

D.4.2 Documentation of four newly developed services



1.1 History of changes

Version	Date	Comments	Main author(s)
1	28.10.2025		Denitsa Dimitrova, Cveta Dimitrova

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1.2 Deliverable Information Sheet

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Project Acronym	DISCOVER
Project Title	Developing Integrated Services for Community energy to accelerate Valid Energy Transition
Project Call	LIFE-2022-CET
Project Duration	36 months
Deliverable Number	D4.2
Deliverable Title	Documentation of four newly developed services
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Work Package	WP4
Lead Partner	IESDI
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List of Abbreviation and Acronym

Abbreviation	Meaning
CEP	Community Energy Projects
OSS	One Stop Shops
DSO	Distribution System Operator
PV	Photovoltaic
EC	Energy Community
REC	Renewable Energy Community
SW	Software
RLM	Real Life Modelling
CEP – RLM	Community Energy Projects Real Life Modelling
DSO	Distribution System Operator
ECASS	Energy Community Analysis and Simulation Services

2 Introduction: DISCOVER Project

2.1 Overview

DISCOVER is an innovative LIFE project with the strategic aim to support the transition to a renewable energy-driven society. By fostering Community Energy Projects (CEPs), DISCOVER will empower stakeholders and citizens and mobilize significant investments in renewable energy generation in pilot regions across Europe. DISCOVER will catalyse the launch of CEPs in 5 diverse European regions respectively in Austria, Bulgaria, Croatia, France and Italy. Local hubs will be set up to pilot innovative support mechanisms for CEPs. The hubs will deliver guidance and practical services on the technical, economic, financial and legal aspects and will help connect CEPs to local service and technology providers. The services will cover all developmental stages of CEPs, accompanying them throughout their entire lifecycle.

Considering the diverse socio-geographical-legislative and market maturity levels across these 5 pilot regions, DISCOVER will follow a regionally specific approach with four local service hubs. On top of that, an interactive online tool will be designed to provide extensive support to local communities embarking on Renewable Energy Projects.

DISCOVER aims to simplify decision-making processes and reduce operational barriers by connecting projects with local service/technology providers and relevant authorities.

During the 3-year timeframe (2023 – 2026), DISCOVER is expected to reach more than 20,000 citizens, support 20 new initiatives (focusing on community PV installation), and trigger a total investment of more than 7.7 million euros. The project will promote and facilitate the recreation of future service hubs in other regions to ensure replication across other European regions.

The DISCOVER consortium stands as a collaborative force spanning over five European countries, each committed to driving the vision of CEPs within their respective region. The consortium comprises active national/ regional leaders in the CEP initiatives, well-connected to citizens, local authorities, and stakeholders.

2.2 Activities in WP4 “Implementation of Community Energy Services in pilot hubs”

The table below illustrates the activities implemented in this work package.

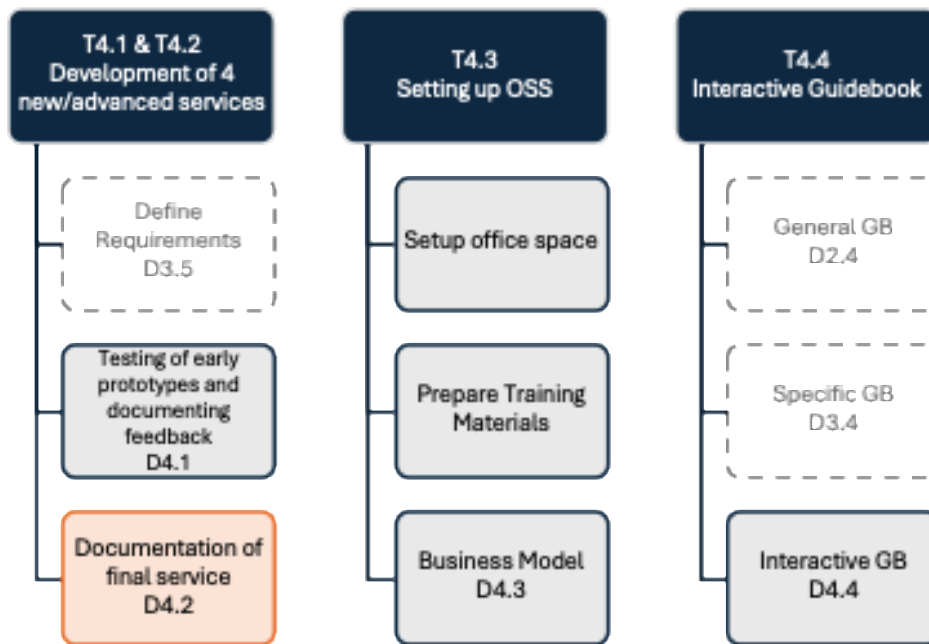


Figure 1: Overview of Activities and deliverables of WP4 (dashed boxes are precursors developed during previous WPs)

The goal of this work package is to establish four OSSs – one in each pilot region. Furthermore, testing and improving the already selected new/advanced services will be done, followed by the implementation of the interactive guidebook, a web version of the specific guidebook. The activities are carried out in close cooperation with key stakeholders, following the methodology for stakeholder engagement (D3.1). This guarantees that the services are developed according to the stakeholders' needs. There is one stakeholder selected as a development partner for each pilot region, who provides consultations during all stages of service development. Additional feedback is collected through questionnaires and organization of workshops. The stakeholder feedback is summarized in a stakeholder feedback report (D4.1 Summary of stakeholder feedback), based on which the services are improved. The finalized services are documented in this report .

The requirements for each new / advanced service are summarized before the development started and can be found in D3.5 “Requirements for new/advanced services”. Based on the stakeholder feedback, gathered during the development phase, refinement of the services and

their technical specification is expected. This methodology follows the lean-development process, which allows to continuously test early prototypes to guarantee a product market fit and optimizing developmental efforts. The core development activities include the collection of relevant information via desktop research and stakeholder involvement, the setup of methodologies, the technical development of tools and user experience (UX) improvements. The results are summarized within "Documentation of four newly developed services". Once fully developed, the services will be integrated into the interactive guidebook — a web platform that makes the specific guidebooks accessible online. This requires representing the CEP lifecycle on an interactive homepage. The results are summarized in the Extended Standardized Service Tool/Web-Platform (D4.4).

WP4 "Implementation of community services in pilot hubs" provides for the actual establishment of the local service hubs through activities aiming at setting-up the OSSs in the four pilot regions (office/room/hotline); development of the business model for each hub/OSS; preparing training materials and organization of trainings for experts who will work in the OSS; setting up a customized multilingual Moodle platform which will serve as a repository of the OSS documentation. The results of the establishment of the hubs are summarized in "Report on OSS business model" (D4.3).

3 Overview of the document

This report "***Documentation of four newly developed services***", results from **the activity related to "Advanced services development & testing"** of the project and, provides comprehensive documentation of the four newly developed services by the project partners APC, AGENA, WB, and IESDI under the coordination and methodological guidance of PIXEL.

3.1 Previous Work

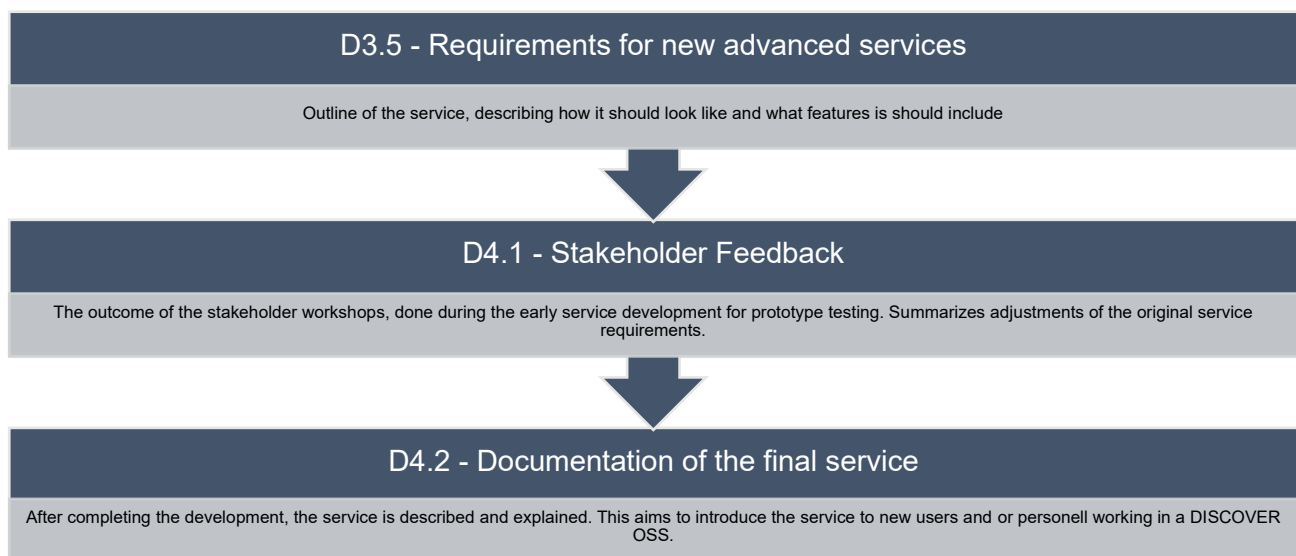


Figure 2: Roadmap of service development

Building on the foundation established in the report on “Requirement for new / advanced services” (D3.5) which outlined the initial service requirements, and “Stakeholder Feedback” (D4.1) which analysed stakeholder feedback, the present report offers a detailed description of each service. It reflects the iterative development process that incorporated input from the stakeholder consultations conducted as part of T4.1 “Workshops for stakeholder involvement”.

The document also demonstrates how stakeholder insights and recommendations have been systematically integrated into the final design of the services. The result is a set of enhanced, user-informed services that align with the stakeholders’ expectations.

3.2 Structure of the document

This document presents detailed specifications for four key services related to Community Energy Projects (CEPs), delivered by the pilot partners. It is organized into two main sections:

a) Section 1: A snapshot of the services

This section contains a graphical or visual overview introducing each of the four services

b) Section 2: Detailed specification of the services

This section contains essential information for all four services. Each service is described in a separate subsection, which includes the following chapters:

- **Detailed specification of the service**

Describes the title of the service, the service provider, the target customers, the motivation behind the service, the customer readiness requirements before using the service, detailed service description, expected results from the service, methods of service delivery, physical and web addresses, contact information.

- **Service Improvement after the stakeholder Consultations (T4.1):**

Describes enhancements made to the service after feedback collected during stakeholder consultations (T 4.1).

- **Limitations and Future Upgrades:**

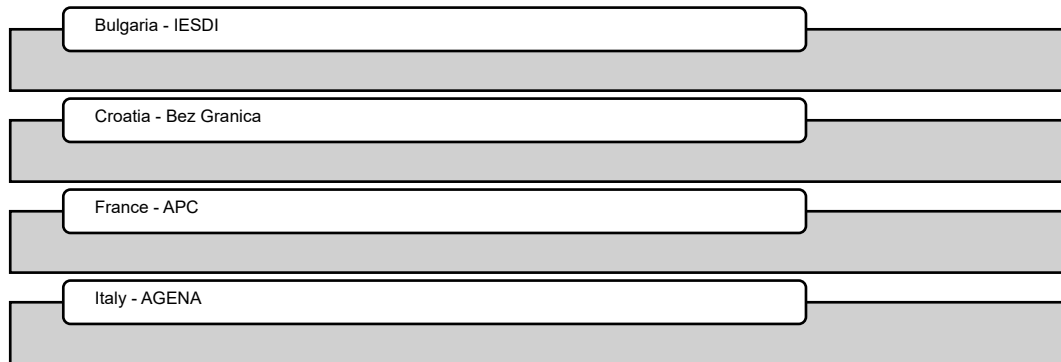
Discusses current service limitations and planned improvements.

- **Applicability to Other Pilot Regions:**

Evaluates the potential for transferring or adapting the service to different geographic or project contexts.

3.3 Snapshot of the service

The four new-advanced services developed in the DISCOVER project are:



They are introduced visually in the following chapter.

3.3.1 France

The French service is an analysis of PV projects, which is visualized as a block diagram (Figure 3), grouped in three phases:

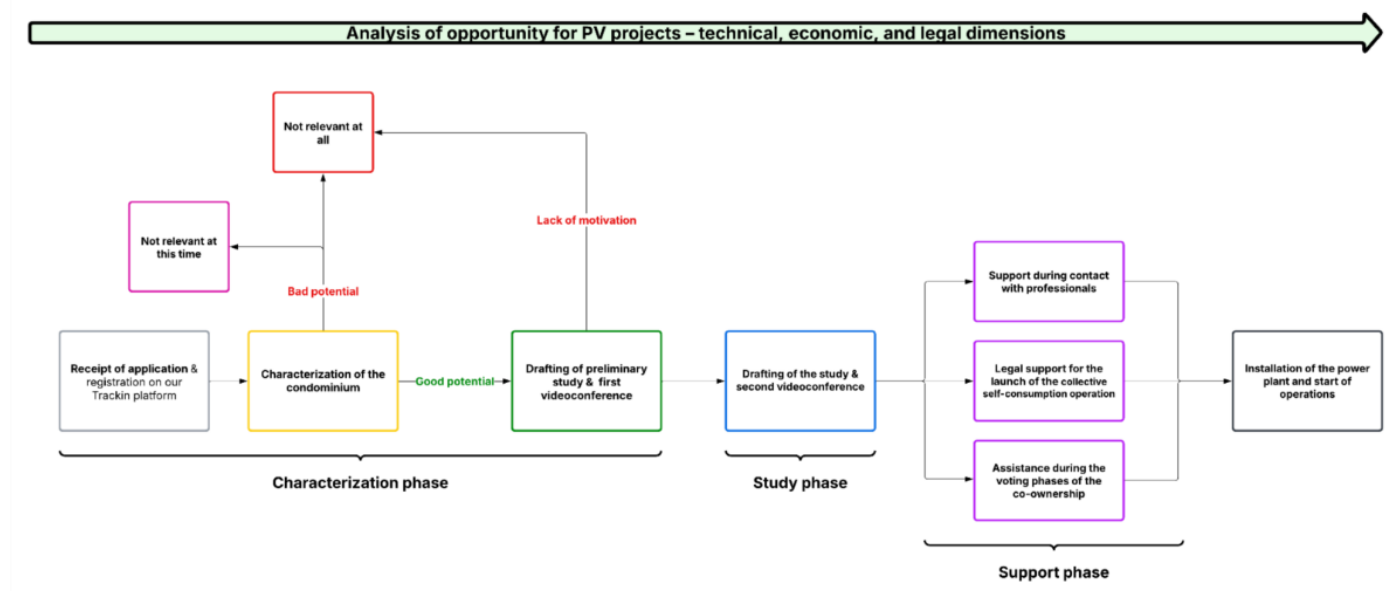


Figure 3: Visual overview of the service: Analysis of opportunity for PV projects – technical, economic, and legal dimensions, APC

3.3.2 Italy

The Italian service describes an assessment for CEPs and is visualized as a process diagram (Figure 4):

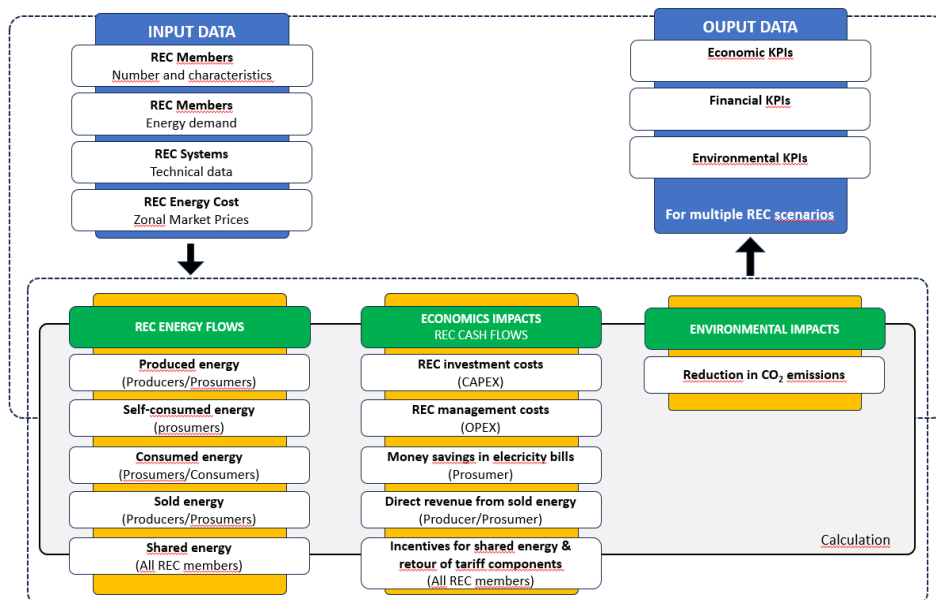


Figure 4: Visual overview of the service: Preliminary Technical – Economical Assessment for CEPs, AGENA

3.3.3 Croatia

Visual overview of the service: Energy Community Analysis and Simulation Services – ECASS, WB

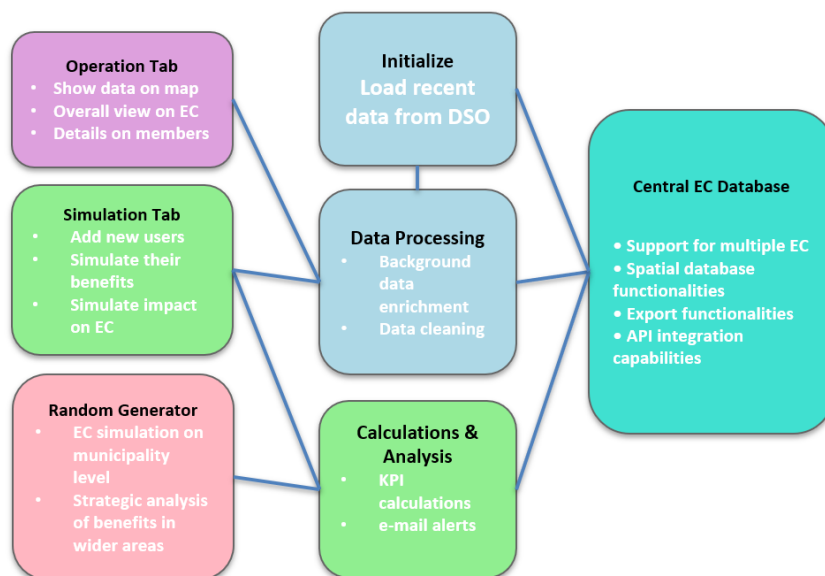
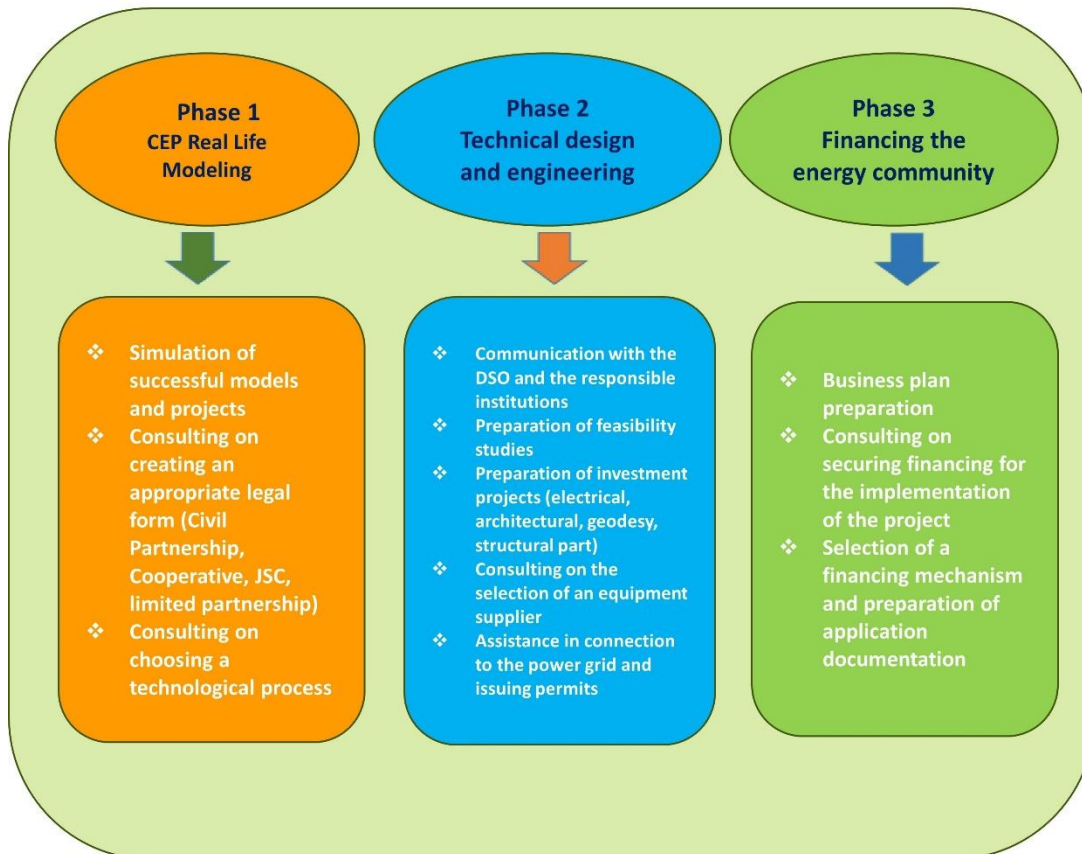


Figure 5: Visual overview of the service: Energy Community Analysis and Simulation Services – ECASS, WB

3.3.4 Bulgaria

The Bulgarian service includes technical and economic models for CEPs which support project initiators to define the business case for their project.



*Figure 6:
Visual
overview of
the service
CEP Real
Life
Modelling
(CEP -
RLM),
IESDI*

4 Detailed description of the services

4.1 France

4.1.1 Key points

Title of the service:	Analysis of opportunity for PV projects – technical, economic, and legal dimensions.
Service provider:	APC
Target:	▪ Main Users: Condominium representatives in Paris who intend to launch a PV project in their building, during the development phase of the CEP
Motivation:	▪ Lack of technical knowledge to evaluate rooftop PV potential for CEP (electrical production capacity, self-consume rate, rentability of PV project in comparison with its current energy contract, surplus' valorisation through a Collective Self-Consumption operation) ▪ Lack of capacity and motivation to finance pre-study by professional stakeholders without the guaranty of real project feasibility (need of a free of charge service to initiate project) ▪ Lack of trust for professional stakeholders at the beginning of a CEP project (need of a neutral and independent service to initiate the project) ▪ Lack of support to convince other co-owners at the council board and to prepare for a majority vote at a future general assembly (need for legitimate authority on the technic-economical-legal matter)
Customer readiness before using the service	To use the service, the user should have registered his condominium to our tracking platform Coach Copro (1 third of Parisian condominiums are now registered). He/She should have strong motivation to initiate a Community Energy Project. He/She must show it at least with fluid interactions and information sharing with APC.
Service description:	The service is delivered through a three-step process focusing on the five main aspects of a CEP PV project (technical, economic, architectural, legal, and social). The three stages are: ▪ The characterization phase, which focuses on the potential of a solar installation and the motivation of the condominium. This first stage concludes with the presentation of a preliminary study via a video conference with the project leaders.

	▪ The study phase, which focuses on a technical and architectural solution specific to the client. It also shows the profitability of this solution and the method of financing it. ▪ The support phase, where the informed client is invited to contact certified professionals to begin a project management design. Here, the service focuses on reviewing quotes, assisting with voting within co-ownerships, and providing specific legal support in the case of a collective self-consumption operation.
Results from the service:	The main aspect of this service is to demonstrate the relevance of PV project for a condominium and to promote its practical implementation. In addition, it must provide all the information and support necessary for the deployment of a legal and technical structure for a collective consumption operation. The service achieves satisfactory results when a client is supported up to the stage most relevant to their situation (e.g., for poor potential, a simple transfer of information; for very good potential, support until the installation is exploited). In this sense, the service always seeks efficiency in carrying out projects with no useless work for both sides.
Service Delivery Methods:	▪ Online: Support is provided through email exchanges, document transfers, and, above all, videoconference meetings at key stages. It is always necessary to submit a formal request for support online via email and by registering on our monitoring platform. ▪ In person: In advanced cases, the service is provided in person through meetings within the condominium (e.g. at general assemblies).
Physical address of the service:	3 rue François Truffaut 75012 - PARIS
Web address of the service:	Coach copro - Service public de la rénovation des copropriétés / www.apc-paris.com
Contacts:	photovoltaïque@apc-paris.com / +33 6 85 85 46 56

4.1.2 Solution

4.1.2.1 User experience

The APC is working to create a personalised support service for co-ownerships wishing to develop a CEP. This service delivers satisfactory results when it supports the user up to the stage most relevant to their situation.

The main aspect of this service is to demonstrate the relevance of a photovoltaic project for a co-ownership and to promote its practical implementation.

In addition, it must provide all the information and support necessary for the deployment of a legal and technical structure for a collective consumption operation.

The service is delivered through a three-step process focusing on the five main aspects of a CEP PV project (technical, economic, architectural, legal, and social). The three stages are:

- **The characterization phase**, which focuses on the potential of a solar installation and the motivation of the condominium. This first stage concludes with the presentation of a preliminary study via a video conference with the project leaders.
- **The study phase**, which focuses on a technical and architectural solution specific to the client. It also shows the profitability of this solution and the method of financing it.
- **The support phase**, where the informed client is invited to contact certified professionals to begin a project management design. Here, the service focuses on reviewing quotes, assisting with voting within co-ownerships, and providing specific legal support in the case of a collective self-consumption operation.

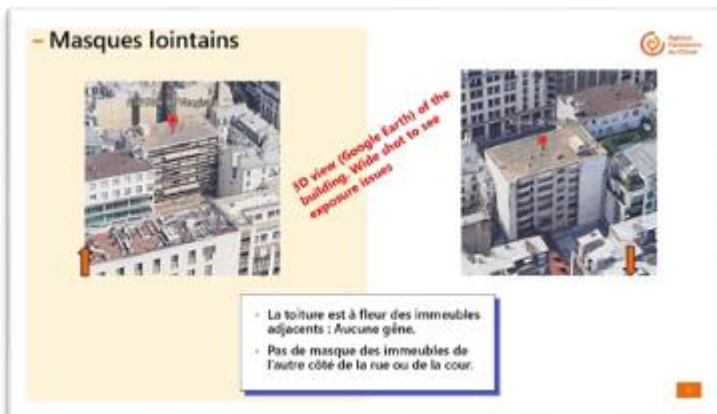
Support is provided through email exchanges, document transfers, and, above all, videoconference meetings at key stages to show our results. In advanced cases, the service is provided in person through meetings within the condominium.

To start the service, we ask the user to register its condominium to Coach copro platform if not already done. It will allow a tracking in the long run of the project duration.

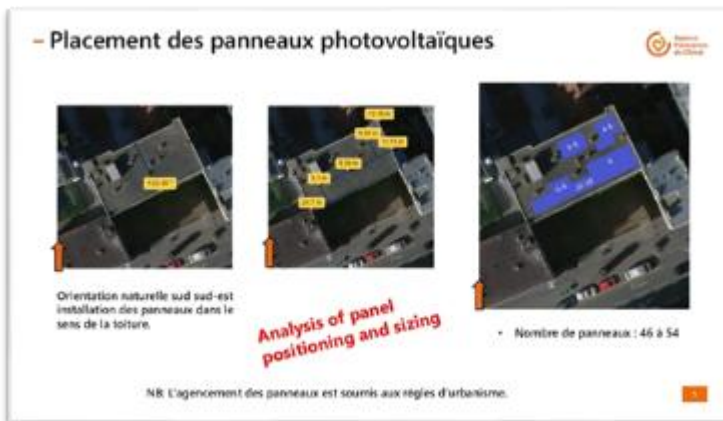
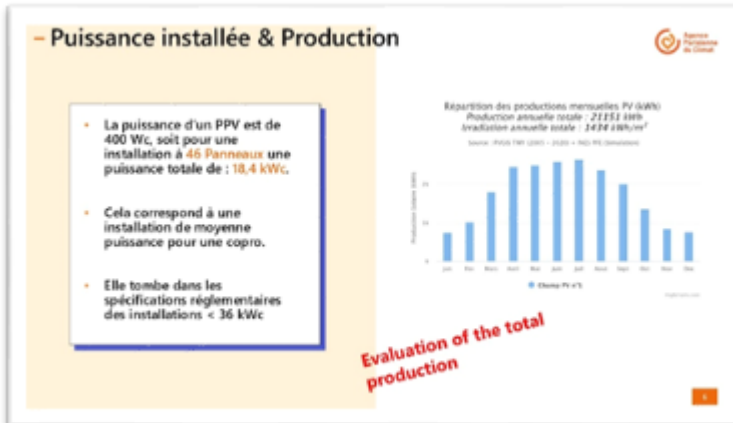
At the start of the service, the user sends a request to our contact email address. They specify their address, the progress of a photovoltaic project in their condominium, the purpose of the request and their situation within the condominium. This allows us to assess the level of expertise required.



Generally, extensive support is required. We then move on to the characterisation phase. Using satellite images of the condominium's roof, we analyse the roof's exposure (1).

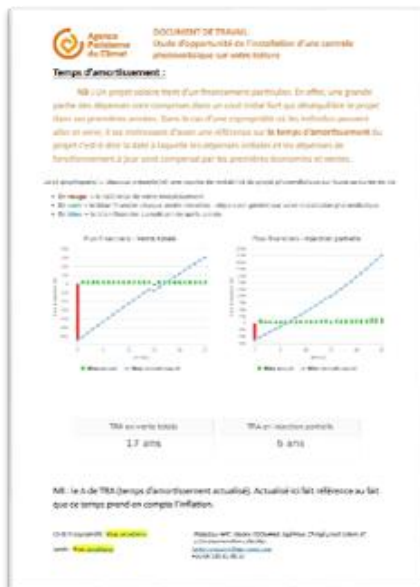


Then, using commercial photovoltaic analysis software, we can estimate the solar production potential of the condominium (2).



These initial results lead to the presentation of a preliminary study and a video meeting with the client.

Subsequently, if the project appears to have sufficient production potential, we start the study phase. APC collects the condominium's load curves to study the most appropriate operating strategy (self-consumption, collective self-consumption etc). This detailed analysis also allows us to analyse the financial viability of the project in detail. Finally, APC also seeks to propose an architectural solution in line with the building and Parisian heritage conservation requirements (3).



This study phase results in the transmission of a comprehensive document that serves as a basis for discussion between professionals and the client.



As a final step, the support phase of our service focus on accompanying project leaders directly to their condominium council board or general assembly to have the project validated and enable its concrete implementation. APC also provide legal advice in the case of collective self-consumption operations.

This support at the general meeting represents the final major output of our assistance, although we can continue to provide support during the investment construction or operation phase of the photovoltaic power plant upon request.



4.1.2.2 Logic

The implementation and continuous improvement of the advanced service is the result of work hidden for its users, at each stage of Discover project.

First, a desktop research on existing services and initiatives for photovoltaic and CEPs in city centres is done (WP2). APC also documented existing PV plants on Parisian rooftops and got in touch with several companies in Paris.

APC had extensive interviews with a wide range of professionals and institutions about the hurdles and levers for CEPs in Paris (WP3).

Workshops with several stakeholders were held to get feedback on the first draft of the service (WP4).

Part of the user interface and the management of the service rely on our Coach Copro tool (tool developed internally since 2013). We propose a human interface to users through video-conferences and eventually in presence contact.

Technical and economic simulations are performed with the publicly developed software, AutocalSol (€300/year license), based on initial data about the building and the PV project.

Besides neutral mediation offered for free, the analysis results in three data-sets: public solar cadastre and AutocalSol simulations to evaluate potential for PV production, a building and community characteristics to evaluate their energy needs, and, if possible, their private load curves to evaluate their consumption profile and match them with production.

4.1.3 Limitations

Firstly, APC service does not yet cover deeply certain essential aspects of project development. Support with financial and legal arrangements is currently too limited, particularly in the case of collective self-consumption operations. Similarly, as the CEP program in Paris is still in its early stages, the feedback we have received on architectural validation by the city authorities does not allow us to take a proven approach to these issues.

This results in a potential disconnect between our (a preliminary feasibility-analysis) service, which is too theoretical, and the actual feasibility study of a project once it is confronted with other professional and administrative stakeholders.

Furthermore, the service is stopping when co-owners decide to pay for a professional study and when a new actor comes in. Without preparation for this transfer of the project to the user, there is a risk that it will be abandoned. Due to the need to guarantee its independence and neutrality, APC service cannot be extended too far on this matter. The co-owners must decide for themselves on the choice of professional and the management of their installation.

This leads to a very tedious pre-project support process that cannot guarantee the success of the latter. Thus, it will be difficult for us to maintain this hybrid strategy without risking either undertaking a lot of unnecessary work or missing out on projects due to a lack of continuity in support. It will undoubtedly be necessary to choose between two strategies, either limiting ourselves to facilitate initiatives with a lighter support, or going as far as integrating comprehensive project development assistance alongside our current expertise.

Parallel to our user-related strategy, APC action also expands into promoting the registration of professionals to the Coach Copro chartered list and the definition of standard expectations from professionals. The tool will also offer quote analysis on demand. APC team is already familiar with such professional mediation in the neighbouring realm of energy renovation projects.

APC service focuses on supporting condominiums. This specificity of target responds to a typical need of a dense, urban city centre like Paris, and it is very likely to arise in other pilot regions or among public stakeholders. However, outside this specific context, the service suffers from this focus, which hinders its replicability in supporting other types of project stakeholders. Paris is a City particularly subject to social and architectural integration challenges. Many historical, dense urban centers in France and Europe could benefit from our experience and service. However, this hinders greatly its applicability in cities with only a small amount of condominiums among their residential stock, and in rural areas.

4.2 Italy

Preliminary Technical – Economical Assessment for CEPs, AGENA

4.2.1 Key points

Service-Title	Preliminary Technical – Economic Assessment for CEPs
Service provider	AGENA
Problem-Statement	CEP initiators face several challenges when starting the process. Municipalities, in particular, struggle with limited economic and human resources. They show lack of understanding, regarding the sustainability of investing in PV and sharing energy among the local authority, citizens, SMEs, which often prevents CEPs from moving forward at an early stage.
Motivation	This new/advanced service attempts to solve this problem. The idea is to provide CEP initiators for a powerful decision support tool, in order to support them in developing a preliminary economic assessment of the project's profitability based on an evaluation of the expected environmental, economic and financial benefits for the whole community and for each member.
Value Proposition	Thanks to its commercial independence and neutrality, AGENA provides unbiased support, free from market-driven influences, allowing stakeholders to make informed decisions with full confidence. Moreover, the new/advanced service is fully developed in –house and it allows its tailored consulting services, offered free of charge, guarantee personalized guidance that meets the specific needs of each customer, further strengthening trust and delivering strategic value. One of the main advantages of having a tool developed entirely in-house is the full transparency and control over all the parameters and assumptions used in the simulations. This ensures that every step of the calculation process is understandable, traceable, and adaptable to the specific needs of users. Moreover, an in-house solution offers the flexibility to quickly adapt to changes in legislation or regulatory frameworks, which is particularly important in the dynamic context of renewable energy communities. Finally, the tool can be continuously improved and refined based on user feedback, allowing for progressive enhancements in both functionality and usability, while ensuring that the simulator remains aligned with real-world requirements and evolving best practices.
Expected Outcome	The preliminary technical-economic assessment provides clarity on the estimated costs and benefits over the CEP's lifespan, enabling project initiators to make informed investment decisions. It will compare different financing models to help identify the best business model for the project. The results will be provided in the form of a report. Financing models: 1.PV plant fully funded by members 2.PV plant funded through a bank loan 3.PV plant funded by a third party (e.g.ESCO or utility) 4.PV plant built using NRRP funds

Target user	This service can be used by different stakeholders: municipalities, citizens, religious entities, SMEs, condominiums and Community Energy Project (CEPs) initiators in general, especially during the planning phase of a CEP life cycle.
Prerequisites for using the service	Before using this service, the user needs to: Authorize AGENA to start the development phase and give access to energy consumptions/ energy bills through https://www.consumienergia.it/portaleConsumi/ - Or alternatively, direct provide energy consumptions data. If the user already has a photovoltaic system project, they should provide the technical specifications of the plant (e.g., installed capacity, orientation, tilt, location). Additionally, the user may be asked to provide: • Information on available roof or land surfaces suitable for installing new PV systems. • The preferred financing model (self-investment, bank loan, third-party financing, public incentives). • Legal/organizational preferences regarding the possible configuration of the community.
Service Accessibility	The service is accessible to CEP initiators in the province of Teramo The service is provided as personal consultancy at AGENA's offices, Piazza Garibaldi 56, 64100 Teramo (TE)/telephone support: 0861-241208 E-mail: discover.cer@agenateramo.it The service is run by AGENA's technical staff (3 people). Additionally, the service will be available online as part of the interactive guidebook in the next months.

4.2.2 Solution

4.2.2.1 User experience

An Excel-based simulation tool has been developed to evaluate the technical, economic, and environmental feasibility of establishing Renewable Energy Communities (RECs) and Collective Self-Consumption (CSC) configurations. The simulator is entirely developed in-house and fully aligned with current Italian legislation.

Structure of the Tool

The simulator is composed of 12 interconnected worksheets:

- 2 Input sheets: *Input REC, Input Members*
- 3 Output sheets: *Overall Final Financial Framework, Final Financial Framework per Member, Printable Summary Sheet*
- 7 Calculation/Support sheets used for intermediate elaborations.

Input Data Requirements

1. REC configuration data (Input REC):

- General details (configuration name, type, address, location).
- Configuration costs (legal entity establishment, smart meters, monitoring platform, annual association fees).
- CAPEX and OPEX data for plant installation and operation.
- Rules for the distribution of revenues among members.



DATI GENERALI	
Denominazione della Configurazione	CER CASTELLI
Tipologia di configurazione	CER
Data costituzione	
Indirizzo completo + CAP	Piazza Roma, 13 - 64041
Comune	Castelli
Provincia	Teramo Central Italia
Utilizza Fondi PNRR (40%)	SI
Verifica preliminare GSE	NO
Costi della configurazione	
Base calcolo	tar. Premi ARERA
Quota di utilizzo %	10
Quota forn. Serv. %	15
Re-distribuzione %	85
	2025 anni success.
Cartificavi imputabili alla CER [%]	0 0
Cartificavi imputabili a Praturerz, Praturerz e	100 100
Quota parte da imputare a Praturerz e Praturerz [%]	0 0
Quota parte da imputare a Canurmerz [%]	100 100
Restitut. Componenti tariffarie (2025)	
Trasmisione (CER + GAC) [€/MWh]	10,57
Distribuzione (GAC) [€/MWh]	0,65
Perdite dirette evitate (GAC) [%]	2,6 BT
Degradamento caratteristico tecnico Impianti [%]	0,4
Data simulazione	24/09/2025

2. Members data (Input Members):

- a. Number and category of members (producers, prosumers, consumers).
- b. Energy demand of each member (annual consumption, or, if available, monthly and time-of-use breakdown). Consumption data obtained either from *standard load profiles* (i.e. residential, schools, offices) or directly from electricity bills.
- c. Standard load profiles are sourced from **ARERA's provincial-level database**.



AGENA
AGENZIA PER L'ENERGIA
E L'AMBIENTE
DELLA PROVINCIA DI TERAMO



DATI GENERALI

Tipo membro

Nome membro

Tipo utenza

Pot. elettrica impegnata al contatore [kW]

Consumo annuale [kWh]

Numero POD

Presenza impianto di condizionamento

RIPARTIZIONE PERCENT. DEI CONSUMI

	Ripartiz. per stagione	Valori da		Ripartiz. per fasce	Valori da
		letteratur			letteratur
Primavera	0,2	0,20	F1	0,3	0,3
Estate	0,15	0,15	F2	0,35	0,35
Autunno	0,25	0,25	F3	0,35	0,35
Inverno	0,4	0,40			
		inserisci (M1)			inserisci (M2)

3. Technical data of new photovoltaic (PV) plants:

- a. Installed peak power, location, solar irradiance, tilt.

DATI IMPIANTO			
Orientamento [°]	Sud ↓	Funzionamento nomin. [h/anno]	1250
Inclinazione [°]	>=30° ↓	Prod. compless. [kWh/anno]	22500
Potenza di picco [kW]	18	Prod. incentivabile [kWh/anno]	22500
Quota d'obbligo [%]	0 ↓	Costo complessivo impianto (€)	27.000,00
Costo max al kWp PNRR [€/kWp]	1500 Inserisci (M3)	Quota a carico PNRR (€)	10.800,00
Utilizzo fondi PNRR	SI	Quota a carico CER (€)	16.200,00
Fondo PNRR domanda allaccio e connes.		calcola (M4) cancella (M5)	
Costo connes. ENEL (€)			
Membro soggetto a tassazione?	NO ↓		
Ammortamento	NO ↓		
Durata ammortamento [anni]	0 ↓		
Quota debito [%]	0 ↓		
Durata debito [anni]	0 ↓		
Tasso interesse [%]	0 ↓		
Tassazione RID [%]	0 ↓		
Tassaz. energia condivisa [%]	0 ↓		

Energy Flow Calculations

Based on user inputs, the simulator estimates:

- Clean energy produced by PV systems.
- Self-consumed energy by prosumers.
- Energy demand of consumers and prosumers not met by PV production.
- Surplus energy injected into the grid and sold to the GSE.
- Energy withdrawn from the distribution grid by REC members.
- Shared energy calculated hourly (average hour of the period considered) as the minimum between surplus injected and simultaneous withdrawals.

Economic Analysis

The simulator performs a **comprehensive cost–benefit analysis** by accounting for:

Costs:

- Establishment of the legal entity.
- PV plant construction (CAPEX), including grid connection.
- Operation and maintenance (OPEX).

- Platform management for real-time monitoring (optional).
- Administrative and legal management costs (including GSE fees).
- Other operational costs (e.g. land lease, third-party fees).
- Financial charges (in case of debt financing).
- Taxation depending on legal form.

Revenues and Savings:

- Sale of surplus electricity to the grid (Dedicated Withdrawal - RID).
- Monetary savings from physical self-consumption.
- Incentives on shared energy, in accordance with MASE (Ministry of Environment and Energy Security) regulations.
- Return of tariff components (transmission, distribution, avoided grid losses) on shared energy.

Surplus energy revenues are calculated using **hourly zonal prices** from the GSE Design Reference Year dataset (2024). Incentives on shared energy (Feed-in Tariff Payable – FITP) are calculated according to the **CACER Decree**, with values depending on plant size, market prices, and geographical location.

Financing Models and KPIs

The tool allows the evaluation of four financing scenarios:

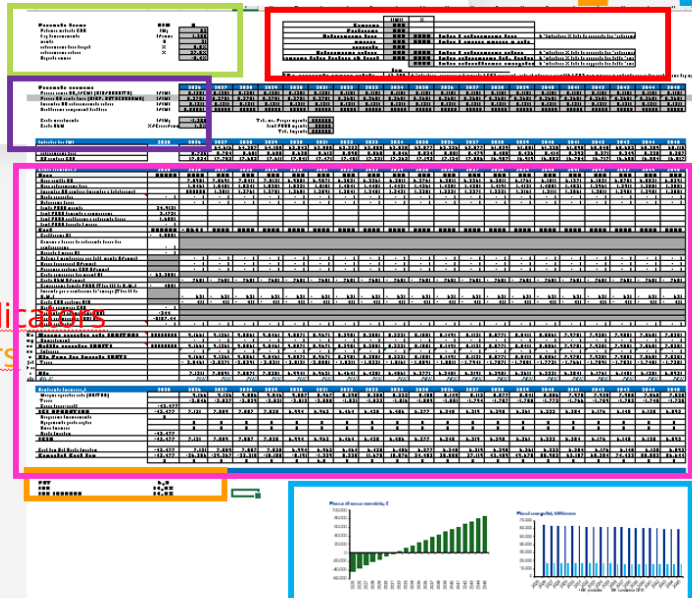
1. Full equity investment by members.
2. Bank loan financing.
3. Third-party investment (ESCO/utility model).
4. Public financing (e.g. NRRP funds).

The simulator estimates key financial and energy indicators:

- **Economic KPIs:** Net Present Value (NPV), Internal Rate of Return (IRR), Payback Period (PBP).
- **Energy and Environmental Indicators:** Physical Self-Consumption Index, Virtual Self-Consumption Index, Total Self-Consumption Index, Energy Self-Sufficiency Index, Annual CO₂ Emissions Avoided.

OUTPUT SHEETS

- **Technical parameters**
- **Economic parameters**
- **Energy and environmental indicators**
- **Financial – economic indicators**
- **Energy and economic flows**
- **Cash flows over 20 years**



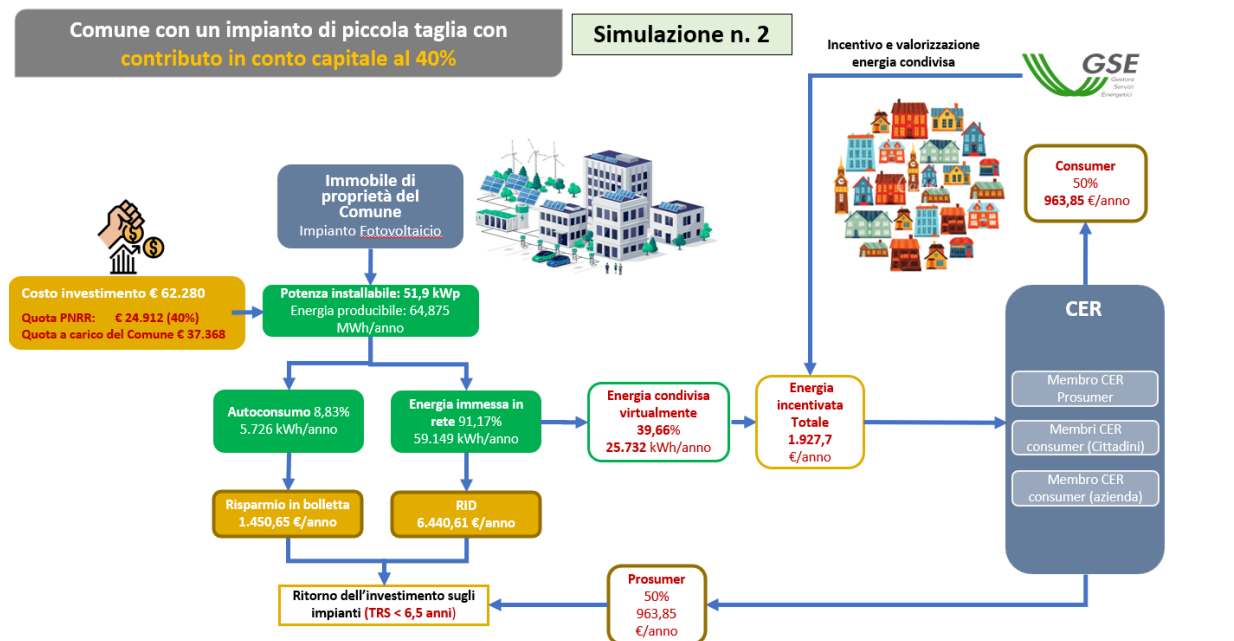
Output and Results

The user receives a **printable summary sheet** including:

- General REC configuration data.
- PV plant technical specifications.
- Energy flows (production, self-consumption, grid injection).
- Economic, energy, and environmental KPIs.
- A **legend** explaining KPIs in non-technical language.
- An **intuitive flow chart** to visualize both energy and financial flows.

Scheda Riepilogo		Simulazione n. 2	
1 - Dati generali configurazione			
Tipologia di configurazione:	CER		
Comune:	Castelli (TE)		
Numero totale membri:	21		
Numero producer/s prosumers:	1		
Numero consumer/s:	20		
Consumi annuali totali (kWh/anno)	82.291		
2 - Caratteristiche generali impianto/i fotovoltaico/i			
Numero impianti FV:	1		
Potenza complessiva (kW):	51,9		
Produttibilità annua complessiva (kWh):	64.875		
Finanziamento ente terzo:	NO		
Contributo PNRR:	SI		
3 - Risultati attesi			
Consumi (kWh/anno)	82.291		
Produzione (kWh/anno)	64.875		
Autoconsumo fisico (kWh/anno)	5.726	8,83%	1)
Energia immessa in rete (kWh/anno)	59.149	91,17%	2)
Energia prelevata dalla rete (kWh/anno)	76.565		
Autoconsumo virtuale (kWh/anno)	25.732	39,66%	3)
Autoconsumo totale (virtuale più fisico - kWh/anno)	31.459	48,49%	4)
Indice di autosufficienza energetica		38,22%	5)
CO2 equivalente evitata per anno:	17,381 t		
4 - Indicatori di fattibilità economico - finanziaria			
Tempo di ritorno dell'investimento (PBT)	< 6,5		6)
Valore attuale netto (VAN)	60.508,60		7)
Tasso interno di rendimento (TIR)	14,70%		8)

Legenda	
1) Indice di autoconsumo fisico:	è l'indicatore % dato dal rapporto tra l'autoconsumo fisico e l'energia elettrica prodotta dagli impianti facenti parte della comunità. Maggiore è tale rapporto maggiore sarà la quota parte di energia prodotta dagli impianti auto-consumata presso il medesimo POD ove è ubicato l'impianto e che quindi determina un risparmio diretto in bolletta.
2) Indice di energia immessa in rete:	è la percentuale di energia prodotta e immessa in rete
3) Indice di autoconsumo virtuale:	è l'indicatore % dato dal rapporto tra l'autoconsumo virtuale e l'energia elettrica prodotta dagli impianti facenti parte della comunità. Maggiore è tale rapporto maggiore sarà la quota di autoconsumo virtuale all'interno della comunità che contribuisce all'incentivo erogato dal GSE.
4) Indice autoconsumo tot. (virtuale più fisico):	è l'indicatore % dato dal rapporto tra tutta l'energia auto-consumata (dato dalla somma di autoconsumo fisico ed autoconsumo virtuale) ed energia elettrica prodotta dagli impianti facenti parte della comunità.
5) Indice autosufficienza energetica:	è l'indicatore % dato dal rapporto tra tutta l'energia auto-consumata (dato dalla somma di autoconsumo fisico ed autoconsumo virtuale) e consumo elettrico dei membri (sia prosumer che consumer) presenti all'interno della comunità. Maggiore è tale rapporto maggiore sarà la virtuosità della comunità energetica dal punto di vista ambientale.
6) PBT:	è l'indicatore che consente di calcolare il tempo entro il quale il capitale investito viene recuperato attraverso i flussi di cassa netti generati. In presenza di investimenti alternativi, il Pay Back Period porterà a scegliere come opzione quello con un "periodo di recupero" più breve, in quanto da tale momento in poi, l'investimento contribuirà alla formazione di utili lordi.
7) VAN:	è l'indicatore che consente di stabilire il valore corrente di un investimento. È ottenuto dalla differenza tra il flusso di cassa totale scontato e un investimento corrente. Se il risultato è positivo, l'investimento è profittevole. In caso contrario, il calcolo darà un risultato negativo.
8) TIR:	è il tasso di attualizzazione che rende nullo il valore attuale di un investimento.



*I valori indicati sono annui e sono riferiti alla media di 20 anni

4.2.2.2 Logic

Behind the simulator lies a significant amount of research, development, and validation work that the user does not directly see, but which ensures the accuracy and robustness of the results.

Research Performed

- In-depth analysis of Italian legislation and regulatory frameworks governing Renewable Energy Communities (RECs) and Collective Self-Consumption (CSC).
- Study of economic mechanisms, including feed-in tariffs, incentives on shared energy, and tariff component returns as defined by ARERA and GSE.

Potenza nominale kW	Tariffa fissa definita in base alla potenza dell'impianto	Tariffa variabile in funzione del Prezzo Zonale	Tariffa massima fonti non fotovoltaiche	Tariffa massima totale impianti FTV		
				Sud	Centro	Nord
P ≤ 200	80 €/MWh (+ comp. geografica per FTV)	0 - 40 €/MWh	120 €	120 €	124 €	130 €
200 < P ≤ 600	70 €/MWh (+ comp. geografica per FTV)	0 - 40 €/MWh	110 €	110 €	114 €	120 €
P > 600	60 €/MWh (+ comp. geografica per FTV)	0 - 40 €/MWh	100 €	100 €	104 €	110 €

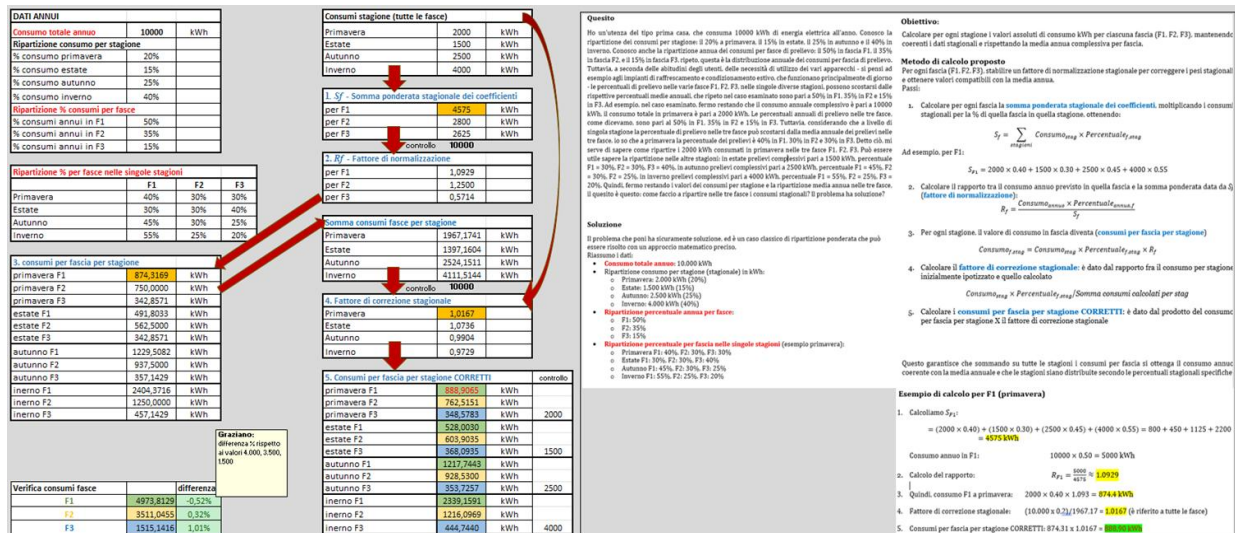
VALORIZZAZIONE	1  CER		2  GRUPPO DI AUTOCONSUMATORI	
	TRASMISSIONE		10,57 €/MWh	
	DISTRIBUZIONE		0,65 €/MWh ¹	
	PERDITE DI RETE EVITATE		1,2% in MT e 2,6% in BT del prezzo zonale di mercato ¹	

Algorithms Developed

- Custom algorithms for the hourly calculation of shared energy, based on the minimum between surplus injected and simultaneous withdrawals.
- Models for energy balancing between producers, prosumers, and consumers under different operational conditions.

The tool performs the breakdown of total annual consumption by season and time-of-use bands. If detailed data are available, they can be entered directly; otherwise, the tool proposes reference values derived from databases and literature sources.

In addition, the tool enables the balancing of average annual withdrawals by time-of-use band, on a season-by-season basis. The diagram below illustrates the underlying logic.

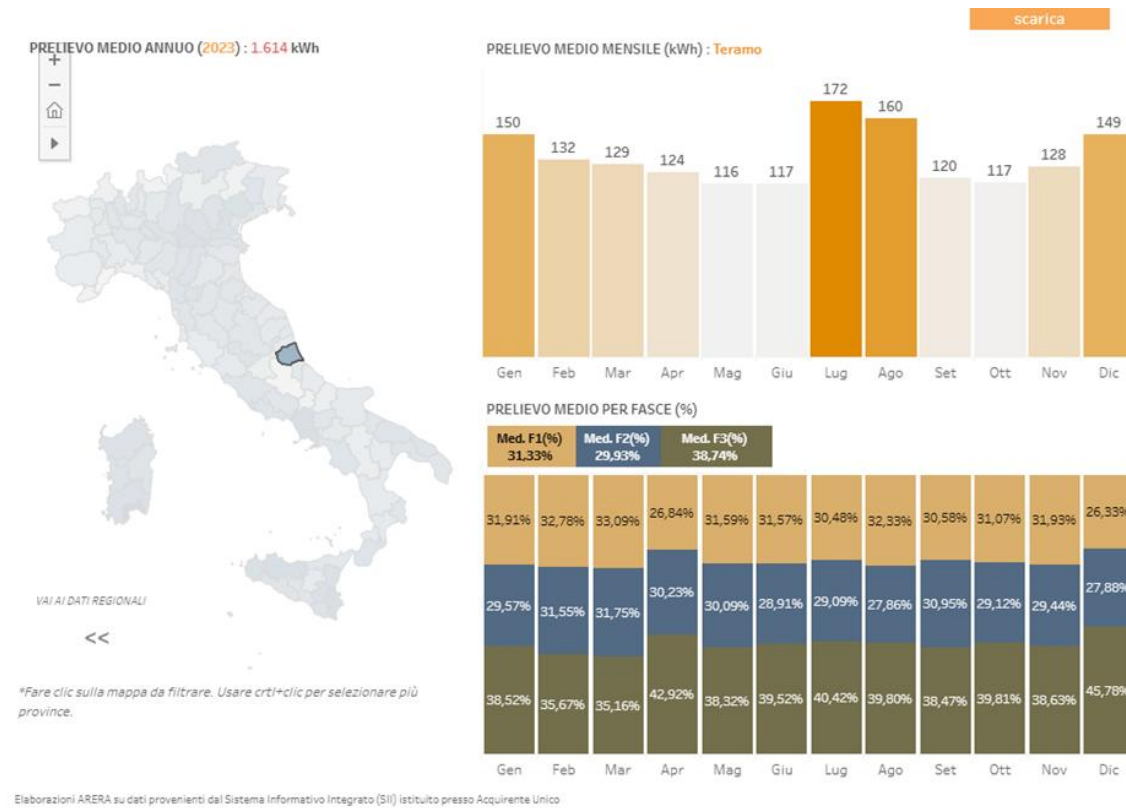


- Economic evaluation algorithms to calculate NPV, IRR, PBP, and other KPIs, ensuring comparability between scenarios.

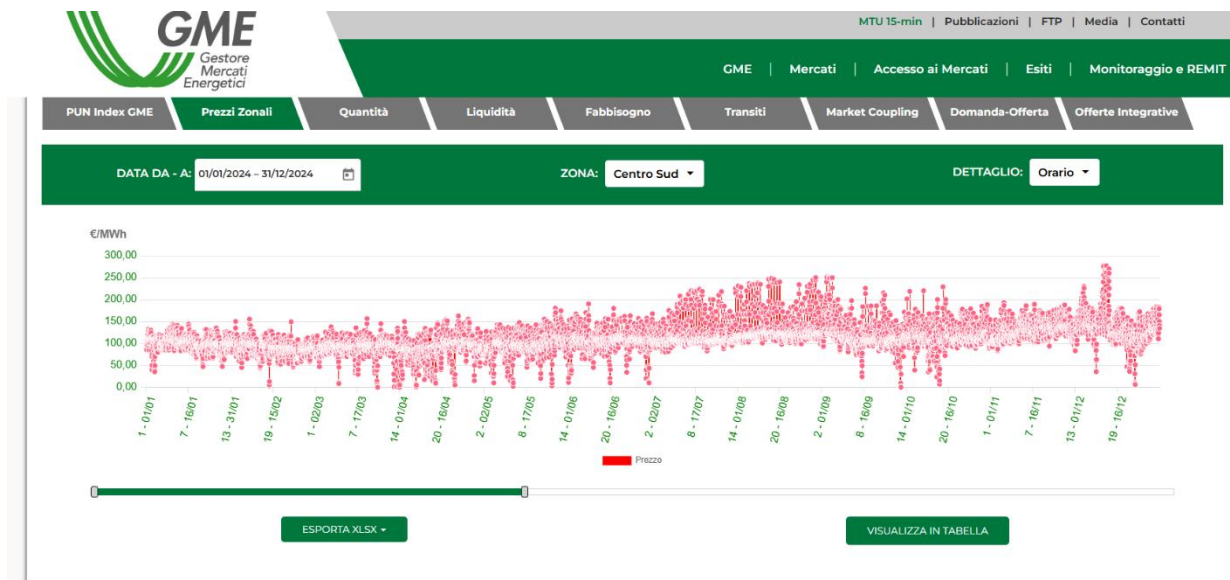
Datasets Used

Standard load profiles (residential, schools, offices) provided by ARERA, with provincial granularity.

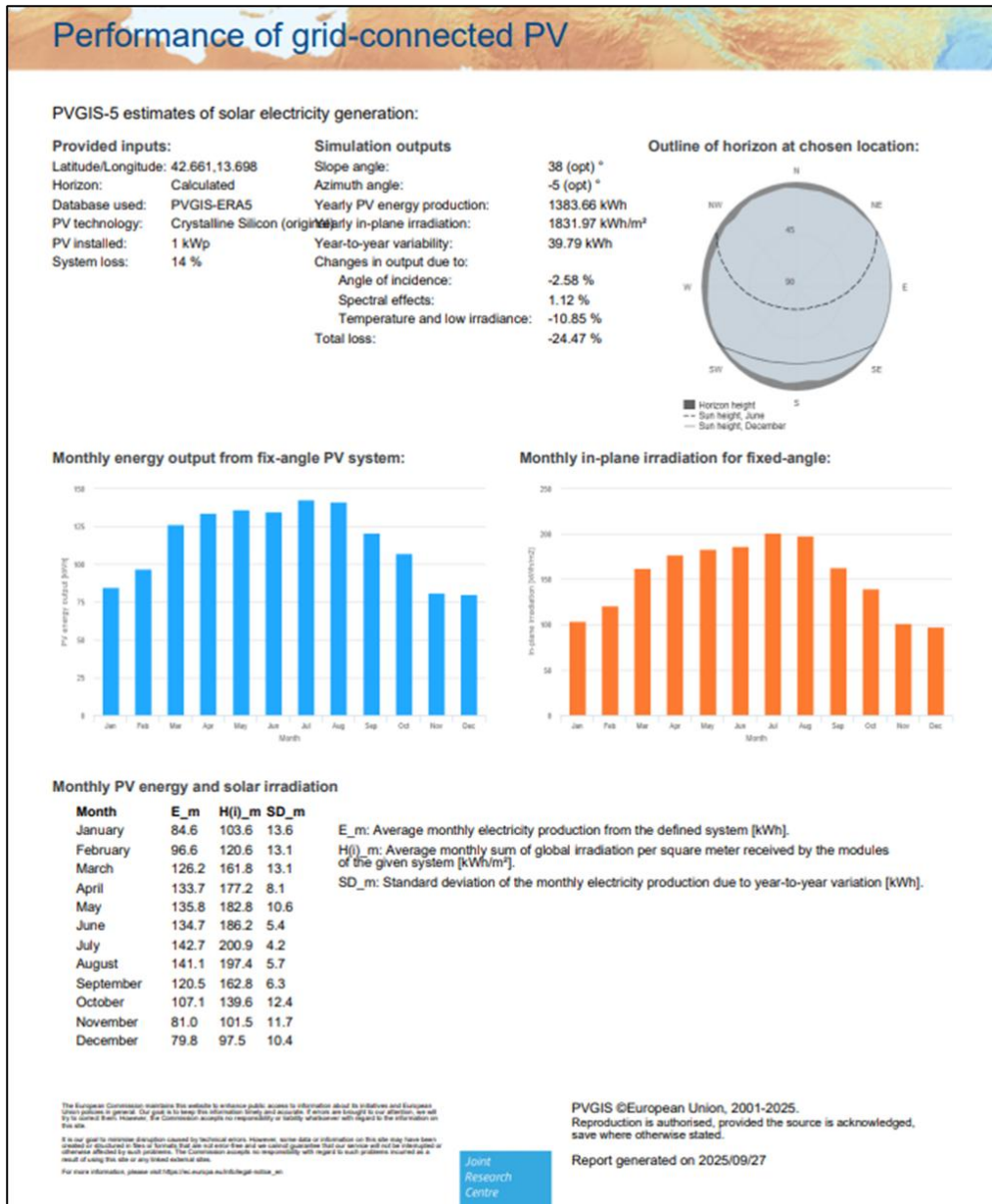
Example for residential user:



Historical hourly zonal price datasets (2024) from GME for Central- South Italy



Meteorological and irradiance datasets for PV system simulation, ensuring location-specific energy production estimates from PVGIS. We consider data for the city of Teramo as representative of all the territorial province.



Regulatory datasets defining **incentive schemes**, **tariff structures**, and **grid cost components**, updated annually by ARERA.

2024-2027

Categorie contrattuali di cui all'articolo 2 del TIT 2024-2027 (Allegato A della deliberazione 27 dicembre 2023, 616/2023/R/eel)	TRAS _p		TRAS _ε	
	Anno 2024	Anno 2025	Anno 2024	Anno 2025
	centesimi di euro/kW per anno		centesimi di euro/kWh	
Utenze in bassa tensione di illuminazione pubblica	-	-	1,057	1,189
Utenze in bassa tensione per alimentazione infrastrutture di ricarica pubblica di veicoli elettrici	-	-	1,057	1,189
Altre utenze in bassa tensione	-	-	1,057	1,189
Utenze in media tensione di illuminazione pubblica	-	-	0,989	1,113
Altre utenze in media tensione	-	-	0,989	1,113
Utenze in alta tensione	2.824,58	3.026,39	0,068	0,076
Utenze in altissima tensione, con tensione inferiore a 380 kV	2.824,58	3.026,39	0,067	0,076
Utenze in altissima tensione, con tensione uguale o superiore a 380 kV	2.824,58	3.026,39	0,067	0,076

Together, these components form a **robust, flexible, and transparent engine**, ensuring that the service delivers reliable results while being adaptable to future regulatory changes and user feedback.

4.2.3 Limitations

The calculation tool has been designed to be flexible, allowing users to input specific values whenever available; however, it has some limitations:

1. **No battery storage:** Currently, the simulator does not account for battery systems, which could be used to increase the amount of physical self-consumption for connected users.
2. **Limited consumption profiles:** Available profiles are restricted to primary residences, secondary residences, offices, schools and commercial. Industrial, or agricultural users are not included.
3. **Geographically specific input data:** Input data currently refer to the province of Teramo, though the tool can be extended to other Italian regions by expanding the underlying database.
4. **Generic tax component:** Taxation depends on the legal form of the community; a default value is provided, but it is the user's responsibility to supply the correct rate according to their specific situation.
5. **Simplified economic assumptions**
6. **PV production estimates:** These are based on irradiance datasets for the city of Teramo; additional granularity would improve accuracy.

7. **Network constraints not modelled:** The tool does not account for local grid limitations.
8. **Evolving regulatory and incentive frameworks:** Since regulations and incentives for Renewable Energy Communities are subject to change, the tool may require periodic updates to remain fully compliant.
9. **Incentives considered:** The tool only includes the PNRR contribution and the 50% Bonus for individuals as relevant incentives for the business plan evaluation.
10. **Simplified O&M costs:** A fixed percentage is applied without distinguishing between ordinary and extraordinary maintenance over the 20-year lifespan of the system.

4.3 Croatia

Energy Community Analysis and Simulation Services – ECASS, Without Borders (WB)

4.3.1 Key points

<i>Service-Title</i>	Energy Community Analysis and Simulation Services (ECASS)
<i>Service provider</i>	Without Border (Bez granica)
<i>Problem-Statement</i>	CEP initiators and operators lack real-time monitoring tools and predictive capabilities to manage energy communities effectively. They struggle to demonstrate potential benefits to prospective members, optimize energy sharing arrangements, and make data-driven decisions about expanding their communities. Without integrated tools combining operational data with simulation capabilities, OSS operators cannot provide evidence-based recommendations.
<i>Motivation</i>	ECASS was developed to bridge the gap between theoretical energy community concepts and practical operational management. The service enables OSS operators to monitor existing communities in real-time, simulate the impact of new members, and generate scenarios for community expansion—all through an intuitive web interface that requires no specialized technical knowledge.
<i>Value Proposition</i>	ECASS provides a comprehensive, integrated platform that combines: (1) Real-time operational monitoring with weather-correlated analysis, (2) Member-by-member performance tracking with economic calculations, (3) Interactive map-based simulation for prospective members, (4) Automated financial analysis comparing grid-only vs. community scenarios, (5) Random community generation for capacity planning. All calculations use real meteorological data from Open-Meteo API, ensuring accuracy based on actual solar irradiation rather than theoretical estimates.
<i>Expected Outcome</i>	Users receive comprehensive energy balance reports showing production/consumption by member and tariff (VT/NT), financial analysis comparing costs with and without community participation, visual dashboards with interactive graphs and maps, simulation results for prospective members including location-specific solar production estimates, downloadable Excel reports for stakeholder presentations, and community expansion scenarios with randomly generated member profiles for capacity planning.
<i>Target user</i>	OSS operators managing energy communities, CEP initiators evaluating expansion opportunities, municipalities planning community energy investments, energy consultants advising clients on community participation, and existing community members seeking to understand their energy balance and financial benefits.
<i>Prerequisites for using the service</i>	Users need: access credentials to the ECASS platform, basic understanding of energy community concepts, member data including meter IDs and locations (lat/lon coordinates), historical energy consumption/production data stored in the SQL database, internet connection for accessing real-time weather data, and for simulations: location coordinates, estimated PV capacity, and monthly consumption estimates for prospective members.

Service Accessibility

The service is accessible as a web-based Streamlit application hosted by Bez granica. It supports multiple energy communities across Croatia and other DISCOVER pilot regions. The platform operates continuously with weekly data refresh cycles. Contact: damir.medved@bezgranica.hr. Technical support available through the OSS network. Access URL provided to authorized OSS operators and community managers.

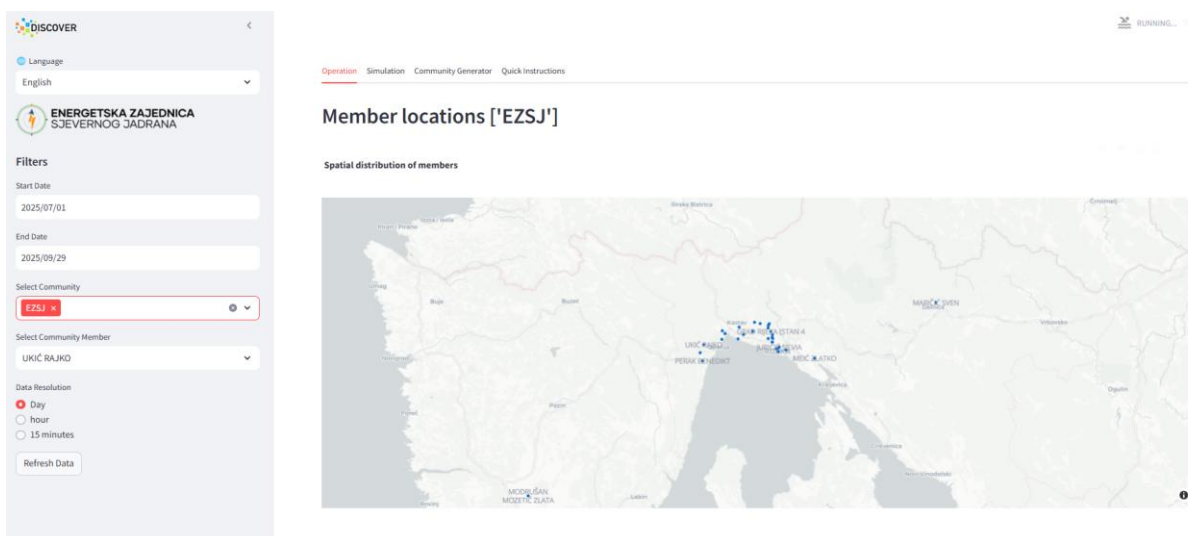
4.3.2 Solution

ECASS is implemented as an interactive web dashboard built with Streamlit, offering four integrated modules accessible through tabbed navigation. Currently supported languages are Croatian and English.

4.3.2.1 User experience

1. Operations Module

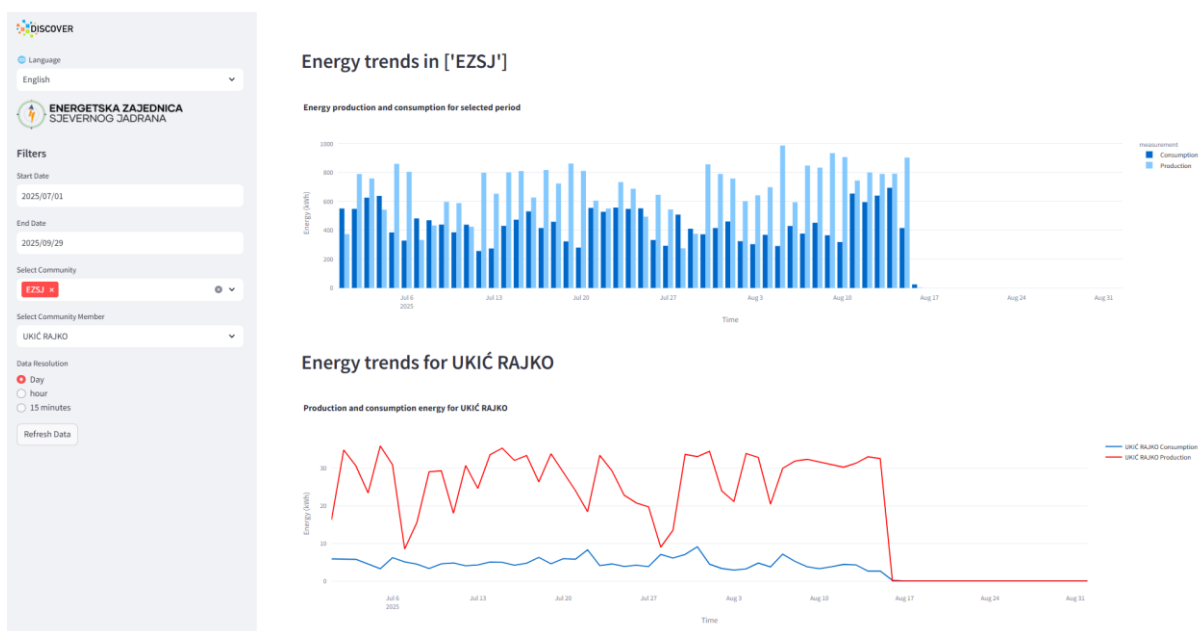
The Operations Module serves as the primary interface for real-time monitoring and analysis of existing energy communities. Users begin their interaction with an interactive Folium map that displays all community members using color-coded markers, with blue indicating existing members and green showing simulated additions. The map is fully interactive, allowing users to zoom, pan, and click markers to view detailed member information. This spatial visualization immediately communicates the geographic distribution of the community and helps identify clustering patterns or isolated members.



Below the map, community energy trends are presented through aggregated time-series graphs showing total energy production and consumption across selected communities. Users have full control over the analysis period and can adjust the data granularity to view patterns at daily, hourly, or fifteen-minute intervals. This flexibility allows both high-level trend analysis and detailed investigation of specific events or anomalies. The

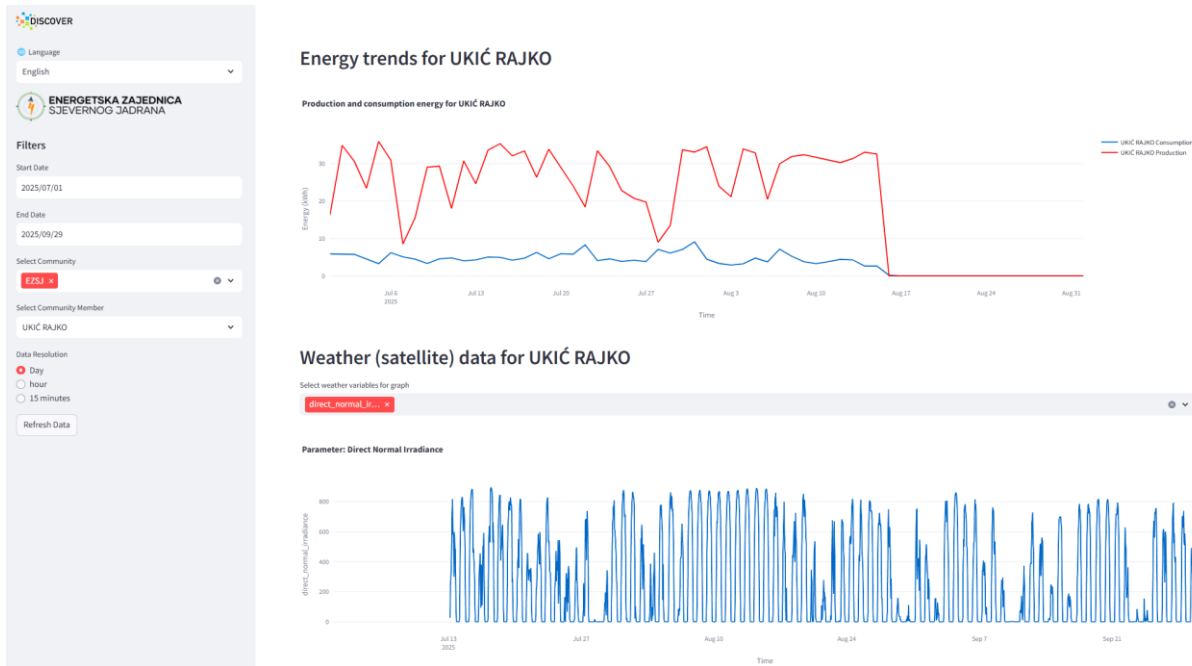
system handles date ranges up to ninety days, providing sufficient historical context for seasonal pattern recognition while maintaining responsive performance.

Individual member analysis provides deeper insights into specific participants within the community. When a user selects a particular member from the sidebar, the system generates detailed energy profiles featuring dual-line graphs that compare production in red against consumption in blue. The system automatically classifies energy use by tariff based on time-of-day rules, distinguishing between higher-rate daytime periods and lower-rate evening and weekend hours. This tariff awareness is critical for accurate economic modelling since Croatian electricity pricing varies significantly between these periods.



The weather integration component represents one of ECASS's most innovative features. Rather than relying on generic solar production estimates, the system fetches actual satellite-based meteorological data from the **Open-Meteo API** for each member's specific location. Users can view direct normal irradiance, which serves as the primary driver of photovoltaic production, alongside temperature, humidity, precipitation probability, and various solar radiation components including direct, diffuse, shortwave, and terrestrial radiation.

The interface allows interactive variable selection, enabling users to choose which parameters to analyze and directly correlate weather patterns with energy production. This correlation capability helps identify underperforming systems, validate production estimates, and explain variations in output to community members.



2. Simulation Module

The Simulation Module enables prospective member evaluation through intuitive map-based interaction. Users simply click directly on the map to select locations for potential new members, and the system immediately captures and displays the coordinates. A configuration form then collects essential parameters including the member's name, solar capacity selected from a comprehensive dropdown offering options from one kilowatt up to two megawatts, and an estimate of monthly consumption.

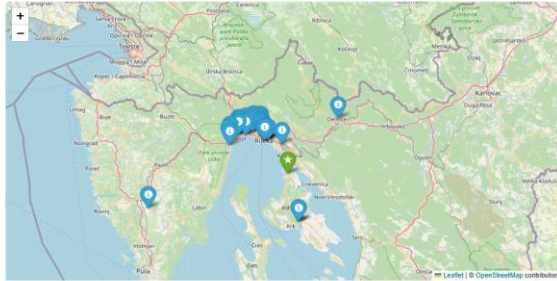
Once submitted, the simulation executes a sophisticated real-time calculation process. The system fetches ninety days of historical direct normal irradiance data for the selected coordinates, calculates average daily solar irradiation measured in kilowatt-hours per square meter, applies a conservative system efficiency factor of seventy-five percent, and estimates monthly production by multiplying capacity, efficiency, average irradiation, and thirty days.

The results compare production against stated consumption, providing immediate feedback through color-coded indicators that show green when production meets or exceeds consumption and orange otherwise.

DISCOVER
 Language
 English
ENERGETSKA ZAJEDNICA SJEVERNOG JADRANA
Filters
 Start Date
 2025/07/01
 End Date
 2025/09/29
 Select Community
 EPSJ
 Select Community Member
 UKIĆ RAJKO
 Data Resolution
 Day
 Hour
 15 minutes
 Refresh Data

Operation **Simulation** Community Generator Quick Instructions

Geolocation of new community members

 Click on the map to select location for potential new member:

 Click on map to select location for new users.
 Potential Member Name
 New Member
 Solar Plant Capacity (kW)
 25
 Monthly Consumption (kWh)
 350
 Add User

The simulation results display goes beyond simple numbers by presenting a comprehensive analysis including summary metrics covering location, capacity, production, and consumption. Two detailed graphs visualize the daily irradiance trend showing the ninety-day historical pattern and daily production estimates displayed as a red bar chart. Each simulated member is added to the main map with a distinctive green star marker, and importantly, all simulated members persist in session state, allowing multiple simulations within a single session that accumulate in the community summary for comprehensive scenario planning.

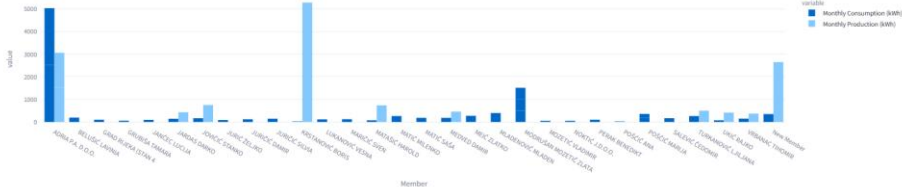
DISCOVER
 Language
 English
ENERGETSKA ZAJEDNICA SJEVERNOG JADRANA
Filters
 Start Date
 2025/07/01
 End Date
 2025/09/29
 Select Community
 EPSJ
 Select Community Member
 UKIĆ RAJKO
 Data Resolution
 Day
 Hour
 15 minutes
 Refresh Data

Energy balance summary for ['EPSJ']

Shared Energy Demand (kWh)	Shared Energy Supply (kWh)	Net Balance (kWh)
10818.4	14664.2	3845.8
Total Cost (grid-only)	Total Cost (community)	
5,698.42 €	4,695.94 €	

Savings if all within community: €1,002.48

Total Production and Consumption by Members


 Save Community Summary as Excel

Important Notice: The presented data is for informational purposes only, may not necessarily be up-to-date and reflect the real situation in EPSJ. Please contact damir.medved@bzazgona.hr for detailed information. This program was realized within the LIFE DISCOVER project implemented in the Primorje-Gorski Kotar County area.

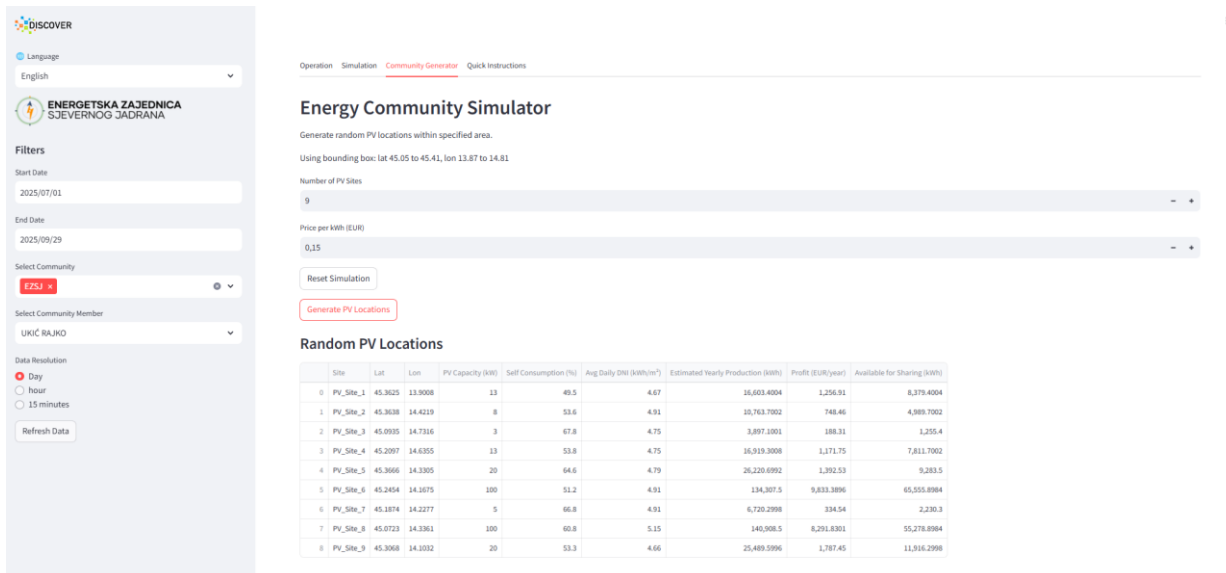


3. Community Generator Module

The Community Generator Module addresses a different use case by enabling rapid scenario planning through random generation. This tool proves particularly valuable when evaluating whether a community concept has sufficient scale to be viable or when exploring the impact of different member composition scenarios. Users configure the number of sites to generate, specify the price per kilowatt-hour for economic calculations, and the system automatically derives an appropriate bounding box from existing member locations.

The random generation algorithm creates realistic scenarios by assigning random coordinates within the bounding box, selecting random capacities from a predefined list ranging from one to one hundred kilowatts, determining random self-consumption percentages between forty-five and seventy-five percent, fetching the ninety-day average irradiance for each location, calculating yearly production, determining available energy for sharing, and computing annual profit potential based on the specified energy price.

The generator produces comprehensive visualization outputs including a detailed data table listing all generated sites, yearly production displayed as a bar chart color-coded by capacity, annual profit presented as a bar chart also color-coded by capacity, an interactive map with orange markers for all generated sites, and community-level metrics summarizing total production, energy available for sharing, and total profit potential. A reset functionality allows users to clear the current generation and start a fresh scenario, supporting iterative exploration of different community configurations.



Energy Community Simulator

Generate random PV locations within specified area.

Using bounding box: lat 45.05 to 45.41, lon 13.87 to 14.81

Number of PV Sites: 9

Price per kWh (EUR): 0.15

Reset Simulation

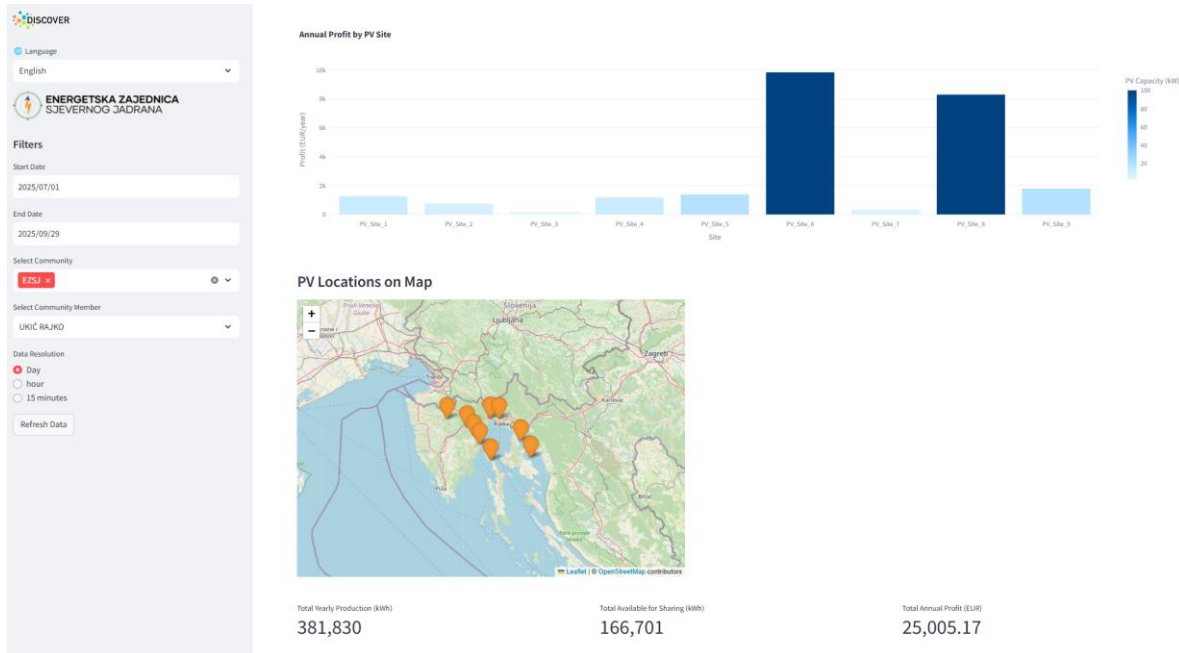
Generate PV Locations

Random PV Locations

Site	Lat	Lon	PV Capacity (kW)	Self Consumption (%)	Avg Daily DNI (kWh/m ²)	Estimated Yearly Production (kWh)	Profit (EUR/year)	Available for Sharing (kWh)
0 PV_Site_1	45.3625	13.9008	13	49.5	4.67	16,603.4004	1,256.91	8,379.4004
1 PV_Site_2	45.3628	14.4219	8	53.6	4.91	10,763.7902	748.46	4,889.7902
2 PV_Site_3	45.0935	14.7316	3	67.8	4.75	3,897.1301	188.31	1,255.4
3 PV_Site_4	45.2087	14.6355	13	53.8	4.75	16,919.3008	1,171.75	7,811.7002
4 PV_Site_5	45.3966	14.3305	20	64.6	4.79	26,220.6902	1,392.53	9,283.5
5 PV_Site_6	45.2404	14.5875	100	52.2	4.91	134,387.5	9,833.3896	65,555.8984
6 PV_Site_7	45.1874	14.2277	5	60.8	4.91	6,720.2998	334.54	2,230.3
7 PV_Site_8	45.0723	14.3361	100	60.8	5.15	140,908.5	8,291.8301	55,278.8904
8 PV_Site_9	45.3968	14.1032	20	53.3	4.66	25,489.5996	1,787.45	11,916.2998

The Community Summary and Financial Analysis section represents the culmination of ECASS's analytical capabilities by integrating data from all modules. The energy balance calculation aggregates consumption and production per member, scales measurements to thirty-day monthly equivalents for consistent comparison, and

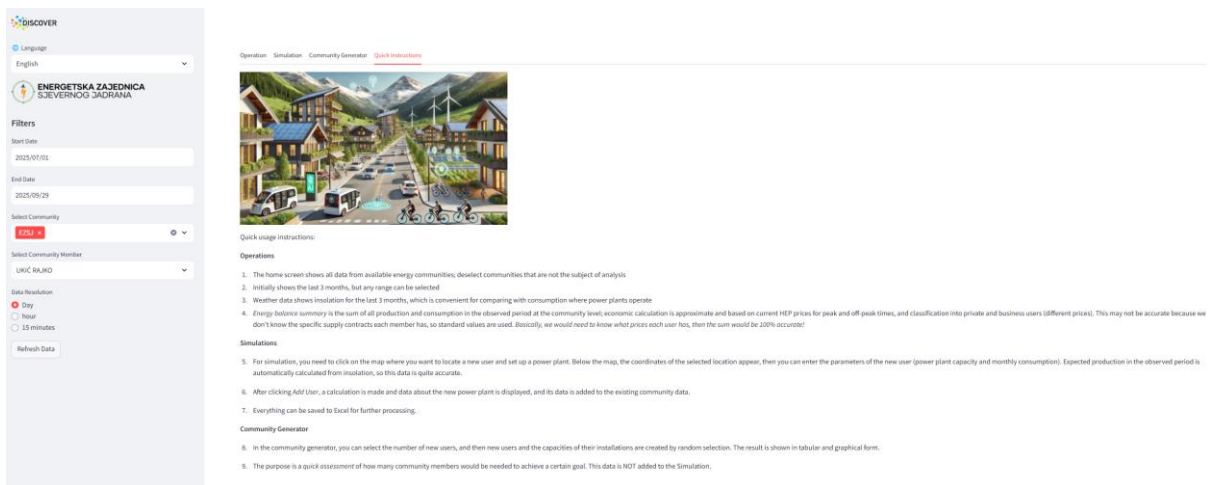
separates energy flows by tariff using time-of-day rules where higher tariff applies Monday through Friday from seven in the morning until nine in the evening, with lower tariff covering all other times.



The economic modelling component implements sophisticated financial calculations that differentiate between four customer classes reflecting Croatian market structure. Private prosumers and private consumers represent residential participants, while business prosumers and business consumers represent commercial participants. For each member, the system calculates two scenarios. Option A represents the grid-only scenario showing costs without community participation, while Option C represents the community scenario including energy sharing benefits. The detailed calculations account for direct on-site consumption as a percentage of production, energy fed to grid representing the remainder of production, grid withdrawal separated by tariff, and revenue from shared energy based on community compensation rates.

Community-level metrics are prominently displayed as metric cards showing total demand for shared energy measured in kilowatt-hours, total supply of shared energy available from all producers, net balance indicating surplus or deficit, total cost under grid-only scenario in euros, total cost under community scenario in euros, and most importantly, community savings highlighted as the difference between scenarios.

The Excel export functionality packages all analysis into a professional format suitable for stakeholder presentations, making it easy to share results with municipal authorities, potential investors, or community members considering participation.

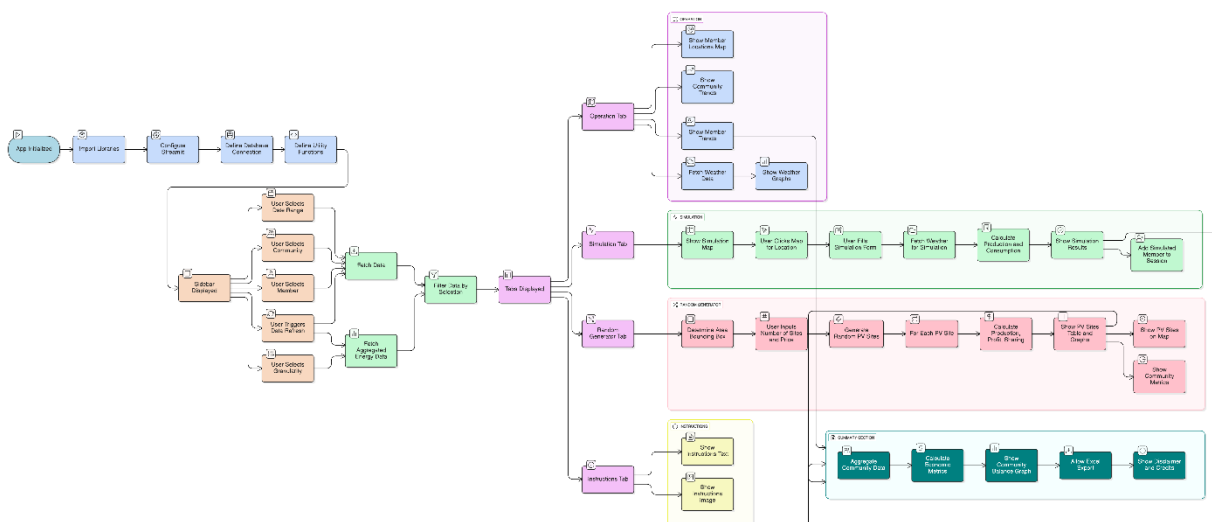


The User Guide Module provides illustrated instructions in Croatian or English covering navigation and filtering techniques, interpretation of meteorological data, simulation workflow procedures, random generation use cases, and data export procedures. This embedded documentation reduces the learning curve for new OSS operators and serves as a quick reference for experienced users.

4.3.2.2 Logic

Technical Architecture

The technical architecture underlying ECASS reflects careful consideration of the performance, reliability, and maintainability requirements inherent in operational energy community management. The system is built on a modern Python stack that balances sophisticated functionality with ease of deployment and maintenance.



Streamlit serves as the web application framework, providing the reactive user interface that automatically updates in response to user interactions without requiring explicit

refresh commands. This reactive model simplifies the code structure while delivering a responsive user experience. Plotly handles interactive visualization, generating the graphs and charts that communicate energy trends and patterns effectively. Folium provides the Leaflet-based mapping capability, with streamlit-folium handling the integration between the mapping library and the Streamlit framework. Pandas manages data manipulation and time-series analysis, offering efficient operations on the energy consumption and production datasets. MySQL Connector establishes direct database integration for energy data, enabling efficient queries against the operational database.

The database schema reflects the fundamental entities in energy community management. The **energy data** table stores time-series measurements with fields for **meter id** linking to specific members, timestamp recording when the measurement occurred, measurement type distinguishing consumption from production, and **energy value** capturing the quantity in kilowatt-hours. The members table maintains participant information including **member name** for identification, type classifying participants as private prosumer, private consumer, business prosumer, or business consumer, **meter id** serving as the primary key, location providing a text description, latitude and longitude coordinates enabling mapping and weather queries, and **energy community** associating members with their community.

The data processing pipeline begins with cached data retrieval to optimize performance. The system generates SQL queries dynamically based on the selected granularity, formatting timestamps as dates for daily analysis, as date plus hour for hourly analysis, or as date plus hour plus fifteen-minute interval for the finest granularity. The queries aggregate energy values by time group and measurement type, filter by date range and optionally by a list of meter IDs, and the caching decorator prevents redundant database queries when the same parameters are requested repeatedly.

Tariff classification happens through a simple but effective rule-based function. Each datetime is evaluated, and if the day falls Monday through Friday and the hour falls between seven and twenty-one, it receives the higher tariff classification. All other times receive the lower tariff classification. This binary classification aligns with the Croatian electricity market structure where time-of-use rates strongly incentivize off-peak consumption.

Weather data integration leverages the Open-Meteo API with careful attention to reliability and performance. The system creates an API client with caching configured to retain responses for one hour, reducing redundant API calls while ensuring reasonable currency of weather data. A retry mechanism handles transient network failures, attempting up to five retries with exponential backoff between attempts. The API returns a comprehensive set of variables including direct normal irradiance as the primary metric, temperature and relative humidity for environmental context, precipitation and precipitation probability for weather pattern understanding, shortwave, diffuse, and terrestrial radiation for detailed solar analysis, and sunshine duration for validation purposes.

The solar production estimation algorithm used throughout the simulation modules applies conservative assumptions validated against real-world installations. System efficiency is fixed at seventy-five percent, accounting for inverter losses, temperature effects, soiling, and other real-world factors that reduce output below theoretical maximum. The average daily irradiance is calculated from ninety days of historical data to capture seasonal variation, and monthly production is estimated as capacity multiplied by efficiency multiplied by average daily irradiance multiplied by thirty days.

Energy balance calculations for each member begin by aggregating total production from all production measurements. Self-consumed energy is calculated as total production multiplied by the self-consumption percentage, representing the portion used directly on-site. Energy fed to grid equals total production minus self-consumed energy, making it available for community sharing. Grid withdrawal is calculated as total consumption minus self-consumed energy, representing the amount that must be purchased from the distribution system operator. Shared energy equals the energy fed to grid, as this is what becomes available for other community members.

The financial modelling implemented through the `koristi.py` module represents sophisticated domain knowledge about Croatian electricity markets. The system builds a detailed data structure for each member that captures monthly patterns aggregated by tariff. Grid consumption is grouped by whether it occurred during higher or lower tariff periods. Production is similarly grouped by tariff. The self-consumption share, configured per customer class, determines how much produced energy is used on-site versus fed to grid. Energy fed to grid is calculated as production multiplied by one minus the share. Direct use is calculated as production multiplied by the share.

This detailed data structure then feeds into cost calculation functions. The grid-only scenario calculates what the member would pay without community participation, applying tariff-specific rates to grid consumption and adding fixed standing charges. The community scenario accounts for the value of shared energy, reducing costs through the avoided purchase of electricity that is instead received from community production. The difference between these scenarios provides the financial benefit of community membership.

Datasets Used:

The datasets powering ECASS combine real-time operational data with historical weather patterns and economic parameters. Real-time energy data originates from the SQL database with measurements captured at fifteen-minute intervals and retained for the complete historical record (data provided by Croatian DSO – HEP). This granular data supports detailed analysis while the database update frequency tracks smart meter readings in near real-time.

Meteorological data from Open-Meteo provides global coverage with one-hour resolution, historical data extending up to ninety days retrospectively, and forecast data extending up to sixteen days forward. The cache duration of one hour balances API rate

limits against the need for current data. Geographic data stored in the members table includes coordinates used for map visualization, weather queries, and simulation constraint enforcement through the bounding box derived from existing members.

Economic parameters reflect the Croatian electricity market structure with HEP electricity prices separated into higher and lower tariff rates, customer class multipliers distinguishing private from business rates, energy sharing compensation rates set according to regulatory framework, and grid connection fees and standing charges representing fixed costs. Solar system parameters use conservative assumptions including seventy-five percent system efficiency, predefined capacity options ranging from one kilowatt to two megawatts, and self-consumption ranges from forty-five to seventy-five percent for random generation scenarios.

Performance optimizations ensure responsive user experience despite the computational demands of real-time data processing and visualization. Data caching through Streamlit's decorator caches expensive database queries and API calls, preventing redundant operations. Session state management allows simulated members to persist across interactions without re-computation. Lazy loading defers weather data fetches until specific locations and dates are requested. Efficient SQL queries aggregate data at the database level rather than transferring large datasets for in-memory processing. Conditional rendering displays UI elements only when relevant data is available, avoiding unnecessary computation.

Error handling provides graceful degradation when external dependencies fail. Fallback direct normal irradiance values of four point five kilowatt-hours per square meter per day apply when the API is unavailable. Missing coordinates are handled gracefully with clear user messaging. Data validation ensures user inputs meet expected ranges and formats. All error messages appear in Croatian language for consistency with the target user base.

4.3.3 Limitations

ECASS operates within several technical and practical constraints that shape its current capabilities and define the roadmap for future development. Understanding these limitations helps OSS operators set appropriate expectations and plan their community management activities accordingly.

Current Technical Limitations:

ECASS requires direct connection to a SQL database hosted at a specific IP address, with no offline functionality or alternative data sources currently supported. This architecture ensures data consistency and enables real-time monitoring but also means the service becomes unavailable during network outages or database maintenance windows. Organizations considering ECASS deployment must ensure reliable network connectivity and database uptime.

Weather API constraints stem from reliance on the Open-Meteo free tier service. While this provides excellent data quality and global coverage, rate limits may restrict intensive simulation scenarios involving many locations. Historical data extends only ninety days into the past, which limits long-term trend analysis though it proves sufficient for most operational and simulation needs. The one-hour minimum cache duration means real-time weather updates cannot support very short-term forecasting, and the sixteen-day forward forecast limit prevents long-range production planning.

The simplified financial model serves most practical needs but omits several factors that affect actual costs and savings. Standard HEP tariffs apply without consideration of customer-specific contract rates that may differ significantly. Demand charges and time-of-use variations beyond the basic higher and lower tariff distinction are not modeled. Community savings calculations assume perfect energy matching without accounting for simultaneity requirements or grid constraints.

Planned improvements

User experience improvements span multiple areas including multi-language support for English, Italian, and Bulgarian to serve all DISCOVER pilot regions, mobile-responsive design ensuring usability on tablets and smartphones used by field staff, offline mode with local data caching for situations with intermittent connectivity, user authentication and role-based access control protecting sensitive member data and enabling appropriate delegation, and customizable dashboards allowing each user role to focus on their relevant metrics.

The applicability of ECASS to other pilot regions demonstrates both the system's flexibility and the practical challenges of cross-border deployment. The platform currently operates in Croatia, specifically Primorsko-goranska županija, which served as the primary implementation site.

The database architecture supports multiple energy communities simultaneously, providing the foundation for geographic expansion.

Implementation challenges

Regulatory framework alignment represents perhaps the most complex adaptation challenge. Financial calculations must reflect each nation's energy community regulations, which differ substantially in their treatment of shared energy, compensation mechanisms, and participant rights and obligations. Tariff structures vary from simple flat rates to complex time-of-use and demand charge arrangements. Grid connection rules, net metering policies, and distribution network access differ across jurisdictions, affecting both the technical feasibility and economic attractiveness of community participation.

4.4 Bulgaria

CEP Real Life Modelling (CEP - RLM), Institute for Entrepreneurship, Sustainable Development and Innovation (IESDI)

4.4.1 Key points

<i>Service-Title</i>	CEP Real Life Modelling (CEP - RLM)
<i>Service provider</i>	IESDI
<i>Problem-Statement</i>	Lack of adequate legal framework, need of increased awareness of the benefits and value of CEPs for community own energy, cumbersome administrative procedures, problematic grid connection.
<i>Motivation</i>	Complicated and long procedures for implementation of a PV project (10 steps with sub-steps, 29 documents, taking at least 8 months) Defining the technological and legal framework – a key challenge (cooperative, public interest company, trust, association, limited partnership) Connection to the grid – complex permitting process
<i>Value Proposition</i>	Using the service, CEP initiators can select and adapt models that boost revenues while reducing administrative burdens. With our OSS support, they can shape a viable project, choose the right technology and legal form, complete applications, secure a connection point, develop a pre-feasibility study and project design, and prepare the permit documentation.
<i>Expected Outcome</i>	Users receive a detailed report on potential model for establishing an EC. It will cover the distribution of production and consumption, financial analysis comparing costs with and without community participation, visual dashboards with interactive graphs and maps, simulation results for potential members, including site-specific solar production estimates, as well as community expansion scenarios at a later stage. By selecting the most suitable technological setup and legal structure for their EC, they will be better positioned to navigate administrative hurdles with the support of the DSO.
<i>Target user</i>	The service is for CEP initiators during the planning phase of their project, specifically during the establishment of an EC and the planning of a PV installation. It is most relevant to small municipalities in Bulgaria looking to develop a clear CEP concept, form an organizing committee, and secure municipal support. This includes obtaining consent for public plots, roofs, or territories identified in Local Development Plans.
<i>Prerequisites for using the service</i>	Before using this service, the user must authorize IESDI to start the development phase; provide energy consumption data (if this information is not available, notify the OSS in order to use standardized load profiles for each of the potential sites in the community); provide information on each of the potential sites for the energy community. If the user has a project for a photovoltaic system, it is necessary to provide the technical specifications of the installation (e.g. installed power, orientation, slope, location). In addition, the user may be asked to provide:

	• Information on available roof or ground surfaces suitable for installing new photovoltaic systems. • Preferred financing model (self-investment, bank loan, third-party financing, public incentives). • Legal/organizational preferences regarding the possible configuration of the community.
<i>Service Accessibility</i>	The service is provided for CEP initiators in Bulgaria as a personal consultation in the offices of IESDI Phone: +359 878837167 Email: DISCOVER@institute-esdi.org The service is managed by the technical staff of IESDI (starting with two people). In addition, the service will be available online as part of the interactive guidebook in the coming months.

Obtaining all necessary permits for PV project development in Bulgaria is complex and slows down CEP progress. This makes it difficult for initiators to plan and choose the best technical setup for an energy community. IESDI supports CEP initiators in defining the optimal technological and economic concept, project scope, and legal form. The CEP-RLM tool simulates PV plant concepts, presenting real-life energy community models with relevant data and reports.

The major stakeholders involved during the service development are the municipalities, partners of IESDI, the Chamber of Energy Communities in Bulgaria (www.cecb.bg) and the Sustainable Energy Development Agency (www.seea.government.bg). The service also draws on insights from investors in pilot municipalities, whose feedback helped IESDI validate assumptions and ensure CEP-RLM meets real market needs.

4.4.2 Solution

The solution offered by the service is to present a **number (6-10) real-life models of CEPs** designed within **Grid One software tool** (<https://grid-one.eu>), which is currently under development and testing. The CEP initiators can find one or two models which allow them to maximize revenues and minimize administrative procedures and unnecessary business and state/municipal bodies dependencies in their specific cases. The models are:

1. Residential & Commercial Cluster Solutions

Target: Apartment blocks, residential complexes, small commercial centers

Services: Installation of rooftop solar panels, small geothermal generators, smart meters, flexible energy distribution

Benefits: Lower energy bills via self-consumption, shared use of charging stations, optimized energy flows within the community



2. Public Buildings Energy Networks

Target: Municipal buildings, schools, hospitals, universities

Services: Integration of multiple renewable generators, battery energy storage systems, energy management software

Benefits: Significant cost savings by peak load management and battery storage, powering technological processes, reduced operational costs



3. Industrial Energy Hubs

Target: Industrial companies with multiple subsidiaries or buildings

Services: Large-scale renewable energy production, advanced battery systems, direct grid connections, real-time energy monitoring

Benefits: Major savings from self-generation, energy arbitrage through battery storage, reliable and efficient energy supply for production needs



4. Agricultural & Forestry Islands

Target: Single farmers, forestry enterprises, hunting associations

Services: Off-grid microgrid setups with small solar installations and mobile energy units

Benefits: Reduced diesel/gas generator dependency, cost savings from onsite energy use for irrigation, heating, and equipment powering



5. E-Mobility Power Stations

Target: Businesses, associations, private investors focused on electric vehicle charging

Services: Renewable energy supply linked with high-capacity EV charging infrastructure

Benefits: High profitability from EV charging services, full use of renewable energy excess, supporting green transportation

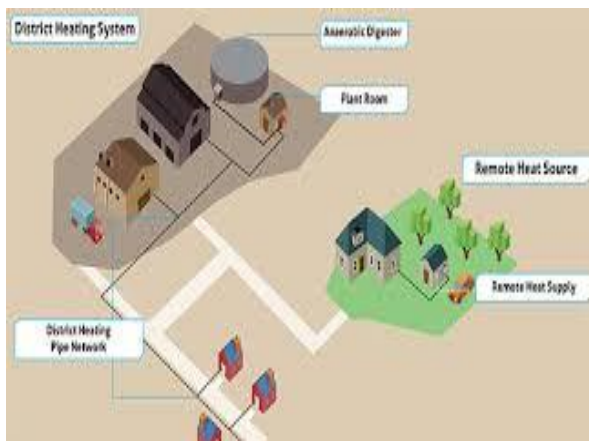


6. District Heating & Geothermal Communities

Target: Groups of residential and public buildings

Services: Solar PV arrays, heat pumps, thermal energy storage tanks, local district heating networks

Benefits: Substantial savings on heating and hot water costs, efficient use of daytime solar surplus, reduced reliance on fossil fuels



7. Energy Sales & Trading Communities

Target: Large renewable parks and diverse customer groups

Services: Large-scale energy production and battery storage, direct power sales, software-managed energy trading

Benefits: Revenue from electricity sales, optimized income via energy arbitrage, flexible distribution both locally and through the grid



Furthermore, the CEP initiators can tweak the model to best fit their financial, material and human resources and connections and build (all services provided in the OSS) a viable, profitable and predictable project. Based on the educated choice of a basic technological concept and best suitable legal form, the initiators will be prepared for the next project development steps – to fill in the application forms and approach the DSO in order to get a response about a point of connection in the selected area, develop (commission) the pre-feasibility study and the project design, consisting of electrical, architectural, geodesic and structural parts and further on - prepare the documents package for application for the building permit.

Defining the models begins with establishing the fundamental parameters of the business concept. The first consideration is the type of technological cluster involved. This requires assessing the relative weight of the investment and identifying any potential technological or legal barriers that could influence its implementation.

Another important factor is the percentage of energy losses that may occur due to the inability to fully utilize or commercialize production. Understanding these inefficiencies helps clarify the project's potential returns and operational limitations.

Finally, the type and structure of the investor group play a crucial role. The composition of the group determines the complexity of the legal entity, the level of interest and commitment among participants, and the approach to raising investment capital. Together, these parameters form the foundation for shaping the model and guiding strategic decisions.

The technical and economic modelling is done with the open-source software Sunny Design (<https://www.sma.de/en/products/apps-software/sunny-design>), until Grid One is fully operational.

User experience

Sunny Design is planning photovoltaic (PV) systems and broader energy systems. It allows users and professionals to create projects that may include:

- Grid-connected PV systems
- PV systems with battery storage
- Smart energy management
- E-mobility
- Off-grid or hybrid systems

IESDI uses Sunny Design as a first-step tool for simulation the establishment of energy communities and/or development of CEPs in general. It takes into account technical component specifications, climate data, and site conditions to calculate optimal solutions and provide cost and ROI assessments.

IESDI uses it to model electricity tariffs, energy consumption, electric vehicles, and storage systems. Project reports, component lists, and visuals are automatically generated. The tool supports importing and exporting custom data such as load profiles, weather files, and component libraries. It's compatible with PV modules, inverters, batteries, and EV chargers.

Workflow Example

The process begins with assessment of the local renewable energy sources and installations for local energy production from RES. The selection of the project location and the collection of site-specific climate data will establish a reliable foundation for the system performance assessment. Based on this information, the appropriate project type on-grid, off-grid, or hybrid is determined.

With the project framework defined, the system design phase follows. This includes configuring the roof layout, positioning the solar modules, and optimizing their orientation to maximize efficiency. A shading and yield analysis is then conducted to evaluate potential energy losses and estimate system output.

4.4.2.1 Phase 1. CEP Modeling

CEP modeling provides a comprehensive suite of analytical capabilities to support the design and evaluation of photovoltaic (PV) project for the establishment of energy communities. It begins with production forecasting, which calculates expected annual and monthly PV output by accounting for orientation, tilt, shading, and geographic location, combined with climate datasets such as irradiance and temperature records.

To complement this, consumption modeling is offered through both standard load profiles covering public, residential and commercial cases and fully customizable profiles that can be defined on an hourly, daily, or monthly basis. These production and consumption datasets are then integrated in a production–consumption matching analysis, which quantifies the proportion of generated energy that is directly self-consumed versus exported to the grid. Further depth is achieved through the integration of flexible loads and storage, enabling the simulation of batteries, electric vehicles, and thermal loads to optimize energy balance and enhance self-consumption strategies.

CEP Model Study

A simulation is done for municipal energy community with a PV plant installed on the roof of a public sport hall, where the annual energy consumption is 360 kWh and the dimensions of the roof are: 25m length by 65 widths and 20m height.

General project data

Name and location (Municipality leading body, location: roof of the sports hall, GPS coordinates)

System type (on-grid, with battery, hybrid, etc.)

Components used (modules, inverters, batteries, EV charging stations)

Enter project data ?

Here you can enter your project data. Advanced project data are preset to typical default values. Check these values and adapt them as needed. Fields marked with an asterisk (*) are mandatory.

Project name *

Dryanovo

Images

Upload images

Determination of PV energy yield red

System design & simulation

Project status

NEW

Customer

+ New customer

Location of the building

Address search or coordinates (latitude, longitude) *

ul. "Pop Hariton" 12, 5370 Dryanovo, Bulgaria

Site for meteorological data *

Veliko Tarnovo, Bulgaria (20 km)

Display meteorological data

Information: the address can be changed by moving the marking or by clicking with the right mouse button in the map.

Map

Satellite



Production simulation

The production simulation provides a comprehensive analysis of the system's energy output over time. It calculates the annual production in kilowatt-hours (kWh) and distributes this output across monthly and daily intervals, offering insights into seasonal and daily variability. When enabled, hourly production profiles further refine the analysis, capturing fluctuations throughout the day.

The simulation also accounts for real-world factors that reduce system efficiency. These include shading effects, as well as losses due to temperature variations, cabling, inverter efficiency, and other system components, ensuring a realistic estimate of net energy production.

Import consumption data
Consumption data from Sunny Portal
Create consumption data

The load profiles can be assigned to different seasons. Here you can adapt the seasons. To do this, select the dates for the beginning and end of summer and winter. Spring and fall will automatically be the seasons in between.

Breakdown of seasons into months

Summer

05-06

to

08-05

Spring/fall

02-06 to 05-05 and 08-06 to 11-05

Winter

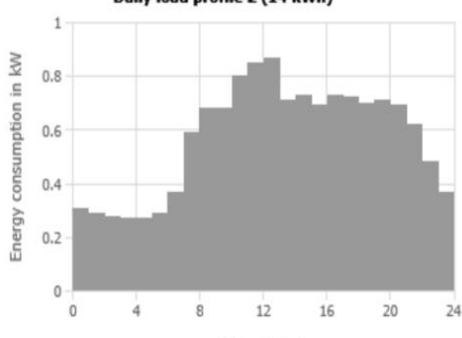
11-06

to

02-05



Daily load profile 2 (14 kWh)



Summer

Mon	Tue	Wed	Thu	Fri	Sat	Sun
-----	-----	-----	-----	-----	-----	-----

Spring/fall

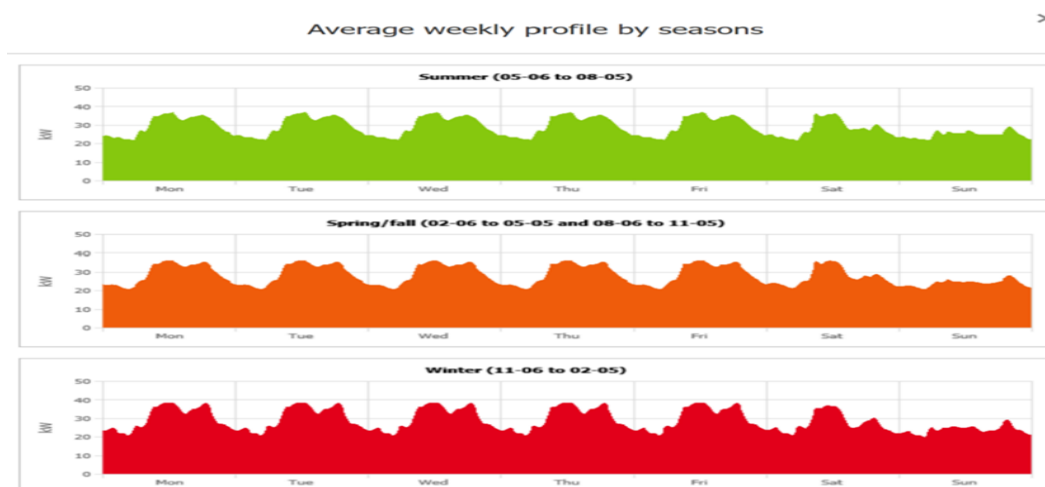
Mon	Tue	Wed	Thu	Fri	Sat	Sun
-----	-----	-----	-----	-----	-----	-----

Winter

Mon	Tue	Wed	Thu	Fri	Sat	Sun
-----	-----	-----	-----	-----	-----	-----

Consumption simulation

To understand the energy requirements of a facility such as a sports hall, the team examines first its input load profile, which includes all significant energy-consuming systems: the lighting, the heating and cooling systems, and the sports equipment. Each of these components contributes differently to the overall energy demand, depending on usage patterns and operational schedules. Next, the team analyses the consumption over various time scales hourly, daily, and monthly. This breakdown allows us to identify patterns in energy use, such as peak hours when activity is highest or seasonal fluctuations that affect heating and cooling needs. Focusing on load extremes noting both the peak loads, represents the highest energy demands during intensive use, and the minimum base load, which is the constant, unavoidable energy consumption even when the facility is largely idle. Understanding these variations is crucial for effective energy planning, system sizing, and cost management.



Production-consumption balance

In examining the dynamics of energy flow, IESDI first look at the production-consumption balance. A portion of the energy generated is used directly on-site, reflecting the system's self-consumption. Another share is exported to the grid, contributing to the broader energy network. Finally, an assessment is made how much of the overall energy demand is met by the PV plant itself, known as consumption coverage, revealing the extent to which solar generation offsets external energy needs.

Specific loads			
	Device	Description	Settings
☐ Specific loads	 Heat pump	Heat pump for heating and hot water Nominal power: 0.0 W Electrical energy requirement: --- Solar fraction: ---	Building: Passive house Heated space: --- Hot water: ---
☐ Take e-mobility into account	 ZOE (22 kWh)	Mileage per year: 15,633 km Solar fraction: --- Number of unplanned charges: 0	AC Typ2 (11 kW) Nominal power of the charging station AC / DC: 11.0 kW / --- Battery loading: 1,875.97 kWh

Result

Without increased self-consumption

Self-sufficiency quota

40.2 %

Self-consumption quota

44.4 %

Distribution of PV energy

Energy yield
119 MWh

Grid feed-in
66,069 kWh

Self-consumption
52,655 kWh

Purchased electricity
78,341 kWh

Details

Annual energy consumption

131 MWh

Annual energy yield

119 MWh

Grid feed-in

66,069 kWh

Purchased electricity

78,341 kWh

Max. purchased electricity power

31.02 kW

Self-consumption

52,655 kWh

Self-consumption quota (in % of PV energy)

44.4 %

Self-sufficiency quota (energy consumption in %)

40.2 %

With increased self-consumption

Self-sufficiency quota

61.5 %

Self-consumption quota

70 %

Distribution of PV energy

Energy yield
119 MWh

Grid feed-in
35,665 kWh

Self-consumption
83,059 kWh

Purchased electricity
50,438 kWh

Details

Annual energy consumption

131 MWh

Annual energy yield

119 MWh

Grid feed-in

35,665 kWh

Purchased electricity

50,438 kWh

Max. purchased electricity power

31.02 kW

Self-consumption

83,059 kWh

Self-consumption quota (in % of PV energy)

70 %

Self-sufficiency quota (energy consumption in %)

61.5 %

Total nominal capacity

224.00 kWh

Annual nominal energy throughputs of the battery

136

Battery (if added)

If a battery is added, it serves as both a reservoir and a buffer for energy. During charging and discharging cycles, the battery stores excess energy when production exceeds demand and releases it when consumption is higher. This dynamic directly impacts self-consumption, allowing more of the energy generated to be used on-site rather than exported. By controlling how much energy is stored and strategically used, the battery helps reduce peak demand, smoothing out fluctuations and optimizing overall energy efficiency.



Financial analysis

Subsequently, a **financial analysis** is performed, incorporating tariff structures, return on investment, and payback period calculations to ensure economic viability. The process concludes with the generation of comprehensive project documentation, including technical reports, detailed layouts, and a bill of materials, providing a complete package for project implementation.

In the financial analysis, we first examine the total cost of the energy produced over time, providing a clear picture of the investment's efficiency. Next, we consider the savings achieved through a reduced electricity bill, highlighting the direct benefit to monthly expenses. Finally, any surplus income generated whether through feed-in

tariffs or net metering adds an additional revenue stream, further enhancing the financial viability of the project. Return (IRR, NPV, payback period).

Costs

Project costs

Financing

Cancel financing model

entered in

ct template

Here you can enter further financing details. You can define the default settings at "My Sunny Design" > "Settings" > "Profitability". Fields marked with an asterisk (*) are mandatory.

Equity capital

100 %

0.00 EUR

Debt capital

0 %

0.00 EUR

Grant amount

0.00 EUR

Type of credit

☒ Annuity loan
 ☐ Redeemable loan

Credit period in years

10

Redemption-free period in years

0

Annual interest rate

4,0 %

Fixed cost

Costs

Project costs

Here you can determine the investment and operating costs of the project. A simplified entry of costs is available, which allows a quick calculation based on specific costs. Each individual cost item can be entered in the detailed cost entry as well as an offer created. You can define the introduction text and final text under "My Sunny Design" > "Settings" > "Offers". Fields marked with an asterisk (*) are mandatory.

Simplified costs entry

Detailed costs entry

Quotation no.

Create quotation

Select template

PV system	Costs per unit	Number	Total
SMA SMA Demo Poly 300W	0.00 EUR	× 355	0.00 EUR
SMA STP110-60 (CORE2)	0.00 EUR	× 1	0.00 EUR
Battery system	Costs per unit	Number	Total
SMA Sunny Tripower Storage X 50	0.00 EUR	× 2	0.00 EUR
SMA Storage-50-20 56 kWh	0.00 EUR	× 4	0.00 EUR
Accessories	Costs per unit	Number	Total
Sunny Home Manager 2.0	0.00 EUR	× 1	0.00 EUR
AC Typ2 (11 kW)	0.00 EUR	× 1	0.00 EUR
Subtotal (net sum)			0.00 EUR
Discount			---
Total (net)			0.00 EUR
Value-added tax			---
Total amount (gross)			0.00 EUR

New position

Annual fixed costs (as percentage of capital expenditure)

1.50 %

0.00 EUR

Financing

Add financing model

Effective savings in EUR

Time period in years

Equity capital

Debt capital

Costs in thousand

Time period in years

With PV system

Without PV system

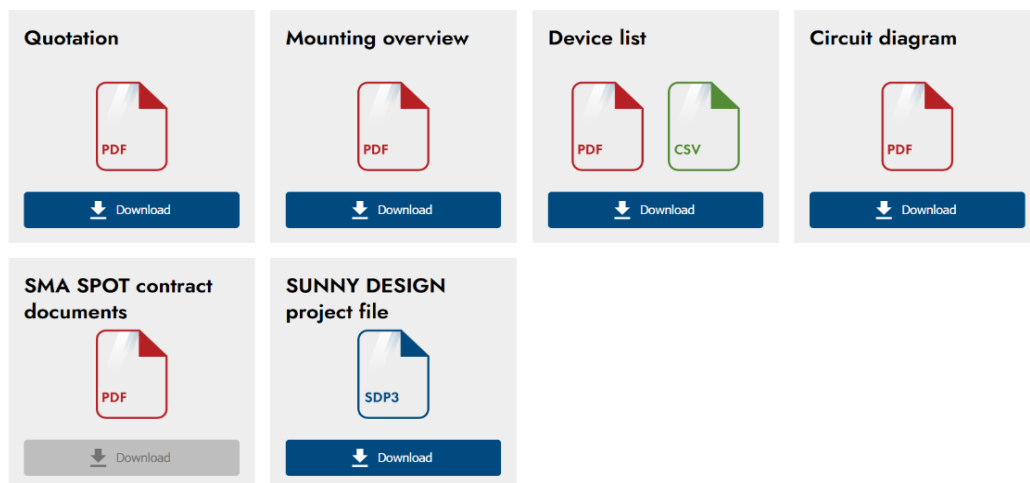
Documentation

The documentation and reports provide a comprehensive record of the solar energy system, covering all aspects from generation to consumption. It begins with a detailed breakdown of the system's charges, including solar heating, production, consumption, and the overall energy balance, offering a clear picture of efficiency and performance.

To aid understanding, system diagrams are included, such as single-line schematics and roof positioning layouts, illustrating how components are interconnected and optimally placed.

Supporting these visuals are tables listing all components and their parameters, ensuring that every part of the system is accounted for with precise specifications.

Finally, the documentation is made readily accessible through an automatically generated report, which can be exported as a PDF or accessed online, providing a user-friendly reference for stakeholders, engineers, or maintenance teams.



Results ?

This overview shows the entries, results and current information on the design of the system. Check the information before creating the project documentation.

Project Dryanovo
Location ul. "Pop Hariton" 12, 5370 Dryanovo, Bulgaria

Customer
Address

Project information			
Total number of PV modules	355	Line losses (in % of PV energy)	---
Peak power	106.50 kWp	Unbalanced load	0.00 VA
Number of PV inverters	1	Annual energy consumption	131 MWh
Nominal AC power of the PV inverters	110.00 kW	Self-consumption	83,059 kWh
AC active power	110.00 kW	Self-consumption quota	70 %
Active power ratio	103.3 %	Self-sufficiency quota	61.5 %
Annual energy yield	119 MWh	Total nominal capacity	224.00 kWh
Additional yield with SMA ShadeFix	9,657 kWh	Annual nominal energy throughputs of the battery	136
Energy usability factor	89.1 %	CO ₂ reduction after 20 years	797 t
Performance ratio	76.5 %	Reactive energy	0 kvarh
Spec. energy yield	1115 kWh/kWp		

4.4.2.2 Logic

The simulation of an energy community is a clear interface with maps, roofs, and charts.

The complex work behind it created by this tool includes:

- Databases with solar and weather data collected over decades.
 - Thousands of PV panels, batteries, and inverters with their technical details already stored inside.
 - Powerful mathematical models that calculate hour by hour how much energy will be produced, consumed, or stored.
 - Teams of engineers, programmers, and designers who built the system, so you only need to enter simple inputs and get a full report.
3. In the absence of available tools and instruments, created by the national public authorities the background of Sunny design platform simulates an entire year of operation, calculates losses, matches production with consumption, and prepares financial results.

4.4.2.3 Phase 2. Technical design and engineering

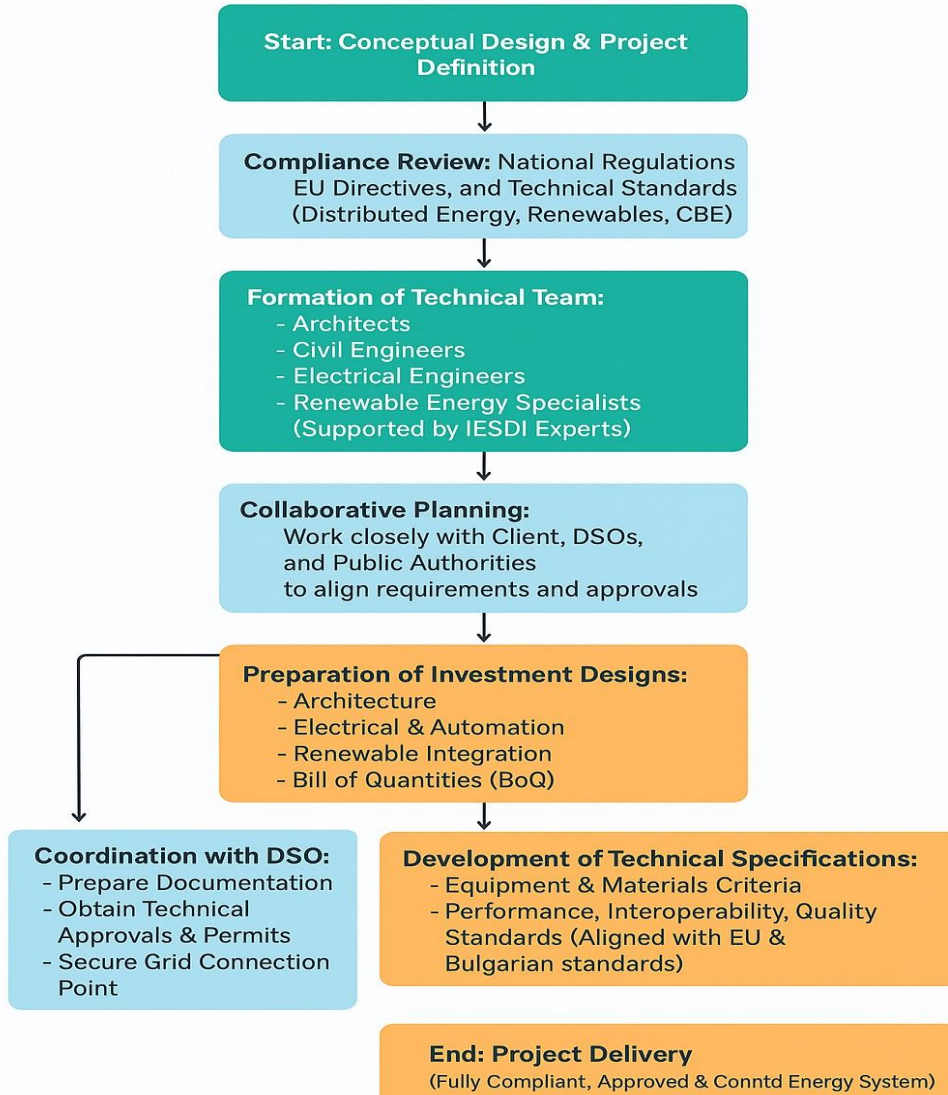
The technical and engineering aspects ensure that all stages from conceptual design to construction supervision are implemented in compliance with national regulations, EU directives, and technical standards governing distributed energy generation, renewable integration, and community-based energy systems.

The activities under this component are led by a qualified external team of architects, civil engineers, electrical engineers, and renewable energy specialists, supported where necessary by IESDI experts. The team will work in close collaboration with the client, the DSOs, and relevant public authorities (if needed) to secure all necessary technical approvals and permits.

This stage includes preparation of Investment designs, consisting of all respective parts, architecture, electrical, automation, etc. supported by site surveys and Bill of Quantities to guide investment and financing decisions. Development of technical specifications will guide the selection of equipment and construction providers, defining performance, interoperability, and quality criteria in line with EU and Bulgarian standards.

Coordination assistance with the DSO follows to get approval and a connection point. It covers preparing the required documentation, obtaining permits, and ensuring smooth coordination among all parties for safe and compatible connections.

Technical & Engineering Implementation Process



4.4.2.4 Phase 3: Financing the energy community

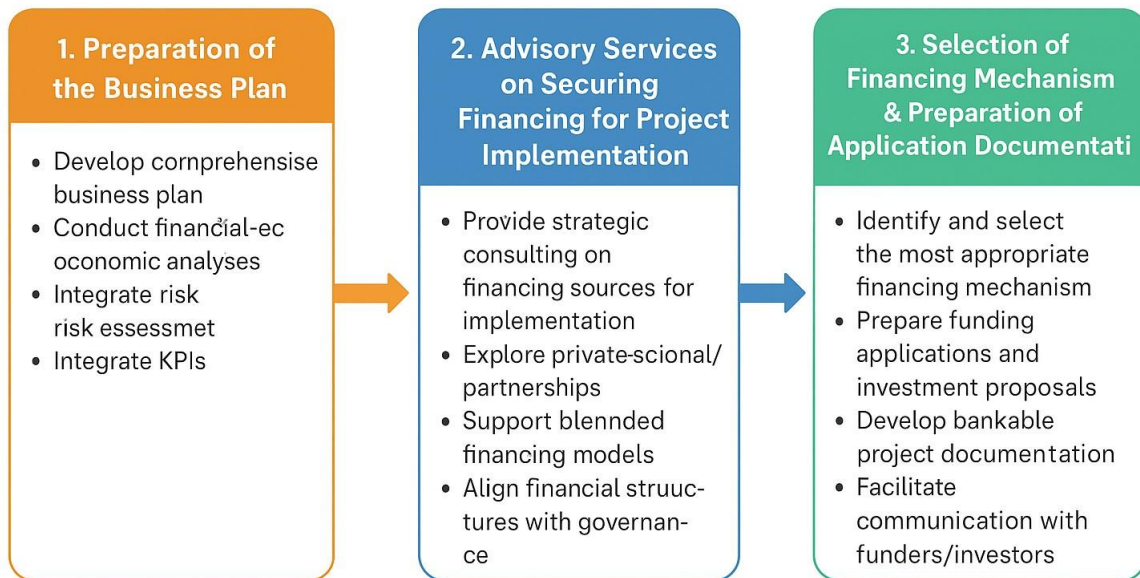
The final phase of the service addresses the financial, economic, and strategic dimensions of establishing the energy community. It ensures that the project moves beyond the technical design phase toward financial viability, investment readiness, and long-term sustainability. The objective is to develop a solid business model and secure the necessary financial resources to transform the community energy concept into a fully operational, economically sound, and self-sustaining entity. It identifies potential revenue streams, assesses risks, and establishes key performance indicators to ensure long-term financial sustainability and the creation of social value.

Providing strategic advisory services to identify and secure the most suitable financing options for the energy community drawing on EU, national, and private funding sources is followed by support in selecting the optimal financing mechanism, preparing the necessary application

documentation, and finalizing financing agreements in line with project timelines and compliance requirements.

The activities under this phase are carried out by IESDI team of economists and external investment advisors. They work in close cooperation with the technical design team, local stakeholders, and potential investors to align technical feasibility with financial viability and community ownership principles.

Financing for the Energy Community



4.4.3 Limitations

Sunny Design provides an easy-to-use interface for preliminary assessments of PV systems and energy communities. Although there are current limitations in terms of multi-user modelling and advanced financial scenarios, some improvements could make it a scalable solution for energy communities in other regions.

Current Limitations

The current system is primarily designed for single-user applications, such as individual residential, commercial, or small business PV systems. It does not yet support built-in mechanisms for energy sharing or coordination among multiple users within a community.

When modelling energy communities, consumption must be represented as a single aggregated profile. This approach simplifies analysis but conceals the unique consumption patterns of individual participants. As a result, there are no options for allocating energy or setting priorities between different users.

The tool relies on standard climate and load data from existing databases. While these datasets use real locations and provide generally realistic results, they may lack the precision needed for highly site-specific or locally variable conditions. Similarly, default consumption profiles may not capture local or seasonal variations in energy use.

Financial modelling capabilities are also limited. The system can estimate return on investment, generation costs, and tariff impacts, but it does not yet support more advanced financial mechanisms such as peer-to-peer trading or dynamic tariff structures.

Finally, the tool is optimized for systems up to a few megawatts (MWp) in size. Larger or more complex community energy projects may require more advanced simulation and modelling tools to ensure accuracy and performance.

Potential for future improvements

The system should introduce multi-consumer functionality, allowing each community member to have their own energy load profile. It should also simulate various energy-sharing methods—whether energy is divided equally, distributed based on contribution, or prioritized according to specific needs.

It should feature enhanced storage and flexibility modelling, accurately representing community batteries, electric vehicles, and demand management strategies to better reflect real-world energy use.

The financial module should be expanded to support advanced options such as collective self-consumption, network billing, peer-to-peer energy trading, and regional incentive schemes.

To ensure data accuracy and integration, the system should connect with local weather stations, smart meters, and IoT devices, while also accounting for seasonal and socio-economic variations in consumption patterns.

Finally, improved visualization and stakeholder engagement tools should offer community members a dashboard to monitor their individual energy use and savings, accessible through mobile or web interfaces for greater transparency and communication.

4.4.4 Applicability to other pilot regions

The CEP-RLM service is applicable to other municipalities and regions with similar building types, including schools, sports halls, and municipal facilities. Its application requires customization to local conditions, such as regional climate and solar irradiation, energy tariff structures, and consumption patterns across residential, commercial, and public sectors.

IESDI will continue to use Sunny Design tool to refine CEP RLM methodologies and expand its deployment across new contexts, parallel to developing Grid One or design a proprietary tool. Planned enhancements, including multi-user simulation and energy-sharing capabilities, will further extend the modelling tool applicability to other Bulgarian pilot projects implementing collective self-consumption. These developments will position the CEP RLM service as a viable solution for advancing decentralized, community-driven energy systems across diverse regions.



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