ECOEMPOWER

ECOsystems EMPOWERing at regional and local scale supporting energy communities

February 2024

D2.1 ECOEMPOWER ENERGY-ICT PLATFORM SPECIFICATIONS AND ENERGY COMMUNITIES USE CASES

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ABBREVIATION LIST

ABBREVIATION	DEFINITION
ACV	Association des Centrales Villageoises
API	Application Programming Interface
BEV	Battery Electric Vehicle
DoA	Description of Action
DSO	Distribution System Operator
EC	Energy Community
EV	Electric Vehicle
EWR	Elektrizitätswerke Reutte
GDPR	General Data Protection Regulation
GSE	Gestore dei Servizi Energetici
HEDNO	Hellenic Distribution Network Operator
HMI	Human Machine Interface
ICT	Information and Communication Technology
IoT	Internet of Things
IT	Information Technology
KPI	Key Performance Indicator
LEC	Local Energy Community
LR	Linear Regression
LS	Least-Squares
ML	Machine Learning
NZEB	Nearly zero-emission building
OSS	One Stop Shop

PAT	Provincia Autonoma di Trento
PV	Photovoltaic
RAE	Regulatory Authority of Energy
REC	Renewable Energy Community
RF	Random Forest
ROCG	Region of Central Greece
ROI	Return Of Investment
SCADA	Supervisory Control and Data Acquisition
SSO	Single Sign-on
UI	User Interface
UC	Use Case
WP	Work Package

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1 EXECUTIVE SUMMARY

This document serves as the inaugural deliverable of Work Package 2 (WP2), offering a comprehensive overview of the technical infrastructure and short-, mid- and long-term plans of the various regional ecosystems of the ECOEMPOWER project. It delves into detailed assessments of site infrastructure, existing equipment, and system specifications. Additionally, one of the main scopes of this deliverable is to describe the methodology employed in defining user scenarios and use cases (UCs) within the ECOEMPOWER Platform, ensuring alignment with the diverse needs of the regional ecosystems. The defined user scenarios and UCs serve as foundational guides for the platform's development, outlining functionalities and interactions to optimize user engagement and utility.

Within WP2, the software platform to be developed will serve as a holistic solution for local energy communities (LECs), aiming to integrate specialized tools to bolster energy management, sustainability, and user engagement. Towards this direction, this document presents the high-level specifications of the platform, building upon initial project conceptualizations, delineating both functional and non-functional requirements for each platform component. Moreover, within this deliverable preliminary platform mockups are provided, drawing insights from the project's conceptualizations and detailed UCs. These mockups offer an early visualization of the platform's user interface (UI), reflecting its design philosophy and functional aspirations.

Finally, this document concludes with insights into the next steps, particularly focusing on the development of the platform in Task 2.2.

Contents

2 Introduction

2.1 Scope of the deliverable

The aim of WP2 is to provide a user-friendly platform for energy communities (ECs) supporting them in the coordination of their energy resources and future activities planning. To achieve this, WP2 adopts a three-step approach, comprising (i) defining the platform requirements and identifying ECs' UCs (Task 2.1), (ii) developing the platform to meet the needs of ECs (Task 2.2), and (iii) validating the platform and energy analyses for the ECOEMPOWER ECs (Task 2.3).

This deliverable results from the work carried out in T2.1 – Platform requirements definition and ECs' UCs. Its scope encompasses a comprehensive characterization of the requirements of ECs, spanning short-, mid-, and long-term activities. These insights serve as the foundation for specifying the software platform and tools to be developed in Task 2.2. Its primary aim is to define user scenarios & UCs and outline the technical requirements of the ECOEMPOWER Platform. Ultimately, this effort aims to ascertain how the ECOEMPOWER platform can enhance value for each pilot within the project.

2.2 Deliverable Structure

D.2.1 is structured in seven sections as follows:

- Section 1: Executive summary – This section provides a concise overview of the document's contents.
- Section 2: Introduction – Section 2 provides an overview of this document including the description of its purpose, structure, and its interdependencies to the other ECOEMPOWER tasks and deliverables.
- Section 3: Overview of the Technical Infrastructure across the Regional Ecosystems – Section 3 provides an overview of the Technical Infrastructure across the 15 pilot sites of the ECOEMPOWER project.
- Section 4: ECOEMPOWER ICT Platform User Scenarios & UCs – This section presents the methodology employed in formulating the User Scenarios & UCs, alongside a comprehensive delineation of the user scenarios & UCs specific to each regional ecosystem.
- Section 5: Technical Requirements of the ECOEMPOWER Platform - Section 5 of the document outlines the ECOEMPOWER Platform by covering its overview, high-level requirements, architecture, and preliminary mockups.
- Section 6: Conclusions and Next Steps – In this Section, key deliverable outcomes are summarized and the subsequent steps or actions to be taken within the project are outlined.

The document concludes with an Annex containing the template utilized for information and data collection distribution in Section 3.

2.3 Interdependencies with other Tasks and Deliverables

The interdependencies between Task 2.1, Task 2.2, Task 2.3, and Task 6.2 are fundamental to ensuring the seamless development and implementation of the ECOEMPOWER project. Task 2.1 lays the groundwork by identifying and characterizing the requirements of ECs, providing crucial input for the development of the software platform in Task 2.2. The platform developed in Task 2.2, tailored to meet the requirements delineated in Task 2.1, will then be utilized in Task 2.3 for platform validation and conducting energy studies in collaboration with the ECOEMPOWER pilot sites. Meanwhile, the data acquired during the initial phase of the project for Task 2.1, including assessments performed in collaboration with Task 6.2, will serve as a baseline for benchmarking purposes, providing essential insights into the existing infrastructure and planned initiatives within the targeted regions. These insights will guide the software platform's development and validation process, ensuring alignment with the specific needs and contexts of the ECs involved in the project. Also, a synergy has been identified with T4.4 and the ECOEMPOWER Community Platform as it could potentially be used to host the various Energy Tools designed in this deliverable.

3 Overview of the Technical Infrastructure across the Regional Ecosystems

In the subsequent sections, an overview of the technical infrastructure across the Regional Ecosystems is provided. This includes detailed examinations of site assessment, existing infrastructure and equipment, alongside system specification. This comprehensive analysis was conducted through collaborative efforts with project pilot partners, who offered valuable insights and input. Furthermore, to enrich the understanding and fine-tune platform specifications for all IT (Information Technology) systems and interactions, a questionnaire was disseminated to gather additional technical details. More specifically, within T6.2, a template for information and data collection, intended to establish the baseline of the pilot sites, has been prepared and distributed to demo partners involved in the pilot sites. With the collaborative effort between WP2 and WP6 supplementary questions concerning technical specifics were incorporated. These additions aimed to acquire additional technical details to derive into platform specifications for all IT systems and interactions to be developed within WP2. The steps considered in the whole process for deriving an overview of the Technical Infrastructure across the Regional Ecosystems are outlined below:

- The project pilot partners shared their feedback on the current status and infrastructure of their respective pilots, including details about equipment and system specifications. It is important to highlight that, as evident in D6.2 (Baseline in the ECOEMPOWER pilot sites), each pilot within the regional ecosystems is at a different stage of progress. This variability may impact the quality of the information obtained in comparison to others;
- Development of a standardized template for collecting data and information from the various project regional ecosystems;
- Collaboration between WP6 and WP2 to include essential information for Task T2.1 into the T6.2 template for collecting additional data and information from the diverse regional ecosystems;
- Share the template with all the project pilot partners (PAT, ACV, eza!, EAZK, ROCG) to obtain relevant information from each ECOEMPOWER pilot site;
- Assess the feedback gathered from pilot sites to acquire pertinent information for the compilation of an overview of the technical infrastructure across the regional ecosystems.

Note that the baseline template distributed consisted of various sections; the ones pertinent to T2.1 are presented in Annex A. After gathering all the data pertaining to T2.1 from the demo partners, an in-depth evaluation of the feedback was conducted.

The gathered information, along with feedback on the status and infrastructure of their respective pilots, is consolidated and presented in the subsequent subsections in a descriptive format.

3.1 RE1: Autonomous Province of Trento (Italy)

In this section, an analysis of the site assessment, existing infrastructure, equipment, system specification and questionnaire results, is conducted for the Autonomous Province of Trento regional ecosystem. For RE1, Pilot Sites are Val di Fassa, Levico Terme and Valle dei Laghi.

3.1.1 Site Assessment and Existing Infrastructure

The territory of the Autonomous Province of Trento is essentially mountainous. The main valley is the Adige Valley, where the two main centres are located: Trento and Rovereto. The remaining territory is characterized by valleys and plateaus, all of which are inhabited and interconnected by main routes. The actual distances in some cases are much greater than those as the crow flies, as the road network follows the orography of the mountains.

Figure 3-1 - Autonomous Province of Trento Regional Ecosystem

From the point of view of electrical infrastructure, the Province of Trento is powered by 32 primary substations (high/medium voltage). The distribution system operator (DSO), for most of the territory, is SET Distribuzione, a publicly owned company. However, certain territories are directly managed by municipalities or companies in which municipalities hold stakes, e.g., the Mezzocorona area, and four areas served by historical electricity cooperatives that are also in charge of the grid. Fassa Valley is one of the Autonomous Province of Trento pilot sites and in Pozza di Fassa there is one of these.

All Italian pilots utilize state-of-the-art electronic meters capable of quarterly measurements, capturing data at one-hour intervals for incentive calculations. Nevertheless, there is a mandatory requirement to install smart meters with readings every 15 minutes by the end of 2024. While a significant portion of the Trentino region has already installed these new meters, a few smaller consortia are currently working on installations due to exemptions for special cases. It is noteworthy that the perimeter of primary cabins does not align with municipal or orographic boundaries. Consequently, some villages that are divided across multiple cabins, and areas, including unconnected ones like two parallel valleys, may fall under the same primary cabin. Moreover, as mentioned below, efforts are underway at various levels to develop digital tools supporting renewable energy communities (RECs).

At the national level, GSE (Gestore dei Servizi Energetici) is the body responsible for accrediting RECs and administering incentives. For some time, it has been operating a self-consumption portal where one can find guides, simulators, and access to the registration of RECs. At the time of deliverable submission, the portal is being updated as the regulations are being finalized these days and the GSE's technical rules have not yet been published. Also, through the GSE website, one can find the interactive map of the primary substations, which are the territorial limit of each REC.

At the local level, the Autonomous Province of Trento has the INFOENERGIA information portal and maintains the provincial register of RECs. On this site one can find all energy-related information, e.g.:

- funding for energy requalification;
- authorization procedures for different renewable energy sources;
- electric mobility;
- RECs and self-consumption groups;
- energy news and events.

On the page dedicated to RECs -which is under major update- there are illustrative slides, links to simulators, as well as in-depth and informative documents.

Also, on the Provincia Autonoma di Trento (PAT) website is the link to the provincial webgis containing the tool for calculating the photovoltaic (PV) energy potential of the entire PAT. For each m^2 of territory, the solar irradiation value has been calculated, considering obstacles (e.g., mountains). Furthermore, the webgis has a tool that allows, by drawing a surface (e.g., on a roof), to know the amount of kW that can be installed and how many kWh of energy it can produce in a year.

Finally, it should be noted that all three pilot projects are intending to establish a REC under the high voltage/medium voltage substation. Currently, national legislation is nearing completion. Until January 2024, national legislation allowed only small-scale experimental REC's beneath MV stations. Now the Ministry of environmental and energy security has published the decree regarding definition of public incentives on 23.1.2024. On 23 February, the technical rules defining how RECs will be registered will be published, and by 8 April, the national digital portals (managed by GSE) for registration and access to PNRR (i.e., National Recovery and Resilience Plan -abbreviation of Piano nazionale ripresa resilienza-) funds will be opened.

3.1.2 Equipment and System Specification

In the three pilot sites, the establishment of RECs, primarily centered around PV power plants, is planned. Additionally, in Val di Fassa and Levico areas, the development of hydroelectric plants is being investigated, although their realization may face challenges due to the complex authorization process and higher costs, which will most probably extend beyond the project timeline.

In Italy, the mechanism of RECs provides for a valorization of shared energy through a virtual exchange. Energy fed into the grid is sold, energy withdrawn from consumers in the REC is bought on the market, but energy produced and consumed simultaneously gives rise to an incentive. This incentive[1] is calculated on the basis of a formula that takes into account:

- the average energy price of the market area;
- the geographical location of the plant;
- the percentage of shared energy in the community;
- In addition to the incentive tariff that GSE disburses to RECs according to the energy produced and consumed simultaneously within the configurations, an incentive is disbursed that reimburses 'grid charges' as the energy exchanged under the same primary substation uses less of the national grid. This tariff is approximately 10€/MWh.

[1] https://www.mase.gov.it/sites/default/files/Decreto%20CER.pdf

The calculation of this incentive is complex and highly variable and must also consider the costs of energy, the costs of setting up the plant, the costs of the legal entity forming the community, and the costs of its operation and management. Furthermore, it must be clear what purposes the REC wants to implement with the incentive received.

Determining this incentive involves a complex and highly variable calculation, which must account for factors such as energy costs, costs of setting up the plant, formation costs for the community's legal entity, as well as operation and management costs. Additionally, it is essential to define the intended purposes for which the REC intends to utilize the received incentive.

To build the One Stop Shop (OSS) to support RECs, it is therefore crucial to have tools to govern this complexity. It would be useful to:

- Oversee potential production and consumption within an area to optimize exchange performance within the REC, even during its establishment phase;
- Develop one or more tools that consolidate various financial aspects, often complex, and generate reliable data through specific inputs, integrating those existing yet on national sites;
- Monitor energy prices and evaluate changes in incentives;
- Access real-time data on production and consumption to make hourly adjustments;
- Track administrative and operational costs and promptly manage them.

Some tools are yet disponible on national portal of GSE or ENEA (simulator of incentives), other are on our energy website portal (map of potential PV). All these tools are grouped on infoenergia.provincia.tn.it website.Similarly, the regulations for RECs also foresee other configurations of diffuse self-consumption, such as "self-consumption elsewhere" (a kind of REC where production and consumption belong to one entity), which could be of interest to municipalities, for example. The OSS must also evaluate these other forms to better target users.

Finally, it is crucial to provide clear, timely, and complete information, even when dealing with complex subjects, to ensure understanding without causing confusion, especially for those who may not be familiar with the topic.

3.2 RE2: Auvergne-Rhône-Alpes and Grand Est (France)

In this section, an analysis of the site assessment, existing infrastructure, equipment, system specification and questionnaire results, is conducted for the Auvergne-Rhône-Alpes and Grand Est regional ecosystem.

3.2.1 Site Assessment and Existing Infrastructure

Association des Centrales Villageoises (ACV) supports a network of 73 RECs across France, including 3 pilot sites in the Auvergne Rhône Alpes region (Centrales Villageoises VercorSoleiL and Eau et Soleil du Lac) and the Grand Est region (Centrales Villageoises de Vezouze en Piémont). They are therefore located in areas with very different characteristics. However, the members of the Centrales Villageoises network share a common statutory basis that enables them to share many tools and services provided by ACV.

Figure 3-2 – Integration of solar panels into the Auvergne-Rhone-Alpes regional ecosystem (Centrales Villageoises VercorSoleiL)

ACV is proactively enhancing communication and volunteer mobilization within the network, as well as developing tools and training programs specifically tailored to site assessment and existing infrastructure within the regional ecosystem. Regarding communication, ACV is contemplating the creation of various tools to improve the visibility of local companies within the ecosystem. Initial ideas include developing templates for communication plans, informative sheets for optimizing website usage, newsletters, and social media channels, as well as graphic design templates for events. Furthermore, ACV plans to conduct training sessions to ensure local companies adeptly utilize these tools for site assessment purposes.

In terms of volunteer mobilization, ACV is considering providing training sessions focused on governance and management of local companies. These sessions would define the principal objectives of the companies, clarify the roles of all members involved, explain the decision-making process, and establish effective channels for information circulation within the organizational structure. Additionally, ACV aims to emphasize the recruitment and retention of volunteers, recognizing their importance in conducting site assessments and evaluating existing infrastructure. This may involve developing tools focused on welcoming volunteers and organizing internal events to invigorate the volunteer experience.

Regarding the development of renewable energy projects, ACV is considering the creation of new tools for business plan analysis, specifically tailored to multi-project analysis within the regional ecosystem. These tools would assist ECs with existing production assets in understanding the influence of new projects at a company level, thereby aiding in site assessment and infrastructure planning.

This support would enhance visibility with citizens, elected representatives, banks, and partners, ultimately fostering the development of renewable energy projects. Moreover, it would ensure the sustainability of local structures, which is crucial for conducting effective site assessments and infrastructure evaluations within the ecosystem.

In the context of site assessment and existing infrastructure within the regional ecosystem, ACV aims to transition local companies from volunteer governance to paid employment. This transition is motivated by the goal of creating employment opportunities and alleviating the workload of volunteers. As such, the objective is that ACV becomes a resource center on which local companies could rely to find fundings for job creation on the scale of the local companies, suggest collaborative job opportunities among local companies, and formulate the requisite job descriptions, among other initiatives.

3.2.2 Equipment and System Specification

Within the French pilot sites, rooftop PV projects have already been developed. Currently, new production units are under development, with the aim of exploiting the electricity produced for collective self-consumption. In addition, each pilot site is working on another type of renewable energy production project, which is more ambitious and longer-term: a hydroelectric project for the Centrales Villageoises Eau et Soleil du Lac, a wind power project for the Centrales Villageoises VercorSoleiL, and a ground-based PV project for the Centrales Villageoises de Vezouze enPiemont.

Figure 3-3 - Rooftop solar implementation in the French regional ecosystem (Centrales Villageoises Vezouze en Piémont)

For production monitoring, each pilot site employs production monitoring platforms tailored to their specific needs. Centrales Villageoises Eau et Soleil du Lac utilizes Fusion Solar, an IT solution supplied by the PV inverter manufacturer for their operational PV plant. The inverter transmits production data from the PV plant to the visualization platform. For Centrales Villageoises VercorSoleiL, 27 power plants utilize the RBEE SOLAR solution, which involves dedicated meters installed on the PV plants transmitting data to the visualization platform, while 2 power plants utilize the IT solution provided by inverter provider SMA. In the case of Centrales Villageoises de Vezouze en Piémont, with its 10 power plants, the IT solution provided by inverter provider SolarEdge is utilized, with the inverter transmitting production data to the visualization platform. It should be noted that the production facilities of the Centrales Villageoises are all connected to the public distribution network, which is managed in these areas by ENEDIS. The pilot sites are linked to the grid as producers, but do not manage it and cannot have influence on the investment choices made in order to develop the electricity network infrastructure.

In addition, it is noteworthy that France has initiated the deployment of smart meters, known as "Linky," for consumers with a capacity of less than 36 kVA. This meter replacement is provided free of charge to consumers and commenced in 2016. As of the end of 2021, approximately 90% of meters, managed by the primary DSO, ENEDIS, have been upgraded to Linky meters. These meters record data at 15-minute intervals. For consumers with capacities exceeding 36 kVA, smart meters are typically already in place, with data recorded every 5 minutes.

These smart meters allow the French Pilot Sites to collect energy data in a 15 minutes time interval. They can easily download the production load curves from their online space on the DSO website. Regarding the consumption load curves, they also can be downloaded but it requires the authorization of the smart meters' owner. At the network level, the Association maintains databases to monitor all Centrales Villageoises, providing project leaders with information about projects undertaken by other Centrales Villageoises. Among these databases, the monthly production database allows for the detailed analysis of the productivity of each PV plant.

Regarding communication, ACV provides individualized websites for each Centrales Villageoises, serving as external showcases to promote their activities, energy productions, and news updates. These websites play a vital role as communication tools for the three pilot sites: Centrales Villageoises Eau et Soleil du Lac, Centrales Villageoises VercorSoleiL, and Centrales Villageoises de Vezouze en Piémont, enabling them to enhance visibility.

3.3 RE3: Allgäu (Germany)

In this section, an analysis of the site assessment, existing infrastructure, equipment, system specification and questionnaire results, is conducted for the Allgäu regional ecosystem.

3.3.1 Site Assessment and Existing Infrastructure

The Allgäu is characterised by a diverse topography, ranging from hilly landscapes to alpine mountain ranges. The different altitudes offer potential for harnessing various renewable energy sources. The southern location of the Allgäu favors a high level of solar radiation, which offers great potential for the use of solar power and solar heat. Additionally, wind turbines can efficiently operate in the higher altitudes due to favorable wind conditions. The landscape of the Allgäu is characterized by idyllic alpine meadows, dense forests, and imposing mountain peaks. The integration of renewable energy technologies should therefore take place with caution in order to ensure environmental and landscape protection at the same time. Land use in the Allgäu is diverse and includes not only agricultural land, but also woodland and residential areas. The integration of renewable energy technologies should be carefully planned to avoid conflicts with other land use requirements and to enable the sustainable development of the region.

The Allgäu has a well-developed electricity grid, which is supported by numerous substations to enable the distribution of electrical energy. Transmission lines connect the region with supra-regional electricity grids to ensure the exchange of energy and facilitate the integration of renewable energies. Alone the electricity grid operated by DSO AllgäuNetz in large parts of the Allgäu comprises around 5,500 kilometers of lines covering an area of approx. 1,700 km², 18 substations and 1,800 transformer stations.

In the municipalities and towns of the Allgäu, local distribution grids efficiently deliver electricity to end consumers. While these grids are generally well-developed, there is room for optimization to enhance the integration of renewable energies. Alongside AllgäuNetze, DSO Lechwerke Verteilnetz stands as one of the major distribution grid operators in the Allgäu region. However, several small electricity grid operators also contribute to the region's energy distribution network. The number of charging stations for electric cars in the Allgäu is steadily increasing, both in urban and increasingly in rural areas. The transport infrastructure in the Allgäu includes a well-developed road network. Public transport such as buses and trains are available, but such services are very limited in the sparsely populated area.

In the case of smart metering systems, meter readings are recorded every 15 minutes and transmitted to the regional grid operator via the smart meter gateway. Smart meters will be mandatory for all German households, as per legal directives setting binding targets for a full rollout by 2030. Beginning in 2025, installation will be compulsory for households with annual electricity consumption exceeding 6,000 kilowatt hours or those with a PV system capacity exceeding seven kilowatts. For most private households - with an annual consumption of less than 6,000 kilowatt hours per year - smart meters will remain optional after 2024. In these cases, the metering point operator will decide whether to install a smart meter. Alternatively, consumers can request the installation of a smart metering system. Even households with lower electricity consumption are entitled to request smart meter installation. However, progress in the rollout has been sluggish, primarily due to regulatory and technical challenges. As of 2023, the installation rate in Germany has reached only 1%. Finally, it should be noted that the utilization of Internet of Things (IoT) devices for optimized energy management is still relatively uncommon in the Allgäu region but is increasingly becoming more popular.

3.3.2 Equipment and System Specification

The Elektrizitätswerke Hindelang pilot site is an established energy supply company that also performs the tasks of a power plant, distribution network and metering point operator. Accordingly, the security requirements and confidentiality obligations of the co-operative must always be ensured at a high level. The range of systems used extends from conventional consumer portals (e.g., via the generation data of the inverter on the cooperative's roof), to measurement and energy data management systems. Microsoft and cloud systems are used for internal administration, as well as an Enterprise-Resource-Planning system for professional energy billing for customers, financial accounting, member administration, etc. Remote meter reading is now an outsourced service for business operations. On the EWH consumer side, smart meters are still far from being the standard, as is the case throughout Germany. On the producer side, there are different types of meters: from an annual reading to a 15-minute or real-time resolution. With regard to EWH grid operation, the option of remote control from >100 kW is mandatory by law. There is a separate software infrastructure for this with the grid operating system. Ultimately, EWH already has comprehensive and large-scale equipment and system base.

Figure 3-4 - Elektrizitätswerke Hindelang eG

The second pilot site, Dorfenergie Eppishausen has the following equipment and systems: The electricity meters are provided by DSO LVN (LEW). All systems currently run as full feed-in systems, i.e. the meters (feed-in meters) are only read optically at the end of the year. One exception is the meter of the Derndorf PV open space system, which is read remotely and receives a monthly evaluation. Data communication protocols exist insofar as an annual statement is prepared by the energy supply company. Daily online generation monitoring can be carried out via the portal ("SMA Sunnyportal"). The situation is different for system monitoring, where there is a router for all systems that transmits the data to a service company. Dorfenergie Eppishausen has concluded maintenance contracts with this company and the systems are monitored for irregularities.

Figure 3.5 - Dorfenergie eG pilot site

Finally, Elektrizitätswerke Reutte (EWR), an energy supply company with grid operation and a sales department, now shows interest in a new project about founding an energy sharing community (ESC). A co-operation between municipalities, farmers, hotels and private individuals is conceivable, all of whom have a great interest in establishing an EC. The new EC would primarily focus on electricity generation, with the emphasis on PV systems and the possible integration of wind energy. In this case, there is a lack of data at the pilot site, as there is neither a functioning EC nor applicable baseline scenarios with good reliability. At least there are ongoing data recordings of electricity generation and consumption in the hotels.

Figure 3.6 - Elektrizitätswerke Reutte pilot site

The initial technical situation of this planned ESC is as follows: Firstly, the meter numbers of the individual generators and consumers are not available in some cases, which is delaying project planning. The sub-meters installed by EWR in the hotels are primarily designed for billing the feed-in tariff. This required data on the hotels' electricity generation and consumption comes from EWR and is sent daily via an MScons interface to the “enerviso” system of the energy management company Egrid. On this basis, appropriate calculations are made for missing entries to ensure completeness.

To save costs, only the smallest possible number of meters was installed. One example of this is the power measurement of a PV system, which was not recorded. Instead, the performance data of a system at another hotel was used and interpolated accordingly. The 1/4-hour data relevant for monitoring is transmitted daily by e-mail to ‘Enerviso’, where the corresponding calculations are carried out and the results displayed.

The hotel data displayed has been coming from the ‘Enerviso’ system for several years now and is based on measured values from EWR. There are still some minor challenges to overcome: On the one hand, there is a hotel that also has a battery with its own metering system. A farmer's PV system, on the other hand, requires an active readout of the data as it is not automatically transmitted on a daily basis. It remains unclear how long the measuring devices used store the historical data. In addition, the process of reading out the measuring points by the EWR measuring centre is time-consuming, as the data must first be read out and then converted into a suitable form.

For a historical period from 15.08.2022 to 13.09.2022, eza! was able to make a first model calculation. This was only possible thanks to the measurement data provided and the close cooperation and processing with a local player who is involved in the energy management of the hotels. The model calculation consists of available, calculated and assumed generation and consumption data from a potential energy sharing community in this region. This modelled comparison illustrates the best possible synchronisation of the 15-minute data by adding further producers, consumers or flexibilities. In its optimised and finalised form, this should serve as a basis for informed decision-making by the relevant stakeholders (EWR, system operators and electricity consumers).

3.4 RE4: Zlín Region (Czech Republic)

In this section, an analysis of the site assessment, existing infrastructure, equipment, system specification and questionnaire results, is conducted for the Zlín regional ecosystem. It should be noted that in RE4, three pilot sites (Vlčnov, Slavičín and Zlín) are considered for the ECOEMPOWER project, which partially differ from those presented in the Grant Agreement (Prague 10, Prague 12 and Prague 6). The decision to switch pilot sites was made based on alignment with the objectives of the ECOEMPOWER project, which better match the characteristics of the newly selected sites.

3.3.3 Site Assessment and Existing Infrastructure

The Energy Agency of the Zlín Region (EAZK) supports the development and management of renewable energy communities (RECs) in the Czech Republic. Operating within the framework of EU Directive (2018/2001), it facilitates the integration of renewable energy into local energy systems. The Zlín Region's ecosystem includes a variety of electricity sharing models and cooperation with local distribution companies (EG.D, ČEZ Distribuce) and the TSO (ČEPS) is required to manage grid operations and data integration, while ERÚ is responsible for price regulation as well as the supervision of power generation and traders.

EAZK is working to enhance the digitalization and management capabilities of energy communities through the use of platforms like the Electro-Energy Data Centre (EDC). Currently in a provisional phase, the EDC is expected to be fully operational by 2026, with the capacity to serve many consumer points. Its functions will include data aggregation, energy storage management, and flexibility services. Efforts are also being made to standardize energy data collection, with plans to integrate smart meters and advanced metering infrastructure (AMI). These systems will enable detailed monitoring of energy usage, including 15-minute interval data collection for all involved consumers.

The agency is also facilitating collaborations between local energy communities (LECs), municipalities, and private sector stakeholders to advance renewable energy production and utilization. Specific initiatives include the energy management of municipality building assets, with a focus on public buildings equipped with renewable energy systems (RES) such as photovoltaic (PV) panels and battery energy management systems (BEMS). These collaborations aim to improve local energy efficiency and promote sustainable energy practices.

Energy sharing in the Czech Republic is implemented through various models to address the needs of different consumers:

- Active customer:
    - Individual Usage (Own Place): Allows consumers to use energy produced on-site, ranging from single-phase (1F) to three-phase (3F) systems.
    - Group Sharing: Supports energy sharing among small groups, with a maximum of 11 connection points (CP).
    - Apartment Building Sharing: Enables residents in apartment complexes to share energy through centralized infrastructure.

- Energy community (a legal entity registered with the ERÚ, a maximum of 1,000 collection points by 2026):
    - Community for Renewable Energy Sources (RES): Facilitates collective energy generation (including heat), a large company can never become a member
    - Energy community: Only electricity

Main barriers in the implementation of the energy community model are in various aspects. First, the technical barrier is exhausted network capacity and prohibited overflows. There is also a lack of smart meters, which should be alleviated by installing smart meters in places with consumption above 6 MWh by 2027 (most likely by 2028).

Second, there are legislative barriers. No member of the community, regardless of ownership interest, may exercise voting rights exceeding 10% of the total votes in the community. This is a disincentive for larger producers to be involved in the community and there are restrictions on company membership and voting rights. The producer is also obliged to pay taxes if his income from sharing exceeds CZK 30,000 (approx. EUR 1,200).

Above models are being applied in pilot sites across the Zlín Region, including Vlčnov, Slavičín, and Zlín, to expand renewable energy adoption and improve local energy systems. In these pilots, the main stakeholders are the municipalities themselves, or companies owned by these municipalities.

The Vlčnov pilot site includes PV systems installed on several municipal properties, such as the town hall, football stadium, cultural center, gardeners' building, volunteer firemen's building, a swimming pool, and elementary school. All these buildings are owned by the municipality. The site has a total installed PV capacity of 221.40 kW and an annual production potential of 222 MWh. The total investment is €275,000.

Figure 3-7 Vlčnov pilot site

The Slavičín pilot site has PV systems installed at a boiler room and an administrative building, both of which are owned by BTH Slavičín, a company fully owned by the municipality. The site includes a battery storage system with a capacity of 129.75 kWh to support a PV output of 139.50 kW, resulting in an estimated annual production of 140 MWh. The total investment is €335,000.

Figure 3.8 Slavičín Pilot Site

Data management at this site is supported by smart electric meters. Efforts are underway to formalize the establishment of an energy community to maximize the site's renewable energy potential.

Zlín does not have any electricity generation plants installed yet but wants to involve a significant part of the city in sharing, including the citizens and companies themselves.

Figure 3.9-5 Zlín Pilot Site

Smart electric meters and Electro-Energy Data Centre (EDC) are involved in data collection and management of these pilots. Future plans include establishing a one-stop shop (OSS) to improve community engagement and service delivery in a complex way. Meaning, assistance in all phases of establishing and managing of community as well as establishment and setting within the EDC and ERÚ.

3.3.4 Equipment and System Specification

Within the pilot sites, multiple renewable energy systems are being developed to enhance local energy production and consumption. Existing RES include rooftop PV installations, while future projects aim to expand into more ambitious technologies such as large-scale PV parks and BEMS integration for public and residential assets.

Data is obtained from multiple sources. Invoices from consumption points, data from distributors (small consumptions are only annual readings, above the 3x200A circuit breaker they are continuous smart meters, which are currently being placed at circuit breakers above 3x80A) and EDC or ERÚ data directly related to sharing. To monitor energy production effectively, pilot sites employ tailored IT solutions and visualization platforms. For example, the EDC will eventually aggregate energy production data from these sites, enabling detailed analysis of grid performance, energy consumption patterns, and the overall impact of renewable energy systems on the local grid infrastructure. Currently, the provisional system supports the collection of online data for consumers with a capacity exceeding 3x200A circuit breakers, with more comprehensive functionalities planned for the full operational phase in 2026.

EAZK is addressing challenges related to grid capacity and the integration of prosumers into the electricity network. By modeling available building and community assets, EAZK aims to optimize energy flows and minimize the operational challenges posed by fluctuating RES outputs. The agency also provides critical insights into grid infrastructure, including its capacity, the number of connected consumers, and the evolving role of renewable energy in grid operations.

3.4 RE5: Central Greece (Greece)

In this section, an analysis of the site assessment, existing infrastructure, equipment, system specification and questionnaire results, is conducted for the regional ecosystem of Central Greece.

3.4.1 Site Assessment and Existing Infrastructure

The Central Greece region, which is home to the regional ecosystem under study, is distinguished by a varied terrain that includes both picturesque coastal regions and alpine landscapes. This area, which is rich in historical and cultural significance, is also emerging as a center for renewable energy projects, with the ECOEMPOWER project specifically concentrating on ECs. It is noteworthy that, as of 10/2023, there are about 114 ECs in Central Greece. One major issue is that the current network has a limited electrical capacity. Domokos, Kamena Vourla, and Amfikleia are the three pilot sites in this region that are part of the ECOEMPOWER initiative. Every location offers a distinct combination of topographical and socioeconomic elements, creating a perfect environment for various EC models.

Domokos is situated close to Lamia on a mountainside with a view of the Thessalian plain. Kamena Vourla is a coastal town situated on the Malian Gulf's southern coast. Amfikleia is a valley-set town situated near the northern base of Mount Parnassus. Standard residential and commercial use are included in the consumption, with an increased focus on integrating heat pumps for the purpose of heating and cooling buildings and providing infrastructure for EVs. It is anticipated that the biogas plant in Amfikleia the PV systems in Domokos and Kamena

Vourla will drastically change the local consumption patterns. Moreover, there is the possibility of Power-to-Gas technology in the future, particularly in places like Amfikleia where agricultural waste can be used as a resource to generate electricity.

A combination of medium and low voltage networks is present in the area, which is essential for the distribution of electricity produced by the ECs. To preserve stability and efficiency during the integration of renewable energy sources, proper grid management is necessary. The exclusive DSO in Greece in charge of running the distribution network is called HEDNO (Hellenic Distribution Network Operator). Nevertheless, it is not always feasible to connect the ECs with the distribution system because of the network's limited capacity. To increase the distribution system's capacity to support additional ECs, new high voltage substations and associated lines are required.

The two primary organizations now educating the public on how to create an EC are RAE (Regulatory Authority of Energy) and HEDNO. To date, the region of Central Greece (ROCG) does not have a department or website that offers online services or guidance to the public on matters pertaining to ECs. However, the ROCG has organized live and virtual seminars and meetings to inform the stakeholders about the ECs.

Figure 3-10 – Aspect of Domokos (left) and Kamena Vourla (right)

Figure 3-11 – Aspect of Amfikleia

3.4.2 Equipment and System Specification

Each pilot site—Amfikleia with a biogas plant (500kW), and Domokos (1.5MW, i.e., *2727 PV modules * 550 W/module*) and Kamena Vourla (500kW, i.e., *909 PV modules * 550 W/module*) with solar PV systems—focuses on a distinct method of producing electricity. The adaptability of renewable energy solutions to regional geographic and socioeconomic conditions is shown in this variety.

Domokos is situated close to Lamia on a mountainside with a view of the Thessalian plain. A PV-based energy village with an emphasis on infrastructure, public buildings, and schools is intended to be established. Heat pumps and virtual net metering are included for effective energy distribution. The community is now in the design process, and there are no more particular data points available.

The second EC will be built at the coastal town of Kamena Vourla, which is located on the Malian Gulf's southern coast. The EC that will be created will have PV installations in cities, with a focus on urban energy infrastructure and the utilization of solar energy from the coastal environment. Local consumption is planned to be supported by virtual net metering. We are currently unable to provide more precise information due to delays in multiple operations/procedures. Both the Domokos and Kamena Vourla pilots will feature PV stations monitored via the inverter's SCADA (supervisory control and data acquisition) system, accessible through a mobile app, and complemented by CCTV surveillance. Furthermore, the stations will be equipped with snow and wind sensors to optimize operational efficiency and resilience.

Amfikleia, which is situated in a valley at the northern base of Mount Parnassus, is going to house a biogas plant. However, the project is still in its early stages, because of funding difficulties and challenges with the procurement of raw materials. The community is now in the design process, and there are no more particular data points available.

4 ECOEMPOWER ICT Platform User Scenarios & UCs

4.1 Methodology for the definition of the User Scenarios & UCs

In this section, we will present the methodology adopted for defining User Scenarios and UCs within the ECOEMPOWER Platform. This process was integral to ensuring that the platform's design and capabilities are inline to the Regional Ecosystems. The approach adopted was iterative and data-driven, underpinned by a need to align closely with the strategic objectives of the ECOEMPOWER project.

The methodology unfolded in several stages, beginning with an in-depth site assessment of each regional ecosystem to gauge current infrastructural capabilities and identify technological integration points. This was followed by a data collection phase, where insights regarding operational flows and energy management practices were gathered and analyzed. These insights were instrumental in grounding the subsequent stages of the process in empirical reality and are presented in the next section of this document.

Upon synthesizing the collected information with the project's general requirements, we proceeded with developing the UCs and possible User Scenarios. This was carried out with the dual objectives of enclosing the platform’s potential use in diverse operational contexts and ensuring that these uses resonated with the stakeholders' needs and aspirations.

The resultant User Scenarios and UCs serve as blueprints for the platform's development trajectory, mapping out the functionalities and interactions that will drive user engagement and platform utility. They also provide a reference framework for the subsequent articulation of the platform's technical architecture, detailing the roles and functionalities of the various layers that constitute the ECOEMPOWER ecosystem. These layers include the robust Data Ingestion & Management Layer, the critical Security Layer, and the multifaceted ECOEMPOWER Analytical Engine with its suite of modular engines – all converging towards an integrated, user-friendly interface.

4.2 Insights from Regional Ecosystems for UCs Development

Section 4.2 offers insights from the diverse regional ecosystems, shedding light on their objectives and the functionalities they seek from a software platform. These insights inform the development of UCs in subsequent sections, guided by the input and experiences of ECs participating in ECOEMPOWER.

4.2.1 RE1: Autonomous Province of Trento (Italy)

The Val di Fassa pilot, located in the Fassa Valley, is embarking on an inspiring energy community project rooted in educational collaboration. Initiated by local students who took part in an inter-school “Lego League” competition, this pilot site has evolved into a vision for a Renewable Energy Community (REC) centered around the Fassa Ladin School and local preschool. A unique feature of this initiative is its focus group, composed of students, teachers, and representatives from a local electrical cooperative, which is a historic partner and key supporter in bringing this project to life. The primary objective of this project is to create an energy community with a local and educational focus. A photovoltaic (PV) system of 130 kW (130 MWh/year of annual production) will be installed on the kindergarten's roof (or on the Church roof), with funding provided by the local electric cooperative. The participants in the REC will include students, their families, faculty, and school staff, embodying a true community-led initiative. Notably, any income generated from the PV system’s energy production will be funneled back into the schools, directed towards purchasing educational materials to benefit all involved. This approach emphasizes social impact over financial gain for individuals, fostering a sense of shared purpose and investment in sustainable energy.

In the Levico Terme pilot, the local municipality is taking the lead in establishing an EC, utilizing the expansive roof space of a school building. This initiative entails the installation of a PV plant on the school's roof, alongside PV systems in a small industrial/commercial district and residential areas in the suburbs. These installations will collectively supply energy to buildings in the historic center where traditional PV installation is unfeasible. In collaboration with a local energy utility, the municipality aims to realize the PV plant, with the primary objective of generating revenue to mitigate energy deficiency. To effectively manage the development of ECs and optimize the configuration for efficiency, a comprehensive technical study of the electric grid and its impact on RECs within its architecture is paramount. The Italian energy grid is structured around a punctual distribution system, and there is limited understanding of how a non-distributive production system will influence this grid architecture. Transitioning from scattered large plants to numerous small prosumers may lead to challenges such as energy peaks during summer days. Moreover, the proliferation of RECs within the same territory could strain the electric system's capacity. Therefore, a comprehensive analysis is essential to ensure the effective integration of RECs while maintaining grid stability and reliability.

Finally, the Valle dei Laghi EC will engage three local municipalities, along with local enterprises and citizens, in a collective effort towards achieving energy self-sufficiency while prioritizing social cohesion and sustainable development principles. The community's vision encompasses the integration of new PV plants on public buildings, schools, and industrial premises, alongside the establishment of biogas plants to utilize excesses from agricultural and livestock activities for electricity generation. In parallel, initiatives to promote electric mobility are underway, including the transition from internal combustion engine vehicles to Battery Electric Vehicles (BEVs) in the public transport fleet and the installation of charging stations for electric cars and bikes in strategic locations throughout the valley. Furthermore, the project aims to renovate public buildings to meet Nearly Zero Emission Building (NZEB) standards, thereby enhancing energy efficiency. There is an opportunity to conduct a comprehensive economic and financial assessment of the investments, operational costs, and incentives associated with the EC's initiatives. This evaluation would provide valuable insights for optimizing resource allocation and ensuring the long-term sustainability of the project.

4.2.2 RE2: Auvergne-Rhône-Alpes and Grand Est (France)

The three pilot ECs, RE2.1 Eau et Soleil du Lac, RE2.2 VercorSoleiL, and RE2.3 Centrales Villageoises de Vezouze-en-Piemont, are part of the Centrales Villageoises model, strategically situated in distinct regions. Each community actively involves citizens, local municipalities, and small to medium-sized enterprises in the development of renewable energy projects, such as PV or hydropower installation, with a strong emphasis on sustainability, community engagement, and social responsibility, such as promoting energy efficiency, offering e-mobility services, and fostering participatory decision-making processes.

Within the Auvergne-Rhône-Alpes and Grand Est regional ecosystem, the pursuit of sustainable energy solutions is underpinned by a commitment to harnessing technology and fostering community collaboration.

In this Regional Ecosystem, the challenge is to improve the local energy autonomy by covering a greater proportion of consumption with local electricity production units.

To help optimise these self-consumption rates, the regional ecosystem could draw on digital tools that enable the production forecasts for the facilities to be finely simulated. Using this data, the active members of the energy communities will be able to work on adapting consumption to production periods, initially by raising consumer awareness, and then using flexibility mechanisms (automatic control of electric vehicle recharging, water heaters, etc.). As a result this tool could be useful for different stakeholders: on the one hand, energy producers whose ambition is to optimise self-consumption rates, and on the other, end consumers (private individuals, local authorities, businesses).

As mentioned in section 3.2.2, the French Regional Ecosystem can rely on smart meters to have an easy access to energy data, both for production and consumption. However, the access to this data requires the explicit authorization from the smart meter's owner. As a result, this could be an obstacle to analysing all the consumption data of members of the energy community.

4.2.3 RE3: Allgäu (Germany)

The German regional ecosystem comprising the three pilots – Elektrizitätswerke Hindelang eG, Dorfenergie eG, and Elektrizitätswerke Reutte– encapsulates a dynamic landscape of citizen-driven energy initiatives in Germany. Each pilot embodies a unique approach to renewable energy generation, community engagement, and sustainable practices. Elektrizitätswerke Hindelang eG serves as a beacon of citizen energy engagement, championing self-organization for renewable energy generation and promoting local energy trading. Similarly, Dorfenergie eG harnesses citizen participation and local expertise to drive solar energy adoption, fostering economic and environmental benefits for its members in Eppishausen and Kirchheim. Meanwhile, Elektrizitätswerke Reutte (EWR) and municipalities in Altlandkreis Füssen and Seeg are in discussions regarding a potential collaboration. There is a strong likelihood of significant interest in models involving citizen participation for renewable energy projects such as wind and open-space PV installations, ideally integrated with storage solutions.

In this ecosystem, introducing a platform capable of monitoring generation and consumption patterns could be pivotal in optimizing consumption behavior and generating an economic benefit from it. By empowering stakeholders to make informed decisions regarding energy investments and participation models, such a platform has the potential to significantly enhance the region's energy management strategies. Moreover, it is within the interest of the regional ecosystem to implement a tool/platform that could provide forecasting of generation and consumption, empowering stakeholders to anticipate energy production trends. An improvement in energy management and resilience will also be achieved by creating a sound basis for investment and participation decisions. Moreover, monitoring electricity imports, degree of self-sufficiency, and local energy trading could foster a sense of regional autonomy and promotes sustainable energy practices tailored to the unique needs of the community, ultimately advancing the region towards a greener and more prosperous future.

4.2.4 RE4: Zlín Region (Czech Republic)

The Zlín Regional Ecosystem is focused on expanding the use of renewable energy, especially through solar panel installations, and improving how local energy communities manage their resources. To support these goals, the region has made energy modeling a top priority to guide and improve decision-making. For less mature energy communities, cost-benefit analysis serves as a helpful tool as they grow and develop.

Energy modeling is especially valuable in Zlín because of the different needs and stages of its pilot sites. For instance, Vlčnov's municipal projects need tools to simulate how solar panels could be integrated across buildings like the town hall, schools, and sports facilities while factoring in energy flows and usage patterns. In Slavičín, where battery storage systems are already in place, modeling can help test how different combinations of solar panels and storage could maximize self-consumption and reduce reliance on the grid. Meanwhile, in Zlín, where solar projects are just starting, the focus shifts toward financial and planning features offered by the ECOEMPOWER ICT Platform.

Energy modeling could also help assess the benefits of energy sharing once regulations allow it. By simulating energy flows between community members, local administrators can evaluate how energy sharing might improve efficiency, balance energy loads, and optimize grid usage. This is especially relevant for projects like Zlín's apartment building energy-sharing model, where managing energy flows among multiple users is crucial.

While energy modeling is the primary focus for advanced and developing projects, cost-benefit analysis remains a key tool for newer or smaller communities. These communities often lack the financial or technical resources for large-scale investments right away. Cost-benefit analysis can give them a clearer picture of the economic feasibility of renewable energy projects by evaluating payback periods, return on investment, and long-term savings. This helps them prioritize projects that offer the most impact with minimal financial risk, allowing for gradual growth and wider adoption of renewable systems.

By combining energy modeling and cost-benefit analysis, the Zlín Regional Ecosystem can provide better support for local energy consultants and community administrators. A platform offering both tools could generate detailed, community-specific reports. For example, EAZK could offer recommendations for Vlčnov's municipal expansions, technical improvements for Slavičín's battery systems, or financial feasibility studies for Zlín's early solar projects.

Through the integration of these advanced tools, the Zlín Regional Ecosystem aims to empower local energy communities, ensuring an efficient, balanced, and financially sustainable shift to renewable energy.

4.2.5 RE5: Central Greece (Greece)

In the municipality of Domokos, a vision for a greener future takes shape with the EC project. This initiative is set to install 1.5 MW of PV systems across public buildings and spaces, revolutionizing the way the town consumes energy. Through virtual net metering, the electricity generated will offset the energy costs of these communal areas, including schools and street lighting, creating a sustainable cycle of energy consumption and cost savings. In tandem, the integration of heat pumps aims to modernize the heating infrastructure with an eco-friendly twist. This narrative embodies a transition to renewable energy, optimizing local resources to foster a self-sufficient community, while also casting a safety net for its most vulnerable citizens through social support mechanisms.

The scope of the Kamena Vourla EC project is to build a renewable energy framework within the coastal town by establishing a 0.5 MW PV system. The project is confined to urban areas, aiming to generate clean electricity that will be distributed to local consumers using virtual net metering. It seeks to foster sustainable development, promote energy independence, and offer economic benefits through reduced utility costs. The Amfikleia EC project is centered around the establishment of a 500-kW biogas plant. This project is aimed at transforming agricultural waste into electricity, heat, and fertilizer, thereby serving a dual purpose of energy production and waste management within the municipality. It delineates the conversion of organic waste from local farms into valuable resources, creating a closed-loop system that benefits both the environment and the agricultural community.

Across the RE5, there is also a unified drive to leverage cutting-edge technology and innovative strategies to enhance the efficiency and resilience of ECs. Each pilot site recognizes the importance of equipping energy system modeling and scheduling tools with advanced grid modeling frameworks, enabling EC administrators to gain deep insights into the dynamics of energy distribution and consumption. By integrating these frameworks, stakeholders can make informed, data-driven decisions to optimize energy management practices, ensuring reliable and sustainable power supply for all users. Additionally, the implementation of advanced scheduling systems within the energy modeling tools holds immense promise for enhancing power dispatch efficiency, thereby improving overall energy distribution reliability. Moreover, optimizing community energy systems for maximized self-consumption is a shared goal, with a focus on utilizing advanced algorithms to balance local energy production effectively.

4.3 UC1: Forecasting Energy Generation and Demand

The Forecasting Tool for Energy Generation and Demand is an integrated solution designed to predict energy needs and production for EC end-users. It combines data processing with user-centric interfaces to deliver accurate and actionable energy insights. UC1 is split into two different subcomponents to highlight specific benefits and functionalities:

- **UC1.a Monthly PV Production Forecasting**: This part focuses on long-term forecasting to help the ECs with their energy planning and resource allocation.
- **UC1.b Short-Term PV Production Forecasting**: In comparison to the UC1.a, this component focuses on providing accurate short term forecasts (hourly or day-ahead) to drive potential flexibility events or optimize energy management.

This tool has the potential to play a key role in helping individuals and community leaders make better decisions, improve energy use, and boost efficiency. By giving a clear, comprehensive look at energy patterns, it supports smarter energy management and contributes to greater sustainability and awareness in communities. With detailed forecasts and user-friendly data visuals, it encourages everyone in the community to get involved in managing and conserving energy. Table 4.1 breaks down the above sub-use cases in their foundational components.

Table 4.1- UC1: Description of different subcomponents

UC1.a: Forecasting Tool - Monthly PV Production Forecasting	
Title	Monthly PV Production Forecasting
Objective	Provide accurate monthly solar PV production forecasts to support long-term energy planning, grid management, and resource allocation.
Background	This use case focuses on forecasting solar PV production on a monthly basis. The tool analyzes historical production data and weather trends to predict future energy outputs. By identifying seasonal patterns, it helps planners anticipate production capacity and guide investments and resource allocation.
Description	The tool aggregates historical solar PV production data and weather metrics (e.g., irradiance, temperature) to generate monthly forecasts. The predictions aim to provide insight into seasonal energy trends, assisting operators with grid balancing and energy communities with long-term planning. The tool's design allows for improvements in prediction accuracy over time as more data becomes available. More specifically, the tool is designed to analyze trends across months or seasons, emphasizing the bigger picture of energy production. Inputs are drawn from historical data and monthly weather averages, ensuring a comprehensive view of production capabilities. These forecasts could also help grid managers align supply with demand and prioritize investments for future capacity.
Relevant Stakeholders	Grid Operators, Energy Community Managers, Aggregators
Preconditions	• Historical PV production data and monthly weather data (e.g., irradiance, temperature) are available. • Forecasted weather data is available for the upcoming months. • The data sources have established data communication methods. • The Forecasting Tool can support time-series modeling and inputs to capture seasonal patterns.
Basic Flow	1. The tool collects historical production data and corresponding weather data. 2. Collected data is cleaned, normalized, and structured to eliminate outliers and inconsistencies. 3. It processes the data to identify trends and seasonal variations in production. 4. The tool applies time-series models (e.g., SARIMA or LSTM) to generate monthly production forecasts. 5. The forecasts help guide grid management and long-term planning for energy production. 6. The tool continuously refines its predictions as new data becomes available.

Alternative Flow	● If the weather data is incomplete, the tool alerts platform administrators to fetch missing data. ● In case of significant deviations between actual and predicted production, the tool retrains the model to improve future predictions.
Postconditions	● Monthly production forecasts for each installation are generated, helping to improve planning and resource allocation. ● Predictions allow grid managers to balance supply and demand based on accurate solar production forecasting..
Expected Results	1. Enables better energy resource allocation and investment strategies. 2. Supports grid stability through accurate seasonal production forecasts. 3. Gradually improves prediction reliability with ongoing data updates.
UC1.b: Forecasting Tool - Short-Term PV Production Forecasting	
Title	Short-Term PV Production Forecasting
Objective	Provide highly accurate short-term (hourly or daily) PV production forecasts to help operators respond to immediate changes in weather and manage energy effectively.
Background	Short-term solar energy output is highly sensitive to sudden changes in weather, such as cloud cover. This use case focuses on rapid, high-frequency forecasting to help operators make quick decisions for local energy optimization and grid stability.
Description	The tool processes real-time weather updates (e.g., irradiance, temperature, cloud cover) combined with historical production data to predict solar output in the next few hours or minutes. Predictions empower grid operators and small-scale energy systems to adapt to rapid fluctuations and maintain balance between supply and demand. Designed for hourly or daily forecasts, the tool adapts to immediate changes in solar energy output. Processes frequent updates, ensuring timely and accurate predictions. Ideal for quick operational decisions, such as grid adjustments or battery usage optimization.
Relevant Stakeholders	Grid Operators, Energy Community Managers, Aggregators
Preconditions	● The platform is designed to support external communication. ● Security protocols and data standards are established for safe and efficient data exchange.
Basic Flow	1. 1. The tool collects real-time weather data (e.g., cloud cover, irradiance, temperature) and production data from a small installation. 2. It processes the data to identify immediate impacts on solar production. 3. The tool applies nowcasting models (e.g., LSTM or XGBoost) to predict short-term production (next few hours).

	4. The tool provides short-term predictions to operators for immediate decision-making. 5. The system continuously monitors weather data and adjusts predictions accordingly.
Alternative Flow	• If real-time weather data is unavailable, the tool provides forecasts based on recent historical data and alerts administrators to fix the data feed. • If actual production deviates significantly from predictions, the system triggers alerts for grid managers to adapt operations.
Postconditions	• Short-term production forecasts (next few hours or day-ahead) are generated, enabling PV operators to adapt operations effectively • Grid managers can respond to fluctuations in solar output and balance the local grid accordingly.
Expected Results	• Short-term production forecasts allow operators and grid managers to respond quickly to sudden changes in weather, improving grid reliability. • Small installations can optimize their energy production and storage in response to real-time predictions.

4.4 UC2: Energy System Modelling and Scheduling

The Energy System Modelling and Scheduling Tool is a smart solution designed to help Energy Communities (ECs) better manage, optimize, and plan their energy use. It's a key part of the ECOEMPOWER Platform, bringing together several features to boost energy efficiency, improve planning, and make the most of renewable energy. This tool gives community managers practical insights to use resources effectively and plan for the future:

- **Energy Profiling and Day-Ahead Planning (UC2.a):** This feature creates detailed energy profiles for buildings by using renewable energy generation and tariff data. It helps schedule energy use to avoid peak times, improve efficiency, and set the stage for community-wide energy planning. Building managers get straightforward recommendations to lower costs and utilize the collective building energy use better.
- **Community Energy Flow Simulation (UC2.b):** This feature focuses on balancing energy use across the community. It identifies where there's extra energy or shortages and simulates ways to share resources more effectively. By using building energy profiles and tariff data, it helps cut costs, improve efficiency, and ensure everyone gets a fair share of resources.
- **Load Management and Scenario Planning (UC2.c):** This flexible feature is useful for daily management and long-term planning. It shows current self-consumption rates and offers ways to use more renewable energy with what's already available. It also provides a custom scenario builder functionality, letting users test out new configurations for RES and see how they would affect the EC. As an additional feature, it recommends the best investments to reach self-consumption goals.

Overall, the Energy System Modelling and Scheduling Tool is a comprehensive way to manage energy for ECs. It provides clear insights, useful data, and easy-to-use strategies to save money, increase energy independence, and plan for the future. Table 4.2. goes into more detail about each feature.

Table 4.2- UC2: Description of different subcomponents

UC2.a: Modelling Tool - Energy Profiling and Optimal Day-Ahead Planning	
Title	Energy Profiling and Optimal Day-Ahead Planning
Objective	Buildings have unique energy use patterns based on their operations, appliances, and renewable energy systems. Flexible loads like HVAC systems, EV chargers, and other deferrable devices can be scheduled to cut costs and improve efficiency. By incorporating data on renewable energy production and tariff rates, this tool helps buildings make the most of locally generated energy when it's abundant and reduce dependence on external energy during costly tariff periods. These energy profiles also play a crucial role in simulating community-wide energy flows, supporting both individual and collective optimization efforts.
Description	This use case generates energy consumption profiles for individual buildings by analyzing historical data and incorporating renewable energy production and tariff details. Flexible loads are scheduled to align with periods of high renewable energy availability or low tariffs, creating day-ahead plans that maximize cost savings and self-consumption. By integrating renewable generation and tariff data, the tool helps buildings optimize energy use both economically and operationally. These profiles also serve as a basis for community-wide energy simulations, identifying surpluses and deficits and improving resource allocation. As new data becomes available, the tool refines the profiles, ensuring schedules become more accurate and efficient over time.
Actors	Building Managers, Energy Community Managers
Preconditions	• Access to historical hourly energy consumption data for each building. • Information about flexible appliances, including operational constraints and usage patterns. • Forecasted RES generation data (e.g., solar, wind) or typical generation patterns derived from historical data. • Day-ahead tariff structures, including hourly prices for energy use and feed-in tariffs (if applicable). • Defined peak and off-peak hours based on tariffs or observed consumption patterns.
Basic Flow	1. Collect historical hourly energy consumption data for individual buildings and gather information about flexible appliances. 2. Incorporate forecasted or typical RES generation data to identify high-generation periods. 3. Integrate day-ahead tariff data to pinpoint low-cost and high-cost hours. 4. Create detailed energy profiles, capturing: a) Peak and off-peak demand periods. b) Flexible load characteristics and constraints. c) Renewable energy availability windows.

	5. Simulate load shifting by scheduling flexible loads to align with RES generation or low-cost hours while ensuring operational constraints, such as runtime and deadlines, are respected. 6. Generate optimized day-ahead schedules by highlighting periods of high renewable energy utilization and minimized peak loads. 7. Based on the schedules, present actionable recommendations for energy efficiency and cost savings. 8. Refine profiles continuously using updated data for improved accuracy.
Alternative Flow	● If forecasted RES generation data is unavailable, use typical generation profiles based on historical trends. ● For buildings with incomplete consumption data, generate proxy profiles using clustering techniques and similar building data.
Postconditions	● Individual buildings receive optimized day-ahead schedules that align with RES generation and tariffs. ● Profiles are updated with new data to improve accuracy and reflect changing patterns. ● Aggregated profiles serve as input for community-wide energy flow simulations.
Expected Results	1. Improved energy efficiency by leveraging renewable energy during high-generation periods (building level) 2. Reduced costs by aligning consumption with low-tariff hours. (building level) 3. Clear insights into energy usage patterns and flexible load opportunities. (building level) 4. Aggregated building profiles provide critical input for optimizing collective energy flows. (community level) 5. Detailed flexibility and RES usage data support effective community-wide energy balancing. (community level)
	UC2.b: Modelling Tool - Community Energy Flow Simulation
Title	Community Energy Flow Simulation
Objective	Simulate and balance energy consumption across buildings to identify surplus/deficit patterns and optimize energy redistribution using tariffs and building-level energy profiles for community-wide cost savings.
Background	Energy communities often experience imbalances in consumption and generation across their buildings, leading to inefficient resource utilization. Identifying surplus/deficit patterns within the community and leveraging tariff data, flexible loads, and shared assets can optimize energy redistribution. This benefits energy community managers by reducing overall costs and enhancing energy efficiency at a collective level. Building-level profiles provide granular insights that serve as the foundation for these simulations, ensuring targeted and effective redistribution strategies.
Description	This use case uses aggregated building-level consumption profiles, RES generation data, and tariffs to model community energy dynamics. By identifying periods of energy surplus

	(excess generation) and deficit (insufficient generation), the tool simulates strategies for redistributing flexible loads and utilizing shared resources like batteries. Tariffs are incorporated to prioritize redistribution strategies that minimize costs during high-tariff periods while maximizing renewable energy usage. The tool provides actionable insights for community managers to balance energy flows, reduce disparities, and achieve community-wide cost optimization, without needing to overly rely on the grif topology or external assistance from DSOs.
Relevant Stakeholders	Energy Community Managers, Aggregators
Preconditions	● Building-level consumption and RES generation profiles aggregated from UC2.a. ● Tariff structures, including day-ahead hourly prices for energy usage and feed-in tariffs (if applicable). ● Details of shared resources, such as batteries, including capacity and charge/discharge rates.
Basic Flow	1. Aggregate building-level consumption and generation profiles as well as community-wide generation data. 2. Analyze hourly consumption and generation data to pinpoint periods of surplus (excess generation) and deficit (higher demand). 3. Highlight buildings with consistent surplus or deficit behavior to prioritize redistribution strategies. 4. Simulate various redistribution strategies by leverage flexible load data from building profiles to redistribute energy from surplus to deficit periods or buildings while taking into consideration the shared resource usage (e.g., charging batteries during surplus, discharging during deficit) and tariff data (e.g prioritize redistribution during high-tariff hours to reduce energy expenses.) 5. Calculate community-wide cost implications for each redistribution strategy while ensuring fair distribution of resources. 6. Present the results to the end user using a) pre- and post-simulation energy flow visualizations, showing changes in surplus/deficit patterns, b) redistribution schedules for flexible loads and shared resource deployment and c) metrics on cost savings, variance reduction in consumption, and resource utilization efficiency.
Alternative Flow	● For incomplete building data, simulate redistribution using proxy profiles based on similar buildings or aggregate averages. ● If RES generation profiles are unavailable, use historical generation trends to estimate likely surplus and deficit periods.
Postconditions	● Balanced energy flows across the community, with optimized use of surplus energy and minimized deficits. ● Actionable cost-saving strategies tailored for energy community managers. ● Improved utilization of shared resources, reducing energy waste and enhancing self-consumption.
Expected Results	1. Clear insights into surplus/deficit patterns and strategies to optimize resource usage. (community managers) 2. Actionable redistribution recommendations to improve community-wide energy efficiency and reduce costs. (community managers)

	3. Enhanced decision-making support through visualized energy flows and cost metrics. (community managers) 4. Balanced energy consumption and improved fairness in resource allocation. (community level) 5. Reduced dependency on external energy sources and enhanced self-sufficiency. (community level) 6. Cost optimization leveraging flexible loads, tariffs, and shared resources. (community level)
	UC2.c: Modelling Tool - Load Management and Scenario Planning
Title	Load Management and Scenario Planning
Objective	Provide a platform to assess, optimize, and simulate self-consumption at the community level using existing resources and explore new RES scenarios to improve energy independence.
Background	Self-consumption is a critical goal for energy communities to reduce reliance on external sources and improve sustainability. Optimizing load management and storage usage helps communities make the most of their existing resources. Additionally, the ability to simulate new RES scenarios provides energy managers with insights into potential improvements and prepares them for strategic investments. By combining operational optimization with scenario exploration, this tool bridges immediate needs and forward-looking planning.
Description	This use case offers an interface for energy community managers to: 1) Assess the current degree of self-consumption using historical and real-time data, 2) optimize load schedules and shared storage usage to maximize self-consumption with existing resources, 3) simulate new RES scenarios by allowing users to define asset specifications and explore their impact on self-consumption rates and 4) enable targeted recommendations for achieving desired self-consumption goals, including optimization of new RES configurations. These functionalities empower managers to enhance operational performance while exploring future possibilities, ensuring data-driven decision-making for energy independence and cost-efficiency.
Relevant Stakeholders	Energy Community Managers, Aggregators
Preconditions	● Aggregated building-level energy profiles, including consumption and flexible load data from UC2.a ● Historical or typical renewable generation profiles for existing resources. ● Specifications for shared resources, such as battery capacity and operational constraints. ● Input fields for defining new RES assets, including type, capacity, and expected generation profiles.
Basic Flow	**1. Self-Consumption Assessment**

	• The tool calculates the current self-consumption rate for the community using available consumption and renewable generation data. • Displays key metrics, including energy independence, storage utilization, and renewable energy curtailment. **2. Optimize Existing Resources** • The user selects the "Optimize Self-Consumption" functionality. • The tool analyzes load schedules, shared storage usage, and renewable generation profiles. • Recommendations are provided, such as load-shifting strategies or adjusted storage deployment schedules to maximize renewable energy utilization. • Results are displayed with metrics such as improved self-consumption rates, reduced reliance on external energy, and updated load schedules. **3. New RES Scenario Simulation** • The user selects the "New RES Scenario" functionality. • Users input characteristics of the proposed RES asset, such as type (e.g., solar, wind, battery), capacity, and expected generation profile. • The tool simulates the impact of the new RES asset on self-consumption, storage usage, and energy independence. • Results include metrics such as changes in self-consumption rates, potential surpluses or deficits, and storage efficiency improvements. **4. Target-Based Optimization** • Users specify a desired self-consumption target. • The tool runs an optimization to recommend the best RES configuration to achieve the target, including type, size, and placement of new assets. **5. Result Presentation** • All outputs are visualized in an intuitive dashboard with graphs, tables, and actionable recommendations. • Users can export reports for operational planning or integration with strategic tools like the Cost Benefit Analysis tool described in (UC3).
Alternative Flow	• If data for existing RES assets is incomplete, historical trends or regional benchmarks are used for simulations. • If users do not have specific RES configurations in mind, the tool generates generalized recommendations based on typical asset performance and community needs.
Postconditions	• Community managers receive optimized load schedules and actionable recommendations for improving self-consumption with existing resources. • Simulations of new RES scenarios provide insights into their potential impact and feasibility. • Targeted RES recommendations enable data-driven decision-making to achieve desired self-consumption goals.
Basic Flow	1. Improved self-consumption and energy independence through load and storage optimization. 2. Reduced energy costs by maximizing renewable energy utilization. 3. Clear insights into the impact of new RES investments on community performance. 4. Strategic recommendations for achieving specific self-consumption targets. 5. Community managers are equipped with tools for both immediate improvements and future planning.

4.5 UC3: Cost Benefit Analysis and Decision Making

The Cost Benefit Analysis and Decision-Making Tool is designed to give energy community leaders, aggregators, and the other related stakeholders a clear understanding of the financial side of energy projects and contracts. As a key part of the ECOEMPOWER Platform, it helps users evaluate project sustainability, optimize energy costs, and plan long-term investments. This tool brings together several features to meet the financial planning needs of energy communities:

- **Scenario Building for Investment Planning (UC3.a):** This feature allows users to model and assess short-term investment options like renewable energy installations or energy efficiency upgrades. It calculates financial outcomes such as upfront costs, operational savings, and payback periods, helping communities identify projects that make the most sense to implement quickly. Scenarios created in the Load Management and Scenario Planning Tool (UC2.c) can be imported here for financial analysis, making it easy to connect and use data across tools.
- **Long-Term Financial Planning and ROI Calculation (UC3.b):** This feature provides financial projections for energy projects over the long term, including lifecycle costs, operational savings, and return on investment (ROI). It allows users to adjust different factors like growing energy demand to ensure that the financial plans stay flexible as conditions change.
- **Contract Negotiation and Tariff Optimization (UC3.c):** This feature helps users find better energy deals by analyzing past energy use and highlighting inefficiencies. It gives actionable recommendations to reduce costs, helping community managers and prosumers negotiate better contracts or switch to more cost-effective tariff plans.

The tool serves as a versatile platform for analyzing a wide range of energy-related data, offering user-friendly interfaces and customizable reporting to suit various user needs. It empowers users with the knowledge and insights needed for effective energy management, encouraging sustainable and cost-effective energy practices within communities. With these features, the tool supports energy communities in reaching their financial goals, increasing energy independence, and ensuring sustainable growth. The discrete functionalities of UC3 are detailed in Table 4.3.

Table 4.3- UC3: Description of different functionalities

UC3.a: CBA Tool - Scenario Building for Investment Planning	
Title	Scenario Building for Investment Planning
Objective	Enable users to create and evaluate investment scenarios, simulating the financial outcomes of proposed projects to identify optimal short-term strategies for energy communities.
Background	Energy communities require tools to evaluate potential investments early in their decision-making process. By exploring different investment options, including renewable energy installations or efficiency improvements, stakeholders can calculate financial outcomes such as capital costs, operational savings, and payback periods. Scenarios developed in operational tools like UC2.c can be directly exported to UC3.a to assess their financial impacts, ensuring a seamless transition from operational planning to financial evaluation.
Description	This use case allows users to select and model various investment scenarios, including renewable energy projects and efficiency upgrades. It calculates the financial outcomes of each scenario, including upfront capital costs, operational savings, and payback periods, enabling stakeholders to compare and prioritize investments. Additionally, operational scenarios created in UC2.c can be imported to simulate their financial implications, fostering synergy between operational and financial planning.
Relevant Stakeholders	Energy Community Managers, Energy Consultants, Prosumers
Preconditions	● Historical financial and consumption data for the community. ● Input fields for specifying details of proposed investments, such as costs, savings, and timelines. ● Operational scenarios exported from UC2.c for financial evaluation. (optional)
Basic Flow	1. The tool retrieves historical financial and consumption data for the community. 2. Users select investment scenarios to model, such as renewable energy installations, battery storage additions, or energy efficiency improvements. Operational scenarios created in UC2.c (e.g., self-consumption optimization scenarios) can also be imported for financial analysis. 3. The tool simulates the financial outcomes of the selected scenarios, calculating: a) Capital costs for implementing the projects. b) Operational savings from reduced energy consumption or improved efficiency. c) Payback periods and short-term cost impacts. 4. Users receive a detailed report summarizing the financial results for each scenario, enabling comparisons.

Alternative Flow	• If specific investment data is unavailable, the system provides estimated costs and benefits using benchmarks from similar projects or communities.
Postconditions	• Users receive a comparative analysis of investment scenarios, helping them prioritize short-term projects based on financial outcomes.
Expected Results	1. Supports informed decision-making by providing clear insights into the short-term financial impact of various investment scenarios. 2. Fosters synergy between operational planning in UC2.c and financial analysis in UC3.a, creating a seamless workflow for stakeholders. 3. Helps communities prioritize cost-effective projects to achieve their immediate energy goals.
UC3.b: CBA Tool - Long-Term Financial Planning and ROI Calculation	
Title	Long-Term Financial Planning and ROI Calculation
Objective	Provide long-term financial projections and ROI calculations for energy investments, helping communities evaluate the sustainability and profitability of projects over a 20-40 year horizon.
Background	While short-term investment planning provides immediate financial insights, long-term financial planning is critical for ensuring that energy projects remain viable and beneficial over decades. This includes factoring in operational costs, savings, and evolving variables such as tariff changes, maintenance costs, and inflation. UC3.b focuses on delivering these extended financial evaluations to guide strategic planning and sustainability.
Description	This use case evaluates the long-term financial performance of energy investments, offering detailed projections over extended time horizons. It considers lifecycle costs, operational savings, and ROI, while allowing users to adjust parameters like inflation, tariff rates, and demand forecasts to reflect evolving market conditions. Unlike UC3.a, which focuses on short-term costs and benefits, UC3.b provides a macro-level view of financial performance, enabling communities to align their projects with long-term goals.
Relevant Stakeholders	Energy Community Managers, Energy Consultants, Prosumers
Preconditions	• Historical financial and consumption data for the community. • Input fields for specifying details of proposed investments, including lifecycle costs and expected savings. • Ability to adjust assumptions such as inflation, tariffs, and demand forecasts.
Basic Flow	1. The tool retrieves historical consumption and financial data, including costs, tariffs, and savings trends. 2. Users input investment options, such as renewable energy systems, efficiency upgrades, or storage solutions, specifying costs and benefits over their expected lifecycle.

	3. The system calculates long-term financial projections for each investment, including: a) Total lifecycle costs (e.g., maintenance, replacement, and operational costs), b) cumulative savings over the specified time horizon. c) Payback periods and ROI over 20-40 years. 4. Users can adjust dynamic variables such as inflation rates and energy price trends. 5. The system generates a comprehensive report detailing financial outcomes over the selected horizon, including comparisons between multiple investments.
Alternative Flow	● If detailed lifecycle cost data is unavailable, the tool estimates inputs using benchmarks from similar projects or industry standards.
Postconditions	● Users receive clear long-term projections, showing how proposed investments will perform financially over decades. ● Stakeholders gain insights into potential risks and benefits associated with evolving economic and operational conditions.
Expected Results	1. Provides energy communities with a detailed understanding of the sustainability and profitability of their investments over extended timeframes. 2. Enables users to plan for long-term economic challenges and opportunities, ensuring that projects align with strategic goals. 3. Offers flexibility to model dynamic variables, empowering stakeholders to adapt to changing market conditions.
UC3.c: CBA Tool - Contract Negotiation and Tariff Optimization	
Title	Contract Negotiation and Tariff Optimization
Objective	Energy contracts significantly impact operational costs. Analyzing consumption patterns against tariff structures helps identify inefficiencies and provides insights for renegotiating better terms or switching to more suitable tariffs.
Background	Effective management of energy storage systems is vital for maximizing cost efficiency, especially in communities with variable renewable energy sources. This tool feature assists in scheduling the charging and discharging of storage systems, aligning with energy demand patterns and market pricing.
Description	This use case enables users to input their current energy contracts and tariffs, compare them against historical consumption data, and receive recommendations for optimization. It evaluates cost savings potential and provides actionable insights for contract negotiation or tariff selection.
Relevant Stakeholders	Prosumers, Energy Community Managers
Preconditions	● Historical consumption data for the community or individual users. ● Input fields for current tariff structures and contract details.
Basic Flow	1. The tool retrieves historical consumption and financial data for the community.

	2. Users input details about their current contracts and tariff structures. 3. The system evaluates consumption patterns against tariff data to identify inefficiencies. 4. Recommendations for optimal contract terms or alternative tariffs are generated based on consumption data. 5. Users receive a report outlining potential cost savings and suggested contract changes.
Alternative Flow	● If tariff data is incomplete, the tool suggests typical tariff structures for the region or similar industries.
Postconditions	● Users receive actionable recommendations for contract adjustments to minimize costs.
Description	1. Reduces energy costs by optimizing tariff structures and contract terms. 2. Empowers users, including prosumers, to negotiate better energy contracts with data-driven insights.

4.6 UC4: Secure Data Collection and Management in ECs

UC4 represents the comprehensive infrastructure layer of the platform, designed to handle data storage, analytics, cybersecurity, and provide an intuitive Human Machine Interface (HMI). This foundational UC ensures the platform's robustness, scalability, and user-friendliness, enabling ECs to manage, analyze, and secure their energy-related data effectively. UC4 consists of three interconnected sub-UCs:

UC4.a: Cloud-Based Data Management for ECs

- Manages the storage and flow of data within the platform.
- Facilitates data sharing between tools and external sources.
- Ensures scalability for accommodating growing data volumes.

UC4.b: Implementing Robust Authentication and Authorization for Enhanced Cybersecurity

- Enhances platform security with authentication and access control.
- Protects sensitive data and ensures privacy compliance.
- Safeguards against cyber threats and unauthorized access.

UC4.c: Creating Intuitive HMI for Energy Data Interaction and Visualization

- Provides users (Prosumers and Administrators) with an intuitive interface.
- Integrates various tools (UC1, UC2, UC3) for seamless navigation.
- Empowers users to interact with energy data, make decisions, and visualize results effectively.

The encompassing framework for data storage, analytics, cybersecurity, and HMI, offers a comprehensive solution that empowers ECs in managing their energy systems efficiently. With UC4.a ensuring streamlined data management and UC4.b bolstering cybersecurity, users can securely access and share energy-related data. UC4.c provides an intuitive HMI, simplifying data interaction and visualization for both Prosumers and Administrators.

This integrated approach enables data-driven decisions, enhances energy efficiency, and promotes sustainable practices. The anticipated outcomes include improved data handling, robust security measures, user-friendly experiences, and informed decision-making, ultimately advancing energy management within communities towards sustainability and cost-effectiveness. It represents a significant leap forward in navigating the complexities of energy management with confidence and clarity, optimizing investments, and fostering community engagement in sustainable energy practices. The three discrete functionalities of UC3 are detailed in Table 4.4.

Table 4.4- UC4: Description of the three interconnected sub-UCs

UC4.a: Cloud-Based Data Management for ECs	
Title	Cloud-Based Data Management for ECs
Objective	To implement a scalable, reliable cloud-based data management system that efficiently handles diverse datasets from ECs, ensuring high availability, security, and easy integration with other tools.
Background	Recognizing the need for robust data handling capabilities, this UC emphasizes the importance of cloud-based solutions in managing large volumes of data from various sources. It aims to provide a centralized, scalable, and secure data storage and processing platform.
Description	UC4.a involves the implementation of a cloud-based data management system, designed to handle, store, and process large volumes of data from various sources within ECs. This system ensures scalability, high availability, and robust security, facilitating effective data-driven decision-making.
Relevant Stakeholders	ECOEMPOWER Developers, End-users
Preconditions	● Reliable cloud infrastructure in place (like Amazon S3, Google Cloud Storage or similar). ● Established data sources and collection mechanisms (MQTT, RabbitMQ or similar data streaming tools). ● Simple Database solutions are in place. ● Defined access control and security protocols.
Dependencies	● **Forecasting Tool (UC1):** Provide real-time and historical data for energy demand and weather forecasts. ● **Energy System Modelling Tool (UC2)**: Share data on energy assets' characteristics and performance for system analysis. ● **Cost-Benefit Analysis Tool (UC3)**: Facilitate access to financial and performance data for energy projects.
Basic Flow	1. Data is collected by the platform from multiple sources (internal or external). 2. Ingested data are organized into structured datasets for easy retrieval and use by the ECOEMPOWER's internal tools. 3. Structured data are securely stored in a cloud-based location. 4. Access control is implemented to manage data accessibility by authorized users (administrators) 5. Platform administrators can access the data and its status through user-accessible and well-documented endpoints, like swagger-API.
Alternative Flow	● In case of data ingestion failure, a fallback mechanism retrieves data from secondary sources or caches are employed.

Postconditions	● Data is accurately and securely stored in the cloud. ● Users can access and analyze data as per their authorization levels. ● The system maintains high availability and scalability to handle increasing data loads.
Expected Results	1. Enhanced data management capabilities within the EC platform. 2. Improved decision-making support through integrated and reliable data. 3. Scalable infrastructure to handle growing data needs.

UC4.b: Implementing Robust Authentication and Authorization for Enhanced Cybersecurity	
Title	Implementing Robust Authentication and Authorization for Enhanced Cybersecurity
Objective	To implement robust security measures for user authentication and authorization, ensuring General Data Protection Regulation (GDPR) compliance and data protection.
Background	The need to protect against cyber security threats is paramount, not only to safeguard user data but also to comply with stringent privacy regulations, such as the GDPR. This UC recognizes the criticality of robust cybersecurity in the energy sector, where the handling and management of energy data necessitate elevated security measures. By focusing on secure authentication and authorization protocols, ECOEMPOWER aims to fortify the platform against potential cyber threats, ensuring the confidentiality, integrity, and availability of user data, and aligning with legal compliance requirements.
Description	This UC focuses on implementing a comprehensive authorization system to enhance the platform's security posture. The system will be designed to manage user authentication and authorization processes, ensuring secure access and compliance with privacy regulations like GDPR. It will be built to support standard protocols and offer features such as identity brokering and user federation, catering to the modern security needs of a digital platform.
Relevant Stakeholders	ECOEMPOWER Developers, End-users
Preconditions	• A suitable authorization system (such as Keycloak or an equivalent) needs to be selected and ready for integration with the platform. • The platform's infrastructure must be prepared for integration with the authorization system, ensuring compatibility with standard protocols like OpenID Connect or SAML. • System administrators and IT security teams should have a clear understanding of the platform's security requirements, including user access levels and data protection needs. • There should be a comprehensive plan in place to adhere to GDPR and other relevant privacy regulations, including necessary adjustments in data handling and user privacy policies.
Basic Flow	1. Users register and log into the platform, initiating the authentication process through the authorization system. 2. The authorization system validates user identities and assigns appropriate access roles and permissions based on predefined criteria. 3. Users access platform features and data in accordance with their assigned roles, ensuring a secure and controlled data environment. 4. The system continuously ensures compliance with GDPR and other privacy regulations. 5. In the event of a security or privacy concern, the system triggers predefined protocols to mitigate risks and ensure data protection.

Alternative Flow	● For users who have entered incorrect credentials multiple times, a security lockdown is triggered, where the user needs to verify their identity through an email confirmation code or contact with the platform administrator.
Postconditions	● Authentication and authorization successfully established ● User data handling adheres to GDPR and other relevant privacy regulations.
Expected Results	1. Users benefit from a streamlined and secure authentication process, reducing the risk of unauthorized access and improving overall user satisfaction. 2. The authorization system efficiently manages user roles and permissions, simplifying access control for administrators and ensuring data privacy. 3. GDPR and other privacy regulations are rigorously followed, mitigating legal risks and demonstrating a commitment to user data protection.
	UC4.c: Creating Intuitive HMI for Energy Data Interaction and Visualization
Title	Creating Intuitive HMI for Energy Data Interaction and Visualization
Objective	The objective of this sub-UC is to design and implement an intuitive HMI that allows end-users (Prosumers) and EC Administrators to efficiently interact with energy data, access the platform's tools, and make informed decisions regarding energy consumption, generation, and community management.
Background	In the context of the platform, multiple tools have been developed (UC1, UC2, UC3) to address different aspects of energy management and decision-making within ECs. UC4.c aims to provide a unified and user-friendly interface that seamlessly integrates these tools, making it easier for users to access and benefit from the platform's capabilities.
Description	This UC involves the development of the platform's UI, which serves as the entry point for users after login. It encompasses features such as tool access, data interaction, data visualization, guidance, and support to ensure a holistic and intuitive user experience.
Relevant Stakeholders	ECOEMPOWER Developers, End-users
Preconditions	● Users have successfully logged in to the platform. ● Data relevant to the user's EC and configuration are available on the platform.
Basic Flow	1. Users log in to the platform. 2. Upon successful login, users are directed to their personalized dashboard. 3. The dashboard provides access to various tools within the platform, including the tools described in UC1, UC2, and UC3. 4. Users can select a tool of interest, which then opens within the interface. 5. Within each tool, users can make interactions and view results. 6. Data is seamlessly retrieved from the platform's data storage (UC4.a) and displayed for user interaction. 7. Visualization tools present energy data in a user-friendly format.

	8. Contextual guidance and support are available throughout the interface to assist users.
Alternative Flow	● In case the platform is down, users receive an error message with an explanation on the front page.
Postconditions	● Users have interacted with one or more tools within the platform. ● Users may have made informed decisions or modifications based on the tools' outputs.
Expected Results	1. Users seamlessly navigate between tools and interact with data. 2. Data is effectively retrieved and presented. 3. Users feel supported and informed through contextual guidance. 4. The interface encourages users to explore and utilize the platform's capabilities for energy management and decision-making within their community.

4.7 Relevant User Cases per Regional Ecosystem

Table 4.5 offers a concise overview of the technical aspects that are going to be addressed by each ECOEMPOWER regional ecosystem. It should be highlighted that this analysis has been conducted in collaboration with all ECOEMPOWER pilot partners to ensure extensive validation and alignment.

Table 4.5- Aspects to be addressed per regional ecosystem.

	RE1	RE2	RE3	RE4	RE5
UC1.a: Monthly PV Production Forecasting	_	X	(X)	_	_
UC1.b: Short-Term PV Production Forecasting	_	(X)	(X)	_	_
UC2.a Energy Profiling and Optimal Day-Ahead Planning	X	(X)	(X)	X	(X)
UC2.b Community Energy Flow Simulation	X	(X)	X	X	_
UC2.c Load Management and Scenario Planning	(X)	(X)	X	X	_

UC3.a Scenario Building for Investment Planning	_	_	_	(X)	X
UC3.b Financial Planning and ROI Calculation	_	_	_	(X)	X
UC3.c Contract Negotiation and Tariff Optimization	(X)	_	_	_	X

The meaning of the symbols is presented below:

- The regional ecosystem can fully support the UC described in terms of needs and available infrastructure/data. This is marked with an "X"
- "(X)" signifies that while the regional ecosystem can mostly support the UC, there might be a need to deviate/alter some parts of the UC to fit the needs of the EC better.

"-" denotes that a regional ecosystem is unable to sufficiently support the UC outlined.

5 Technical Requirements of the ECOEMPOWER ICT Platform

5.1 Overview of the ECOEMPOWER ICT Platform

The ECOEMPOWER ICT Platform is built to meet the goals outlined in the ECOEMPOWER Description of Action (DoA) and the energy use cases discussed in the previous sections of this deliverable. It's designed as a flexible, modular suite of tools for Energy Communities, tailored to support a wide range of needs in energy management, sustainability, and user engagement. While the platform allows for seamless integration into a unified system, each tool, such as forecasting, energy scheduling, or cost-benefit analysis, can work independently or connect with other external platforms, like the ECOEMPOWER Community Platform that is being developed in WP4. At the heart of the platform is a cloud-based data management system that uses standard communication protocols like MQTT and REST for efficient data handling. This setup is designed to work with the data and infrastructure available in different energy communities, making it easy to operate in a range of environments. Each tool is modular, so users can pick and choose the components that fit their needs.

The following figure displays the first iteration of the platform's design, highlighting the main functional blocks in three-high level sections:

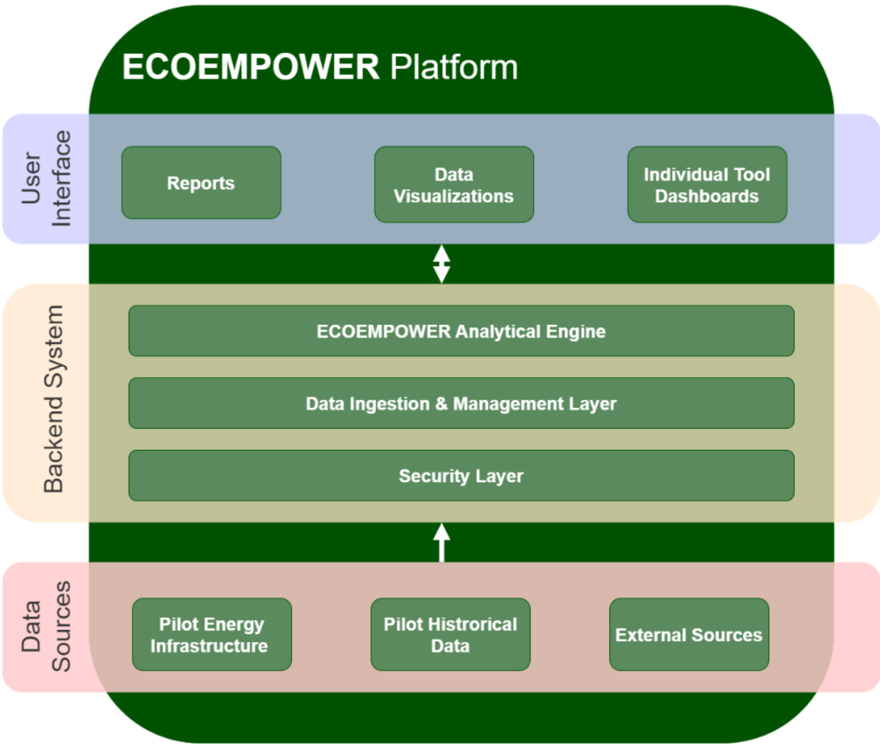

Figure 5-1 – The 3 high-level layers that enable the ECOEMPOWER Platform

Data Sources Layer: Collects key information from pilot energy infrastructure and external sources. These data streams feed into the system's tools to enable comprehensive energy analysis.

Backend System Layer: Hosts the ECOEMPOWER Analytical Engine, which includes data ingestion and management, security, and modular engines for energy forecasting, scheduling, and financial analysis. Each backend component works independently but supports integration when needed.

User Interface Layer: The interactive front end provides customized reports, visualizations, and tool-specific dashboards, ensuring users can easily access and engage with insights and analytics generated by the backend system.

This modular, adaptable design makes ECOEMPOWER suitable for a variety of deployment scenarios. It can function as a fully integrated platform or allow individual tools to be added to existing systems. The next sections will explain the platform's components, features, and how they work together in more detail.

The coming sections further develop each of the subcomponents in a detailed description of the functions, the interrelations, and the overall synergy that defines the project.

5.2 Platform Architecture

In this section, we present the high-level requirements of the ECOEMPOWER Platform, having in mind the insights and needs of the ECs as well as the modular and independent nature of the Energy Tools that are under development. We begin with the initial platform requirements, progressing to a detailed exposition of both functional and non-functional necessities across key architectural components. These include: the Data Ingestion & Management Layer, ensuring efficient data handling; the Security Layer, focusing on protection and user authentication; the ECOEMPOWER Analytical Engine that is supporting the various tools of the Platform; the modular Engines/sub-components supporting the ECOEMPOWER Tools like the Energy Forecasting Tool (precise energy prediction), the Energy Modelling and Scheduling Tool for (effective energy strategies) and the Cost-Benefit Analysis and Decision Making Tool (evaluating the impact of energy decisions); and the User Interface Layer, aimed at providing a seamless and engaging user interaction.

Following the functional and non-functional requirements of each platform component, we will outline the technical architecture of the ECOEMPOWER Platform, detailing the specific roles and functionalities of its various layers.

Specifically, we move from the overarching structure of the platform into the particularities of its integral layers. These include: (1) the Data Ingestion & Management Layer, which is fundamental in handling the vast array of data essential for energy management; (2) the Security Layer, ensuring the integrity and protection of data and user interactions within the platform; (3) the ECOEMPOWER Analytical Engine, acting as the backbone of the platform providing the framework for advanced data processing and machine learning (ML) capabilities; the ECOEMPOWER Toolset containing (3a) the Predictive Analysis Engine, specialized in energy demand and weather condition predictions; (3b) the Simulation and (3c) the Optimization Engines, focusing on the modelling and the optimization of energy distribution; (3d) the Financial and Strategic Analysis Engine, providing financial insights and strategic guidance; and (7) the UI Layer, which ties all functionalities together into a coherent, user-friendly interface.

Each layer is explored in terms of its technical composition, underlying technologies, and their respective contributions to the project's vision and goals.

5.2.1 Data Ingestion & Management Layer

The Data Ingestion & Management Layer is a key part of the ECOEMPOWER Platform, designed to efficiently handle all the data needed for informed decision-making. It can work as part of the full platform or as a standalone module to support individual tools. Its main tasks—collecting, organizing, and storing data—ensure that the information stays accurate and useful. This allows tools like forecasting, simulation, and optimization to function smoothly and deliver reliable results.

This layer plays a crucial role in delivering accurate analytics and predictions, supporting the performance of ECOEMPOWER tools while staying compatible with external systems. Its modular design also makes it a flexible option for organizations that need a standalone solution for data ingestion and management in other platforms or applications. The layer's success relies on the quality and volume of energy data it receives from Pilot Infrastructures and external sources, making it adaptable to different data environments.

5.2.1.1 Requirements

Functional Requirements:

1. **Efficient Data Ingestion Tailored to Pilot Data:** The platform must efficiently analyze and manage pilot data, needing a design that's adaptable to the specific data formats and frequencies of the pilots.
2. **Data Normalization:** The platform should standardize data from various sources to a common format for consistent processing.
3. **Secure Data Storage:** The platform should implement data encryption and security measures for protection against unauthorized access.
4. **Backup and Recovery Mechanisms:** The platform should perform regular data backup and include efficient recovery systems in case of data loss.

Non-Functional Requirements

1. **Scalability for Data Volumes:** The platform could benefit from the ability to handle increasing data amounts without performance loss.
2. **Robustness for Data Integrity:** The platform should maintain data accuracy and consistency throughout its lifecycle.
3. **High Data Throughput:** The platform should efficiently handle large data volumes to prevent bottlenecks.

5.2.1.2 Technical Description

The Data Ingestion & Management Layer is designed to handle large amounts of data efficiently. It can be used as part of the full platform or as a standalone subsystem of the individual Energy Tools, making it adaptable to different needs. Its main functionality is to collect, organize, and store data, ensuring it's ready for analysis and decision-making in energy management.

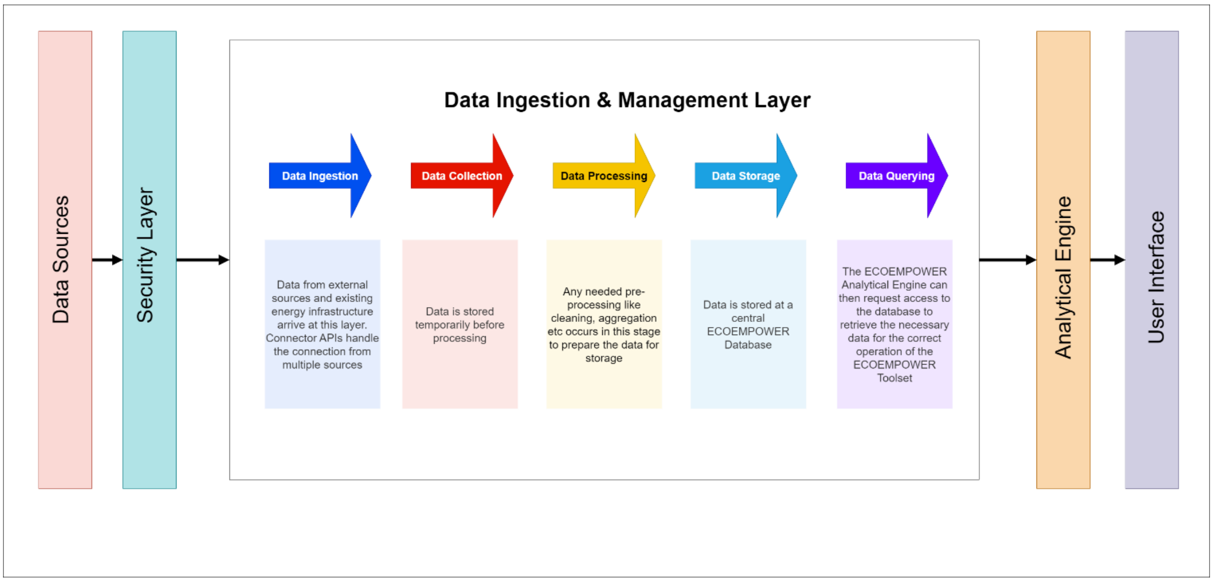

Figure 5-2 – Data Ingestion & Management Layer

The main functionalities of the Data Ingestion & Management Layer are presented in Figure 5.3. This layer can handle both real-time data, like weather and energy usage, and historical data. It collects data from multiple sources, including real-time streams like weather updates and energy usage patterns, as well as historical datasets. Using industry-standard protocols like MQTT and REST APIs, it easily integrates with external platforms and tools. After collection, the data is processed and normalized to ensure it's consistent and reliable, making it ready for use in forecasting, simulation, and optimization tools or for export to external applications.

The layer's data storage system can handle growing datasets as energy infrastructures expand, and its modular design allows it to function as an independent storage solution for other platforms or applications.

Advanced querying capabilities make it easy to access stored data. Optimized indexing and query tools enable quick and efficient retrieval of information, supporting analytics and decision-making processes for both ECOEMPOWER tools and external systems. This feature is especially useful for tasks like energy forecasting, financial planning, or resource optimization.

Overall, the Data Ingestion & Management Layer is designed to adapt to a variety of situations, whether it's managing data for ECOEMPOWER or other platforms. It's a secure, scalable, and reliable system that helps energy communities handle their data effectively and make smarter decisions.

5.2.2 Security Layer

The Security Layer is a key part of the ECOEMPOWER Platform, designed to protect both user data and platform operations. It ensures data integrity, confidentiality, and resilience while maintaining flexibility. Built to align with the platform's modular approach, the Security Layer can function as part of the full platform or as a standalone module to secure individual tools or external systems. This design provides strong protection while ensuring compliance with standards like GDPR.

The Security Layer focuses on three main areas: 1) User Authentication and Authorization that ensures only authorized users can access the system through secure login and role-based controls, 2) Data Encryption that protects data throughout its lifecycle, whether it's being stored or transferred, safeguarding it from unauthorized access and 3) interoperability that ensures seamless integration with other system components and external platforms without compromising security.

Together, these features provide a robust defense against unauthorized access and data breaches while maintaining smooth platform performance. Regular assessments further strengthen the system, ensuring vulnerabilities are identified and resolved quickly.

5.2.2.1 Requirements

Functional Requirements:

1. **Authentication Tool Implementation:** The platform must implement a robust authentication tool (e.g., Keycloak or similar) for secure user authentication, ensuring safe platform access.
2. **Authorization Management:** The platform must manage user permissions and roles to ensure appropriate access control within the platform.
3. **Data Encryption:** The platform should encrypt sensitive data both in storage and during transmission to safeguard against unauthorized access.
4. **Regular Security Audits:** The platform could conduct periodic security assessments to identify and mitigate potential vulnerabilities.

Non-Functional Requirements:

1. **Regulatory Compliance:** The platform must adhere to data protection regulations such as GDPR, ensuring the platform meets legal standards for data security and privacy.
2. **Minimal Performance Overhead:** The security measures should not significantly impact the system’s performance, maintaining a smooth user experience.
3. **Quick Adaptability to Security Threats:** The system should be able to quickly adapt to new security threats, updating its defenses quickly.

5.2.2.2 Technical Description

The Security Layer in the ECOEMPOWER Platform is a critical component, dedicated to ensuring the integrity and confidentiality of the platform and its data. This layer encompasses various subcomponents, each focusing on specific aspects of security, from user authentication to data protection. In Figure 3, we depict the general data flow of the Security Layer and its immediate interactions with the other layers and actors of the ECOEMPOWER Platform. The Analytical Engine obtains data through secure requests from two primary sources: Energy Infrastructure, which provides operational data, and External Data Sources, which offer additional contextual information. These requests are mediated by the Security Layer, where Keycloak manages authentication and authorization, ensuring that only valid and authorized requests receive responses. Within Keycloak, realms, users, groups, and other entities define the scope and permissions for access. The User Interface acts as the conduit for user interaction with the platform, handling access requests and displaying the results of the Analytical Engine's processing. Users gain access to the platform after receiving authentication tokens from Keycloak, enabling a secure and personalized experience. The Security Layer can also be a modular component that could be integrated to the individual Energy Tools as an individual component.

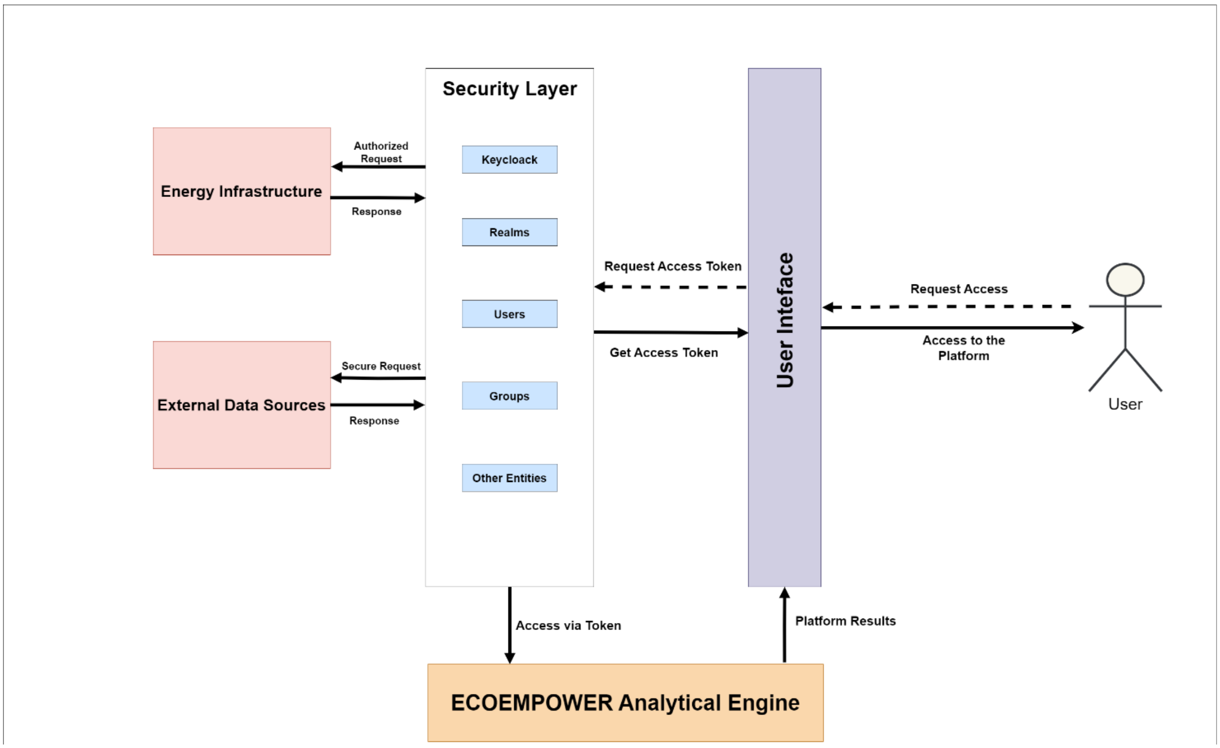

Figure 5-3 – Security layer of the ECOEMPOWER platform

The main functionalities of the Security Layer can be summarized below:

User Authentication and Authorization: This functionality is responsible for verifying the identity of users and ensuring they have appropriate access to the platform's resources. It manages user credentials and roles, linking these with specific resources and actions within the platform. This system is designed to be robust and flexible, accommodating a variety of user types with different access needs.

Data Encryption and Security: A key aspect of this layer is the encryption and protection of data, both in transit and at rest. This functionality ensures that sensitive information, such as user data and energy usage statistics, is securely encrypted, safeguarding it from unauthorized access and potential breaches. The focus is on implementing industry-standard encryption techniques to provide a high level of security.

Interoperability and Integration: The Security Layer is also designed to integrate seamlessly with other components of the platform, such as the Data Ingestion & Management Layer and the UI Layer. This ensures that security measures are consistently applied throughout the platform, providing a unified and comprehensive security approach.

In summary, the Security Layer of the ECOEMPOWER Platform plays a pivotal role in maintaining the platform's overall security posture. Its architecture is structured to address various security challenges, providing a secure environment for efficient energy management.

5.2.3 ECOEMPOWER Analytical Engine

The ECOEMPOWER Analytical Engine serves as the central processing unit for data-driven energy management, providing advanced analytical, predictive, and modeling capabilities. Designed with a modular and flexible architecture, the Analytical Engine supports individual tools—such as Forecasting, Energy Modeling and Scheduling, and Cost-Benefit Analysis—that can function independently or as part of the integrated

ECOEMPOWER Platform. This dual capability ensures that each tool can address specific energy management needs while maintaining the ability to interoperate seamlessly for a comprehensive understanding of energy dynamics.

The Analytical Engine's strength lies in its ability to process large volumes of data, uncover patterns, and deliver actionable insights. By combining machine learning (ML), predictive analysis, and scenario modeling, it enables energy communities to optimize energy resource allocation, plan for varying energy demands, and make informed financial decisions. Importantly, the engine's performance and accuracy are closely tied to the quality of the input data. High-fidelity pilot data is essential for generating reliable forecasts and recommendations that drive cost reductions and enhance energy efficiency.

5.2.3.1 Requirements

Functional Requirements:

1. **Support Modular Tool Integration:** The platform should be designed to allow selective integration of various tools (like forecasting, scheduling, cost analysis), where integration is needed. This will ensure that while each tool can operate independently, there's a provision for cohesive functionality and data sharing where it adds value to the platform's overall efficacy.
2. **Data Sharing Between Tools:** The platform should provide efficient data exchange mechanisms among tools for coherent data utilization and analysis.
3. **Alerting and Notification Systems:** The platform could provide automated alerts and notifications for important events or anomalies detected by the tools.

Non-Functional Requirements:

4. **Interoperability Among Tools:** The platform must ensure all tools work synergistically, allowing for smooth data and information flow.
5. **Modularity:** Tools should be modular for easy updates, upgrades, and maintenance.
6. **High Reliability:** The tool set must be reliable, minimizing downtime and errors, ensuring consistent performance.
7. **Scalability:** The platform should be capable of scaling up to handle increasing data and user loads without performance degradation.
8. **User-Friendly Interface:** The interfaces (or Dashboards) of the individual tools should be intuitive and accessible to users with varying technical expertise.

5.2.3.2 Technical Description

The ECOEMPOWER Analytical Engine is designed to provide the computational backbone for energy forecasting, modeling, and strategic decision-making. Its architecture emphasizes flexibility, enabling it to support standalone deployments of individual tools or fully integrated workflows within the ECOEMPOWER Platform.

At its core, the engine processes diverse datasets—ranging from energy consumption patterns and environmental data to financial inputs—using advanced analytical techniques. The engine's machine learning

(ML) capabilities allow it to predict energy demands, simulate energy scenarios, and recommend optimized resource distribution strategies. By leveraging state-of-the-art ML algorithms, such as time-series analysis and predictive modeling, the engine ensures that insights are both accurate and actionable.

The Analytical Engine is structured around loosely coupled tools that interact with its core processing capabilities while maintaining their independence:

- Energy Data Analysis and Forecasting: Predicts energy production and demand trends using historical and real-time data, enabling proactive planning.
- Energy System Modeling and Scheduling: Simulates energy flows, models load management scenarios, and optimizes energy usage based on specific inputs.
- Cost-Benefit Analysis and Decision Support: Evaluates the financial and strategic implications of energy investments and management strategies.

The interoperability of the Analytical Engine is key to its effectiveness. It seamlessly integrates with the Data Ingestion & Management Layer, ensuring continuous access to updated and normalized data. This connectivity allows the tools to operate with accurate and reliable inputs. Additionally, the Analytical Engine can connect to external platforms, offering its capabilities as an independent module for forecasting, simulation, or cost analysis without requiring the full ECOEMPOWER deployment.

The Analytical Engine's outputs are delivered through dedicated dashboards in the User Interface Layer, where results are visualized in a user-friendly format. Whether deployed as part of the platform or integrated with external systems, these dashboards present complex analyses as actionable insights, ensuring accessibility for decision-makers.

In the following figure, we depicted the basic data flow of the ECOEMPOWER Analytical Engine and its interrelations with the other platform components. The modular approach we have chosen for the individual engines will be further explained in following sections.

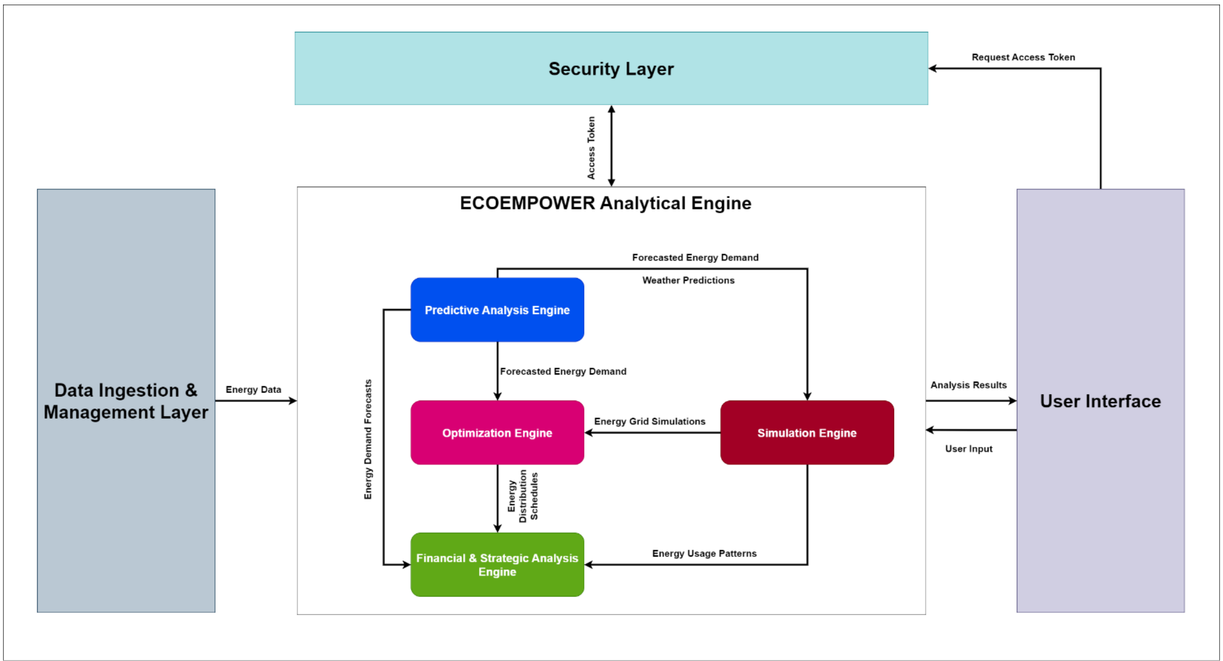

Figure 5-4 – Analytical engine within the ECOEMPOWER platform

In summary, the ECOEMPOWER Analytical Engine combines sophisticated data analysis and ML modeling to empower energy management decisions. Its structure and capabilities are central to the platform's ability to offer predictive insights and strategic guidance in energy utilization.

5.2.4 Predictive Analysis Engine

The Predictive Analysis Engine, a crucial backend system of the ECOEMPOWER Analytical Layer, is engineered for the accurate prediction of energy needs and weather conditions, serving as a cornerstone for proactive energy management. This engine integrates advanced algorithms with external data sources, providing critical insight into energy trends and environmental factors. Such predictive capabilities are vital for ECs to strategically plan, optimize resource allocation, and reduce the risks associated with variable energy demands and weather conditions. Consequently, the Predictive Analysis Engine plays a key role in enhancing operational efficiency and informing strategic energy management decisions.

5.2.4.1 Requirements

Functional Requirements:

1. **Accurate Weather and Energy Demand Forecasting**: The system must be able to provide precise forecasts, leveraging advanced algorithms and meteorological data to predict energy demand and weather conditions.
2. **Integration with External Data Sources**: It should incorporate external data sources like weather services to enhance forecast accuracy.
3. **Automated Report Generation**: Capability to automatically generate and distribute comprehensive forecast reports.

Non-Functional Requirements:

1. **High Accuracy and Precision in Forecasts**: The forecasts generated through this layer should be of high precision, reducing the margin of error to enhance reliability.
2. **Fast Data Processing**: The engine must process data rapidly to provide timely forecasts, crucial for operational decision-making.
3. **User-Friendly Report Formats**: The outputs generated should be in formats that can easily be presented in user-friendly reports, enhancing the usability of the forecasting tool, and facilitating easier interpretation by users.

5.2.4.2 Technical Description

The Predictive Analysis Engine provides accurate forecasts for energy demand and weather conditions, making it a central part of the ECOEMPOWER Platform. Its flexible design allows it to work seamlessly within the platform or operate on its own, connecting with external systems when needed.

At its core, the engine uses advanced algorithms to process both historical and real-time data. It leverages models like SARIMA for time-series forecasting and machine learning methods such as LSTM and XGBoost, which are built to handle seasonal trends, emerging patterns, and complex data relationships. These models are fine-tuned to deliver reliable predictions across different energy scenarios.

The engine also integrates live weather data, including temperature, cloud cover, and solar irradiance, to make its forecasts as up-to-date and accurate as possible. By processing this real-time information, it adjusts predictions to reflect current conditions, which is especially useful for energy communities that rely on renewable sources.

To ensure the forecasts are easy to use, the engine automatically generates reports tailored to its users. These reports translate complex data into clear, actionable insights for grid operators, energy managers, or prosumers. They can also be scheduled for regular distribution, ensuring stakeholders get timely updates without manual effort.

Accuracy remains a priority, so the engine includes built-in processes to improve over time. It continuously compares predictions with actual outcomes, tuning its models to adapt to changing data and maintain consistent performance.

The forecast results are displayed through interactive dashboards in the platform's User Interface. These dashboards allow users to explore trends, adjust views, and analyze forecasts to support decision-making. For standalone use, the engine can export its results through APIs or in compatible formats, making it easy to connect with other systems.

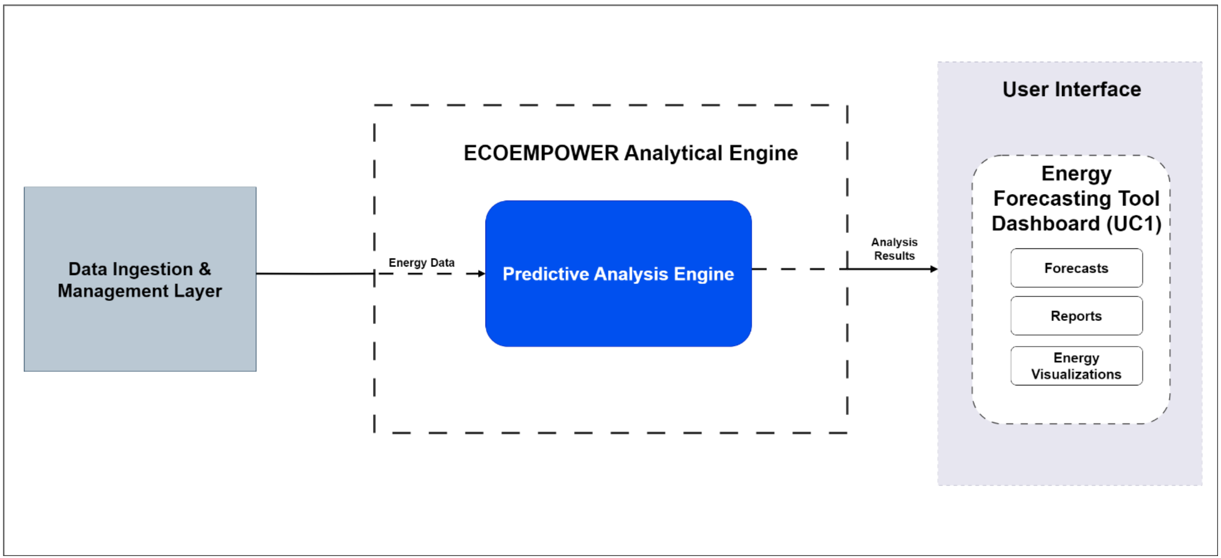

Figure 5-5 – Predictive analysis engine within the ECOEMPOWER platform

The Predictive Analysis Engine is the technical core of the Forecasting Tool, operating as the backend processor that drives the forecasting capabilities within the ECOEMPOWER Platform. This engine encapsulates all the backend and data processing mechanisms required for predictive analytics.

In contrast, the Forecasting Tool serves as the front-end interface, presenting the data processed by the Predictive Analysis Engine in a user-friendly dashboard format within the UI Layer. This dashboard allows end-users to interact with the data, customize views, and understand the predictive outcomes generated by the backend engine.

The relationship between the two components can be described as a complementary system where the Predictive Analysis Engine provides backend and analytical depth, while the Forecasting Tool delivers the visualization and user interaction capabilities.

5.2.5 Simulation Engine

The Simulation Engine is a backend component within the ECOEMPOWER Analytical Layer, built to model energy systems for scenario analysis and strategic planning. Using advanced simulation algorithms combined with historical data and user-defined inputs, it allows energy communities to test different strategies and see their potential impacts. This helps them anticipate energy demands, improve distribution, and strengthen system resilience, while also supporting the integration of renewable energy and advancing sustainability goals.

Thanks to its modular design, the Simulation Engine can work as part of the full ECOEMPOWER Platform or operate independently as a standalone tool. This flexibility makes it easy to integrate with other systems or tools, allowing stakeholders to run targeted simulations and optimizations without relying on the entire platform.

5.2.5.1 Requirements

Functional Requirements:

1. **Advanced Energy System Modeling Algorithms**: The tool must utilize advanced algorithms for accurate and detailed energy system modeling.
2. **Scenario Analysis**: It should have the capability to run multiple energy scenarios, helping to predict system behavior under various conditions and facilitating strategic planning.
3. **Customization Based on User Input**: Allow user inputs to tailor models to specific community or scenario needs.

Non-Functional Requirements:

1. **Flexibility in Energy Scenario Modeling**: The tool should be flexible enough to model a range of energy scenarios, accommodating different types of energy systems and resources.
2. **Efficient Computation**: The algorithms should be optimized for efficient computation, enabling quick processing of complex models.
3. **UI Integration**: It should integrate with a user-friendly interface that allows users to easily set up simulations, input parameters, and understand results.

5.2.5.2 Technical Description

The Simulation Engine provides a dynamic and interactive environment for testing and optimizing energy management strategies. At its core, the engine employs advanced mathematical and computational models to emulate the behavior of energy assets—such as generation sources, storage systems, and energy consumption—under various user-defined conditions. This enables energy managers to evaluate system performance, anticipate challenges, and plan for future energy demands with a high degree of confidence.

A defining capability of the Simulation Engine is its support for scenario analysis and testing, which allows users to explore multiple energy strategies in a risk-free virtual environment. By simulating “what-if” scenarios—such as shifts in energy production, policy changes, or market fluctuations—the engine helps stakeholders assess the consequences of their decisions before implementation. This proactive approach supports risk mitigation and ensures that energy distribution strategies are both effective and resilient.

The engine also emphasizes customization and flexibility. Users can input specific parameters—such as load profiles, generation capacities, and policy constraints—to tailor simulations to their unique needs. This ensures relevance across energy communities with differing infrastructures, energy mixes, or operational goals.

The outputs of the Simulation Engine are delivered through the User Interface (UI) Layer, where results are visualized in an accessible and interactive format. Simulation outputs include key performance indicators (KPIs), system behavior trends, and comparative insights across different scenarios. The intuitive dashboards allow users to explore complex results through visual elements such as charts, graphs, and adjustable views, enabling them to make data-driven decisions efficiently.

To enhance its utility, the Simulation Engine seamlessly integrates with the Optimization Engine within the ECOEMPOWER Analytical Layer. While the Simulation Engine models and tests energy system behaviors, the Optimization Engine identifies the most efficient resource allocation strategies. This collaboration ensures a holistic approach to energy system planning, balancing feasibility with performance optimization.

In standalone deployments, the Simulation Engine can function independently, exporting its results via standard APIs or formats for integration with external platforms. This modular design makes it an ideal solution for energy communities or third-party tools requiring sophisticated energy modeling capabilities without relying on the full ECOEMPOWER Platform.

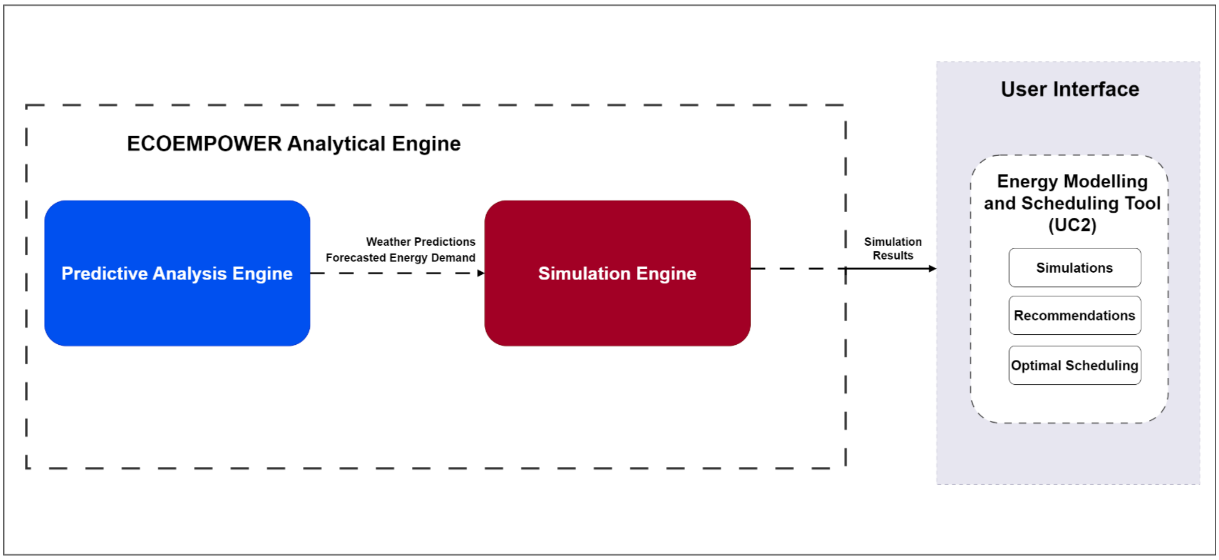

Figure 5-6 – Simulation engine within the ECOEMPOWER platform

While the engine provides the analytical and simulation capabilities, the front-end tool translates this into practical, understandable visualizations. Together, they could empower ECs with the potential ability to strategically plan, analyze risks, and make informed decisions regarding the implementation of energy distribution strategies, thus enhancing the overall efficacy and sustainability of energy management.

5.2.6 Optimization Engine

The Optimization Engine is a core backend component of the ECOEMPOWER Analytical Layer, specifically developed to support energy profiling, flexible load management, and scenario-based planning for energy communities (ECs). Its primary function is to analyze energy consumption profiles, renewable generation patterns, and tariff data to generate optimal day-ahead schedules for individual buildings and community-level resource usage. By focusing on the redistribution of flexible loads, it maximizes energy efficiency, reduces costs, and supports the self-consumption goals of ECs.

Unlike traditional power dispatch systems, this engine operates with a focus on load shifting strategies, community energy balancing, and optimization of renewable energy self-consumption. Its modular design ensures that it can function as part of the integrated ECOEMPOWER Platform or as a standalone module, enabling flexible adoption by external tools and energy management systems.

5.2.6.1 Requirements

Functional Requirements:

1. **Resource Optimization Algorithms**: The engine must utilize optimization algorithms to determine the most efficient resource allocation strategies.
2. **Day-ahead Scheduling**: The engine must support day-ahead scheduling for individual buildings and aggregated communities, ensuring energy usage is cost-effective and resource-efficient.
3. **Renewable Energy Optimization**: Should specifically optimize the use of renewable energy sources, minimizing losses and maximizing self-consumption within communities.

Non-Functional Requirements:

1. **Adaptability**: The engine must be adaptable to a changing energy landscape, with the ability to incorporate new data and technologies as they become available.
2. **Scalability**: It should be scalable, able to manage various optimization systems.
3. **Robustness and Reliability:** The optimization process must be robust, consistently providing reliable and actionable optimization strategies.

5.2.6.2 Technical Description

The Optimization Engine is designed to deliver actionable strategies for energy efficiency by generating optimal load schedules that align energy usage with renewable generation and tariff patterns. It processes large datasets—including historical consumption data, forecasted renewable energy availability, and energy tariffs—and applies advanced mathematical optimization algorithms to identify opportunities for load shifting.

At its core, the engine includes:

- Load Optimization Algorithms: These algorithms analyze the characteristics of flexible loads, such as operational constraints, runtime requirements, and deadlines, to generate optimal schedules. By redistributing energy usage from peak hours to off-peak periods, the engine reduces energy costs and improves renewable energy utilization.
- Resource Balancing: The engine identifies energy consumption imbalances—such as surpluses or deficits—and optimizes load allocation to improve efficiency. It can suggest adjustments to load profiles that maximize the use of available renewable generation while minimizing reliance on external energy sources.
- Scenario-Based Analysis: Users can simulate changes to renewable energy availability, consumption patterns, or operational constraints to explore the impact on load schedules and overall energy efficiency. This functionality allows for data-driven decision-making and supports forward-looking energy planning.

The engine could also potentially operate proactively by leveraging inputs from the Predictive Analysis Engine, which provides renewable energy generation forecasts and consumption trends. By combining these predictive insights with historical energy data, the Optimization Engine ensures its recommendations are both timely and relevant.

On the output side, the Optimization Engine generates optimized schedules and actionable recommendations that are delivered through intuitive dashboards in the User Interface Layer. These outputs include:

- Optimized day-ahead schedules for individual buildings or aggregated communities.
- Insights into periods of high renewable utilization and opportunities for flexible load shifting.
- Scenario-based results, showing the impact of specific load adjustments or new operational constraints on energy efficiency and costs.

The engine's design emphasizes adaptability and scalability, enabling it to accommodate a wide range of energy systems and deployment scenarios. Whether managing individual buildings, larger ECs, or external systems, it dynamically adjusts its optimization strategies to reflect changes in data inputs, resource availability, or system goals.

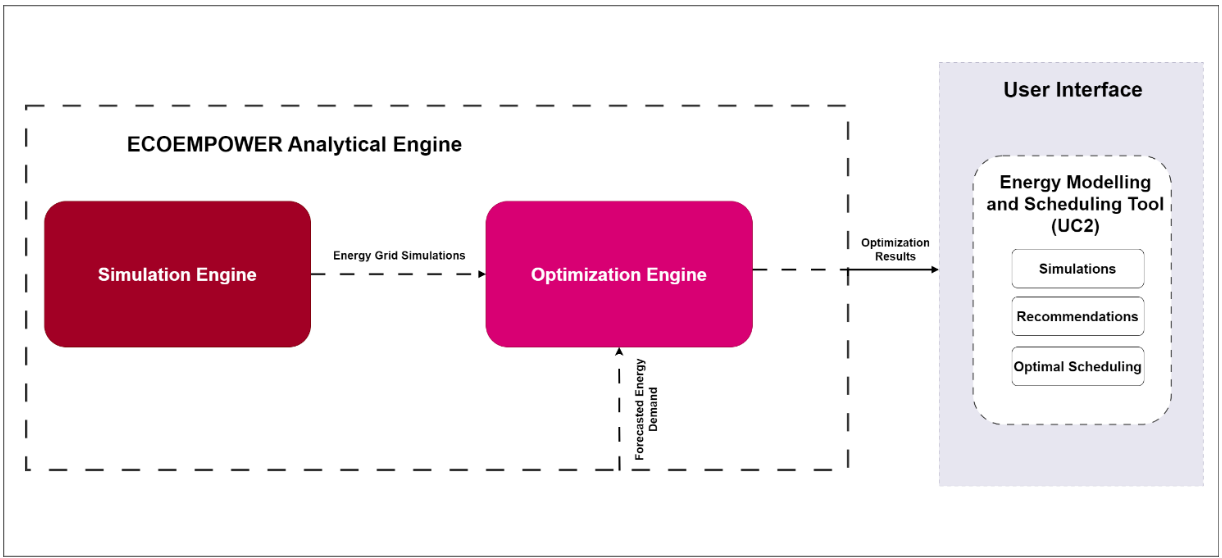

Figure 5-7 – Optimization engine within the ECOEMPOWER platform

The Optimization Engine serves as a counterpart to the Simulation Engine within the Energy Modeling and Scheduling Tool, playing a pivotal role in the ECOEMPOWER Platform. This engine, focusing on efficiency and resource allocation, works in parallel with the Simulation Engine to provide a comprehensive energy management solution.

5.2.7 Financial and Strategic Analysis Engine

The Financial and Strategic Analysis Engine evaluates the economic and strategic viability of energy strategies by leveraging advanced cost-benefit analysis methodologies and financial simulation techniques. This engine processes inputs such as historical consumption data, renewable energy generation forecasts, investment details, tariff structures, and operational constraints to deliver clear financial insights for stakeholders.

5.2.7.1 Requirements

Functional Requirements:

1. **Detailed Cost-Benefit Analysis**: The engine must support comprehensive cost-benefit analyses for various energy investments and scenarios.
2. **Scenario Simulation**: Ability to simulate different energy scenarios, helping users understand potential outcomes and impacts.
3. **KPI Tracking**: Track KPIs related to energy usage and financial aspects, providing valuable insights for decision-making.
4. **Customized Reporting**: Generate tailored reports that detail energy consumption, financial implications, and other relevant metrics.

Non-Functional Requirements:

1. **Accuracy in Financial Calculations**: High precision in financial calculations to ensure reliable cost-benefit analysis.
2. **Intuitive Scenario Comparison Interfaces**: User-friendly interfaces for comparing different scenarios, aiding in easier understanding and decision-making.
3. **Efficient Processing of Complex Models**: The tool should quickly process complex models, providing timely insights for decision-making.

5.2.7.2 Technical Description

The Financial and Strategic Analysis Engine brings together a variety of data sources—like historical energy usage, renewable generation forecasts, tariff structures, and user-defined investment inputs—to assess the financial viability of energy strategies. By processing all this information, it offers clear recommendations to improve energy efficiency, reduce costs, and maximize return on investment (ROI).

One of the engine's core strengths is its ability to simulate financial scenarios. This allows stakeholders to compare different investment options, such as renewable energy installations, efficiency upgrades, or storage solutions. It generates detailed financial projections over long timeframes, taking into account factors like inflation, changing tariffs, and operational expenses. These insights help stakeholders plan for both the financial sustainability and long-term profitability of their projects, aligning energy decisions with broader economic goals.

Another key feature is its contract optimization capability. The engine analyzes energy consumption patterns alongside existing tariff structures to spot inefficiencies. It then provides actionable insights—such as renegotiating contracts or switching to alternative tariffs—that better match usage behaviors, helping to cut operational costs.

To make the results easy to understand, the engine connects with the User Interface Layer, where findings are presented through interactive dashboards and clear financial reports. These reports break down complex data into practical, actionable insights, making it simple to compare scenarios and make informed decisions. Outputs include detailed cost breakdowns, projected savings, ROI estimates, and visual trends that help users quickly see the impact of different strategies.

Thanks to its modular design, the engine is highly flexible. It works seamlessly within the ECOEMPOWER Platform but can also function independently as a standalone tool, integrating with external energy management systems. This adaptability means it can be used for focused financial analysis or as part of broader strategic planning, depending on what's needed.

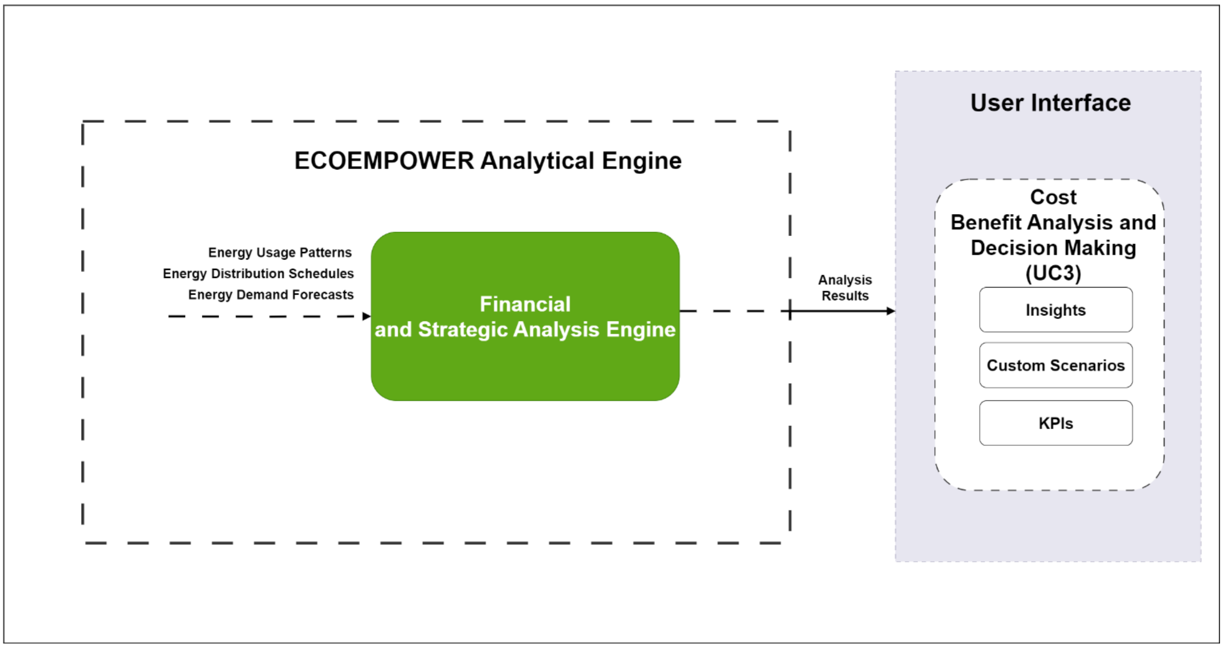

Figure 5-8 – Financial and strategic engine within the ECOEMPOWER platform

5.2.8 UI Layer

The UI Layer of the ECOEMPOWER Platform is the front-end interface that turns the platform's powerful analytics into clear, easy-to-understand insights. It's designed to offer an intuitive and seamless experience, ensuring users can interact with the tools effectively.

The UI Layer takes a modular approach, with dedicated interfaces for each tool whether it's forecasting, modeling, scheduling, or cost-benefit analysis. This allows users to access and work with specific tools independently while maintaining a consistent and user-friendly design across the platform.

Each tool's interface can operate on its own or as part of the full ECOEMPOWER system. This flexibility means stakeholders can choose how they want to use it: they can integrate standalone tools into their existing systems or access them directly through the ECOEMPOWER Platform.

In summary, the UI Layer bridges the gap between complex analytics and real-world usability, offering a clean, modular design that adapts to users' needs and makes energy management both simple and actionable.

5.2.8.1 Requirements

Functional Requirements:

1. **Intuitive and Modular Design**: The UI should be designed to be intuitive, modular and responsive, ensuring ease of use and effective user interaction.
2. **Effective Data Visualization**: Incorporate sophisticated visualization tools and techniques to present complex data clearly and engagingly.

Non-Functional Requirements:

1. **High Usability**: The interface must be user-friendly, catering to users with varying levels of technical skills.

2. **Accessibility**: Ensure the UI is accessible to all users, including those with disabilities.
3. **Adaptability to Various Devices**: The design should be flexible to work seamlessly across different devices, from smartphones to desktops.

5.2.8.2 Technical Description

The UI Layer is structured so that each tool—whether for forecasting, modeling, scheduling, or cost-benefit analysis—has its own dedicated interface. This modular setup allows each tool to work independently or as part of the full ECOEMPOWER Platform.

- Forecasting Tool UI: Displays predictive energy data through time-series charts, seasonal trends, and accuracy reports. Users can adjust forecast parameters, compare predictions to actual results, and export insights for further analysis.
- Modeling and Scheduling Tool UI: Provides interactive dashboards for energy profiling, load shifting, and scenario planning. Simulation results are visualized to highlight energy surpluses/deficits, optimized schedules, and resource usage metrics.
- Cost-Benefit Analysis Tool UI: Breaks down financial results like costs, savings, ROI, and payback periods. Users can test different investment scenarios by tweaking inputs and immediately see how the numbers change.

This modular approach gives users the flexibility to use what they need. Tools can operate independently or connect seamlessly within the broader platform. For those already using other systems, these tools can also integrate smoothly with external platforms.

The UI Layer pulls its data from the Analytical Engine, the system that processes information like forecasts, simulations, and optimizations. The results are presented as clear insights that users can act on immediately.

Security is also built into the platform. The UI Layer works with the Security Layer, which uses tools like Keycloak to manage logins and permissions. Features like role-based access control and single sign-on (SSO) will be considered to ensure that users only see what they're authorized to access.

In essence, the technical architecture of the UI layer is structured to act as the bridge between the ECOEMPOWER Platform's advanced analytical capabilities and its end-users. By offering an intuitive, secure, and adaptive interface, it plays a crucial role in ensuring that the platform's sophisticated energy management tools are accessible, understandable, and useful for all stakeholders involved.

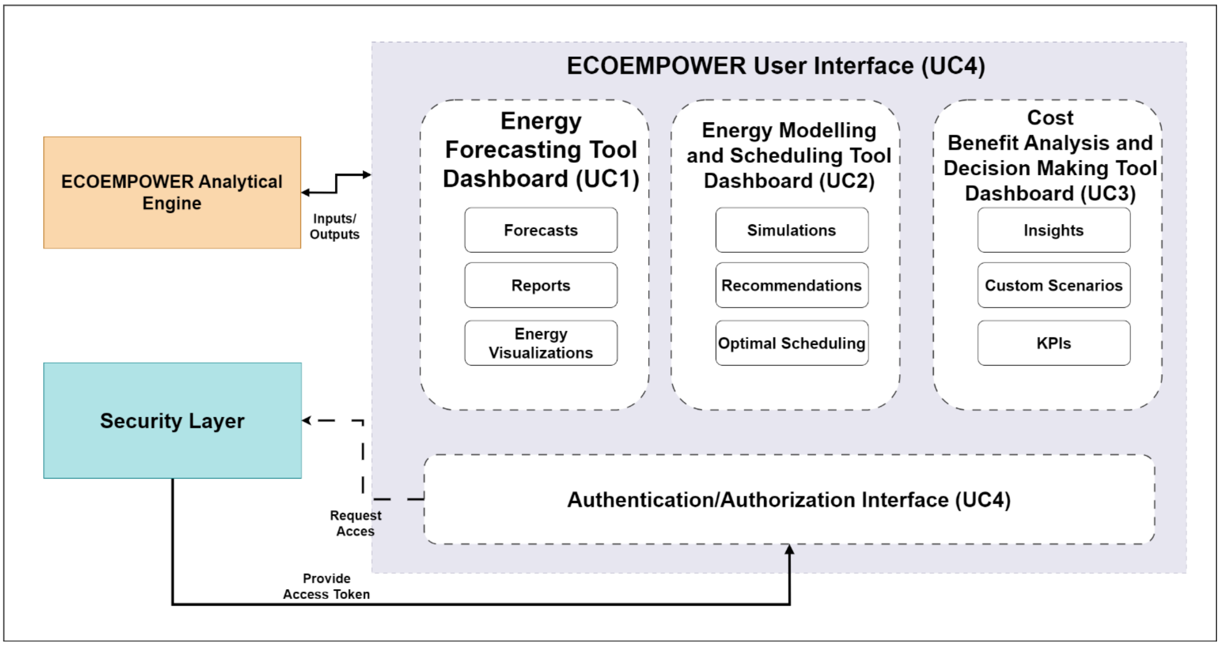

Figure 5-9 – UI layer of the ECOEMPOWER platform

5.3 Preliminary Platform Mockups

In this section, we showcase the preliminary platform mockups for the ECOEMPOWER Platform, drawing on the first insights from our initial project conceptualizations and detailed UCs. These mockups represent an early visualization of the platform's UI, encapsulating the essence of its design philosophy and functional aspirations.

The process of developing these mockups was meant to incorporate design best practices and a user-centric focus. This involved understanding the needs and behaviors of the platform's potential users, ensuring that the design is intuitive, accessible, and engaging. Emphasis was placed on creating a seamless user experience, with attention to layout, color schemes, typography, and interactive elements that fit with the Project Theme and color palette, as well as enhance usability and appeal.

The conceptualization of these mockups was heavily influenced by insights gathered from the UCs. Each element of the interface was designed to address specific functionalities and requirements identified in the UCs. For instance, the main dashboard was conceptualized to provide a comprehensive overview of energy data and forecasts, aligning with the need for easy access to critical information and analytics.

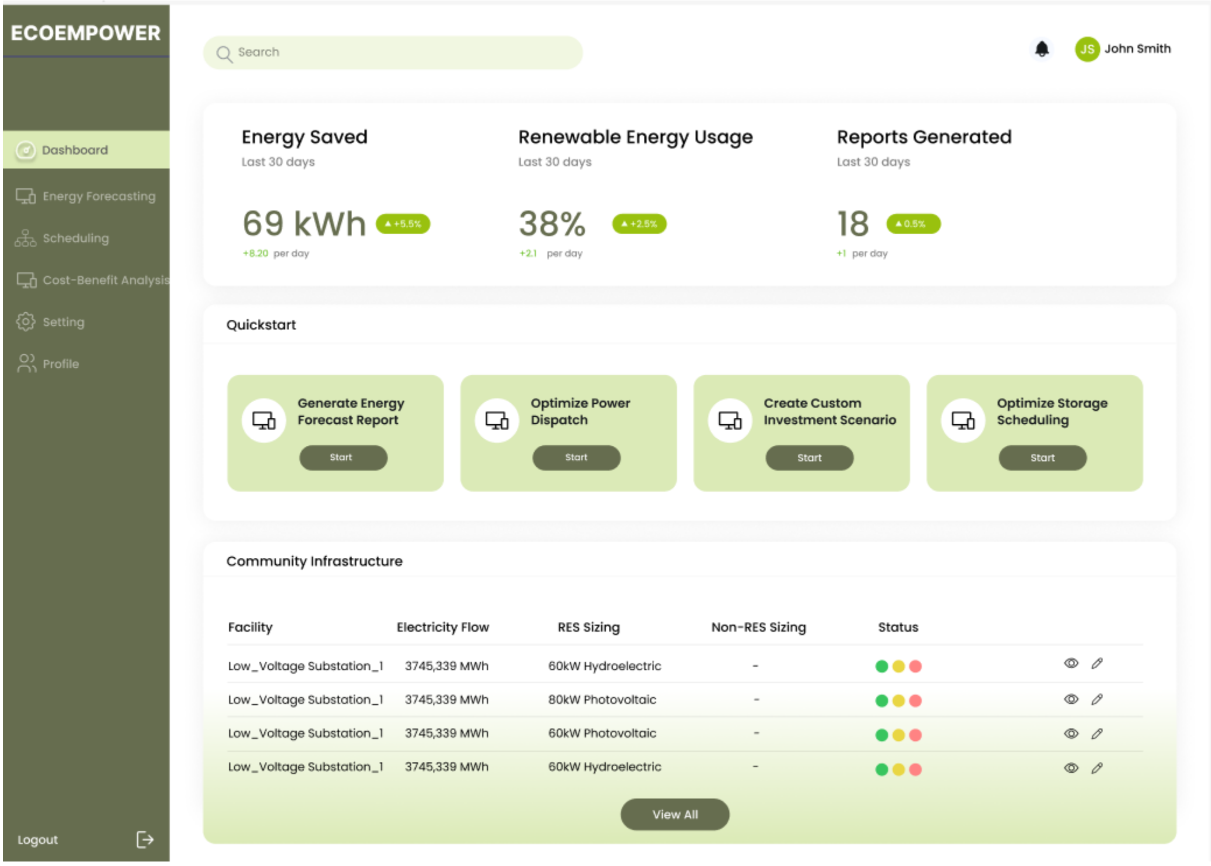

Figure 5-10 – Preliminary mock-up of the main ECOEMPOWER dashboard

The above preliminary mockup offers a conceptualized vision of the main dashboard for the ECOEMPOWER Platform. This interface wishes to incorporate a modular approach and user-centric design. In the future development efforts, additional parameters will be considered in the design of the ECOEMPOWER ICT Platform, so this dashboard could change. In this initial design there are:

- Central to the dashboard is the prominent display of essential KPIs that articulate the benefits derived from the platform, informed by the Financial and Strategic Analysis Engine. As the platform evolves, these indicators will be further refined to provide pilot-specific metrics, tailored to the unique requirements and data of Regional Ecosystems;
- The dashboard features a strategically placed Quickstart section, offering users immediate access to the most vital functions of the platform. This design choice ensures that users can effortlessly navigate to generate reports and act on recommendations, eliminating the need to traverse the entire platform for critical actions. This intuitive design approach underscores the commitment to adhere to best practices in UI/UX design;
- The lower segment of the dashboard is dedicated to presenting a snapshot of the community's energy infrastructure. This inclusion is vital for providing users with a clear understanding of their systems immediately, enhancing their ability to manage and optimize their energy resources effectively.

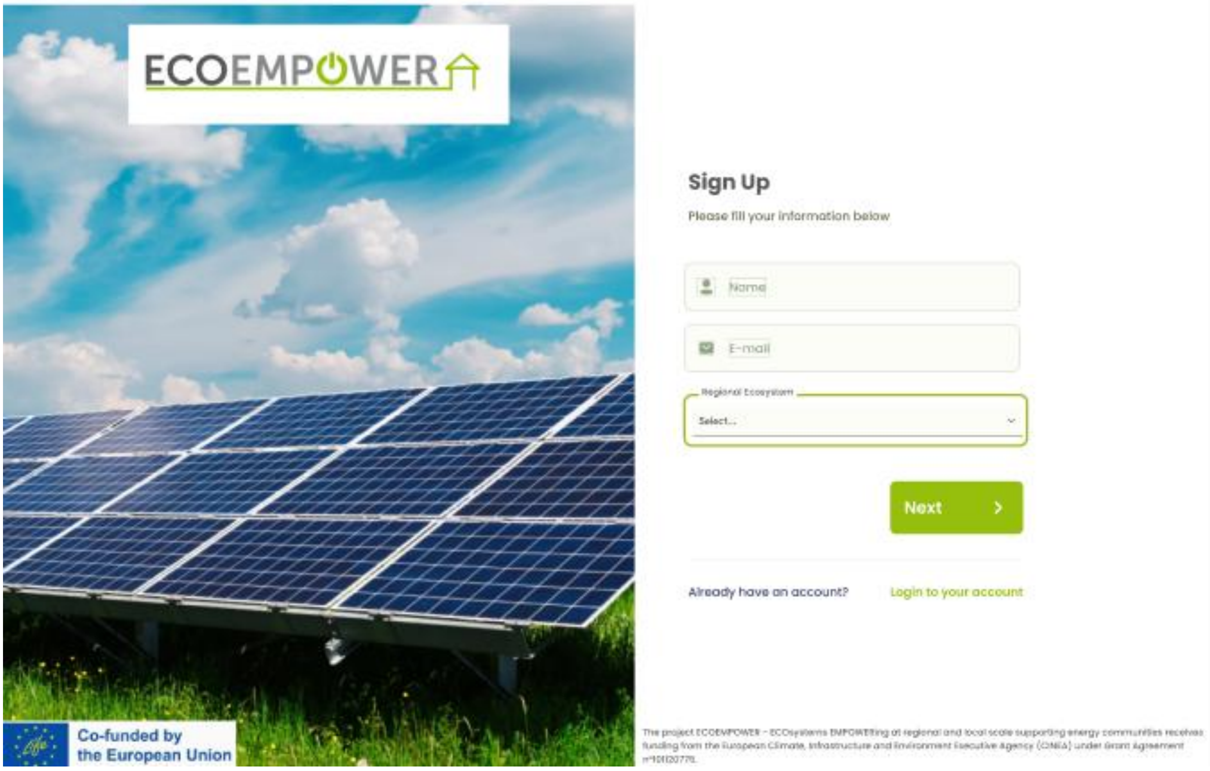

Figure 5-11 – Registration mock-up

The Registration mockup for the ECOEMPOWER Platform is designed to streamline the user access process while adhering to the highest standards of data protection compliance, as mandated by GDPR. This UI or a similar one could serve as an entry point to the platform.

The Registration Mockup is intentionally designed to capture only the essential user information, reflecting a commitment to GDPR's principles of data minimization and privacy by design. This approach not only aligns with legal requirements but also simplifies the user's registration journey.

Keycloak is planned to be employed as the underlying access management system, providing robust security measures, and enabling seamless access control. The goal is to manage authentication across different Regional Ecosystems, ensuring that users have a tailored experience with access to pilot-specific features and capabilities based on their registration details.

During registration, users are prompted to identify their Regional Ecosystem affiliation. This step is pivotal as it determines the scope of access and customization of the platform's features to meet the specific needs and regulations of different pilots. By associating users with their respective ecosystems, the platform ensures that the experience is both personalized and relevant.

To created additional synergy with the rest of the ECOEMPOWER Tools, an integration with the Community Platform is also being investigated. In that case, the registration process as well as the access control will happen through the web interface of the Community Platform.

The mockups are designed with GDPR compliance at the forefront, ensuring that the platform respects user privacy and data protection from the very first interaction. Clear options for consent management, data access, and transparency will also be taken into consideration for the registration process.

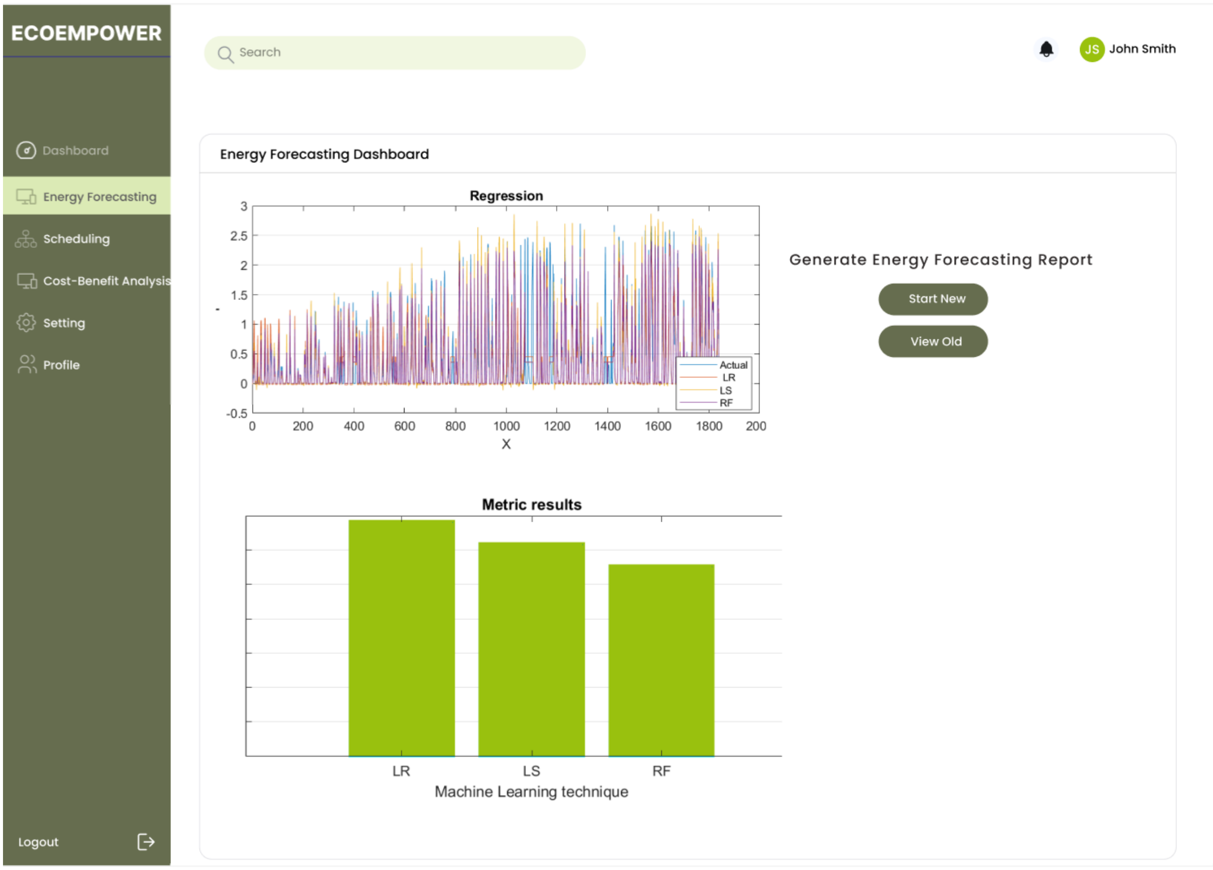

Figure 5-12 – Illustrative example of the potential outcomes generated by the energy forecasting tool

In Figure 5-12, we provide an illustrative example of the potential outcomes generated by the energy forecasting tool that is going to be developed in Task 2.2. Specifically, the upper subplot displays indicative curves of PV production alongside the corresponding results generated by various ML regression algorithms (Linear Regression - LR, Least-Squares –LS– boosting, and Random Forest - RF). On the other hand, the lower subplot depicts the mean absolute percentage error metric results between the actual curve and the predictions made by the ML algorithms. It is important to emphasize that these results are presented solely for demonstrative purposes. The tool being developed in Task 2.2 will undergo further enhancements, such as the integration of necessary pre-processing techniques. Additionally, it should be noted that a similar approach could be applied to demand forecasting processes.

6 Conclusions and Next Steps

As we conclude this deliverable, we encapsulate the essence and the trajectory of the ECOEMPOWER Platform, reflecting upon the meticulous planning and detailed architectural design that has underpinned our discussions.

We provided an overview of the technical infrastructure across ECOEMPOWER's five Regional Ecosystems and their pilot sites, highlighting the varied landscapes and the distinct challenges and opportunities they present. We formulated distinct UCs based on the Pilot Partners' insights and needs, while simultaneously fully aligning with the expectations of the Project. Finally, we detailed the technical requirements of the ECOEMPOWER Platform, covering its comprehensive overview, functional and non-functional requirements, and proposed architecture. The preliminary mockups provided visual insights into the platform's UI, exemplifying the user-centric approach that guides our design principles.

The deployment of the ICT Platform and the possible integration with the ECOEMPOWER Community Platform pose some challenges that should be explored in the next months of the project, as a unified ECOEMPOWER Suite of tools could provide a lot of added value. Dealing with the language barrier in the later stages of validation is also something that should be taken into consideration, as a lot of the technical terminologies could be unknown to non-native English speakers.

The next phases of the ECOEMPOWER project are defined according to the project's roadmap and the expectations presented in the DoA. More specifically, we will immediately launch T2.2 and prepare for the forthcoming submission, D2.2. As we enter the active development phase, our focus will be on translating the intricate technical requirements and mockups into a fully operational platform. Following this, rigorous testing protocols will be implemented to guarantee the platform's robust performance, usability, and security across all dimensions. Additionally, pilot specific workshops will be conducted to ensure seamless integration within the Regional Ecosystems and among their stakeholders. Throughout this process, we will closely monitor the progress of the OSS and adapt the ECOEMPOWER ICT Platform accordingly to provide support.

7 List of Tables

8 List of Figures

A. Annex A

1. **General information about the Regional Ecosystem**: All regional ecosystems were requested to fill in a table (as presented below) of descriptive information that also includes technical details (such as electricity grid characteristics, sizing, metering infrastructure, etc.).

Table 8.1 - Data description in various pilot sites

Input data	**Description of pilot sites**
Electricity flows	1st
	2nd
	3rd
Electrical grid characteristics	1st
	2nd
	3rd
RES sizing	1st
	2nd
	3rd
Non-RES sizing	1st
	2nd
	3rd
Metering infrastructure	1st
	2nd
	3rd
Data communication protocols	1st
	2nd
	3rd

2. **OSS evaluation**: This section is necessary for assessing the OSS (primary objective of ECOEMPOWER) during the lifetime of the project:
   - Can you share with us any interesting experiences from the users who are using (or have used) the services of the OSS? Additionally, please provide any other relevant information you deem compelling (Answer only if yes to the first question)
   - In the context of the existing OSS, are there any additional services or functionalities you would like to see implemented to meet your expectations? (Answer only if yes to the first question).
   - Could you share insights on the features and capabilities you believe would add significant value for the users of an OSS in your ecosystem?

Please also talk about the Regulatory framework and if there are regulatory incentives for ECs within your regional ecosystem.