homogeneous and is concentrated mainly in the north and east of the peninsula, with Catalonia leading with 104 initiatives, followed by the Valencian Community with 98, the Basque Country with 76 and Navarre with 64, plus Galicia with 64, Castile and León with 56 and Aragon with 43. Navarre also stands out in relative intensity because it has the highest number of communities per 100,000 inhabitants, something explained by a mix of local dynamics, the presence of institutional support and active support networks that facilitate start-up and management.

Internally there is broad citizen presence: 92% of communities include individuals as participants and municipalities appear as partners in 26.9% of cases, while governing bodies are moving toward parity, with 40% of communities achieving at least half women on their boards—a significant jump from the previous year. At the same time, real operational status continues to grow and 17.7% report having their first energy project in operation, so a significant portion of the ecosystem is still in design, permitting or deployment phases. This is consistent with the sequence of incorporations: 62 communities before 2020, 40 in 2021, 146 in 2022, 211 in 2023 and 200 in 2024, a trajectory that confirms recent acceleration.

Average community size is small, which fits the local approach and the sector's maturity level: 58.42% of communities have fewer than 20 members; 19.58% fall between 21 and 50; 12.44% between 51 and 100; and only 1.21% exceed 500 members. Legally, associations predominate, with a 2023 split of 67.3% associations, 31.1% cooperatives and 1.6% other forms, a trend that holds in 2024 thanks to ease of setup and contained upfront costs without losing democratic control. In terms of activities, PV for self-consumption is clearly the majority: in 2024 there are 340 initiatives under study and 297 in process or operation in collective self-consumption, far ahead of electric mobility with 125 under study and 47 in progress, energy retrofits with 100 and 60, storage and management with 93, thermal actions with 80, and other renewables with 79. This map confirms the weight of distributed generation while complementary lines gain ground as technology-specific support allows. The type of territory also matters, since most communities are implemented in rural settings with 69.3% of the total, while urban ones account for 21.4% and neighborhood communities 6.3%. This suggests the instrument is especially useful in lower-density municipalities and counties where proximity between generation and consumption and community organization provide advantages. In financing, there is a relevant shift: in 2024, 58% of communities report having received some public support versus 85% the previous year, and members' own funds appear in 63% of cases, while bank financing reaches 32%, direct municipal support 11% and collective loans 4%. Thus, the weight of public funding declines and internal contributions increase, which conditions replication and scaling. On the social side, 33% of communities say they work on a local priority, with energy poverty the most cited at 29%, followed by gender equality at 19%, vulnerability at 18% and rural development at 16%. In parallel, 66.8% of communities formed in 2024 report support from a Community Transformation Office, a figure that reinforces the idea that technical assistance and facilitation are levers that help move from idea to operating project.

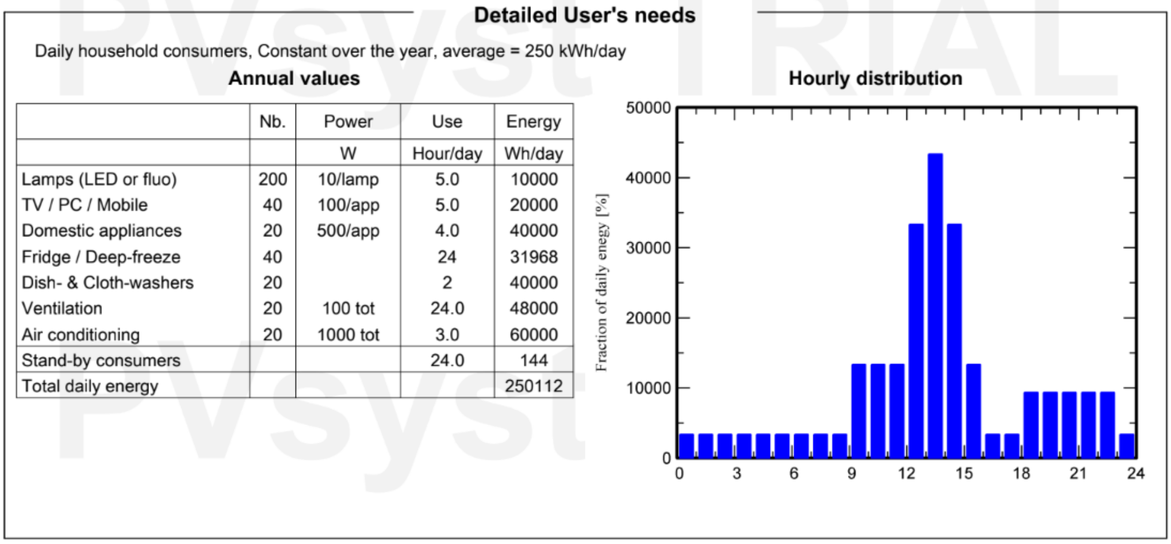
1.3 ECONOMIC ANALYSIS OF CCEEs

To carry out the economic analysis, an energy model of the system will first be built in PVSyst to obtain energy flows, and second, the economic model in Excel consisting of a Project Cash Flow for a CCEE to assess whether the investment is justified and to compare the different scenarios.

Two scenarios are proposed in line with the reality of CCEEs in Spain. First, a conventional PV system is modelled; second, the implementation of batteries in the same project is studied. In both, different public financing scenarios will be considered to assess their impact on the viability of CCEEs.

The baseline scenario seeks to create the most generic case possible, so based on CCEE data in Spain the following CCEE is defined:

Characteristics: CCEE in Catalonia (highest concentration of CCEEs) for 20 dwellings (most common number of participants) with the following hourly consumption profile provided by PVSyst:



	Nb.	Power	Use	Energy
		W	Hour/day	Wh/day
Lamps (LED or fluo)	200	10/lamp	5.0	10000
TV / PC / Mobile	40	100/app	5.0	20000
Domestic appliances	20	500/app	4.0	40000
Fridge / Deep-freeze	40		24	31968
Dish- & Cloth-washers	20		2	40000
Ventilation	20	100 tot	24.0	48000
Air conditioning	20	1000 tot	3.0	60000
Stand-by consumers			24.0	144
Total daily energy				250112

1.3.1 PV SCENARIO

For the PV scenario, the aim is to supply the community's consumption to minimize the energy exported to the grid from the system. Therefore, after several iterations an installed capacity of 39 kWp is set. Specifically, the details are as follows:

Project summary

Geographical Site	Situation		Project settings	
Tarragona	Latitude	41.12 °(N)	Albedo	0.20
Spain	Longitude	1.25 °(E)		
	Altitude	28 m		
	Time zone	UTC+1		

Weather data
Tarragona
Meteonorm 8.2 (2001-2020), Sat=100% - Sintético

System summary

Grid-Connected System — **No 3D scene defined, no shadings**

Orientation #1		Near Shadings	User's needs	
Fixed plane		no Shadings	Daily household consumers	
Tilt/Azimuth	36 / 0 °		Constant over the year	
			Average	250 kWh/Day

System information

PV Array		Inverters	
Nb. of modules	78 units	Nb. of units	3 units
Pnom total	39.0 kWp	Total power	36 kWac
		Pnom ratio	1.08

PV Array Characteristics

PV module		Inverter	
Manufacturer	Generic	Manufacturer	Generic
Model	Mono 500 Wp Twin half-cells bifacial	Model	12 kWac inverter with 2 MPPT
(Original PVsyst database)		(Original PVsyst database)	
Unit Nom. Power	500 Wp	Unit Nom. Power	12.0 kWac
Number of PV modules	78 units	Number of inverters	3 units
Nominal (STC)	39.0 kWp	Total power	36.0 kWac
Modules	6 string x 13 In series	Operating voltage	350-600 V
At operating cond. (50°C)		Pnom ratio (DC:AC)	1.08
Pmpp	35.8 kWp	Power sharing within this inverter	
U mpp	449 V		
I mpp	80 A		

Total PV power		Total inverter power	
Nominal (STC)	39 kWp	Total power	36 kWac
Total	78 modules	Number of inverters	3 units
Module area	185 m²	Pnom ratio	1.08
Cell area	171 m²		

Since a large part of the undergraduate thesis was devoted to designing the CCEE, no further detail is given here and the focus is placed on the economic model. From the PVSyst model we extract the following parameters needed to run the Project Cash Flow:

Annual production = 65,726 kWh

Energy consumed from the grid = 43,046 kWh

Energy injected into the grid = 17,481 kWh

Energy consumed from the grid without the PV scenario = 91,291 kWh

The costs incurred are as follows, taken from ACCIONA internal analysis:

CAPEX	**31.200,0 €**
Legal constitution/energy community consultancy	3.000,0 €

Installation project (€)	28.200,0 €
Supply and installation of solar panels	11.137,6 €
Supply and installation of inverters	3.921,7 €
Supply and installation of photovoltaic structure	2.060,0 €
Supply and installation of electrical and mechanical parts, protections and panels	8.681,0 €
Supply and installation of monitoring and display system	293,5 €
Health and safety	312,5 €
Engineering and construction management	339,7 €
Legalization of the installation. Other procedures.	231,0 €
Lifting equipment	1.223,0 €
OPEX	**585,0 €**
Energy consumed	58,5 €
Monitoring and SCADA	87,8 €
Maintenance	292,5 €
Insurance	87,8 €
Administrative management	58,5 €

As for the purchase price of energy from the grid, an estimate is made using the 10-year PPA price provided by OMIP. Specifically, the solar coverage in prices—70% (firming)—and the retailer's margin—10%—must be taken into account. The calculation is as follows:

Energy purchase price from the grid = €57.44/MWh * 70% * 90% = €36.19/MWh

With all the ingredients, the model can be built with a 25-year horizon and a 5% WACC. The results are as follows:

Taking into account the maximum IDAE subsidy (60% of CAPEX):

CCEE

Installation power	39 kWp
No. of households	20
O&M (€/kWp)	15 €
CAPEX (€/kWp)	800 €
ROI	**5 años**
TIR (%)	**18,31%**

For the case in which no subsidy is obtained, the result is:

CCEE	
Installation power	39 kWp
No. of households	20
O&M (€/kWp)	15 €
CAPEX (€/kWp)	800 €
ROI	**13 años**
TIR (%)	**5,98%**

As can be seen, the investment is justified in all cases, since even without subsidies the IRR is higher than the WACC. Moreover, this comparison shows the role subsidies play in CCEEs, as they increase profitability by more than 12 percentage points.

1.3.2 PV + BATTERY SCENARIO

For the battery case, exactly the same system as before is used; however, batteries are added so that the system operates in island mode, i.e., without exchanging energy with the grid.

To this end, PVSyst calculated that batteries with a capacity of 47.2 kWh are needed. In the economic model, the CAPEX of these batteries—whose retail cost is €6,891—is added and, as mentioned above, the savings calculation excludes any energy exchanges with the grid. In short, the following results are obtained in the economic model:

Taking into account the maximum IDAE subsidy (60% PV CAPEX + 30% BESS CAPEX):

CCEE	
Installation power	39 kWp
No. of households	20
O&M (€/kWp)	15 €
CAPEX (€/kWp)	1.054 €
ROI	**5 años**
TIR (%)	**17,85%**

For the case in which no subsidy is obtained, the result is:

CCEE

Installation power	39 kWp
No. of households	20
O&M (€/kWp)	15 €
CAPEX (€/kWp)	1.054 €
ROI	**9 años**
TIR (%)	**9,60%**

As can be seen, the results are very similar to the PV-only scenario, which indicates that BESS is already an economic reality, something reflected in the market where battery projects keep increasing.

1.4 SOCIAL IMPACT ANALYSIS

Energy communities place social purpose at the center. The European framework recognizes their role, and in Spain the draft Royal Decree develops an environment that facilitates start-up, removes hurdles, opens information and financing channels, and calls for distributor cooperation. With this framing, they are understood not only as a self-consumption tool but as local institutions that distribute environmental and economic benefits in their surroundings. ECODES shows very strong growth during 2024 and, even so, limited operational maturity. The indicators report records many new communities and around 20% with self-consumption installations already in operation, which means most are still in design and permitting. The observatory highlights citizen participation and the role of municipalities as drivers, which is consistent with the social purpose. Energy poverty indicators from Comillas Pontifical University for 2023 quantify disproportionate expenditure in 17.01% of households, insufficient expenditure in 12.53%, payment arrears in 9.58% and inability to maintain an adequate winter temperature in 20.71%. After a period of highly volatile prices, reducing and stabilizing energy costs has a direct effect on vulnerable families.

The social impact of a community arrives through three mutually reinforcing channels. Affordability, because shared self-consumption lowers the average cost of energy and reduces exposure to price spikes, with scope for internal allocation and prioritization of lower-income households. Participation, because opening membership and keeping control in members' hands increases learning and cohesion. Territorial cohesion, because implementation in municipalities and counties retains value and activates local jobs and proximity services. IDAE's CE-Implementa calls, linked to the Recovery Plan, have acted as a lever. In the fifth call, storage was required in electrical projects and €30 million were allocated with a cap of €1 million per project, a signal that pushes the creation of local capabilities in flexibility and demand-side management. ECODES' analysis links the growth in the number of communities to the use of aid and support services in 2023 and 2024, with signs of greater financial diversification.

To assess these impacts, a social discount rate is used. In this work it is called social WACC and is applied only to social-value flows such as savings for vulnerable households, avoided emissions or improved comfort. It is not a financial WACC and does not depend on debt or equity. It serves to bring to the present benefits and costs that arrive in different years and to compare them consistently. The approach used is Ramsey's, common in public appraisal, because it links discounting with pure time preference, the sensitivity of welfare to consumption and the expected long-term growth of per-capita consumption.

Formula for the social discount rate

$r_s = \rho + \eta \cdot g$

ρ = pure time preference

η = elasticity of the marginal utility of consumption

g = expected real growth of per-capita consumption

Values are set at ρ = 1.0%, η = 1.0 and g = 1.5%. The European Commission, in DG REGIO's 2014–2020 Cost–Benefit Analysis Guide, recommends a 3% social discount rate for non-cohesion Member States and 5% for cohesion countries, which places a reference range that fits our 2.5% real result before sensitivities and the operational use of 3.0% real. The Commission's and JASPERS' Economic Appraisal Vademecum 2021–2027 maintains this approach and allows Member States to adjust the rate by asset life and type of benefits, using 3% as a general reference and 5% for cohesion countries. In addition, EU sectoral guides such as CINEA's for CEF-2 transport projects use 4% as a social rate, which supports sensitivity tests at 4%. With this documentary support, ρ = 1.0% provides a small pure time preference, η = 1.0 is the standard most used for diminishing marginal utility, and g = 1.5% reflects a reasonable real per-capita growth for Spain over long horizons.

As a result we obtain r_s = 2.5% real. To operate with a prudential margin, it is rounded to 3.0% real so as to protect against inaccuracies in parameter assumptions.

Calculation of the Social Net Present Value

$VANS = \Sigma\ [(B_t - C_t) / (1 + r_s)^t]$

r_s nominal = $(1 + r_s \text{ real}) \cdot (1 + \pi) - 1$

Example with π = 2.0%. Approximate nominal r_s = 5.06% when real r_s = 3.0%.

Choosing 3.0% real as the central value is justified because it is consistent with European cost–benefit guides that accept social rates in that range for Member States with comparable characteristics and because the type of benefits from energy communities is long-term and difficult to capture with financial metrics alone. With this assumption, significant weight is maintained on benefits arriving from year 10 onwards—such as sustained reductions in bills and arrears and cumulative emissions reductions—and configurations that provide the most social value in the territory can be prioritized rigorously.

1.5 REGULATORY ANALYSIS

The legal framework for energy communities in Spain rests first on European Union law and then on national rules that regulate self-consumption, grid access and connection, and economic support instruments. Directive (EU) 2018/2001 (RED II) introduced the figure of renewable energy communities and ordered Member States to create a facilitating framework that removes obstacles, guarantees cooperation from the distribution system operator, and allows the production, consumption, storage, sale and sharing of renewable energy, with priority for social, environmental and economic benefits over financial profit according to Article 22. The same directive requires assessing obstacles and potential and incorporating these elements into national energy and climate plans and status reports.

In parallel, Directive (EU) 2019/944 defined citizen energy communities within the electricity market and set principles of open and voluntary participation, right of exit, non-discriminatory market access directly or via aggregation, and distributor cooperation with regulated compensation according to Article 16.

In the Spanish transposition, the key item pending approval is the draft Royal Decree that develops the figures of renewable energy communities and citizen energy communities. The text entered public consultation in April 2023; the draft defines renewable energy communities as legal entities with participation by individuals, SMEs or local entities located in proximity to the projects and with the main purpose of social, environmental and economic benefit and governance autonomy. It requires a minimum of five members and proximity criteria. It recognizes rights to produce, consume, store, sell and share energy, access markets and act as representative in collective self-consumption (Articles 3–6). For citizen energy communities it limits scope to the electricity sector with analogous rules of open participation, minimum members and effective control by members (Articles 9–10). The draft incorporates a facilitating framework that obliges administrations to remove barriers, facilitate financing and information, and ensure cooperation from the distribution system operator with communities (Article 7). Operationally, it introduces a prior responsible declaration before the Directorate-General for Energy Policy and Mines and monthly publication of a public list of communities that have filed it (Article 8). Regarding economic instruments, it links to the Renewable Energy Economic Regime and provides specific quotas for community-owned installations in the indicative auction calendar of Royal Decree 960/2020 (Article 15).

While this specific development is not yet approved, practical rollout of communities relies on horizontal rules of the electricity system. The central piece for self-consumption is Royal Decree 244/2019, which regulates administrative, technical and economic conditions for individual and collective self-consumption. Building on this, Royal Decree-laws 18/2022 and 20/2022 extended the proximity distance for network-through self-consumption first to 1,000 meters and then to 2,000 meters on a general basis for locations such as rooftops, industrial land and artificial structures, according to the consolidated wording of Royal Decree-law 20/2022 that amended Article 3 of Royal Decree 244/2019.

For access and connection to networks, communities are governed by Royal Decree 1183/2020, which sets principles, deadlines, guarantees and procedures for access and connection permits, and by CNMC Circular 1/2021, which establishes the methodology and the technical and procedural conditions. This regulation obliges grid operators to have online platforms and provides predictability to developers, including storage and distributed generation, which are common in community projects.

In metering and allocation, IDAE's Collective Self-consumption Guide, version 2.1 (July 2024), details equipment requirements and metering configurations for collective schemes that are essential for the proper operation of communities running under shared self-consumption.

Beyond electricity, communities can drive energy efficiency, renewable heating and cooling, and sustainable mobility, opening the door to thermal and transport projects and not only photovoltaics. The draft Royal Decree makes this explicit in the electricity, thermal and mobility areas, and RED II supports sector coupling and participation by vulnerable consumers.

On economic support—although it is not base regulation—it forms part of the environment that conditions the pace of implementation. IDAE's CE-Implementa program has regulatory bases (Order TED/764/2024) and several calls (fifth and sixth) with specific requirements and eligibility. The fifth call in 2024 allocated €30 million and made storage mandatory in electrical renewables projects with an investment cap of €1 million per project, thus steering toward small-scale projects. IDAE's portal and electronic office show the history of calls and community procedures and confirm the validity of these lines as a lever while the specific regulatory development matures.

From an institutional and procedural perspective, three points stand out. First, the absence of a definitive Royal Decree on communities generates practical heterogeneity in legal forms, proximity criteria and governance and shifts part of operations to the self-consumption regime and general grid and market rules. The draft Royal Decree seeks to close this gap with the responsible declaration, the public list and a facilitating framework with clear obligations for administrations and distributors. Second, the proximity radius for allocation in self-consumption is currently, as a general rule, 2,000 meters for the cases enabled by Royal Decree-law 20/2022, and the 2025 initiatives have not changed it due to the repeal of Royal Decree-law 7/2025. Third, access and connection regulated by Royal Decree 1183/2020 and Circular 1/2021 remain decisive for project viability, including those that incorporate storage and distributed generation, and fit with the European mandate to offer a non-discriminatory environment to communities.

In short, the European framework is clear and in force. It recognizes renewable energy communities and citizen energy communities and requires the establishment of a facilitating framework with barrier removal, distributor cooperation, market access and differentiated support. In Spain, the specific regulatory development remains at the draft stage with detailed content on definition, governance, rights, responsible declaration and quotas in the renewable economic regime, while day-to-day operations rely on the self-consumption regime of Royal Decree 244/2019 and the proximity extension of Royal Decree-law 20/2022, on access and connection under Royal Decree 1183/2020 and Circular 1/2021, and on support lines such as CE-Implementa. Approval of the specific Royal Decree should provide legal certainty, homogeneity in requirements and procedures, and a pro-competition environment aligned with the European mandate on energy sharing, distributor cooperation and access to support instruments with dedicated quotas.

1.6 ALTERNATIVE SOLUTIONS

The challenge addressed by energy communities—democratizing access to clean energy at local level, reducing costs, increasing resilience and generating social value—can also be tackled with configurations that do not require formally establishing a community. The main difference lies in governance—who decides and how benefits are shared—and in eligibility for certain public support. All these alternatives share the same technological building blocks: PV self-consumption, storage, demand-side management, renewable thermal solutions and EV charging.

One option is shared self-consumption without creating a community. Royal Decree 244/2019 allows several consumers to allocate the energy from a common installation using coefficients within a proximity perimeter that—after the extensions of Royal Decree-law 20/2022—can reach 2,000 meters in the enabled cases. IDAE's Collective Self-consumption Guide describes the metering and allocation configurations and serves as a practical reference. For investment, IDAE's indicative CAPEX ranges for PV self-consumption are between €500 and €1,000/kWp, while storage in residential or third-sector applications ranges between €140 and €490/kWh depending on program and typology. Technological maturity of PV, batteries and metering instrumentation is full at TRL 9.

There is also individual self-consumption with or without batteries for households and SMEs, which reduces procedures and sizes capacity to the consumption profile; reference CAPEX ranges are the same in order of magnitude with variations by scale and works, and battery price trends were downward in 2023 and 2024, improving the feasibility of PV-plus-storage coupling, with commercial technology at TRL 9.

Another alternative is the on-site PPA under an energy services model in which the developer finances, designs, installs, operates and maintains the plant at the client's site and the client pays for energy at a long-term agreed price; for the end user, CAPEX is zero and the project's cost per kWp remains within the reference ranges, with mature technology and contracts at TRL 9.

There is also the subscription-based "solar community," where a promoter builds a nearby plant and sells shares to consumers within the regulated radius, equivalent to shared self-consumption with a single promoter and multiple consumers; for the end user, CAPEX is usually zero or reduced and the PV project shows costs on the order of €500 to €1,000/kWp with full maturity at TRL 9.

For the thermal vector, district heating networks with biomass, solar thermal or aerothermal led by the municipality or by an energy services company can be used without creating a community. As a reference, indicative costs published by IDAE place solar thermal between €650 and €950/kW, aerothermal around €650/kW (about €3,900 per typical dwelling) and biomass near €350/kW. The CAPEX of the thermal distribution network depends on length and urban density and is assessed case by case. In electric mobility, community-use charging infrastructure can be deployed in residents' garages, industrial estates or municipal car parks and integrated with PV and local storage. As an order of magnitude, an AC charging point presents installed costs between €800 and €1,300, with simple cases from €500, subject to works and protections, and MOVES III aid can cover a percentage of eligible cost. Technology in all these cases is mature at TRL 9. Taken together, these alternatives solve the same energy problem as a community with different institutional implications and with comparable investment ranges and levels of technological maturity.

A comparative table of alternative technologies to CCEEs follows:

Alternative (without CCEE)	Purpose	Indicative CAPEX	TRL	Main source
Shared self-consumption (PV ± BESS)	Local generation for multiple consumers with distribution by coefficients	PV €500–1,000/kWp; BESS €140–490/kWh (residential/third sector, depending on program)	9	IDAE – Self-consumption/storage; RD 244/2019; RDL 20/2022; IDAE Guide
Individual self-consumption (PV ± BESS)	Reduced bills and price exposure for individual consumers	IDAE order of magnitude for PV and BESS; depends on scale and project	9	IDAE – Aid portals; sectoral cost reports
On-site PPA (ESCO service)	Self-consumption without customer investment; long-term agreed price	User: €0; PV project: ranges per kWp similar to reference	9	On-site PPA models; IDAE FAQ on compatibility
Subscription-based 'solar community'	Collective access to nearby PV without creating ECCs; subscriptions/shares	User: £0 (or fee); PV project £500–1,000/kWp (order of magnitude)	9	RD 244/2019 + RDL 20/2022; IDAE ranges
Renewable heating network (biomass/solar thermal/aerothermal)	Renewable heat at neighbourhood/municipality level without CCEE	Generation: solar thermal €650–950/kW; aerothermal ~€650/kW; biomass ~€350/kW; grid: case by case	9	IDAE – indicative costs; ADHAC guides

Community EV charging (typical AC)	Local electromobility; integrable with PV and power management	~€800–1,300 per point (simple cases ~€500); MOVES III grants	9	Sector guides; MOVES III calls for proposals

1.7 CCEEs OUTSIDE SPAIN

The development of energy communities in Europe shows different degrees of maturity by country, although they share recurring underlying features. The cooperative model with the principle of one person, one vote predominates, citizen and municipal involvement is high, and the technological focus is on photovoltaics and wind in the electricity vector, while several countries have a tradition of community ownership in heat networks. At European scale, REScoop.eu brings together thousands of initiatives and a broad social base. In 2024 it reported more than 2,250 affiliated cooperatives and 1.5 million citizens, and in 2025 it refers to a network close to 2,500 communities and 2 million people, confirming sustained growth based on civic participation.

Germany concentrates the densest cooperative ecosystem. The 2024 report by the DGRV confederation counts 1,038 energy cooperatives founded since 2006 with around 220,000 members, €3.6 billion of aggregate investment in renewables and close to 8 TWh of annual generation, contributing nearly 3% of the country's renewable generation. The same dataset summarizes an average per-member contribution of about €3,600 and about 3 million tons of CO_2 avoided in the electricity sector, as well as around 1,200 direct jobs and a high level of professionalization. In parallel, the federal government has launched a citizen-energy program for onshore wind which, after its update in June 2024, finances planning and permitting costs with the goal of adding between 150 and 200 MW per year under citizen ownership, reinforcing the pre-investment phase where the largest financial barriers usually appear.

The Netherlands shows an extensive cooperative movement connected to the territory. The Lokale Energie Monitor 2023 records 714 active cooperatives and around 131,000 members and participants, with presence in 89% of municipalities. During 2023, 146 new solar projects were implemented and the pipeline amounts to an additional 374 MWp. The cooperative operating fleet reaches around 319 MWp in solar and 336 MW in onshore wind. Accumulated citizen investment in wind and solar is around €165 million. Beyond generation, work is growing in demand management, storage and heat with 70 heat initiatives (4 operational), along with programs to fight energy poverty and promote savings. Recurrent frictions include siting new projects, grid congestion and the need for greater internal professionalization.

Denmark offers a clear benchmark in the thermal vector. Citizen or municipal ownership of district heating networks has been dominant for decades and shapes a very mature community model. A 2024 PlanEnergi analysis identifies 354 heat networks, of which 286 belong to consumers through user cooperatives, 58 are municipal and 10 are private commercial. Although municipal networks serve larger cities, the non-profit, cost-based orientation is structural, which explains high acceptance levels, cost-regulated prices and a strong base for integrating thermal renewables such as sustainable biomass, large-scale solar thermal and district heat pumps, as well as industrial or urban excess heat.

Belgium has flagship cooperatives. Ecopower, founded in 1991 and a founding member of REScoop.eu, has more than 67,000 members and 55,000 member-customers as a supplier in Flanders. It manages around 75 MW of renewable capacity with a strong share of onshore wind and adds micro-hydro, cogeneration, palletization and about 250 decentralized PV installations. It reports around 74 GWh of annual green output and roughly 61,000 tons of CO_2 avoided. Its capitalization design—with €250 shares per member and a cap of 20, together with equal voting rights—explains its stability and scalability.

Italy has been accelerating since 2024 with a specific economic scheme for renewable energy communities. The so-called Decreto CER, in force since 24 January 2024, activates two main instruments. An incentive tariff applied to energy shared within self-consumption configurations for sharing, including communities, groups of self-consumers and remote self-consumers. And a non-repayable grant of up to 40% of eligible costs funded by the PNRR, with priority for smaller municipalities. The GSE's 2024 operating rules opened the application platform in April 2024 and set a 5 GW contingent through 2027 or until the cap is reached. The regulator ARERA adapted the tariff framework in early 2024 to reflect the value of self-consumption and shared energy. The result is a pro-sharing framework that is driving projects in permitting and construction focused on small- and medium-scale PV and on storage where appropriate.

In the United Kingdom, the community sector remains active though with different tempos by nation. The Community Energy State of the Sector 2024 report estimates combined annual production of around 617 GWh and about 228 kilotons of CO_2 avoided in 2023 and 2024, with year-on-year increases above 9%. Projects still face blockages from grid connection, revenue uncertainty and lack of patient capital. In Scotland, the public CARES program managed by Local Energy Scotland has channeled more than £67 million and advised over 1,300 organizations, enabling around 66 MW of community capacity and launching generation calls in 2024 and 2025, which partly mitigates initial financial obstacles.

The comparative analysis suggests several patterns with direct implications for Spain. Cooperative forms dominate in the most advanced countries—such as Germany, the Netherlands and Belgium—because they reduce the cost of capital through local savings and open participation, stabilize decision-making with democratic governance and align remuneration with social goals such as fair prices and local funds. Economic instruments geared toward energy sharing—like Italy's 2024 scheme—and support for the pre-investment phase—like Germany's citizen-wind program—catalyze project entry by reducing risks in permitting and connection. Denmark's thermal vector shows that user ownership in district heat can generate high social impact when governance and tariffs are cost-based. The Dutch experience indicates that internal professionalization and technical capacity, together with alliances with grid operators and aggregation and storage programs, help overcome congestion and maximize shared energy. UK evidence confirms that without stable revenues or soft finance, growth slows despite social demand, so the institutional design of support and cooperation with networks is decisive for scaling.

These lessons translate into operational hypotheses. The scale achieved by German and Dutch cooperativism requires clear vehicles for citizen capital and consistent policies over more than a decade. Italy's bet on a tariff for shared energy and a high-percentage grant indicates that a direct incentive scheme accelerates adoption when the community base is still emerging. The Danish example in heat suggests that, in territories with significant thermal demand, user-owned models with cost-based regulation can offer social acceptance and sustained tariff reductions, provided urban planning and demand density allow it.

In conclusion, Europe shows that energy communities thrive when vehicles for citizen participation capable of mobilizing local savings converge with economic instruments designed for energy sharing, structural cooperation with grid operators and sufficient internal professionalization to take projects from idea to operation. Transferring these elements to the Spanish context—with its network and regulatory specificities—is key to moving from subsidized pilot projects to a self-sustaining, scalable ecosystem.

2. Future of Energy Communities in Spain

The climate-neutrality goal for 2050 is the framework for any projection of energy communities (CCEE) in Spain. The Government's Long-Term Decarbonization Strategy (ELP) sets a path in which electricity is fully renewable and external energy dependence falls to around 13% in 2050, with a reduction close to 50% in primary energy consumption compared to 2020. The ELP also underscores decentralization, digitalization, storage and demand management as cross-cutting factors of the transition to 2050. This regulatory and energy-policy framework gives CCEEs a structural role in electrifying end uses, lowering costs and sharing environmental and social benefits at local scale.

As an intermediate milestone, the update of the 2023–2030 PNIEC approved by Royal Decree 986/2024 sets a total installed capacity of 214 GW in 2030, of which 160 GW are renewables and 22.5 GW correspond to storage. This reinforces that the Spanish system will move toward high shares of variable generation that require grid flexibility and demand response. This 2030 anchor defines the starting point for the 2030–2040 decade, during which CCEEs will likely move from subsidized pilot projects to stable ecosystems providing distributed generation, community storage and local flexibility services.

At European scale, the electricity market-design reform adopted in 2024 consolidates energy sharing and strengthens the participation of consumers and local entities in markets, opening the door to aggregation and flexibility schemes compatible with CCEEs. With this regulatory boost—and the experience of countries more advanced in community energy (Germany, the Netherlands, Denmark, Italy)—the growth of CCEEs depends on three levers: citizen-capital vehicles in cooperative form, explicit incentives for shared energy and local flexibility markets with DSO cooperation.

On the technological and economic front, photovoltaics maintains a clear cost advantage. International reports place the global weighted LCOE of utility-scale PV around USD 0.044/kWh in 2023, with a downward trend, and battery costs continue to fall. This combination of low-cost PV and competitive storage fits Spain's solar potential—with high productivity factors on rooftops and ground—and the national Storage Strategy, which quantifies approximately 20 GW by 2030 and 30 GW by 2050, adding utility-scale and distributed.

DESCRIPTION OF THE TARGET SCENARIO (2050)

In 2050, the Spanish power system runs on 100% renewable electricity. Distributed generation has a strong presence and is supported by rooftop PV in housing, tertiary and light industry, by community batteries, and by active demand management with electric vehicles and heat pumps. CCEEs are regular market participants: they aggregate distributed resources, share energy within their low-voltage network and, where appropriate, sell flexibility services to the distributor (DSO) and to the system operator. This role is supported by a specific enabling framework in the form of a Royal Decree and by the rollout of flexibility markets arising from the European market-design reform.

In numbers, the target scenario posits that by 2050 a significant share of households and SMEs belong to some community-energy structure—cooperatives, local associations or municipal consortia. Citizen participation reaches critical masses similar to mature European ecosystems, adapted to the Spanish context, and materializes in tens of thousands of local projects of different scales. From 2030, the weight of distributed generation over electricity demand grows steadily. As a whole, CCEEs contribute a relevant fraction of national collective self-consumption and integrate distributed storage capacity attributable to stationary batteries and to the electric-vehicle fleet with managed charging and vehicle-to-home or -community where efficient. Total system storage converges toward the magnitudes of the national strategy—around 30 GW in 2050—with significant shares at distribution level and behind the meter, depending on urban density and the penetration of EVs and heat pumps.

In renewable heat, evolution varies by climate. In temperate areas, heat pumps dominate building heating with support from solar-thermal communities and low- to medium-temperature networks where density justifies them. In cold or mixed climates, municipal or cooperative heat networks integrate centralized heat pumps, large-scale solar thermal and sustainable biomass, replicating the user/municipal ownership pattern seen in Nordic countries. The role of thermal CCEEs is to provide efficient local services and stable tariffs, prioritizing vulnerable groups when provided for in their statutes.

3. Transition from actual to future scenario

Spain's CCEE ecosystem starts from recent expansion with operational maturity still limited. PV predominates in shared self-consumption schemes and there is significant dependence on public aid and on facilitation services (OTC). In the European comparison, consolidated cooperatives appear as vehicles for citizen capital, economic instruments that favor sharing, and flexibility markets at distribution level in development, together with mature experiences of user-owned district heating. To reach the 2050 target in Spain, the shift must be from pilot projects to a stable ecosystem, capable of large-scale energy sharing, of providing flexibility services and of generating measurable net social value. The recommendations are structured into four blocks: regulatory and market framework; financing and incentives; governance and organizational capacity; and infrastructure and technology portfolio. They close with a timeline and a conclusion that summarizes the proposed change.

3.1 REGULATORY AND MARKET FRAMEWORK

The goal is to set stable, complete rules that enable the models that work best in Europe and that Spanish regulation already points to. The specific Royal Decree on CCEEs (REC/CEC) must be finalized with three pieces: an enforceable facilitating framework with clear obligations for public administrations and for the distribution system operator (DSO) to remove barriers and cooperate with CCEEs; a one-stop shop for the responsible declaration, data exchange and fast-track processing of standard configurations; and an up-to-date public list of active CCEEs that allows traceability, control and access to financing.

Energy sharing and dynamic allocation in collective self-consumption also need to be fully implemented. This requires closing the details of metering, hourly settlement and billing, and guaranteeing access to data (quarter-hourly readings and power-quality data) so that CCEEs can optimize their mix of generation, storage and flexible loads.

The transition to the 2050 scenario requires flexibility markets or schemes at distribution level. The DSO must be able to procure local services from distributed resources aggregated by CCEEs—such as congestion management, voltage support, peak shaving and post-fault support—with standardized tenders, verification and pay-for-performance. This lever turns CCEEs into recurring economic actors beyond savings from shared energy.

It is advisable to refine the proximity rule for shared self-consumption, moving from a purely geometric criterion (radius) to a topological/electrical one when DSO tools allow it—based on the same low-voltage network, the same transformer substation or the same medium-voltage feeder. This aligns allocation with grid reality, improves efficiency and reduces administrative disputes, keeping a simple standard for ordinary cases and a technical channel for complex networks.

3.2 FINANCING AND INCENTIVES

The second block seeks to move from an investment-subsidy scheme as the near-exclusive driver to a mix that supports income from energy sharing and from flexibility, complemented by citizen capital and reserving soft CAPEX for phases where it is truly additional. First, it is advisable to introduce a stable incentive for shared energy—tariff-based or a sharing bonus—that complements self-consumption savings and recognizes the value of shifting consumption to local generation. This is the signal that accelerates adoption when the community base is incipient and that facilitates bankability without always relying on discrete subsidies.

Second, it is useful to create pre-development programs that cover engineering, permitting and organization up to ready-to-build, with milestone-based disbursement and capped amounts, focusing non-repayable CAPEX where its additionality is highest. Third, it is recommended to set up local-savings vehicles such as credit/energy cooperatives or municipal revolving funds that offer patient debt to CCEEs and vulnerable households, with partial public guarantees and impact criteria.

Fourth, in the investment-aid lines that remain, it is advisable to prioritize storage and digitalization—metering, control, cybersecurity—and to condition part of the aid on measurable social results, for example, number of vulnerable households served, percentage reduction in the target group's energy spending or improvement in local energy-poverty indicators.

3.3 GOVERNANCE, PROFESSIONALISATION AND ADMINISTRATIVE BURDEN

The third block addresses the organizational friction observed in Spain. Setting up and managing a CCEE is a barrier, especially for small communities. First, it is advisable to standardize bylaws and model contracts—for associations or cooperatives, internal PPAs, O&M services, dynamic allocation, storage and charging—with member-protection clauses and simple entry/exit mechanisms. Templates vetted by the administration reduce legal costs and timelines.

Second, the network of Community Transformation Offices should be consolidated with performance metrics. Their role should not be limited to kick-off; they are key to professionalization in accounting, compliance, procurement, tendering, relations with the DSO and monetization of flexibility.

3.4 GRID INFRASTRUCTURE, DATA AND DIGITALISATION

The fourth block starts from the premise that the leap to 2050 depends on grids prepared to meter, settle and procure flexibility. First, universal smart metering is needed with adequate resolution and latency, and secure data access for CCEEs—including consumption, injection, grid-state and event data. The priority is to enable dynamic allocation and hourly settlement of shared energy.

Second, DSOs need local planning tools that integrate distributed resources such as PV, batteries, EVs and heat pumps, together with flexibility-procurement models. For CCEEs, this translates into interfaces—tenders, APIs, verifiers—that lower transaction costs.

Third, it is advisable to promote replicable pilots of flexibility markets in areas with congestion or voltage limits, with public evaluation of results and a rollout plan to extend the model.

3.5 TECHNOLOGY PORTFOLIO AND PROJECT DESIGN

The fifth block turns what regulation and financing enable into projects. First, photovoltaics remains the economic pillar of CCEEs. The default design should include PV and community storage sized to increase self-consumption and free up capacity at peak hours, with reliability criteria such as O&M SLAs, spares and cybersecurity.

Second, community e-mobility is an immediate flexible load. The CCEE can operate the charging infrastructure, manage capacity and capture flexibility, integrating social tariffs when dealing with municipal fleets or vulnerable groups.

Third, for the thermal vector, low-temperature projects—heat pumps, solar thermal—are recommended and, where density allows, heat networks with user or municipal ownership. This approach is consistent with European examples and multiplies social impact in comfort, health and reduced thermal energy poverty. Finally, it is advisable to explore multi-service portfolios—efficiency, demand management, audits and energy education—to stabilize revenues and diversify risks.

4. Conclusions

The analysis shows that energy communities in Spain are in an early expansion phase. The social and municipal base is growing, but operational maturity remains limited. Most initiatives are organized around shared PV self-consumption. Storage is entering incipiently and, to a lesser extent, services in e-mobility and the thermal vector appear. This pattern matches the technological and economic reality of the Spanish power system, where PV has a cost advantage and there is ample available rooftop space on municipal, residential and industrial buildings.
The work confirms that the recent take-off has been supported by aid instruments—particularly CE-Implementa calls—and facilitation services through OTCs. This has turned citizen and municipal initiatives into projects with technical and administrative viability. Even so, reliance on investment subsidies reveals an original fragility: if community income rests almost solely on direct self-consumption savings, scalability is conditioned by the availability of public funds, the complexity of procedures and local organizational capacity.
On the regulatory front, Spain already has horizontal pillars—self-consumption, access and connection, metering and allocation. It remains critical to complete the specific regulatory development of REC and CEC. The absence of a definitive framework introduces heterogeneity in legal forms and procedures and prevents full deployment of essential instruments, including operational dynamic allocation, a one-stop shop, a public list, regulated DSO cooperation and differentiated quotas or economic signals for shared energy. The European comparison suggests that the most mature ecosystems combine citizen-capital vehicles such as cooperatives with stable economic signals for shared energy and with income channels from flexibility at distribution level. These elements make projects bankable and professionalize operations beyond subsidy cycles.
The social-impact study supports CCEEs as suitable tools to improve energy affordability, local resilience and community cohesion. A purely financial analysis tends to undervalue their long-term benefits. Evaluation with a 3% real social WACC—and reasonable sensitivities—captures net social value in the form of effective savings for vulnerable households, reduced arrears, thermal comfort, avoided emissions and social capital. This justifies targeted public support where additionality is greatest.
The 2050 target scenario is plausible if and only if four complementary transitions are addressed. The first is regulatory: close the REC/CEC framework, make sharing operational with hourly settlement and enable flexibility markets or schemes at distribution level. The second is economic: shift from ex-ante subsidy to recurring income from shared energy and flexibility, co-financed with citizen savings and local patient debt. The third is organizational: reduce the burden of setup and management through standard templates, professional OTCs and catalogues of standard configurations, lowering fixed transaction costs. The fourth is technological and data-related: consolidate PV-plus-storage as the default design, integrate managed charging and enable quality metering and data to allocate and verify grid services.
In sum, Spain has structural advantages—solar resource, a network of medium-sized cities, municipal capacity—that can move CCEEs from pilot projects to a self-sustaining ecosystem with added social value. The combination of a stable framework, predictable income and organizational capacity is the necessary condition for PV predominance to translate into lasting savings, avoided emissions and reduced energy poverty, aligning rollout with the objectives of the ELP and the 2030 Agenda.

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