MASTERPIECE -
Multidisciplinary Approaches and Software Technologies for Engagement, Recruitment and Participation in Innovative Energy Communities in Europe

Deliverable 2.8

ARCHITECTURE DESIGN AND FUNCTIONAL BLUEPRINT – UPDATE

Title	ARCHITECTURE DESIGN AND FUNCTIONAL BLUEPRINT – UPDATE
Document description	It formalises and synthesises (technically and functionally) all envisaged operational blocks within the project's conceptual idea, based on the activities foreseen in T2.5. An early version of this report (M9) will support the technical development and integration in WP3-4-5, to be then updated (M24) based on the feedback from pilots' evaluation in T5.6 (update).
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Lead Partner	UMU
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Version 3	UMU	18/02/2025	Contributions in Section 3
Version 4	Pilot managers	26/02/2025	Reviews of Section 3
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Version 6	UMU	10/03/2025	Final Contributions and ready for review
Version 7	CERTH & R2M	14/03/2025	Reviews
Version 8	UMU	17/03/2025	Final version and submission

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1 EXECUTIVE SUMMARY

This Deliverable represents the closure of WP2, aligning seamlessly with its core—the EC triangle concept. Throughout this document, it is highlighted how the work carried out in WP2 has laid a solid foundation, not only for the pilots' evolution but also for the broader developments across other WPs. The EC triangle has established a fundamental framework for understanding both existing and future ECs, shaping their structure and guiding their growth. Furthermore, the pilots play a crucial role in putting all these concepts into practice. They are the living demonstration of how the research, insights, and developments from WP2 translate into real-world applications. Therefore, the main goal of this Deliverable is to provide a comprehensive understanding of two key aspects:

1. **The pilot context and their path evolution** – how they have developed into what they are today, providing an overview of use cases, evaluation context, and KPIs within the EC triangle.
2. **The final architecture and component evolution** – ensuring a standardized and unified approach, with a strong emphasis on interoperability.

By capturing these insights, this Deliverable not only reflects on the progress made but also sets the stage for the continued refinement and scalability of the pilots.

2 INTRODUCTION

This document provides an updated version of Deliverable 2.7 while highlighting the relationship between the knowledge acquired and developed in WP2 through the EC triangle framework and its application in the pilots.

2.1 Relation to other tasks and documents

The relationship between this deliverable and other tasks and documents can also be analysed through the lens of the three dimensions of the EC triangle. From the regulatory and economic perspective, Deliverable 2.2 summarized the work carried out in Task 2.1, focusing on the impacts, the EU policy framework and its application at the national level (pilots), as well as the barriers that interconnect with the social dimension. On the social-behavioural side, Task 2.2 provided its final reporting in Deliverable 2.6, offering insights into the maturity, readiness, and aspirations of ECs, while also refining the EC journey. This work was enriched through multiple workshops with pilots, where end-user perspectives were explored and linked to ECs, feeding into WP3 for further developments.

From the technological perspective, Task 2.5 served as the bridge between WP4, WP5, and WP2, ensuring alignment across needs, interoperability, final architecture and components, with the crossing point of providing security and privacy. Additionally, all the insights and feedback collected were integrated into Tasks 2.3 and 2.4, where pilots played a central role alongside surveys and KPIs. Further contributions came from WP5 through Deliverables D5.3, D5.6, and D5.7, which document the evolution and refinement of pilot use cases, KPIs, and strategies. These findings, combined with the final reporting of WP2 tasks in Deliverable 2.4, illustrate how each work has played a crucial role in shaping the pilots' journey. Ultimately, all these contributions converge in this Deliverable, capturing the essence of the pilots' evolution and the broader impact of WP2. In addition, to the architecture of MASTERPIECE platform.

2.2 Structure of the document

The present document is structured as follows: It begins with an introduction, highlighting the relationship to other tasks and documents. Section 3 provides an in-depth exploration of the three-dimensional EC triangle concept. In Section 4, the focus deeps to the pilots and their evaluation path, including use cases and KPIs, apart from evaluation, test cases, and monitoring overview. Section 5 presents the final version of the architecture and components, discussing their evolution and the tools developed. The document concludes in Section 5, summarizing the key findings and conclusions.

3 THE THREE-DIMENSIONAL EC TRIANGLE CONCEPT VISION

The concept of the EC triangle was introduced at the beginning of WP2 and presented in D2.1. Throughout the project, it has served as a fundamental framework for research and conceptual developments. Its importance lies in providing a multidimensional perspective on ECs and understanding how they interact and enrich each other. An EC may be more developed in one dimension than another, but this does not make it weaker. On the contrary, it helps identify its foundation, strengths, and areas for improvement, facilitating its creation and evolution. The work carried out in WP2, along with the knowledge transferred to other WPs, has demonstrated how regulatory-business, social-behavioural, and technological dimensions work together and represent the final three sides of the EC triangle in Figure 1. These dimensions do not function in isolation; each plays a crucial role in meeting the needs of existing and future ECs.

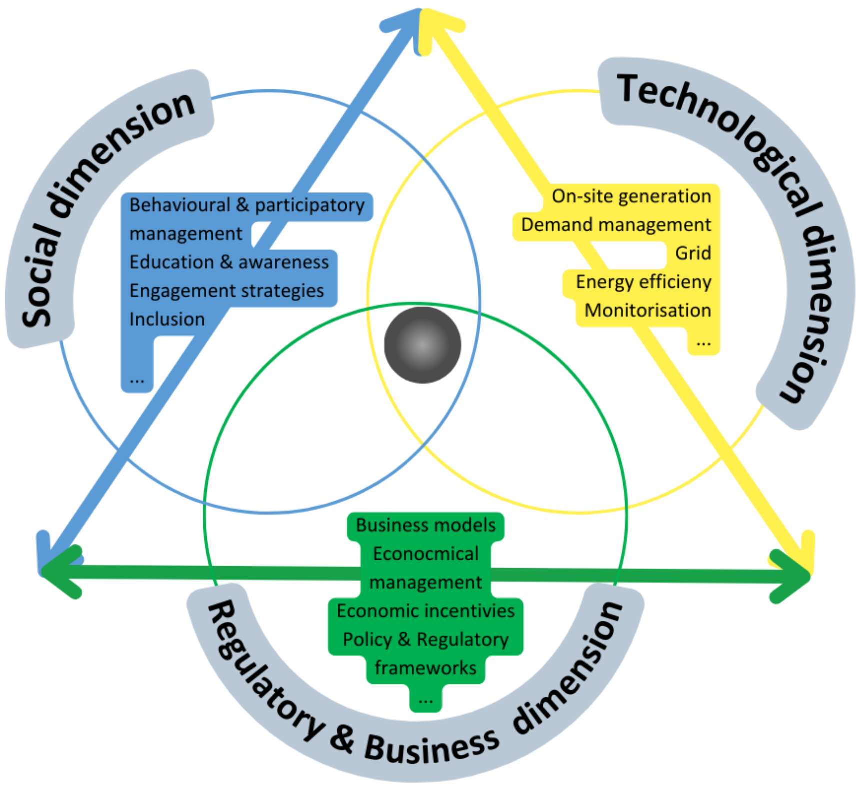

Figure 1 EC triangle concept vision.

The technological dimension extends beyond smart devices and generation installations—it also focuses on interconnectivity, ensuring that technologies serve end-users effectively and support the other two dimensions. The regulatory and business dimension, which includes financial and regulatory aspects, is key to understanding how ECs evolve in different policy countries. While the EU promotes and supports ECs, each country faces unique challenges and barriers, explaining why each pilot project has taken a distinct path. This dimension influences the other two in a parallel and interconnected manner. Finally, the social dimension is at the core of ECs including the behavioural aspects. Without people, these communities would not exist. This dimension must constantly evolve and adapt, ensuring accessibility and simplicity to empower citizens as key actors in the energy transition.

When the technological, regulatory & business and social dimensions intersect in the triangle, it suggests a holistic approach, but not all energy communities need to focus on all three. This is because energy communities are a broad concept and are developing in many different shapes and forms across Europe. This inherent flexibility in purpose allows for different prioritization of dimensions. Some ECs may prioritize social needs—like community engagement, education, and empowerment—while others may focus more on technology or regulation. The intersection shows an ideal scenario, but each community can adapt based on its specific needs, whether they are primarily social, technological, or regulatory. This allows for flexibility in how energy communities evolve, depending on the unique context and objectives of the community. ECs can grow sustainably while placing communities at the heart of the transition.

4 PILOTS AND EVALUATION

Pilots are the cornerstone of this Deliverable, as they bring the EC triangle concept to life through real-world applications. Each pilot has followed its own unique journey, shaped by the multidimensional concept defining its context. The pilots' use cases are not arbitrary—they are the result of an evolving process influenced by regulatory frameworks, financial possibilities, technological readiness, and the needs and engagement of the communities involved. Their evolution began in Deliverable 2.2 with the identification of example real scenarios within WP2 research work, leading to the first set of use cases in D5.3. These use cases were further refined in D5.6 and finally detailed in Deliverables 5.7 and 2.4, through close collaboration between pilot managers, WP2, and WP5, alongside WP3 and WP4, to define the concrete steps needed to bring them to reality. The following sections will tell their story— by examining their development through these three dimensions, we gain insight into the motivations, challenges, and decisions that shaped each pilot's specific use cases and their corresponding KPIs.

In addition, the EC journey—already referenced in deliverables of WP2 and WP4 (regarding tool mapping within the journey) as the path an EC follows from its initial conception to full operation and continuous evolution—serves as a key framework for understanding the pilots' status. Mapping the pilots onto this journey allows us to pinpoint where each one stands at this moment, providing valuable insights into their progress and next steps. The work behind is grounded in Deliverable 2.6, where further details can be found, particularly focusing on the social and behavioural dimension. The overall view presented in Figure 2 serves as a reference point, offering a quick and intuitive way to position the pilots within their development path and facilitating the contextualization of the following sections.

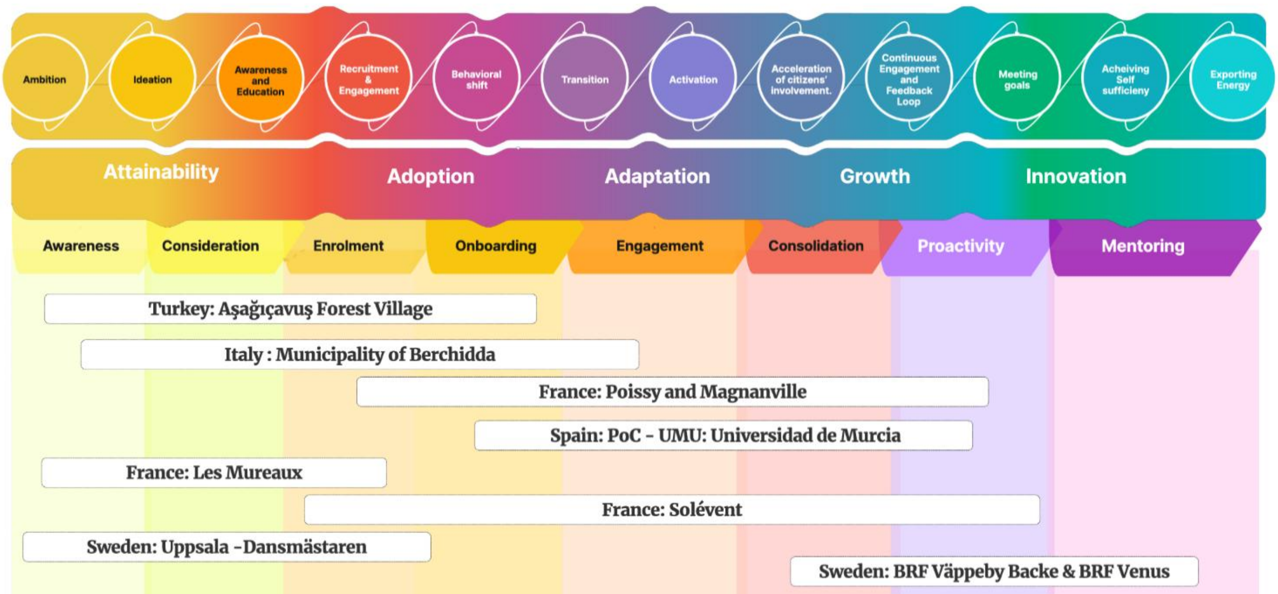

Figure 2 Pilot mapping in the EC journey.

4.1 Pilots

4.1.1 Spain – PoC - University of Murcia

Technological dimension

The PoC was shaped by the availability of a large quantity and variety of data sources, allowing for a more detailed understanding of energy consumption, production, and demand patterns. However, having access to data was not enough; the challenge was how to use this information effectively to drive meaningful actions. A key factor in the evolution of use cases was the need to go beyond simple monitoring and focus on control and intervention mechanisms. It is related also when exploring how solar PV generation could be leveraged efficiently within the university environment. Instead of treating solar energy as a generic supply source, in the PoC it is explored how to direct its use (in a simulated way) toward specific needs, such as climate shelters—designated study areas where air conditioning demand could be offset by solar production.

The campus, functioning as a controlled environment with different faculties and infrastructures, provides an unexplored context to balance buildings with modern energy systems and those with outdated infrastructures led to the development of a use case focused on equitable energy sharing, ensuring that solar energy will be not only utilised efficiently but also contributed to reducing energy disparities within the community.

Thus, the technological evolution of the PoC was driven by the need to transform data into real, actionable strategies, leading to use cases that focus on demand-side energy flexibility, targeted renewable generation, and fair distribution mechanisms.

Regulatory & Business Dimension

At the regulatory level, a major consideration which is beyond the scope of this project is to formally establish an Energy Community due to the administrative controls governing decision-making at a higher institutional level. This limitation influenced the direction of the use cases, as it was clear that the PoC could not be (at the actual moment) formed as an actual EC with full market participation. Instead, the focus is towards demonstrating energy approaches (e.g. energy savings through flexibility mechanisms) showcasing the potential benefits of it as a demonstrator.

Spain has adapted its regulatory framework for Energy Communities (ECs) in line with European directives to encourage decentralized energy production and citizen participation. The Royal Decree-Law 23/2020 incorporates EU Directives 2018/2001 on renewable energy and 2019/944 on the internal electricity market, establishing two distinct types of energy communities: Comunidad de Energías Renovables (CER) and Comunidad Ciudadana de Energía (CCE). CER is strictly focused on renewable energy projects, while CCE allows for a broader range of activities, including both renewable and non-renewable energy. Unlike CERs, CCEs do not have geographic restrictions and can actively participate in energy markets. While both models foster sustainability and local economic benefits, CERs operate under more restrictive guidelines, whereas CCEs provide greater flexibility for energy initiatives.

Setting up an EC in Spain involves a complex administrative process. First, the entity must be legally established as a cooperative, association, or limited company. The next step is obtaining authorization and registration with the Registro Administrativo de Instalaciones de Producción de Energía Eléctrica, followed by the development and implementation of the energy project. Securing financing is another critical aspect, with funding opportunities available through grants, public subsidies, private investment, and crowdfunding.

Spain's Recovery, Transformation, and Resilience Plan recognizes ECs as key actors in the transition to a sustainable energy system and supports their development through Component 7, "Deployment and Integration of Renewable Energies." In addition, ECs are a priority in the Strategic Project for Economic Recovery and Transformation and the National Integrated Energy and Climate Plan (PNIEC), both of which allocate funding and incentives to encourage ECs expansion.

To foster local ECs, financial instruments play a crucial role in attracting private investment and ensuring a 5 to 8-year return period. Several types of financial instruments support ECs in Spain. Grants and public subsidies are provided for legal structuring, technical development, and financial planning, with specific funding for innovative energy technologies. Soft loans from institutions like ICO (Instituto de Crédito Oficial) and risk coverage funds help mitigate financial risks. Tax reductions include lower VAT on equipment and installation costs and local tax deductions in collaboration with municipalities. Crowdfunding mechanisms, including donations, bonds, and equity shares, have become an increasingly popular way to finance ECs in Spain, while fostering citizen engagement. Additionally, eliminating network usage fees and compensating distribution companies through incentives help promote the local generation and distribution of renewable energy.

Despite financial support, energy communities in Spain face several challenges, including bureaucratic hurdles, complex legal requirements, and difficulties integrating into the existing energy market. Establishing an EC requires navigating a highly regulated landscape, ensuring financial sustainability, and managing technical operations, all of which can be barriers for smaller groups or individual participants. Due to these obstacles, a more accessible and practical approach might be to focus on self-consumption, energy efficiency, and equitable energy access rather than engaging in complex external market transactions.

Social dimension

The PoC has leveraged the university environment to demonstrate Energy Community principles, engaging both faculties as stable entities with infrastructure and operational needs and students as dynamic participants with high engagement potential. This distinction was essential, as faculties represent long-term energy management and decision-making structures, while students contribute to behavioural shifts and awareness-building, key to fostering a culture of sustainability within an EC.

Recognising infrastructure disparities, the concept of altruistic buildings emerged, where better-equipped faculties are aimed to help balance energy needs for less-resourced ones, promoting a fairer and more inclusive energy system. Meanwhile, to connect students with real-time energy dynamics, climate shelters (detailed in D2.4) were introduced, focus on encourage them to adjust their daily habits based on energy availability, making sustainability a practical and relatable experience.

The PoC aim to educate and engage the university community in the broader vision of ECs, emphasising collective action, shared responsibility, and sustainable energy behaviour. By actively experiencing how cooperation improves energy efficiency, participants will gain a deeper understanding of ECs and their role in the energy transition.

4.1.2 Italy – Berchidda

Technological dimension

Berchidda presents with both prosumers and consumers shaping its transition toward to create an EC. A key driver for this transition is the integration of photovoltaic PV installations, which provide the foundation for increasing local energy self-sufficiency. The presence of a mix of consumers and prosumers highlights the need to motivate and facilitate the shift from consumer to prosumer, ensuring that more citizens can actively participate in energy production and consumption.

Regulatory and business dimension

Italy provides a supportive framework that actively encourages their formation.

Brief Legislative Recap:Key Milestones in Italy's Renewable Energy Community Framework.

a) *LEGISLATIVE DECREE no. 199 of 8 November 2021. Implementation of Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources, laying the legal foundation for Renewable Energy Communities (RECs) and widespread self-consumption in Italy.*
b) *ARERA | Resolution 27 December 2022 727/2022. Approves the Integrated Text on Widespread Self-Consumption (TIAD), establishing regulatory guidelines for the management of collective and distributed energy self-consumption.*
c) *22 November 2023 Green light from the European Commission for the MASE decree: The European Commission approves the MASE decree, confirming compliance with EU regulations and enabling Italy to implement the financial support framework for RECs and self-consumption.*
   MASE (Ministry of Environment and Energy Security) Implementing decree of 23/01/2024 that officially launches incentives to promote the creation and expansion of Renewable Energy Communities and widespread self-consumption models across Italy.
d) *23 February 2024 GSE | CACER and TIAD DECREE – Operating rules published for access to widespread self-consumption services and PNRR contributions under the CACER (Community Self-Consumption and Renewable Energy Decree) and TIAD framework.*

The main recipients of funding for the promotion of renewable energy communities are local authorities, as they are considered the most suitable entities to mobilise and coordinate other local actors.

The Electricity Market Report 2024 for Italy shows that the number of RECs almost doubled during 2024, proof of a growing interest in collective and sustainable energy consumption models. Furthermore, in 50% of cases, these are plants under 200 kW, with an average of 60 kW. The largest plants, over 200 kW, represent only 34% of the total.

In 58% of cases, the initiative for the creation of an REC is a public body that acts in particular by providing space for the installation of the plants and for organisational activities related to the aggregation of members. In many circumstances there are concrete commitments that go in the direction of supporting the reduction of expenses, of providing support to families experiencing economic hardship (energy poverty) and of financing projects that bring value to the local areas. This last aspect seems to compensate for the economic returns that are modest to date, also due to the small size of the systems. But it must be added that the process has just started a year ago and it's the beginning of a long journey.

This supportive environment shifts the focus from overcoming legal challenges to ensuring that citizens fully understand the regulatory and financial benefits of participation. Providing clear guidance on available incentives, economic advantages, and administrative steps is key to encouraging greater engagement and ensuring that the EC model is both accessible and financially viable for all interested members.

Social dimension

Berchidda is a tightly connected community, where strong social bonds, collaboration, and civic engagement are deeply ingrained in local culture. This makes it an ideal setting for an EC built on active participation and shared responsibility.

Despite existing interest in ECs, past efforts to inform residents have been fragmented due to multiple parallel developments in the town. To address this, it is crucial to streamline communication and provide structured information, ensuring that the community is well-informed and confident in its ability to transition to an EC.

Public events, serve as key moments for capacity-building and collective discussions. Leveraging these well-established gatherings creates an opportunity to engage citizens directly, explain the socio-economic benefits of ECs, and encourage active participation. Given Berchidda's strong culture of cooperation and shared decision-making, this approach ensures that the transition to an EC is not just a technical or economic process, but a community-driven effort shaped by education, collaboration, and inclusivity.

4.1.1 Turkey – Aşağıçavuş Forest Village

Technological dimension

The Turkish pilot builds on an existing technical infrastructure, where each household already has individual solar installations. Rather than treating these as separate systems, the approach focuses on optimising solar energy use at the community level, encouraging a more collective and efficient energy management strategy. Additionally, energy data sources are already available, allowing insights into production and consumption patterns.

A key challenge is the lack of internet access in households, which limits the use of digital tools for energy monitoring and coordination. To overcome this, a community representative was established to act as a bridge, facilitating knowledge-sharing, organisation, and engagement in energy-related decisions. The focus is on helping residents understand and act on this data, ensuring that technical advancements translate into practical energy-saving behaviours within the community treated as a whole through MASTERPIECE's solution.

Regulatory and business dimension

Unlike in EU member states, Turkey does not have a formal legal framework for ECs. Instead, similar models operate as energy cooperatives, which follow different governance and economic structures. This regulatory gap means that citizens lack clear guidance on how to form and operate an EC, creating hesitation and uncertainty.

In Turkey, the legal foundation for the establishment and operation of renewable energy cooperatives is based on key regulations that govern cooperative activities and the renewable energy sector. The Cooperatives Law No. 1163 (1969) defines cooperatives as voluntary partnerships established to meet the mutual economic, social, and cultural needs of their members through mutual assistance, solidarity, and guarantees. This law establishes the basic principles of cooperation, including democracy, equality, justice, and solidarity. Cooperatives must be founded by at least seven members, and their organizational structure and operational rules are defined by the Ministry, which also determines the minimum number of members required.

In addition to this foundational law, the Renewable Energy Sources for Electricity Generation Law No. 5346 (2005) plays a crucial role in establishing the framework for renewable energy cooperatives. The law aims to promote the widespread use of renewable energy sources, enhance their economic and environmental contributions, reduce greenhouse gas emissions, and protect the environment. This law is supplemented by regulations that facilitate the establishment of renewable energy production facilities through cooperatives, such as the Regulation on Unlicensed Electricity Generation (2013), which enables cooperatives to produce electricity without a license under certain conditions. The regulation sets specific production limits based on the number of cooperative members, with a maximum capacity of 5 MW for larger cooperatives.

These legal frameworks are essential in supporting the growth of renewable energy cooperatives in Turkey. However, challenges remain, including bureaucratic hurdles, regulatory gaps, and insufficient incentives for local energy initiatives. In the context of energy democracy, Turkey's legal framework needs further development to promote more inclusive and sustainable energy systems. The establishment of renewable energy cooperatives under the current laws offers opportunities for local communities to become more energy-independent, but reforms are needed to address the evolving needs of the energy sector.

Despite the absence of EC-specific regulations, households can sell surplus energy to the grid, providing an economic incentive. The focus, therefore, is on building awareness of the financial and sustainability benefits of collective energy management, helping residents navigate existing structures while preparing for future regulatory developments. Instead of addressing legal barriers, the pilot emphasises education and practical implementation, ensuring that the community understands how to maximize energy efficiency and financial returns under the current system.

Social dimension

The pilot takes place in a rural, closely-knit community where strong social ties and traditional structures influence decision-making. However, a key challenge is low energy literacy, as many residents have limited knowledge of ECs and sustainable energy practices. Despite this, there is a strong interest in learning and engagement, making education a priority.

Given the absence of digital access, and the final strategy was introduced as the two-phased one — starting with awareness and training sessions, followed by practical participation and community-driven decision-making. A community representative plays a crucial role in ensuring information flows effectively and that all residents can take part, despite technological limitations.

Public gatherings and workshops serve as key mechanisms for explaining ECs, sustainability practices, and energy optimisation strategies using MASTERPIECE tools. The community's willingness to adopt new behaviours is a major driver, making this pilot an opportunity to build an EC from the ground up, where knowledge, cooperation, and shared responsibility shape the transition.

4.1.1 Sweden – Dansmästaren and BRF Väppeby Backe & BRF Venus

Technological dimension

The Swedish pilot sites are built upon existing energy infrastructure, with access to renewable energy generation and storage. This technical foundation allows for the exploration of EC models but requires a clear understanding of how to optimize and integrate these resources within a collective framework.

The primary focus is on empowering citizens to make informed decisions about energy production, storage, and investment and begin forming EC's. Digital tools play a crucial role in engagement, recruitment and simplifying complex calculations, offering insights into financial feasibility, and potential returns on investment and sustainability for those considering EC formation. While the infrastructure is in place, the challenge lies in bridging the gap between available technology and community-driven energy engagement and management, ensuring that individuals and organizations have the knowledge, confidence and tools to utilize these resources effectively.

Regulatory and business dimension

A major constraint in Sweden is the lack of transposition of EU directives on ECs, which creates uncertainty regarding the administrative and legal framework for forming and operating an EC. Without a clear regulatory structure, potential participants face ambiguity in defining roles, responsibilities, and benefits, making it difficult to move beyond awareness and early consideration phases.

This limitation has shaped the approach of use cases, focusing primarily on education, engagement, and feasibility studies rather than direct EC implementation. The aim is to equip communities with the necessary knowledge and tools, allowing them to be prepared for future regulatory developments when ECs become more formally recognised and also by providing these pilot sites as an example at a national level.

Additionally, unforeseen administrative barriers, such as delays in infrastructure approvals and procedural requirements, have impacted the ability of Austerland pilot site to proceed with EC development (out of the management and control of the pilot managers and the project). These challenges highlight the need for clearer policies and better coordination between regulatory bodies and community initiatives, reinforcing the importance of strong foundational knowledge and strategic planning in advancing ECs in Sweden. However, the rest 3 pilot sites will continue with the focus already commented.

Social dimension

One of the key drivers of the Swedish pilots is enhancing energy literacy and engagement. Despite access to renewable energy technologies, knowledge about ECs remains low, making education and awareness-building essential first steps.

Community organizations, such as housing associations, play a crucial role in fostering collective action and encouraging residents to explore EC models. There is a strong interest in learning and participating, but many individuals lack the information needed to take the next steps. By focusing on strengthening social bonds and increasing understanding of ECs, the pilots aim to build confidence and motivation among potential participants, ensuring that they are well-prepared for future energy transitions.

By creating structured learning opportunities, fostering discussions, and providing practical tools, the pilots ensure that ECs are not only understood but also considered as viable options for communities looking to enhance their energy independence and sustainability. The approach emphasizes that successful ECs are not just about technical and financial aspects but also about community collaboration and shared responsibility.

4.1.1 France – Solévent & Poissy and Magnanville & Les Mureaux

4.1.1.1 Solévent

Technological dimension

The French pilot is built upon an existing EC, where citizens have invested on PV installations on schools' rooftops and sell the electricity at the national feed in tariff. With a functioning EC already in place, the focus is on the integration of digital tools to enhance EC management and engagement. By providing real-time visibility into solar energy production, both EC managers and members can better understand energy generation and make informed decisions. Additionally, schools will be encouraged to adjust their consumption habits to align with solar generation patterns, leveraging recommendations and aggregated consumption insights. The goal is to maximise the consumption when the solar panels produce energy, ensuring that renewable energy is used where and when it is most beneficial.

Regulatory and business dimension

France provides a well-established regulatory framework for ECs, allowing for their administrative and operational development without major legal obstacles. The pilot benefits from an already formalized EC, removing the challenges of setting up governance structures and legal compliance.

The national feed in tariff allows Solévent to secure its business model for 20 years.

A recent regulatory update has expanded the geographical distance allowed between EC participants, making it easier for new members to join and benefit from shared energy resources. This change enhances the scalability and inclusivity of the EC model, allowing for greater community participation. The regulatory environment in France generally supports ECs, making it possible to focus on improving engagement and operational efficiency rather than overcoming legal hurdles.

Social dimension

The French pilot emphasises active participation and inclusivity, fostering a strong sense of community ownership over local energy resources. With a diverse membership that includes local authorities, municipalities, social housing and individual citizens, the EC serves for collaboration and knowledge-sharing on sustainable energy use.

Encouraging engagement and social interaction is a key objective. Digital tools facilitate communication, transparency, and collective decision-making, strengthening the relationship between EC members. Schools, as a significant part of the community, play a dual role. As they are managed by the municipalities, Solévent's projects increase the part of renewable energy in the territory, but they also serve as educational hubs for sustainability, helping future generations understand and embrace clean energy practices.

The EC is also open to new members, leveraging the experience of Solévent, which has a strong history of community-driven energy initiatives. Solévent is working on new business models for future project (such as energy sharing). This openness ensures that the EC continues to grow and adapt.

4.1.1.2 France – Poissy and Magnanville

Technological dimension

In France, more than 8 out of 10 French people are equipped with the Linky meter, a smart meter that allows monitoring of electricity consumption, consulting tailor-made electricity offers, remote monitoring of operations and simplification of self-consumption installations. A lot of data exists, but its use is not satisfactory, mainly due to lack of knowledge of its owners.

The Poissy and Magnanville pilot projects were born from a desire to decarbonize the energy mix, to open up access to renewable energies and to locally self-consume the production developed.

The projects do not rely on existing photovoltaic installations. The Energy Community is formed around a joint project to develop a shared production plant and shared production. The sizing of the installation and the energy community, the access and analysis of energy data, the complementarity of consumption profiles, the fair distribution of production are the issues to which the MASTERPIECE project must provide answers.

Regulatory and business dimension

A key regulatory shift has increased the allowable distance between EC participants, making it easier for a broader range of stakeholders to join collective investment schemes. This expansion of geographical eligibility enhances the feasibility of joint ownership models, allowing more businesses and residents to co-invest and benefit from shared PV installations. Note that this development does not impact the PoCs of Poissy and Magnanville. These municipalities are not eligible for these exemptions.

The pilot places a strong emphasis on fair governance, ensuring that the joint ownership model is transparent and equitable for all members. This involves defining clear rules for participation, cost-sharing, and benefit distribution. The legal and economic frameworks supporting ECs in France play a crucial role in enabling this model, as they provide a structured pathway for community energy projects to develop and thrive.

However, with electricity prices remaining low in France, the economic model of self-consumption energy communities is fragile. Currently, potential members remain cautious. The PoC must provide concrete results to prove the economic opportunity of these self-consumption operations. In addition, the valuation of co-benefits is under study.

Social dimension

The success of this pilot relies heavily on engagement and fostering a collective mindset. Encouraging participation in a shared investment model requires a strong sense of trust, cooperation, and long-term commitment among members. The pilot strengthens social bonds between participants, creating a model that is not just about energy efficiency but also about community-driven economic empowerment. This collective approach ensures that both small consumers and larger stakeholders are equally invested in the success of the EC, reinforcing the principle that local renewable energy projects work best when they are inclusive and participatory.

4.1.1.3 France – Les Mureaux

Technological dimension

Les Mureaux Pilot builds upon France's existing smart grid infrastructure. In France, since 2022, more than 8 out of 10 French people are equipped with the Linky meter, a smart meter that allows the monitoring of electricity consumption, the consultation of tailor-made electricity offers, the remote monitoring of operations and the simplification of self-consumption installations.

A lot of data exists, but its use is not satisfactory, mainly due to a lack of knowledge of its owners. This pilot seeks to brdge that gap by integrating digital tools that allow members to better monitor and manage their consumption.

In France, self-consumption is encouraged late. The law of February 10th, 2000, establishes the principle of the purchase obligation and supports the deployment of photovoltaic production plants for resale. The contracts last 20 years and the installations are generally oversized compared to the needs of the equipped household. It seems interesting to offer an alternative and a way of integrating these installations to supply Energy Communities.

The POC of Mureaux is built on an aggregation model between existing installations and new installations (5kW PV power generation and 9.6 kWh battery storage with shellies for specific measurements). The Energy Community is built around a common project to share local PV electricity production from the POCs and excess energy from schools. The sizing of the energy community, access to and analysis of energy data, the complementarity of consumption profiles, the management of energy flows and the equitable distribution of production are the challenges to which the MASTERPIECE project must provide answers.

Regulatory and business dimension

A key regulatory factor influencing this pilot is the expansion of geographical eligibility for EC participation (Currently, 2km for urban area), which should be increased to allow for a broader range of members to join and include new members such as farmers. This regulatory shift enhances accessibility and makes it easier for communities to form and expand ECs beyond previous limitations.

Les Mureaux Pilot focuses on developing a business model that integrates association creation, co-investment, and co-consumption, fostering an inclusive energy ownership structure, financial sustainability, and long-term investment. By combining businesses, citizens, and local stakeholders, the pilot seeks to establish a governance framework that ensures fair participation and benefit distribution.

Social dimension

The success of this pilot depends on raising awareness and educating citizens about ECs, ensuring that they understand the benefits of collective solar energy ownership and management. By providing accessible information at an early stage, it encourages more individuals to explore participation opportunities and develop a stronger interest in renewable energy self-consumption.

Digital tools will facilitate transparent decision-making, allowing members to track energy production, be more engaged, vote on key community matters, and participate in private discussions about future developments. Les Mureaux EC aims to empower its members to take ownership of their energy future, thus, become in the region a model for socially responsible and community-driven initiatives.

4.2 Evaluation

As the Project as has progressed, what was introduced in D2.3 in M6 as part of the Evaluation plan, still in an early stage, has been upgraded after the work done in the pilots in the last months.

With the experience obtained in this period, several points included in the Evaluation plan have been selected and extended, adapting them for the needs of each pilot. Most of the work that is being done in the context of evaluation is focused on KPIs and Test cases, as described in the following sections, and in order to unify the evaluation methods, others aspects to consider in the context of evaluation have been merged with these two big blocks, such as the platform tests described in D2.3, which are performed using Test cases, or service use analytics, which are connected to some KPIs of the pilots.

4.2.1 Global KPIs

This section describes how the first five global KPIs, which are aligned with the key objectives of the project, can be mapped to the three-dimensional EC triangle concept. Table 1 shows how the different results generated by the project are connected on the one hand with both the key objectives and project objectives, and on the other hand, with each dimension.

The remaining global KPIs have not been included in this analysis since they are mainly focused on dissemination and exploitation activities.

An extended view of the KPIs is available in D2.3 (definition) and D5.6/D5.7 (calculation method and baselines).

Table 1 Global KPIs within the EC triangle.

Key Objectives		Project Objectives		Triangle dimensions		
ID	Name	ID	Description	Technological	Regulatory & Business	Social
K1	Adherence to the ECs after the Intervention Program	PO-1	To develop **technical** and **social** innovations to empower traditional energy consumers and to make them active agents of collaborative energy communities, paving the way towards a new energy market paradigm.	MASTERPIECE platform (tools)		Participatory management, Engagement, Education & awareness
K2	Master Plan of services and Services Blueprints	PO-2	To create user-centric solutions that based on **participatory** approaches such as co-creation and naturally accelerate citizens' involvement.	Architecture and services blueprint		
K3	Increase of federated services	PO-3	To propose new **business** strategies and incentive mechanisms that activate the reactions of market participants craving for business opportunities that imply **energy use** and **cost** reduction.	Federated services		
K4	Secure data management	PO-4	To configure a standardised and sound **cybersecurity** infrastructure so the active citizens are protected against cyber-attacks, at the same time that privacy is defended in accordance with the revised EPBD and the GDPR law.	Identity Management mechanisms Access Control System Secure data management	European regulations	Trust of stakeholders for using the MASTERPIECE solution
K5	Validation of large-scale acceleration programs	PO-5	To demonstrate the applicability and replicability of methodological, **technical**, and **business** innovations in a variety of real-life pilots in different geographical locations, with heterogeneous **social** and **economic** environments and different **regulatory**/administrative frameworks.	Real-life demonstrators (pilots)	Regulations Multiple business models	Real-life demonstrators (pilots)

4.2.1 Use case KPIs

After having linked the pilots with the three-dimensional EC triangle concept in previous sections, this one goes directly to the use case KPIs and analyses them at an individual level, offering a more detailed view of the impact each dimension has on each one of them. An extended view of the KPIs is available in D2.4 (definition) and D5.6/D5.7 (calculation method and baselines).

In this regard, the content included in the technological dimension is focused on technical aspects/conditions/restrictions other than the components themselves, since the components are technical results by definition and it would make no sense to replicate them multiple times. Instead, we studied what they can offer to other dimensions, as can be seen in the following table.

Table 2 Use Cases & KPIs within the EC triangle.

Pilots/Use cases/KPIs			Triangle Dimensions		
UC	UC Name	KPI			
Spain – UMU: POC			Technological	Regulatory & Business	Social
UC1	Fostering a Socially Responsible Energy Community	KPI 1: Number of people who have interacted with the tool.			Education and awareness (MEET App)
UC2	Promoting Collaboration and Self-Consumption from PV	KPI 1: Number of people reached and percentage that attained the collaborative behaviour.	Support for generation (PV) Control and monitoring (actuation) Energy saving (DR-FLEX) More efficient buildings		Climate shelters Sustainable habits Education and awareness
UC3	Management of Demand and Fair Pricing	KPI 1: 10% Energy savings.	Support for generation (PV) Control and monitoring (actuation) Support for grid integration Energy saving (DR-FLEX)		
UC4	Achieving Sustainable Energy Transition and Equitable Access	KPI 1: % Increase in grid energy independence (community level).	Support for generation (PV) Control and monitoring (actuation) Support for grid integration Energy saving (DR-FLEX) More efficient buildings		Altruistic buildings (cooperation) sustainability (DR-FLEX)
Italy - BER: Municipality of Berchidda			Technological	Regulatory & Business	Social
UC1	Promoting the transition from consumer to prosumer in an informed and conscious manner among citizens	KPI 1: Number of individuals informed.			High organisation of taking into account public events/meetings (MEET App). Active participation
UC2	Achieving Active Participation and Sensibilisation in Sustainable Energy Usage	KPI 1: More than 50 citizens have collaborated and expressed interest in creating the official EC.			High organisation of taking into account public events/meetings. Active participation (ECOOP).
Turkey - UEDAS: Aşağıçavuş Forest Village			Technological	Regulatory & Business	Social

UC1	Understanding ECs and engagement of citizens.	KPI 1: Nº Interaction within the learning process.			Awareness and education (MEET App) Encourage participation/engagement (RECOMME)
		KPI 2: Rate of understanding of the EC environment.	Households don't have Internet connection.		Education (MEET App). Old people living there in old houses: Limitation to one EC representative.
		KPI 3: Rate of acceptance to create an EC.			Interest in joining an EC (ECOOP)
UC2	Achieving Active Participation and Sensibilisation in Sustainable Energy Usage.	KPI 1: Energy shifted to solar generation periods - from the Community point of view (kWh)	PV installations in each household Community treated as a whole Diverse data regarding generation, surplus, etc.		Desire to adopt new behaviours to energy optimisation (DR-FLEX)
		KPI 2: Community participation rate (%)			Desire to adopt new behaviours to energy optimisation (DR-FLEX)
France - SEIN: Poissy and Magnanville			Technological	Regulatory & Business	Social
UC1	Evaluation of Joint Ownership Model for collective PV installation Investment.	KPI 1: Up to 60 engaged members | Establishing 3 categories of members: Residential, Small and Medium businesses, Large Groups or Consumers.		Business planning (SIT)	Engagement (ECOOP)
		KPI 2: CAPEX per kW installed < 2500 EURkW | Yearly OPEX per kW PV installed < 50 EUR.	PV installations	Economic analysis (SIT)	
UC2	Promoting Inclusivity, fair governance, and Equity, in Collaborative Self-Consumption ECs.	KPI 1: At least 3 actor profiles represented in EC: public and private economic actors, academic actors, households.			Promote representativeness (RECOMME)

		KPI 2: Balanced governance - at least 3 votes per category of stakeholders during decision making.			Promote fair governance (RECOMME + ECOOP)
France - RDIUP: Les Mureaux			Technological	Regulatory & Business	Social
UC1	Empowering Citizens' Access to Solar-Powered Energy Community Ownership.	KPI 1: Eagerness to learn more about ECs.		Limit distance participant restriction has decrease because it has increased the km	Awareness and education (MEET App) Participation (ECOOP)
		KPI 2: Acceptance to join a Solar-powered ECs (%).	PV installations	Limit distance participant restriction has decrease because it has increased the km	Interest in joining an EC (ECOOP)
France - ALEC: Solévent			Technological	Regulatory & Business	Social
UC1	Management of the EC and participation of the members in the activities.	KPI 1: Number of logins and time spent on ECOOP.			Participation (ECOOP)
		KPI 2: Number of interactions between participants (participation frequency in private chat rooms and discussions and number of meetings organised within the EC).			Participation (ECOOP)
UC2	Enrolment and on-boarding on the EC.	KPI 1: Number of new members interested in joining the EC.			Awareness and education (MEET App) Interest in joining an EC (ECOOP)
		KPI 2: Qualitative feedback of RECOMME (online questionnaire).			Education (RECOMME)
UC3	Achieving Active Participation and Sensibilisation in Sustainable Energy Usage.	KPI 1: In the recommendation of DR-FLEX there will be the option for the person using it, to indicate if it has acted based on the	PV installation	Limit distance participant restriction has decrease because it has increased the km	Desire to adopt new behaviours to energy optimisation (DR-FLEX)

		recommendations. [User Action Confirmation Rate (%)]			
Sweden - UPPSALA: Dansmästaren			Technological	Regulatory & Business	Social
UC1	Understanding ECs and engagement of citizens.	KPI 1: 10 or more citizens have been informed about the possibility to start and/or participate in an EC.			Strong interest in engagement, education (MEET App and RECOMME)
UC2	Empowering Citizens in Renewable EC.	KPI 1: The success ratio in residents taking further steps to start an EC is 10 or more percentage points.		NO transposition of ECs EU directives	Awareness and education (MEET App) Participation (ECOOP)
UC3	Registering an official EC.	KPI 1: UPP is an official EC.		NO transposition of ECs EU directives	Interest in joining an EC
Sweden - NGENIC: BRF Väppeby Backe & BRF Venus			Technological	Regulatory & Business	Social
UC1	Strengthening social bonds and energy literacy.	KPI 1: 5 or more residents have been informed about the possibility to start and/or participate in an EC.			Strong interest in engagement, education (MEET App and RECOMME)
		KPI 2: The success ratio in residents taking further steps to start an energy community is 10 or more percentage points.		NO transposition of ECs EU directives	Awareness and education (MEET App) Participation (ECOOP)
Sweden - NGENIC: Austerland			Technological	Regulatory & Business	Social
UC1	Empowering citizens in PV community energy ownership showing the return on investment.	KPI 1: % Average return investment for at least 5 people from Group 2		Unforeseen administrative barriers (out of the management and control of the pilot managers and the project), have impacted the ability of **Austerland** pilot site to proceed with EC development	

4.2.2 Test cases

In terms of component evaluation, test cases are the reference element introduced in D2.3 and later extended in D5.7, aimed at validating certain key aspects of each component, paying extra attention to those which are relevant to confirm that they are working as expected.

Although in some cases it is enough by validating the availability of the component, in others the validation goes even further and checks the actual logic of the process, to confirm that the generated output is correct.

The following Table 3 provides a summarised view of all the Test cases reported in D5.7, highlighting the main goals of each one.

Table 3 Summary of the Test Cases.

Group	Component	Component Test Case	Test Case Goal
MASTERPIECE tools	SIT	SIT-001	Test and verify that the configuration of an EC is **user-friendly**.
		SIT-002	Test that users **can generate the sustainability planning** after optimization.
	COMPASS	COMPASS-001	Verify that users **can search for incentives** using keywords combined with initial filters (e.g., type of incentive, location) on the first page, and that the returned results match the specified criteria.
		COMPASS-002	Verify that users **can refine incentive search results** with additional sub-filters.
	MEET App	MEETAPP-001	Verify that users **can create a social discussion/event** in the app.
		MEETAPP-002	Verify that users **can successfully complete a quiz** in the app.
	RECOMME	RECOMME-001: Community Members Profiling	Characterize and **profile the users** based on their inputs in the tool.
		RECOMME-002: Profile Clustering	**Cluster the users** based on their profile.
		RECOMME-003: EC Active Competition framework	Encourage users to **adopt eco-friendly behaviors** with a gamified approach.
	ECOOP	ECOOP-001	Test and verify that the **creation of an EC** and or portfolio in a **user-friendly manner**.
		ECOOP-002	Test and verify that the **configuration of metering** device in an **automated way**.
		ECOOP-003	Test and **verify the joining process** between EC Manager and Members (portfolios).
	DR-FLEX	DR-FLEX-001	**Validate** the proper execution of DR-FLEX for **demand optimisation** in an EC.
		DR-FLEX-002	This component aims to proactively **assess and forecast demand side flexibility levels**.
		DR-FLEX-003	This component aims to **reduce costs sustaining thermal comfort to end-users** and at the same time meet as much as possible the DSO demand requests.
	MAPS DEC	tbd (tool recently added to the masterpiece tool)	
DLT Secure Platform Components	Real-Time Data Repository	RTDR-001	Validate the **availability** of the component by making requests to the REST API it offers.

	Historical Data Repository	HDR-001	Validate the **availability** of the component by making requests to the REST API it offers.
	Data Healing	DH-001	Uphold high **data quality** standards across the DLT platform to enable accurate, reliable, and consistent data insights.
	Secure Energy Flow Monitoring	SEFM-001	Validate that the aggregation script correctly iterates over the entities, checks the aggregation type, and performs the daily, weekly, and monthly aggregations according to the entity aggregation type on the defined time, resulting in successful updates to the **blockchain** and context broker.
	Security and Privacy Engine	S&PE-001	Validate the correct execution of **Security and Privacy** Engine for data access.

4.2.3 Monitorization & validation

As part of the evaluation plan, described in D2.3, one of the activities required to guarantee the proper functioning of the solution is the continuous monitoring of all the involved elements, including the supervision of data sources, platform tests, and any other additional action identified for similar purposes.

The first explicit reference was introduced in D5.1, in the form of *Verification Plan*, which is expected to be reported in D5.2. It combines automated synchronous monitorization, focused on detecting instant anomalies on a regular basis (i.e. once per hour), with in-depth validation of data sources, components, etc. both in an automated way, using tools like Jenkins, and with user interaction when it is necessary, for example when some user input is needed as part of the verification of certain process.

As stated in D5.1, it is important to find a proper balance between reliability and scalability, and these two aspects will be taken into consideration during the definition of the Verification Plan, to guarantee a proper quality of the information at a reasonable cost, so that the monitoring tools do not generate too much overhead to the solution.

5 ARCHITECTURE AND COMPONENTS – FINAL VERSION

The ICT architecture in MASTERPIECE has evolved continuously since the last version of the document, where a mock-up of the architecture was first introduced. This section presents the final version, shaped by the development, refinement, and integration of its various tools and components. It reflects the progress made throughout this period, leading to a more mature and fully integrated system. Additionally, the evolution of these tools and components is also outlined.

5.1 Architecture evolution

Since the last version of this document, the components that build the MASTERPIECE solution have undergone significant changes and improvements, leading to an overall evolution of the platform's architecture. Initially, the smart services of MASTERPIECE were introduced as isolated solutions with minimal interaction between them.

Over time, efforts have been made to group, integrate, and enhance cooperation among these components. As a result, they have been consolidated into more cohesive tools, each composed of one or more components working together. To ensure seamless collaboration between these tools and their components, a significant effort has been dedicated to structuring, managing, and processing information related to the participating Energy Communities and their data.

A key focus has been achieving a standardised and uniform approach to accessing and modelling the data stored within the MASTERPIECE platform. This has greatly improved cooperation, data accessibility, and storage, enabling all tools to generate and consume information using the same data models and standards. This approach ensures compliance with the FAIR principles—interoperability, accessibility, findability, and reusability—enhancing the overall efficiency and effectiveness of the system.

Figure 3 shows the final version of the Masterpiece ICT platform architecture. The architecture is structured into different layers, each grouping components based on their purpose.

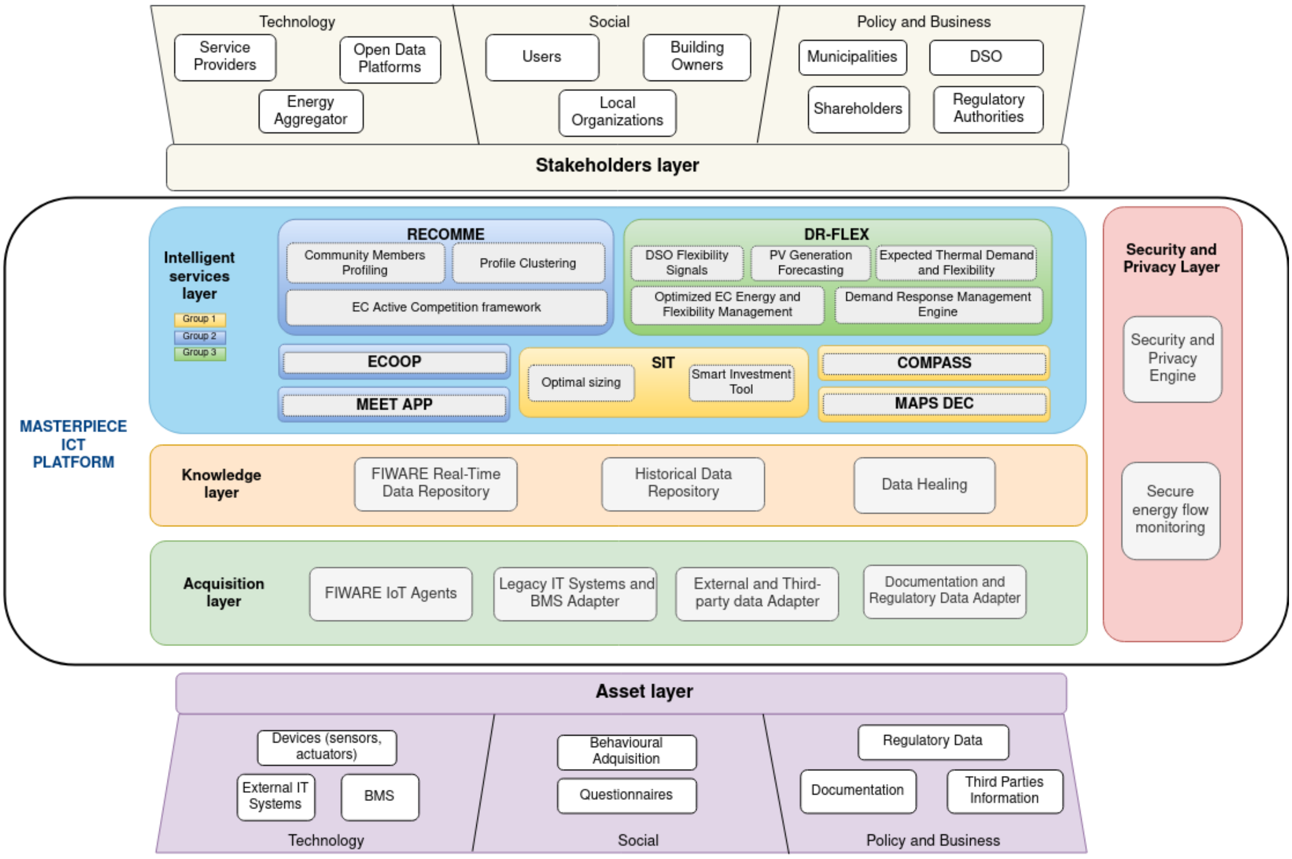

Figure 3 Masterpiece ICT Platform Architecture.

At the **Intelligent Services layer**, the smart services offered by the MASTERPIECE solution are considered tools. The tools are grouped according to their purpose and the phase of the EC journey they are in. The groups are as follows:

- Group 1: Simulation & EC Management
- Group 2: Discovery, Awareness, Enrolment Engagement, and Profiling
- Group 3: Flexibility, demand response and demand optimisation framework

Figure 3 shows the tools and the groups to which they belong in this layer. These seven tools consist of one or more internal components that work together to deliver their functionalities. They are based on rich, well-structured data, managed by the lower layer.

This underlying layer, the **Knowledge layer**, is a key component of the platform, as it is responsible for the management and standardisation of data. It ensures that all platform information is properly structured and accessible, serving as the unified access point for all tools to retrieve and interact with data consistently. This is made possible through the adoption of the NGSI-LD standard, which enables seamless interoperability across the platform. To achieve this, the Knowledge layer relies on two key components for information management:

- FIWARE Real-Time Data Repository: This component is a Context Broker developed by FIWARE, fully compliant with the NGSI-LD standard. It enables real-time management of all contextual data within the platform, ensuring up-to-date and dynamic information processing.

- Historical Data Repository: This component is responsible for storing and providing access to historical data, allowing tools to retrieve past information when needed.

Together, these components ensure seamless data management, supporting both real-time and historical data access in a standardized and efficient way. Additionally, a Data Healing component complements the layer by identifying and correcting errors in raw sensor data, enriching the data to ensure accuracy and reliability. This component has been moved to this layer from the previous version of the architecture, as it is better suited for ensuring data consistency and quality within the platform.

The lowest layer, the **Acquisition Layer**, is the closest to the field, where data originates. It is responsible for collecting information from assets related to Energy Communities and integrating it into the platform. This layer enables the injection of heterogeneous data from external platforms, devices, and other sources into the Knowledge Layer, ensuring that all contextual information is standardised and homogenised. It plays a crucial role in transforming raw data into enriched, context-aware information. The Acquisition Layer is composed of both existing and custom-developed components. Among them, the FIWARE IoT Agents allow the integration of IoT devices using protocols like MQTT, facilitating real-time data acquisition. Additionally, custom components developed specifically for MASTERPIECE enable seamless integration with Building Management Systems (BMS), external data platforms, and other sources. This structure ensures flexible and efficient data ingestion, supporting a wide range of sources while maintaining consistency within the platform.

Across all the previously mentioned layers, there is the **Security and Privacy Layer**, which ensures the necessary mechanisms for authentication, authorization, and privacy in data processing within the platform. This layer provides strict control over who can access the platform's resources and how they interact with them, ensuring a high level of granularity in access management. In addition to access control, this layer also enables mechanisms for aggregating energy data based on Distributed Ledger Technology (DLT).

5.2 Tools and components evolution

As mentioned in the previous section, the components reported in earlier versions of this document have undergone significant evolution. These initial components have now been developed into fully functional tools that form the backbone of the MASTERPIECE digital ecosystem. The tools have been grouped into three main component categories (see previous subsection) that align with the EC triangle, enabling the creation, management, and optimization of energy communities. These advancements reflect the transition from conceptual components to practical, user-facing tools. The evolution of these tools and components are visually represented in the architecture diagram of Figure 3 and detailed reported in the already submitted D4.2. The conceptual description of each tool is provided in Table 4.

Table 4 Tools evolution.

Tool	Description	Technology developer	Task related
RECOMME	RECOMME is a digital tool that enhances the formation and management of Energy Communities by analysing member profiles, identifying behavioural patterns, and fostering engagement. It uses data-driven models to understand the social, economic, and energy consumption characteristics of EC members, helping communities build resilience and optimize member participation. By leveraging clustering techniques and comparative analysis, RECOMME supports the creation of more cohesive ECs, encourages active involvement, and provides insights that drive more effective community development strategies	CERTH	T3.4
COMPASS	COMPASS is a web-based tool designed to assist citizens and communities in developing energy projects. It provides an intuitive interface to easily access a database of funding schemes, technical assistance, capacity-building programmes, and policy guidance, all aimed at making community energy projects more accessible and sustainable. The tool offers advanced search and filtering capabilities to help users quickly identify the incentives that best match their needs. While COMPASS functions as a standalone platform, it can also connect with other tools through dedicated links to display specific subsets of incentives.	R2M	T3.1/ T4.1
MEET APP	The MEET App is a mobile platform designed as the first point of contact for individuals new to ECs. It provides educational resources, including articles and EU public data, to help users understand EC concepts, benefits, and available incentives. Additionally, it offers a collaborative space where users can join discussions, share knowledge, and promote initiatives. With a geo-based search feature, the app makes it easy to find relevant conversations and events, fostering engagement and awareness within energy communities.	R2M	T4.1
ECOOP	ECOOP is a tool that connects energy community managers, producers, and consumers to build and scale energy communities. It enables managers to define community goals based on different factors like capacity, investment, and location, while ensuring regulatory compliance (e.g., distance between generator and consumer). Members can showcase assets, generate reports, vote, and engage in discussions. The platform also allows for the exploration of eligible communities, sending invitations to participants, and provides insights through performance indicators, supporting collaborative and sustainable energy initiatives.	RDIUP	T4.1
SIT	SIT (Smart Investment Tool) is an advanced tool designed to simulate and optimise self-consumption configurations. It creates tailored sustainable plans for users, incorporating various energy system components and actions needed for a cost-effective energy transition. The tool also allows users to simulate the energy	RDIUP	T4.2

	delivered by the grid or the energy exported to the grid in case of energy trading. It helps users generate personalised plans that provide clear, actionable information, supporting pilot sites in replicating and implementing effective energy solutions.		
MAPS DEC	MAPS DEC is a tool designed to manage self-consumption configurations for sharing renewable energy. It supports individual self-consumption systems, collective self-consumption groups, and Renewable Energy Communities (RECs). MAPS DEC can handle multiple RECs simultaneously, accommodating a variety of users, both residential and non-residential, and managing different types of renewable energy production plants and storage systems.	MAPS	T4.3
DR-FLEX	DR-FLEX is a tool designed to optimise self-consumption and energy demand through Demand Response strategies. It helps users maximise the use of renewable energy, like solar power, reducing reliance on the grid, while allowing for real-time adjustments to consumption based on grid needs. By participating in DR programs, users can earn economic benefits and contribute to grid stability. DR-FLEX also features an intuitive dashboard offering personalised energy efficiency recommendations and integrates flexibility assets such as HVACs, enhancing community-wide energy management.	UMU	T4.4
DLT Secure platform	The DLT-based Secure Platform consists of the underlying components that support and enable the smart services of the platform. These components work together to ensure secure, interoperable data exchange and efficient integration of data from multiple sources. Key elements of the platform include the data repositories and agents for device integration, the Data Healing component for maintaining data integrity, the Secure Energy Flow Monitoring component for managing energy transactions, and the Security and Privacy Engine to ensure data protection and compliance with privacy regulations. These foundational components provide the necessary infrastructure for the effective operation of the platform's higher-level services.	ODINS	T4.5

6 Conclusions

This Deliverable marks the final step of WP2, consolidating the research, developments, and practical applications that have emerged throughout the project within WP2 period. The EC triangle framework has been fundamental in understanding and shaping Energy Communities, providing a structured approach that integrates regulatory and business, technological, and social dimensions. This multidimensional perspective has not only guided theoretical advancements but has also been instrumental in real-world implementation through the pilots.

The pilots have played a pivotal role in bringing these concepts to life, translating research into actionable strategies tailored to their unique contexts. Their evolution, from initial scenario identification to fully developed use cases, has demonstrated the adaptability and scalability of ECs, shaped by national regulations, technological maturity, and community engagement. The iterative collaboration between WP2, WP5, and other work packages has enabled continuous refinement, leading to standardized methodologies, enhanced interoperability, and a more robust understanding of EC dynamics. Moreover, the EC journey framework has provided a dynamic roadmap to track the development stages of ECs, positioning pilots within this framework and offering insights into their future progression. This approach not only facilitates a deeper understanding of each pilot’s evolution but also serves as a reference for future EC implementations.

In parallel, the final version of the MASTERPIECE architecture has undergone significant improvements, evolving into a well-structured platform that ensures seamless interaction between tools and components. Initially conceived as a set of isolated smart services, the platform has now been transformed into an integrated system that enhances data accessibility, cooperation, and standardization. The adoption of the NGSI-LD standard has played a crucial role in achieving interoperability, ensuring compliance with the FAIR principles—interoperability, accessibility, findability, and reusability. This structured approach has improved the platform’s ability to support real-time and historical data management, fostering more efficient decision-making and operational strategies for ECs.

In conclusion, WP2 has successfully laid the groundwork for ECs by establishing a comprehensive knowledge base that has guided pilot implementation while influencing the broader project ecosystem. The developments in the triangle aspects documented in this Deliverable ensure that the findings remain valuable for the continued advancement and sustainability of the project and future ECs across different contexts.