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 cater to 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.
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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.

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!, PSOE, 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, a 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.

3.1.1 Site Assessment and Existing Infrastructure

Figure 3.1 - Autonomous Province of Trento Regional Ecosystem

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.

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. Stenico, one of the Autonomous Province of Trento pilot sites, 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 mandated 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 the Stenico 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. Another possibility involves the inclusion of a biogas plant; however, this option also presents significant time and cost considerations, especially as its realization relies on an external party, potentially complicating its availability to the CER.

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;

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

- 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.

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;
- 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.

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 68 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

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 in Piedmont.

Figure 3.3 - Rooftop solar implementation in the French regional ecosystem

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.

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.

Figure 3.4 - Elektrizitätswerke Reutte pilot site

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. By 2030, all such consumers are expected to have smart meters installed. 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 3.5 - 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.

Finally, Elektrizitätswerke Reutte (EWR), an energy supply company, now wants to venture into a new project by founding an EC. 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. It is therefore important to monitor the project progress of this pilot site in the future so that their equipment and software needs become clear.

Figure 3.6 - Dorfenergie eG pilot site

3.4 RE4: Prague (Czech Republic)

In this section, an analysis of the site assessment, existing infrastructure, equipment, system specification and questionnaire results, is conducted for the Prague regional ecosystem. It should be noted that in RE4, three pilot sites (Prague 10, Prague 11 and Prague 9) 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.

3.4.1 Site Assessment and Existing Infrastructure

In conducting a site assessment for Prague, it is imperative to account for its varied topography and the potential it offers for different renewable energy sources. This assessment should meticulously evaluate solar potential in areas with minimal architectural shading, wind patterns conducive to wind energy installations, and the presence of water bodies suitable for hydroelectric power. Moreover, given the city's temperate continental climate characterized by seasonal variations, the assessment must comprehensively analyze factors such as solar irradiance levels, wind speeds, and temperature ranges to optimize energy production. Prague's urban landscape, comprising historical buildings, residential areas, commercial zones, and green spaces, necessitates consideration of zoning regulations, opportunities for rooftop solar installations, and available open spaces for community energy projects. Furthermore, the site assessment should prioritize environmental considerations to ensure that proposed energy projects do not adversely impact Prague's natural and built heritage.

Figure 3.7 – Prague Regional Ecosystem

In Prague, comprehensively understanding the capacity, distribution, and condition of the existing electrical grid is paramount for future energy planning. This entails evaluating the infrastructure of substations, transmission lines, and local distribution networks to ensure their compatibility with additional renewable energy inputs and smart grid technologies. Additionally, the integration of electric vehicle (EV) charging stations within the EC necessitates an assessment of the existing transportation infrastructure, including roads, public transport routes, and parking facilities. Evaluating the energy efficiency of existing buildings, including residential, commercial, and public sectors, and assessing their potential for retrofitting with energy-saving technologies are crucial steps. Furthermore, deploying smart meters, energy management systems, and IoT devices for efficient energy use and monitoring relies on robust communication networks and data handling capabilities, highlighting the importance of elaborating on their linkage to EC systems. Lastly, assessing water and waste management systems is vital for identifying opportunities for energy recovery, such as biogas production from organic waste or utilizing wastewater heat recovery systems.

3.4.2 Equipment and System Specification

The development of an EC in Prague necessitates a detailed specification of equipment and systems to ensure efficient, sustainable, and reliable energy generation, distribution, and consumption. This specification outlines the key components and technologies that will be integrated into the EC, considering the local context, environmental sustainability, and the goal of achieving energy independence and resilience. For an Energy Information and Communication Technology (ICT) platform, it is crucial to consider the equipment and system specifications in Prague:

- Solar PV Panels - specifications including durability, efficiency ratings, and compatibility with the architectural aesthetics of Prague;

- Wind Turbines - specification will detail the rated power, rotor diameter, and height to optimize performance while minimizing visual and auditory impact;
- Micro-Hydro Power Systems – specification for flow rate, head, and environmental impact, ensuring minimal disruption to aquatic ecosystems;
- Biomass and Biogas Systems - Specifications for bioenergy systems including capacity, feedstock requirements, and emissions control technologies, focusing on the utilization of local waste resources;
- Battery Storage - specifications for capacity, depth of discharge, efficiency, and lifecycle, the system should include management software for optimizing charging/discharging cycles and integration with renewable energy sources;
- Thermal Storage - specifications for thermal storage solutions, such as water tanks or phase change materials, to store excess heat generated from solar thermal panels or waste heat recovery systems for space heating or domestic hot water.

3.5 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.

3.5.1 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 3.8 – Aspect of Domokos (left) and Kamena Vourla (right)

Figure 3.9 – Aspect of Amfikleia

3.5.2 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 Villa Banale di Stenico pilot aims to establish RECs in the vicinity of Villa Banale, a district within the Stenico municipality. The focal point involves the installation of a mini hydroelectric plant within the aqueduct pipeline. To optimize energy consumption and maximize incentives, a digital application could be exploited, aggregating data of electricity production and consumption. Through such a platform, end-users could be encouraged to adopt efficient energy practices, thereby enhancing the overall sustainability of the community's energy usage.

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 VehiclesEVs (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. It is within the interest of the regional ecosystem to harness the potential of data integration solutions for streamlining operations and ensuring seamless communication among diverse stakeholders. For example, by gathering diverse energy usage data from various sources within the community, stakeholders aim to gain comprehensive insights that inform collective decision-making and drive sustainable energy practices. Additionally, the automation of energy forecast reports will play a crucial role in providing timely and accurate information to end-users, enabling them to make informed decisions about their energy usage and contribute to overall energy efficiency efforts. Moreover, empowering end-users to optimize self-consumption of solar energy further reinforces the commitment to sustainable practices, as individuals are encouraged to reduce reliance on external energy sources and maximize the utilization of locally generated renewable energy.

Furthermore, the exploration and evaluation of different investment options in energy assets offer opportunities for stakeholders to strategically allocate resources and drive collective progress towards a more resilient and sustainable energy ecosystem, benefiting the entire regional community. Finally, the introduction of an efficient online tool tailored to streamline the initial assessment phase of wind, PV or hydroelectric projects within ECs holds significant promise. By empowering interested stakeholders to list and store information on identified locations, facilitating a comprehensive first-level analysis based on predefined criteria while offering customization options to align with specific project requirements, would greatly benefit the regional ecosystem by enhancing the efficiency and effectiveness of renewable energy initiatives.

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 fostering economic prosperity. By empowering stakeholders to make informed decisions regarding energy investments and subsidy allocations, 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, thereby enhancing overall energy management and resilience. 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: Prague (Czech Republic)

Prague's Regional Ecosystem is committed to expanding renewable energy, especially PV installations, while promoting community engagement and inclusivity. In line with this commitment, the regional ecosystem is keen on leveraging advanced technological solutions to enhance energy management and decision-making processes.

The Prague Regional Ecosystem demonstrates a strong interest in conducting comprehensive economical and financial evaluations. One such initiative involves the exploration of functionalities that could be offered by a platform tailored to the needs of ECs. This envisioned platform could potentially empower EC administrators to explore various configurations, assessing different combinations of renewable energy sources and storage options to optimize overall energy efficiency and sustainability. Furthermore, there is a keen interest within the ecosystem for a tool that can streamline cost-benefit analysis processes. Such functionality would enable stakeholders to evaluate key metrics like payback period and net present value, offering quantitative insights into the financial viability of proposed energy projects. These insights would be invaluable for informed decision-making and resource allocation strategies. Moreover, energy consultants operating within the Prague Regional Ecosystem could leverage the platform to generate tailored reports for stakeholders, providing detailed analyses and recommendations to drive the region's transition to sustainable energy practices.

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

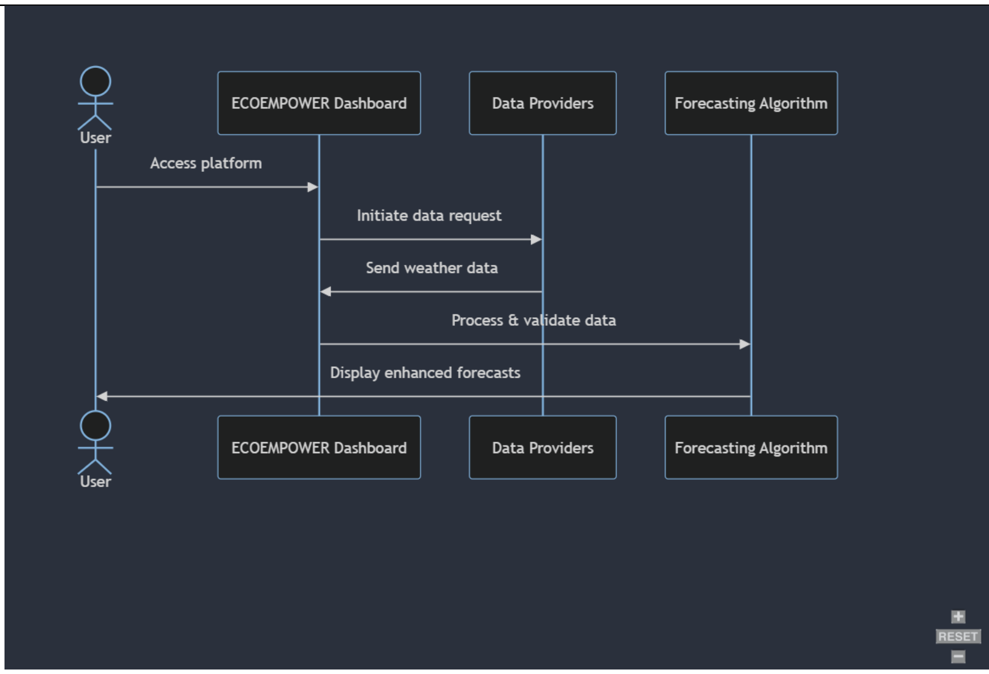
The Forecasting Tool for Energy Generation and Demand is an integrated solution designed to predict energy needs and production for EC end-users. It combines data processing with user-centric interfaces to deliver accurate and actionable energy insights. UC1 is split into four different subcomponents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

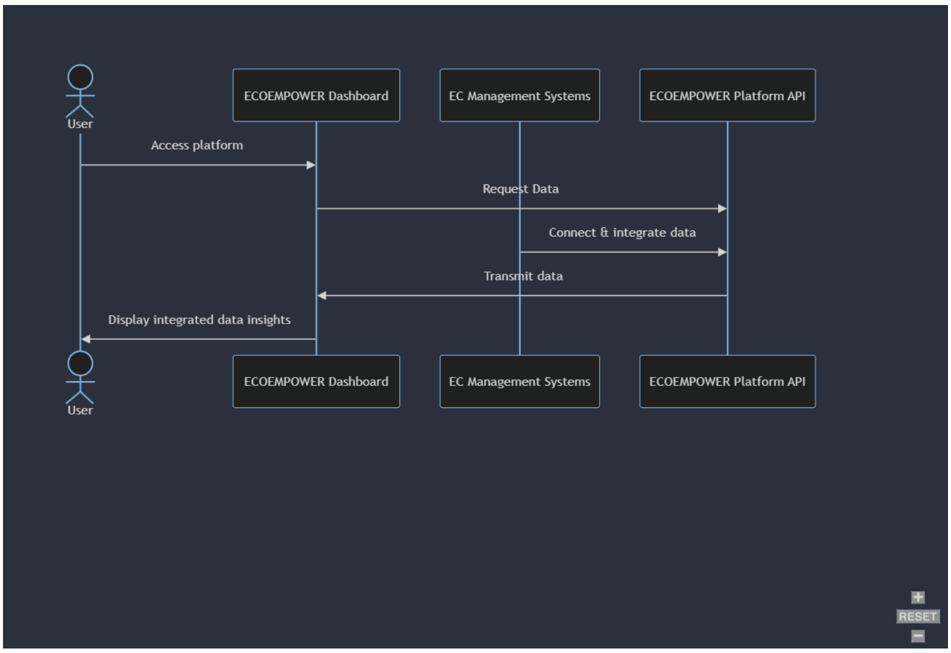
- **UC1.a Seamless Integration of External Weather Data Sources**: This component focuses on integrating external weather data into the forecasting tool, enhancing the accuracy and reliability of energy predictions.
- **UC1.b Developing Data Integration Solutions for ECs**: This part addresses the challenges of varying technical capabilities in ECs, ensuring that even those with basic systems can contribute to and benefit from the tool.
- **UC1.c Automated Energy Forecast Reports for End-Users**: This functionality automates the generation of energy forecasts, delivering vital information to end-users in a comprehensible format.
- **UC1.d Simplified Dashboard for Visualization of predicted Online Energy Generation and Demand**: This aspect provides end-users with an intuitive interface to view and interact with forecasted energy data, fostering informed energy management decisions.

Ultimately, this tool could be proven pivotal in enhancing decision-making for individuals and community leaders, optimizing energy consumption, and promoting efficiency. It facilitates informed energy management decisions by providing a holistic view of energy dynamics, contributing significantly to sustainability and energy awareness within communities. By offering detailed forecasts and easy-to-understand data visualizations, the tool empowers all community members to engage actively in energy management and conservation practices. The four different subcomponents of UC1 are detailed in Table 4.1.

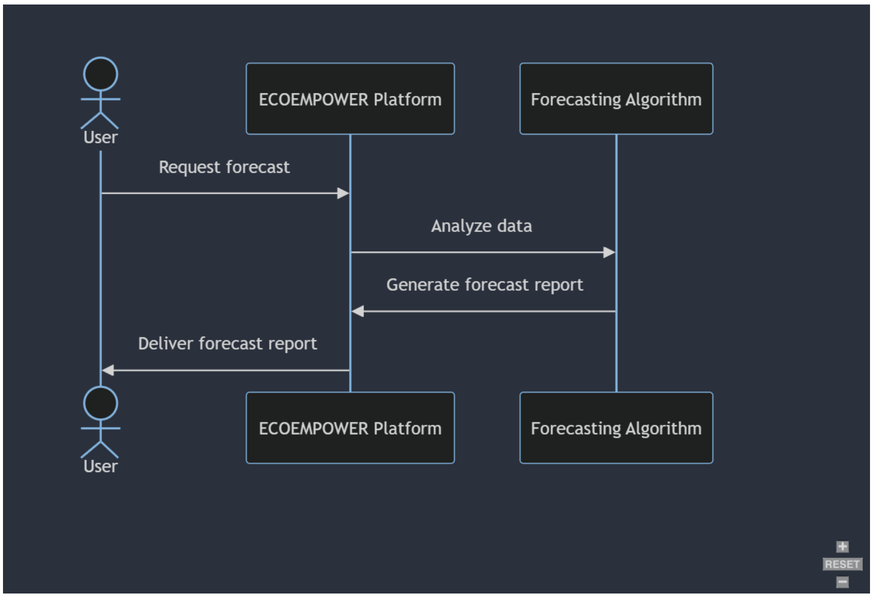
Table 4.1- UC1: Description of different subcomponents

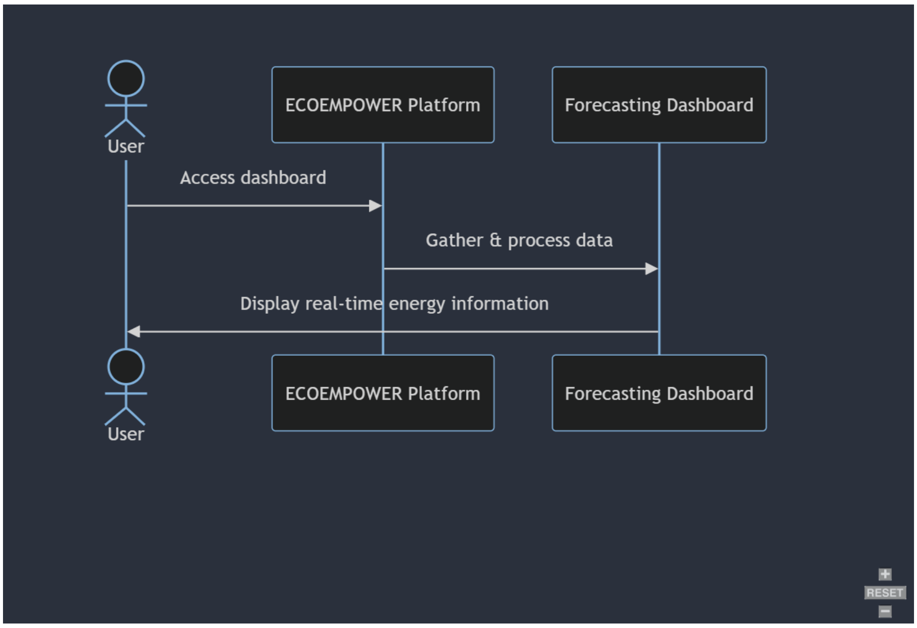
UC1.a Seamless Integration of External Weather Data Sources into the Forecasting Platform	
Title	Seamless Integration of Weather Data Sources into the Platform
Objective	Establish a seamless and automated integration between the energy forecasting platform and weather data sources, ensuring continuous and accurate data flow for enhanced forecasting capabilities.
Background	Weather data is a critical component in energy forecasting, especially for renewable energy sources like solar and wind. The forecasting platform requires accurate weather information to make reliable predictions. Establishing an automated integration with external weather data providers ensures a steady stream of essential data.
Description	This UC is about making sure the ECOEMPOWER platform always has a source of accurate weather information. The system is set up in a way where the platform automatically gets data from either external or internal sources, like weather stations. This way, it is ensured that the energy forecasting tool is accurate and can provide results helping everyone plan better for their energy needs.
Actors	ECOEMPOWER Platform, Data Providers (external/internal data sources)
Relevant Stakeholders	End-Users (prosumers), Platform Administrators (EC Administrators), ECOEMPOWER Developers
Preconditions	• Appropriate data sources and providers have been identified. • The data sources have established data communication methods. • The platform has the infrastructure to handle large volumes of data. • The platform is equipped with necessary API (Application Programming Interface) capabilities.
Basic Flow	1. The platform initiates a connection to data providers using APIs or other data exchange protocols. 2. Data providers transmit weather data to the platform. 3. The platform processes and validates the incoming data to make sure they are in the correct format. 4. Integrated data is analyzed by the platform and made accessible to the forecasting algorithms. 5. The system continuously monitors the data feed for any disruptions or anomalies and alerts administrators if issues arise.

	
Alternative Flow	• In case of data source failure, the system automatically switches to a predefined backup source or utilizes cached data to maintain continuous operation.
Postconditions	• The platform has a reliable and up-to-date source of weather data, crucial for energy forecasting. • Data integrity and consistency are maintained, ensuring high-quality forecasts.
Expected Results	1. Forecasting Algorithm will be able to anticipate and respond to weather dependent energy fluctuations. 2. Enhanced capability of the platform to respond to changing weather conditions.
UC1.b Developing Data Integration Solutions for ECs	
Title	Developing Data Integration Solutions for ECs
Objective	Develop and implement a flexible system for enabling seamless integration between the energy forecasting platform and various energy management systems and data sources of the ECs, facilitating data exchange and system interoperability for enhanced energy management.
Background	Efficient energy management in communities involves the integration of various energy systems and sources. Developing a Data Integration System is crucial for enabling the communication with the energy forecasting platform, sharing data (historical or otherwise) and insights, which is essential for comprehensive energy management and optimization.
Description	This UC is about building bridges between ECOEMPOWER's energy forecasting system and the pilots' existing infrastructure, renewable energy systems and sensors. UC1.b enables these systems to talk to each other, sharing important information. This helps the

	ECOEMPOWER's Platform to get a complete picture of energy use and needs, making the forecasting better and helping everyone manage energy more effectively.
Actors	ECOEMPOWER Platform, EC Management Systems, Platform Administrators (EC Administrators), ECOEMPOWER Developers/Stakeholders
Relevant Stakeholders	End-Users (prosumers)
Preconditions	● The platform is designed to support external communication. ● ECs have some means of recording or storing energy-related data, even if rudimentary. Security protocols and data standards are established for safe and efficient data exchange.
Basic Flow	1. The platform's technical system (that could be represented by an API) receives predefined specifications and requirements based on the data exchange needs with external energy data sources. The platform is developed and configured to support these specifications, ensuring robustness, security, and compatibility with various data formats. Clear instructions and templates are provided to the EC administrator to guide them in preparing and submitting their data. 2. The EC systems provide the available data to the ECOEMPOWER Platform. 3. Upon receiving data, the platform performs necessary verification and cleanup processes to ensure data accuracy and consistency. 4. The forecasting algorithms receive the data through the ECOEMPOWER Platform and utilizes them to offer accurate predictions. 
Alternative Flow	● If an EC system cannot integrate with the ECOEMPOWER Platform, alternative methods of integration or data exchange are explored. ● If a community cannot use the provided data submission methods, alternative arrangements, such as direct communication with the ECOEMPOWER Stakeholders for data entry, are made.

	• In case of inconsistent or incomplete data submissions, the ECOEMPOWER Stakeholders request additional information or clarification from the community.
Postconditions	• The platform can effectively integrate data from a wide range of community sources, regardless of their technical capabilities. • ECs are able to contribute data to the platform using methods that are feasible for them.
Expected Results	1. The platform successfully integrates and communicates with multiple of the EC's energy management systems, facilitating a smooth and efficient exchange of relevant data. The EC Systems can send data seamlessly, enhancing their functionality and the overall efficiency of energy management. 2. Enhanced accuracy in energy forecasts, as they are based on actual community data.
UC1.c Automated Energy Forecast Reports for End-Users	
Title	Automated Energy Forecast Reports for End-Users
Objective	Automatically generate and deliver energy forecast reports to end-users, providing them with accurate and timely information about future energy generation and demand.
Background	Accurate energy forecasting is crucial for effective energy management. End-users rely on these forecasts to plan their energy usage, optimize costs, and make informed decisions. The ECOEMPOWER platform's forecasting algorithm plays a key role in analyzing data and producing these forecasts.
Description	This UC is about giving the end-users a clear picture of what to expect in terms of energy needs. Our system takes all the complex data gathered in UC1.a and UC1.b, like weather, historical data and EC System data, and uses it to predict future energy trends. Then, it puts this information into simple reports that are distributed via the ECOEMPOWER Platform. Users can then use these reports to make better decisions about using energy in their homes or businesses.
Actors	ECOEMPOWER Platform, End-Users (prosumers)
Relevant Stakeholders	ECOEMPOWER Developers/Stakeholders, Platform Administrators
Preconditions	• The platform has access to relevant data inputs (such as weather data, historical energy usage, etc.) described in UC1.a and UC1.b. • End-users have access to the ECOEMPOWER Platform via the web or the OSS.
Basic Flow	1. The forecasting algorithm (through the ECOEMPOWER Platform) processes the input data (weather, system data, etc.) to predict future energy generation and demand. 2. Based on the input data, the algorithm generates energy forecasts for various time frames (e.g., daily, weekly, monthly). 3. The system automatically compiles these forecasts into user-friendly reports. These reports could include not just raw data but also insights, summaries, and potential recommendations.

	4. The reports are presented to the end-users through the ECOEMPOWER Platform through either the web or the OSS. 
Alternative Flow	• In the event of a significant anomaly or unexpected pattern in the forecast data, the system flags the issue for review by technical staff and informs the users accordingly through an error message.
Postconditions	• End-users are regularly updated with accurate energy forecasts in an easy-to-understand format. • The platform maintains a continuous cycle of data processing, forecast generation, and report dissemination.
Expected Results	1. Improved energy management and decision-making among users based on accurate forecasts. 2. Enhanced understanding of energy patterns and trends within the community.
UC1.d Simplified Dashboard for Energy Generation and Demand Visualization	
Title	Simplified Dashboard for Energy Generation and Demand Visualization
Objective	Provide end-users with an easy-to-use, interactive dashboard that displays the Forecasting Tool's data on energy generation and demand, aiding in immediate understanding and decision-making regarding energy usage.
Background	Access to the Forecasting Tool's outputs is crucial for effective and immediate energy management. A simplified, user-friendly dashboard on the platform allows end-users to visualize this data effortlessly, helping them understand current energy dynamics and make timely decisions.
Description	The dashboard, an integral component of the ECOEMPOWER platform, is designed to present current information about energy utilization and generation in an accessible and visual format. Users have the convenience of accessing this dashboard at any given moment via the web or the OSS to obtain a precise understanding of the ongoing energy scenarios.

	This facilitates informed decision-making regarding their energy consumption and management practices.
Actors	ECOEMPOWER Platform, End-Users (prosumers)
Relevant Stakeholders	Platform Administrators (EC Administrators), ECOEMPOWER Developers/Stakeholders,
Preconditions	● The platform has access to all data sources and systems portrayed in UC1.a, UC1.b and UC1.c ● The dashboard is designed with user experience in mind, ensuring ease of use and understanding.
Basic Flow	1. The platform gathers and provides forecasting data regarding energy generation and demand. 2. The processed data is visually represented on the dashboard through visual aids (charts, graphs, or gauges) for easy interpretation. 3. End-users access the dashboard to view energy information online. They can interact with the dashboard to explore different data points or time frames. 4. The dashboard also provides the energy forecast reports described in UC1.c in a dedicated section of the Dashboard. 5. End-users can interact with the outputs of the Forecasting Tool (by viewing, adjusting or downloading) 
Alternative Flow	● In case of technical issues or the lack of real-time data feeds, the dashboard displays the most recently available data. ● If the end-user finds certain data representations confusing, they can request assistance from the OSS.
Postconditions	● End-users have a clear understanding of energy generation and demand within their community. ● End-Users can view all the outputs of the Forecasting Tool in a single page, focusing on the data most relevant to them.

Expected Results	1. Increased user engagement with the platform due to the intuitive and informative dashboard. 2. Improved decision-making by users based on received energy data. 3. Enhanced awareness of energy consumption patterns, leading to more efficient energy use.

4.4 UC2: Energy System Modelling and Scheduling

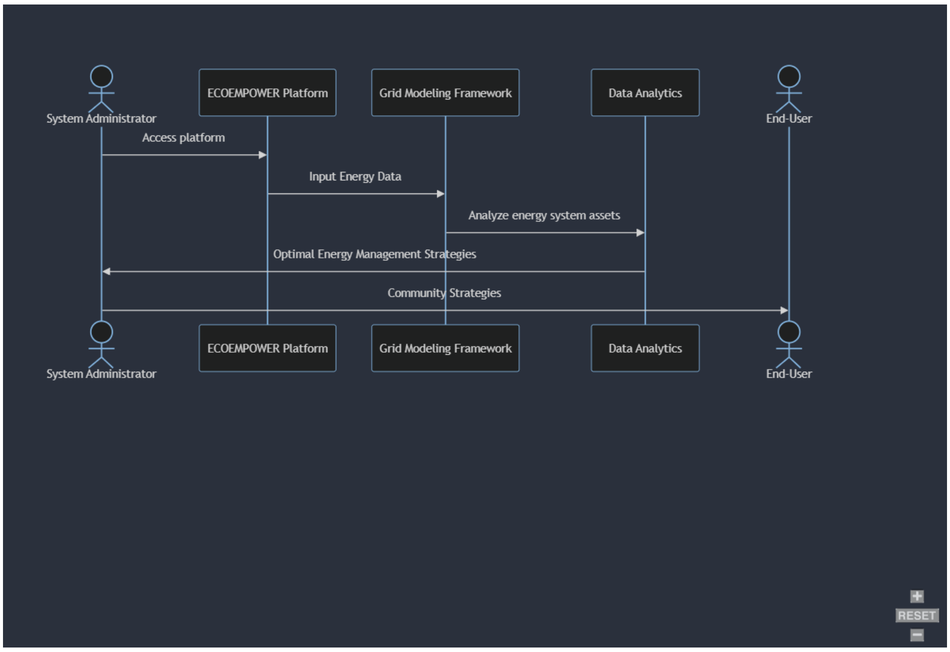
The Energy System Modeling and Scheduling Tool is an advanced solution designed to optimize and manage energy systems within ECs. It serves as a pivotal feature of the ECOEMPOWER Platform combining various functionalities to enhance energy efficiency, sustainability, and user engagement:

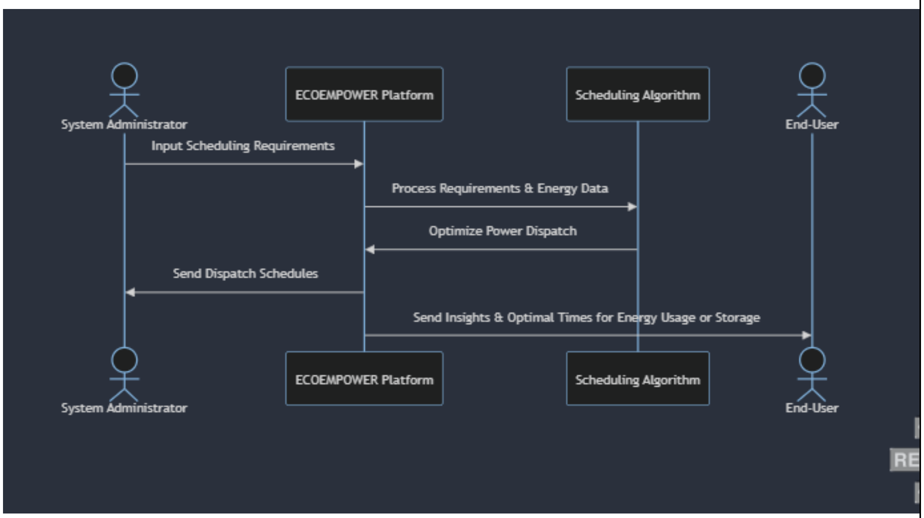
- **Integrating Grid Modeling Framework (UC2.a)**: This component involves integrating a grid modeling framework to analyze energy system assets and their interactions. It provides System Operators and Energy Analysts with vital insights into the energy dynamics of the community, enabling effective planning and decision-making.
- **Advanced Scheduling for Optimal Power Dispatch (UC2.b)**: The tool implements sophisticated scheduling algorithms to optimize power dispatch. This feature is crucial for balancing energy supply and demand, ensuring efficient utilization of available resources, and reducing reliance on external power sources.
- **Optimizing for Maximized Self-Consumption (UC2.c)**: Focused on enhancing self-consumption, this component allows communities to make the most of locally generated energy, such as solar power. It aids in reducing energy costs and increasing sustainability by optimizing the use of self-produced energy.
- **Developing an Intuitive Interface (UC2.d)**: The tool features a user-friendly interface that simplifies complex energy data and models. It enables both end-users and administrators to easily interact with, understand, and manage various aspects of the community's energy system. The interface includes real-time data visualizations, dashboards, and access to reports, enhancing user experience and participation in energy management.

The Energy System Modeling and Scheduling Tool collectively offers a comprehensive approach to managing community energy systems. It facilitates informed decision-making through detailed analysis and visualization of energy data, optimizes energy consumption patterns, and encourages active participation from all community members. By integrating these diverse functionalities, the tool not only improves energy efficiency and sustainability but also empowers communities to take control of their energy futures. The four different subcomponents of UC2 are detailed in Table 4.2.

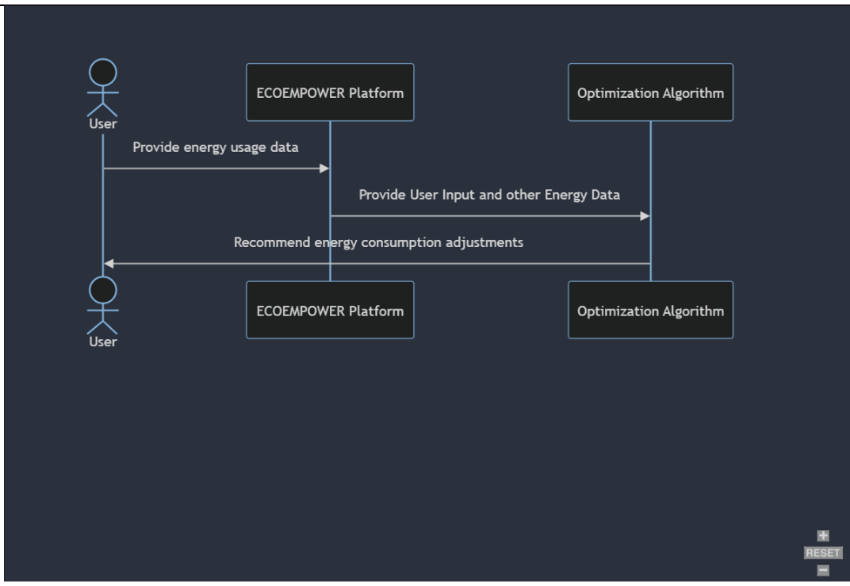
Table 4.2- UC2: Description of different subcomponents

UC2.a: Integrating Grid Modeling Framework for Enhanced Energy System Analysis	
Title	Integrating Grid Modeling Framework for Enhanced Energy System Analysis
Objective	Equip the energy system modeling and scheduling tool with a grid modeling framework that enables System Administrators (EC Managers/Administrators) to effectively manage and optimize community energy systems, with the platform itself playing a crucial role in data processing and analysis.
Background	Understanding the intricate dynamics of community energy systems is essential for efficient management. The integration of a grid modeling framework into the tool provides in-depth insights into these dynamics, aiding relevant actors in making data-driven decisions.
Description	This enhancement introduces a sophisticated grid modeling framework into our energy system tool. The ECOEMPOWER Platform itself plays a key role in processing complex energy data, helping System Administrators understand and optimize the community's energy dynamics. While end-users don not interact with the system directly, they benefit from the improved energy efficiency and sustainability it brings to their community.
Actors	ECOEMPOWER Platform (Energy System Modeling and Scheduling Tool), Platform Administrators (EC Managers, EC Administrators)
Relevant Stakeholders	End-Users (prosumers, residents), ECOEMPOWER Developers
Preconditions	● The platform can incorporate and run a grid modeling framework. ● The existence of diverse energy assets (renewable sources, storage units, consumption points) within the community. ● Relevant energy data for the community is available and accessible.
Basic Flow	1. The platform integrates the grid modeling framework, enhancing its analytical capabilities. 2. Platform Administrators input or oversee the input of energy data into the platform. 3. The platform processes the data, running simulations to uncover optimal energy management strategies. 4. Platform Administrators use the insights provided by the platform to make informed decisions on energy distribution and initiatives.

	As an optional step, platform Administrators could communicate findings and strategies to end-users, mainly through community engagement events. 
Alternative Flow	• If the platform encounters data inconsistencies, it flags these issues for review by System Administrators.
Postconditions	• The platform becomes a central tool for analyzing and managing the energy system, providing actionable insights. • Platform Administrators are empowered with data-driven decision-making tools. •
Expected Results	1. A robust, data-centric approach to energy management in the community. 2. Enhanced efficiency and sustainability of energy use. 3. In case of community events, greater community engagement in energy-related decisions and initiatives.
	UC2.b: Implementing Advanced Scheduling for Optimal Power Dispatch
Title	Implementing Advanced Scheduling for Optimal Power Dispatch
Objective	Implement an advanced scheduling system within the energy modeling and scheduling tool that optimizes power dispatch, enhancing the efficiency and reliability of energy distribution for end-users and administrators.
Background	Efficient energy distribution within ECs hinges on the ability to optimally schedule power dispatch. An advanced scheduling system within the platform can automate and optimize this process, considering various factors like demand patterns, renewable energy availability, and storage capacities.

Description	The advanced scheduling system is a key component of the Energy system modelling and scheduling tool, designed to intelligently manage how power is distributed throughout the community. It factors in when and how much energy people use, along with how much energy is available, especially from renewable sources. This system not only makes energy use more efficient for the community but also helps individual users and administrators make better decisions about their energy use.
Actors	ECOEMPOWER Platform, Platform Administrators, End-Users
Relevant Stakeholders	ECOEMPOWER Developers/Stakeholders
Preconditions	● The platform is equipped with data processing capabilities to handle complex scheduling algorithms. ● Administrators and end-users have access to the platform (via web or OSS) for inputting and receiving information. ● Relevant energy data from the community are available and accessible.
Basic Flow	1. The ECOEMPOWER Platform integrates advanced scheduling algorithms capable of analyzing energy patterns and optimizing dispatch. 2. Energy data, like user consumption patterns, renewable generation forecasts, and grid constraints, is collected and processed by the platform. 3. The system uses this data to dynamically schedule energy dispatch, aiming to balance supply and demand efficiently. 4. Administrators receive detailed dispatch schedules and insights, enabling them to oversee and adjust overall community energy distribution. End-users receive relevant information, such as optimal times for energy usage or storage. 
Alternative Flow	● In case of unexpected changes in energy supply or demand, the system informs the administrators.
Postconditions	● The EC experiences more efficient power distribution, with reduced losses and improved use of renewable sources.

	• EC administrators/Operators have enhanced control over energy distribution, and end-users enjoy more reliable and cost-effective energy.
Expected Results	1. Increased overall energy efficiency in the community. 2. Improved satisfaction among end-users due to cost-effective energy supply. 3. Enhanced ability of EC administrators to manage energy resources proactively.
	UC2.c: Optimizing Energy Systems for Maximized Self-Consumption in Communities
Title	Optimizing Energy Systems for Maximized Self-Consumption in Communities
Objective	Optimize community energy systems for maximized self-consumption, utilizing advanced algorithms within the platform to efficiently balance local energy production, storage, and usage.
Background	With the increasing adoption of personal energy generation methods, such as solar panels, communities face the challenge of optimizing these resources. Maximizing self-consumption not only improves energy efficiency but also reduces reliance on external power sources, leading to economic and environmental benefits.
Description	This aspect of the Energy system modelling and scheduling tool is dedicated to optimizing the utilization of energy generated within the community, such as electricity produced by solar panels. It employs advanced technology to strategically manage the consumption of locally generated energy, prioritizing its use over external sources. This approach not only facilitates economic benefits for the community by reducing energy costs but also contributes to environmental sustainability. Additionally, it offers community members greater insight for decision-making regarding their energy usage practices.
Actors	ECOEMPOWER Platform, End-Users (prosumers)
Relevant Stakeholders	ECOEMPOWER Developers/Stakeholders, Platform Administrators
Preconditions	• The platform is equipped with algorithms capable of analyzing and optimizing energy flow. • Administrators and end-users are able to input data related to their energy production and consumption.
Basic Flow	1. The system includes algorithms designed to maximize self-consumption by analyzing local energy production, storage capacity, and consumption patterns. 2. The platform gathers data from end-users and community assets, such as energy generation data from solar panels and usage data from homes and businesses. 3. The system calculates the optimal way to distribute locally generated energy, prioritizing self-consumption and reducing excess energy export to the grid. 4. The system provides recommendations to both administrators and end-users on how to adjust their energy usage or production for optimal self-consumption. 5. End-users can use the information for their energy management activities

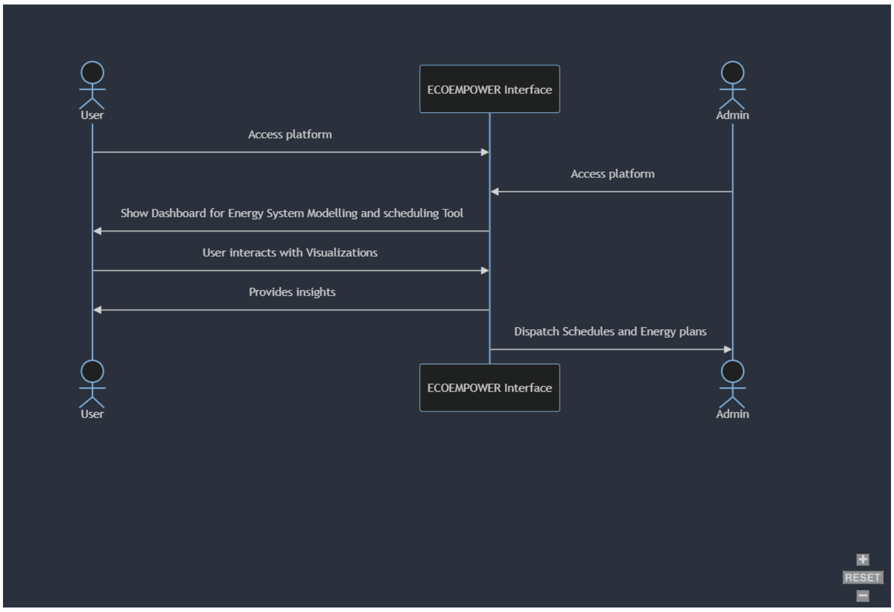
	
Alternative Flow	● I If new types of energy assets are introduced to the community, the system should automatically adjust its optimization strategies to accommodate these changes. ● In cases where self-consumption cannot be maximized due to low generation or high demand, the system suggests alternative measures, such as efficient energy usage or storage strategies.
Postconditions	● Enhanced capability of the community to utilize locally generated energy effectively. ● Administrators and end-users have clear strategies and actions to increase self-consumption.
Expected Results	1. Increased overall energy efficiency and cost savings within the community. 2. Empowered end-users who actively participate in optimizing the community self-consumption.
UC2.d: Developing an Intuitive Interface for the Energy System Modeling and Scheduling Tool	
Title	Developing an Intuitive Interface for the Energy System Modeling and Scheduling Tool
Objective	Create a user-friendly and intuitive interface for the entire energy system modeling and scheduling tool, enabling both community energy administrators and end-users to effectively interact with, understand, and manage various aspects of the community's energy system.
Background	Managing a community's energy system involves complex tasks, including modeling energy systems, scheduling power dispatch, and optimizing self-consumption. An intuitive interface is crucial to present this complexity in a simplified manner, making it accessible for administrators and understandable for end-users.
Description	The development of the interface focuses on transforming intricate energy data and models into a format that is straightforward and interactive. It caters to a diverse user base, encompassing both the experienced administrators responsible for overseeing the community's energy management and the residents interested in their personal energy consumption patterns. The design of this interface aims to simplify the complexities of energy

<table>
<tr><td></td><td>management, thereby facilitating a more comprehensive and engaging interaction with the community's energy system.</td></tr>
<tr><td>Actors</td><td>End-Users, Platform Administrators</td></tr>
<tr><td>Relevant Stakeholders</td><td>ECOEMPOWER Developers/Stakeholders, ECOEMPOWER Platform</td></tr>
<tr><td>Preconditions</td><td>

- The platform is equipped with the energy management functionalities described in UC2.a, UC2.b and UC2.c.
- Users have varying levels of technical proficiency and require different types of interaction with the system.

</td></tr>
<tr><td>Basic Flow</td><td>

1. The platform integrates a customizable dashboard designed for both end-users and administrators. This dashboard prominently displays key energy metrics, including current energy consumption, production statistics, and predictive forecasts.
2. End-users access the dashboard to view information about their energy consumption and production.
3. The platform’s visualization tools simplify complex energy data into understandable formats like graphs and charts, aiding in the comprehension of their energy consumption and production patterns.
4. EC administrators have also access to dispatch schedules or energy plans based on the forecasts, enabling them to make data-driven decisions for optimal community energy management.



</td></tr>
<tr><td>Alternative Flow</td><td>

- In case of technical issues or the lack of real-time data feeds, the dashboard displays the most recently available data.
- If the end-user finds certain data representations confusing, they can request assistance from the OSS.

</td></tr>
<tr><td>Postconditions</td><td>

- Administrators are equipped with a tool that enhances their ability to manage the community's energy system effectively.
- Increased transparency and understanding of the community’s energy dynamics.

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</table>

Expected Results	1. Streamlined management and optimization of community energy resources. 2. Enhanced community participation in energy initiatives, driven by a clearer understanding of energy systems and impacts.

4.5 UC3: Cost Benefit Analysis and Decision Making

The Cost Benefit Analysis and Decision-Making Tool is an integrated solution designed to assist community energy administrators and end-users in making informed decisions about energy management and investments. This comprehensive tool combines various functionalities to analyze, visualize, and optimize energy strategies based on financial and efficiency metrics:

- **Creating Custom Investment Scenarios (UC3.a):** This feature enables users to explore and evaluate different investment options in energy assets, helping them to tailor strategies to their specific goals and resources.
- **Evaluating Energy System Configurations (UC3.b):** Users can assess the impacts of different energy system setups, comparing various combinations of renewable sources, storage solutions, and consumption patterns to find the most efficient and sustainable configuration.
- **Optimizing Storage Scheduling (UC3.c):** Focusing on maximizing the economic use of energy storage systems, this component provides strategies for optimal charging and discharging to align with energy demand and pricing.
- **Generating Customized Reports (UC3.d):** The tool generates tailored reports that offer insights into energy consumption, financial implications of energy strategies, and performance metrics, enabling users to make data-driven decisions.
- **KPI-Based Cost-Benefit Analysis (UC3.e):** Users can conduct comprehensive cost-benefit analyses using Key Performance Indicators (KPIs), benefiting from an interactive and user-friendly interface that simplifies complex data interpretation.

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. The deployment of this tool is anticipated to lead to more strategic and well-informed energy decisions, optimized investment in energy assets, and enhanced community engagement in sustainable energy practices. It represents a significant advancement in enabling communities to navigate the complexities of energy management with data-driven confidence and clarity. The five discrete functionalities of UC3 are detailed in Table 4.3.

Table 4.3- UC3: Description of different functionalities

UC3.a: Creating Custom Investment Scenarios for Optimal Asset Allocation	
Title	Creating Custom Investment Scenarios for Optimal Asset Allocation
Objective	Enable the creation of customized investment scenarios within the Cost Benefit Analysis and Decision-Making Tool, allowing end-users and administrators to explore and evaluate various asset allocation strategies for optimal financial and energy efficiency outcomes.
Background	Effective investment in renewable energy assets is crucial for maximizing returns and achieving sustainability goals. Custom investment scenarios help in understanding the potential impacts and benefits of different asset allocations, guiding users towards financially sound and energy-efficient decisions.
Description	This aspect of ECOEMPOWER's decision-making tool is designed to help community members and administrators simulate and evaluate different investment strategies in renewable energy assets. By creating custom scenarios, users can explore how various allocations impact financial returns and energy efficiency. The tool's simulations and comparisons guide users towards making informed decisions that best suit their energy needs and financial goals.
Actors	ECOEMPOWER Platform (Cost Benefit Analysis and Decision-Making Tool), Platform Administrators (EC Managers, EC Administrators), End-Users (prosumers, residents)
Relevant Stakeholders	ECOEMPOWER Developers
Preconditions	• The platform can simulate various investment scenarios based on different asset allocations. • Users have access to necessary data, such as costs, returns, and energy performance of various assets.
Basic Flow	1. End-users and administrators use the tool to create and define investment scenarios, inputting variables like budget, desired energy assets (solar panels, storage systems, etc.), and expected energy needs. 2. The tool processes these inputs to simulate potential outcomes of each investment scenario, considering financial returns, energy efficiency, and environmental impact. 3. Users compare different scenarios side by side to evaluate their effectiveness and feasibility, utilizing the tool's analytical capabilities. 4. Based on the analysis, users make informed decisions about asset allocation, aligning their investments with both financial and energy goals.
Alternative Flow	• If users lack certain data, the tool provides estimates, benchmarks or default data for standard asset types to assist in scenario creation.

Postconditions	● Users have a clear understanding of the potential outcomes of different investment strategies in renewable energy assets. ● Informed investment decisions could lead to optimized asset allocation within the community.
Expected Results	1. Enhanced ability for users to make strategic investment decisions in energy assets. 2. Increased financial and energy efficiency within the community. 3. Empowerment of users with data-driven insights for better asset management.
UC3.b: Evaluating the Impact of Different Energy System Configurations	
Title	Evaluating the Impact of Different Energy System Configurations
Objective	Provide a feature within the Cost Benefit Analysis and Decision-Making Tool that allows users to assess the impacts of various energy system configurations, facilitating informed decisions about system design and optimization.
Background	Designing an effective energy system requires careful consideration of various configurations and their impacts. This feature of the tool helps in evaluating different setups, such as combinations of renewable energy sources, storage solutions, and grid connections, to identify the most efficient and sustainable options.
Description	This function of ECOEMPOWER's decision-making tool enables community members and administrators to evaluate how different setups of energy systems might perform. It looks at various combinations of energy sources and storage options, simulating their outcomes in terms of cost, efficiency, and environmental impact. This helps users choose the best configuration for their specific needs, ensuring their energy systems are both effective and aligned with their goals.
Actors	ECOEMPOWER Platform, Platform Administrators, End-Users
Relevant Stakeholders	ECOEMPOWER Developers/Stakeholders
Preconditions	● Users have access to data on different energy system configurations and their parameters. ● The tool is equipped with simulation capabilities to model the impact of these configurations.
Basic Flow	1. Users, including residents and EC administrators, input various potential energy system configurations into the tool, detailing components like solar panels, wind turbines, batteries, and connection types. 2. The tool processes these configurations, simulating their performance, efficiency, cost implications, and sustainability impact. 3. Users are provided with a comparative analysis of each configuration, highlighting advantages and drawbacks in terms of energy output, financial costs, and environmental impact.

	4. Based on this analysis, users can make informed decisions about the most suitable energy system setup for their specific community context or personal requirements.
Alternative Flow	● For users uncertain about specific parameters, the tool can offer default or commonly used configurations as a starting point.
Postconditions	● Users gain insights into the most effective energy system configurations for their needs. ● Better-aligned energy systems with community goals, whether for cost savings, energy efficiency, or sustainability.
Expected Results	1. Improved understanding among users of the potential impacts of different energy system configurations. 2. More effective and tailored energy solutions implemented within the community. 3. Enhanced ability of users to balance financial, environmental, and efficiency considerations in their energy planning.
UC3.c: Optimizing Storage Scheduling toMinimize costs	
Title	Optimizing Storage Scheduling to Minimize Costs
Objective	To enable the efficient scheduling of energy storage systems within the community through the Cost Benefit Analysis and Decision-Making Tool, optimizing the use of stored energy to maximize cost savings and overall system efficiency.
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 feature of ECOEMPOWER's decision-making tool focuses on optimizing the use of energy storage systems like batteries, especially for residents and businesses that have them. It determines the optimal times for charging and utilizing stored energy, considering varying energy costs and consumption requirements. This smart scheduling helps everyone save money and potentially make our community's energy use more efficient and sustainable.
Actors	ECOEMPOWER Platform, End-Users (prosumers)
Relevant Stakeholders	ECOEMPOWER Developers/Stakeholders
Preconditions	● The platform is equipped with algorithms to analyze and optimize storage scheduling. ● Users have energy storage systems and are able to extract/integrate their data to the platform.
Basic Flow	1. Users input or connect their storage system data to the tool, including capacity, charge/discharge rates, and existing usage patterns.

	2. The tool processes this data, employing advanced algorithms to determine the most cost-efficient scheduling for charging and discharging the storage systems, considering energy prices and demand patterns. 3. Users receive tailored recommendations on when to store or use their energy, optimizing for cost efficiency and system performance.
Alternative Flow	● In cases where users cannot input or connect their storage system to the tool, the users can view some default recommendations on when to store and use their energy.
Postconditions	● Users are able to make the most economical use of their energy storage systems. ● Enhanced efficiency in energy consumption and/or cost savings for the community.
Expected Results	1. Reduction in energy costs for users with storage systems. 2. Improved balancing of renewable energy generation and consumption within the community. 3. Increased overall efficiency and sustainability of the community's energy system.
UC 3.d: Generating Customized Reports for Informed Energy Decisions	
Title	Generating Customized Reports for Informed Energy Decisions
Objective	To equip the Cost Benefit Analysis and Decision-Making Tool with the functionality to generate customized reports that provide comprehensive insights into energy usage, investments, and efficiency, aiding end-users and administrators in making data-driven energy decisions.
Background	Access to detailed and customized reports is crucial for understanding the complexity of energy consumption and the financial implications of various energy strategies. This feature of the tool allows users to obtain tailored reports that align with their specific energy goals and requirements.
Description	This function of ECOEMPOWER's tool is all about providing detailed and tailored reports to users, whether they are homeowners, businesses, or community administrators. These reports give valuable insights into energy usage, the costs and benefits of different energy strategies, and how well renewable energy installations are performing. By having this information in a format that's easy to understand and specific to their needs, users can make better-informed decisions about how to manage and invest in their energy usage.
Actors	End-Users, ECOEMPOWER Platform
Relevant Stakeholders	ECOEMPOWER Developers/Stakeholders
Preconditions	● Users have access to the platform via the web or OSS.

	• The platform has data integration capabilities to gather and analyze energy-related information.
Basic Flow	1. Users specify their needs for customized reports, which may include energy consumption patterns, cost savings from different energy initiatives, or performance metrics of renewable energy installations. 2. The platform aggregates relevant data and performs comprehensive analysis, synthesizing information into meaningful insights. 3. Users receive their reports through the ECOEMPOWER Platform (view or direct download from the platform). 4. Users review the reports, gaining a deeper understanding of their energy usage and efficiency, and apply these insights to make informed decisions about energy management and investments.
Alternative Flow	• If a user requires additional information or a different report format, the platform can adapt to these needs in subsequent report generations.
Postconditions	• Users have a clear and detailed understanding of various aspects of their energy consumption and efficiency. • Enhanced decision-making process based on comprehensive and customized data.
Expected Results	1. Empowerment of users with knowledge and insights for better energy strategy planning. 2. Increased awareness of energy efficiency and cost-saving opportunities. 3. Implementation of a data-driven approach to energy management within the community, facilitated by the tool's provision of detailed and tailored reports.
	UC3.e: Developing a User-Friendly Tool for KPI-Based Cost-Benefit Analysis
Title	Developing a User-Friendly Tool for KPI-Based Cost-Benefit Analysis
Objective	To create a feature within the Cost Benefit Analysis and Decision-Making Tool that allows users to conduct cost-benefit analyses based on KPIs, providing an intuitive interface for assessing the financial and energy efficiency impacts of different energy strategies.
Background	Understanding the best course of action in community energy management often means diving into some detailed financial and energy numbers. ECOEMPOWER's Cost Benefit Analysis and Decision-Making Tool will break down these complex figures and will serve up the key facts and figures in a way that's easy for anyone to understand. This feature will help users quickly understand the cost-effectiveness and/or efficiency of various energy options.
Description	This feature of our decision-making tool is designed to help users easily understand and carry out cost-benefit analyses based on important metrics. It simplifies complex

	financial and energy data, allowing community members and administrators to clearly see the impacts of their energy choices. Through an intuitive interface, users can explore various scenarios and understand key aspects like costs, savings, and environmental benefits, aiding them in choosing the most effective energy strategies for their needs.
Actors	End-Users, Platform Administrators, ECOEMPOWER Platform
Relevant Stakeholders	ECOEMPOWER Developers/Stakeholders
Preconditions	● Availability of relevant data for KPI calculations, such as energy costs, savings, usage patterns, and environmental impact metrics. ● Lists of possible KPIs (e.g., Return Of Investment , energy savings, carbon footprint, payback period) and their calculation algorithms are available. ● Users possess basic understanding or are provided guidance to interpret KPIs and cost-benefit analyses.
Basic Flow	1. Users create an energy-related scenario that the system can model. The scenario could include different combinations of energy investments, usage patterns, or efficiency improvements. 2. For each scenario, users input relevant data that will be used to calculate KPIs. 3. The platform processes this data and displays the outcomes in a visual format, such as charts or graphs. This visualization presents the calculated KPIs for each scenario, making it easy for users to understand the implications of different energy strategies. 4. Users can compare different scenarios side by side, examining how each performs according to various KPIs. This feature allows for a direct comparison of the benefits and drawbacks of each potential energy strategy.
Alternative Flow	● If users encounter unfamiliar KPIs or complex financial concepts, the users can the tool have generate explanatory messages or simplified summaries.
Postconditions	● Users have a clear understanding of the financial and energy efficiency implications of different strategies. ● Enhanced ability for informed decision-making based on quantifiable metrics.
Expected Results	1. Users gain the ability to make more informed and strategic energy decisions through detailed scenario analysis and KPI-driven insights. 2. The tool facilitates the creation of realistic and effective energy management strategies, grounded in accurate data and projections. 3. Users achieve optimized resource allocation and maximized returns on energy investments by leveraging comprehensive cost-benefit analyses.

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 multi-factor authentication and strict 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.
Actors	ECOEMPOWER Platform, Platform Administrators (EC Managers, EC Administrators)
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.
Actors	ECOEMPOWER Platform, Platform Administrators, End-Users
Relevant Stakeholders	ECOEMPOWER Developers/Stakeholders
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 uccessfully stablished • 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.
Actors	ECOEMPOWER Platform, End-Users, Platform Administrators
Relevant Stakeholders	ECOEMPOWER Developers/Stakeholders
Preconditions	• Users have successfully logged in to the platform. • Data relevant to the user's EC and configuration are available n 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 4.1 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 Seamless Integration of External Weather Data Sources	_	_	(X)	_	_
UC1.b Developing Data Integration Solutions for ECs	(X)	(X)	(X)	_	_
UC1.c Automated Energy Forecast Reports for End-Users	_	(X)	(X)	_	_
UC1.d Simplified Dashboard for Visualization of predicted Real-Time	_	_	(X)	_	_

Energy Generation and Demand					
UC2.a Integrating Grid Modeling Framework	(X)	_	_	_	(X)
UC2.b Advanced Scheduling for Optimal Power Dispatch	_	_	(X)	_	(X)
UC2.c Optimizing for Maximized Self-Consumption	_	(X)	(X)	_	(X)
UC2.d Developing an Intuitive Interface	(X)	(X)	(X)	(X)	(X)
UC3.a Creating Custom Investment Scenarios	_	(X)	_	_	_
UC3.b Evaluating Energy System Configurations	(X)	_	_	(X)	(X)
UC3.c Optimizing Storage Scheduling	_	_	(X)	(X)	_
UC3.d Generating Customized Reports	_	_	(X)	(X)	_
UC3.e KPI-Based Cost-Benefit Analysis	(X)	_	(X)	(X)	_

The meaning of the symbols are 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 Platform

5.1 Overview of the ECOEMPOWER Platform

The ECOEMPOWER Platform, in its initial design phase, is being meticulously crafted to align with the defined requirements of the ECOEMPOWER Description of Action (DoA) and the energy use UCs presented in the previous sections. The ECOEMPOWER platform, is envisioned as a comprehensive solution for the Energy Communities and aspires to integrate a suite of specialized tools designed to enhance energy management, sustainability, and user engagement. At its core, the platform will incorporate a cloud-based data management system, utilizing a variety of communication protocols (like MQTT, REST etc) for efficient data ingestion and management according to the EC' available data and infrastructure. Key to its architecture is the modular design of each tool, including forecasting, energy scheduling, and cost-benefit analysis, each developed independently yet integrated harmoniously. Central to the platform's security is the implementation of Keycloak, providing robust user authentication and data protection mechanisms. The UI will be crafted with React and will aim to prioritize an intuitive and engaging experience, enhanced by sophisticated data visualizations. This eases the delivery of high-level design to create interoperability among components of the platform that assures a sense of a unified yet flexible ecosystem.

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

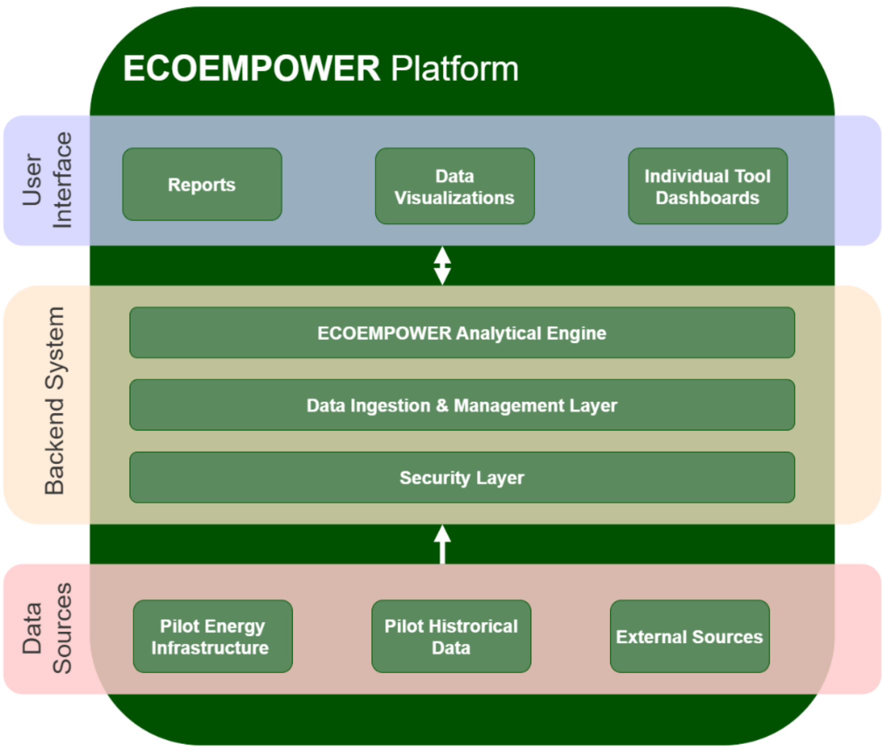

Figure 5.2 The 3 high-level Layers that enable the ECOEMPOWER Platform

The Data Sources Layer visualizes the critical information coming from various origins to fuel the system's analytical capabilities. This includes data from Pilot Energy Infrastructure, as well as data from External Sources, that are used to power the system's analytical capabilities. These data assets enable the functionality of ECOEMPOWER's back-end system, ensuring a comprehensive understanding of energy dynamics within Local Energy Communities (LECs).

At the heart of the platform lies the Backend System Layer. The ECOEMPOWER Analytical Engine is responsible for processing and interpreting the data points collected and producing insights and analytics for the energy communities. A Data Ingestion & Management Layer is tasked with the seamless integration and management of data coming from the Data Sources Layer, while a Security Layer ensures data integrity and protection. This Backend System is engineered to support the tools of the ECOEMPOWER suite, enabling energy forecasting, scheduling, and economic analysis, all while being inline security protocols.

The User Interface Layer of ECOEMPOWER is the platform's interactive UI, designed with the user's experience at the forefront. It encompasses Reports, Data Visualizations, and individual tool Dashboards, each crafted to present information in an intuitive and engaging manner. This layer is the conduit through which the analyses and insights generated by the backend system are communicated to the users.

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, building upon our initial project conceptualizations. This segment methodically lays out the foundational requirements for the platform's primary architectural layers. 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 platform's overall functionality. This approach provides a comprehensive understanding of how each component interplays to create a robust and efficient energy management platform.

5.2.1 Data Ingestion & Management Layer

The Data Ingestion & Management Layer is pivotal to the ECOEMPOWER Platform, ensuring efficient handling of diverse data streams critical for informed decision-making. This layer's design focuses on data collection, normalization, and storage, crucial for maintaining data integrity and relevance. Effective data management facilitates accurate analytics and predictions, underpinning the platform's overall performance. Moreover, this layer sets the groundwork for advanced data processing and analysis, enabling the platform to extract meaningful insights from large datasets, which is essential for optimizing energy management strategies. It is important to note that the capabilities of this Layer, such as the Data Storage and the Data Normalization capabilities, are heavily dependent on the quantity and quality of the available Energy Data that will be received from the individual Pilot Infrastructures.

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 and include efficient recovery systems in case of data loss.

Non-Functional Requirements

1. **Scalability for Data Volumes:** The platform could be benefitted 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 in the ECOEMPOWER Platform serves as a central hub for handling all data-related activities, crucial for the platform’s overall functionality and efficiency. This layer is tailored to efficiently manage the vast influx of data, ensuring its proper storage, accessibility, and processing, which are pivotal for informed decision-making in energy management.

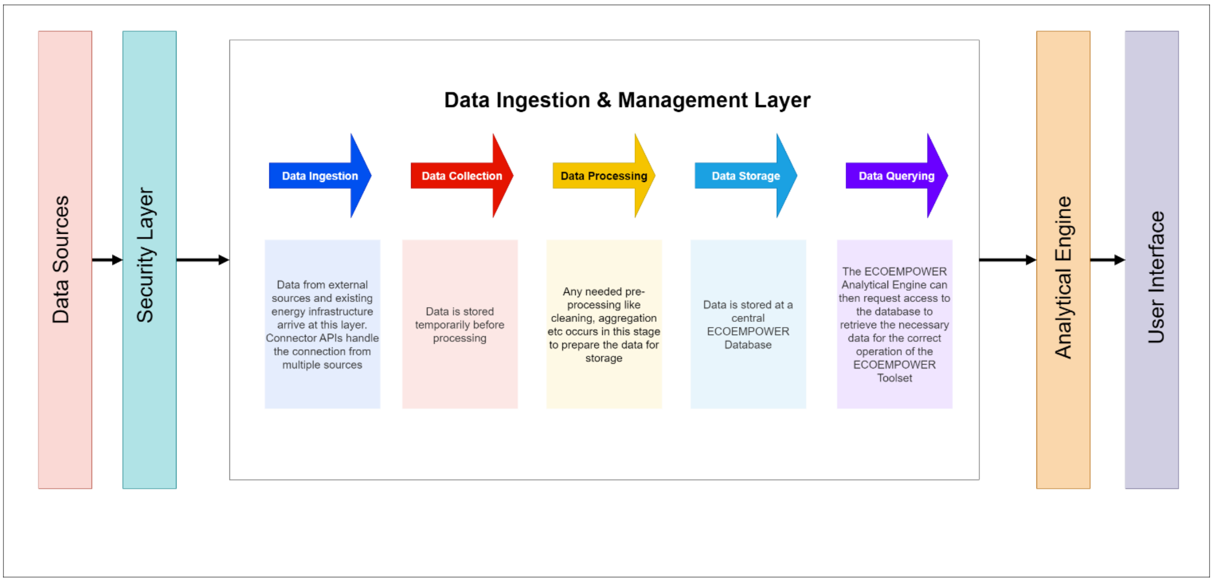

Figure 5.1 – Data Ingestion & Management Layer

The main functionalities of the Data Ingestion & Management Layer are presented in Figure 5.3 and can be grouped in the following overarching categories:

1. Data Collection and Ingestion: These functionalities will be responsible for gathering data from various sources, including weather information, energy usage patterns, and user interactions. The data collected could be diverse in nature, ranging from online data streams to more static, historical data sets. The collection process is designed to be robust and seamless, ensuring data integrity and timeliness.
2. Data Processing and Normalization: The data processing capabilities of the layer are tasked with transforming the raw data into a format suitable for analysis. This involves normalizing data from various sources to a common standard, ensuring consistency and reliability in the data used across the platform. The processing is vital for the platform's forecasting and scheduling functionalities, enabling them to operate on the most current data available.
3. Data Storage and Management: The “heart” of this layer will contain data storage and management capabilities, which will focus on securely storing the ingested data. This layer is designed to handle the normalized data coming from the Data Processing Layer. This ensures that data is stored securely and is easily retrievable for processing and analysis, enabling the platform's analytics and forecasting tools.
4. Data Querying: The querying functionality of the Data Ingestion & Management Layer is a component that facilitates dynamic access to the stored data. By leveraging indexed searches and optimized query languages, the layer provides swift retrieval of data, enabling the Analytical Engine to access the datasets needed for energy predictions, optimization calculations, and financial analysis. The design of the data querying process ensures that data can be filtered, aggregated, and delivered to the different

components of the Analytical Engine with minimal latency, thus supporting the platform's responsive and intelligent energy management capabilities.

The architecture of the Data Ingestion & Management Layer is thus a composite of these interlinked subcomponents, each playing a specific role in managing the lifecycle of data within the ECOEMPOWER Platform. This layer forms the backbone of the platform, supporting the complex data handling required for efficient energy management and decision-making.

5.2.2 Security Layer

The Security Layer is integral to the ECOEMPOWER Platform, playing a critical role in protecting both platform integrity and user data. It focuses on implementing robust authentication, data encryption, and consistent security audits, which are vital for maintaining trust and ensuring compliance with strict data protection standards. The security measures implemented would prevent unauthorized access and data breaches, essential for safeguarding sensitive information. Regular audits help identify and address potential vulnerabilities, enhancing the platform's resilience against evolving cyber threats.

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: the 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.

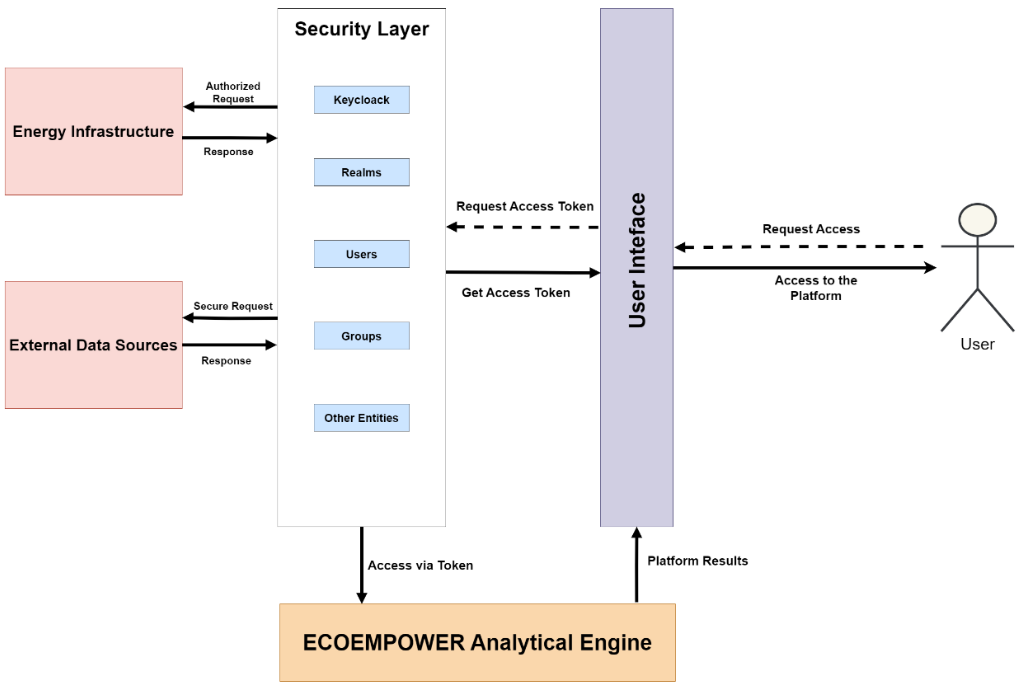

Figure 5.2 – Security layer of the ECOEMPOWER platform

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.

Security Monitoring and Audits: This subcomponent is tasked with identifying and addressing potential security vulnerabilities within the platform. It involves assessments and updates to the security protocols, ensuring the platform remains resilient against evolving cyber threats.

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, encompassing the backend systems of the forecasting, energy modeling, and scheduling tools, offers the platform's main functionality. Each tool, engineered to operate both individually and in conjunction, can offers insights for effective energy management. The ability to function independently allows for specialized focus and flexibility in each domain, while their synergistic operation facilitates a comprehensive understanding of energy dynamics. This dual capability is essential for creating a robust platform that can adapt to various energy scenarios, making it invaluable for efficient energy resource allocation and strategic planning. It is important to note that the efficacy and benefits of the ECOEMPOWER Platform, particularly in achieving potential cost reductions and enhancing energy management, are directly dependent on the quality of the Energy Pilot Data. High-fidelity data is the cornerstone upon which the Analytical Engine will build the insights, enabling the platform to deliver precise forecasts and strategic recommendations.

5.2.3.1 Requirements

Functional Requirements:

1. **Tool Integration:** The platform should be designed to allow selective integration of various tools (like forecasting, scheduling, cost analysis), where integration is beneficial. 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:

1. **Interoperability Among Tools:** The platform must ensure all tools work synergistically, allowing for smooth data and information flow.
2. **Modularity:** Tools should be modular for easy updates, upgrades, and maintenance.
3. **High Reliability:** The tool set must be reliable, minimizing downtime and errors, ensuring consistent performance.
4. **Scalability:** The platform should be capable of scaling up to handle increasing data and user loads without performance degradation.
5. **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 functions as the central processing unit for energy management and decision-making. This backend engine is primarily focused on advanced data analysis, ML modeling, and predictive capabilities, forming the foundation for three key tools that will be elaborated upon in later sections. The overall functionalities and features of this layer can be summarized below:

Advanced Analytical Engine: At its core, the toolset houses a powerful analytical engine capable of processing large datasets from various sources. This engine is responsible for dissecting complex energy consumption patterns, environmental data, and user interactions to derive meaningful insights. The emphasis is on leveraging data to inform all aspects of energy management within the platform.

ML and Predictive Modeling: Integral to this toolset is its ML modeling capability, which is employed for predictive analysis and forecasting. Utilizing state-of-the-art ML algorithms, the toolset can predict energy demands, model potential scenarios, and suggest optimal energy distribution strategies. These predictions are vital for proactive planning and efficient energy resource allocation.

Loosely Coupled Tools Integration: The ECOEMPOWER Toolset encompasses three loosely coupled tools - Energy Data Analysis and Forecasting, Energy System Modeling and Scheduling, and Cost-Benefit Analysis and Strategic Decision Support. Each of these tools taps into the analytical and predictive power of the engine yet operates with a degree of independence. This design allows for flexibility and specificity in each tool's function while maintaining a cohesive analytical approach.

Integration and Interoperability: Designed for seamless integration with other platform layers, especially the Data Ingestion & Management Layer, the toolset ensures a consistent and up-to-date data flow. This interoperability is key to the effectiveness of the analytical engine, enabling it to deliver accurate and actionable insights.

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.

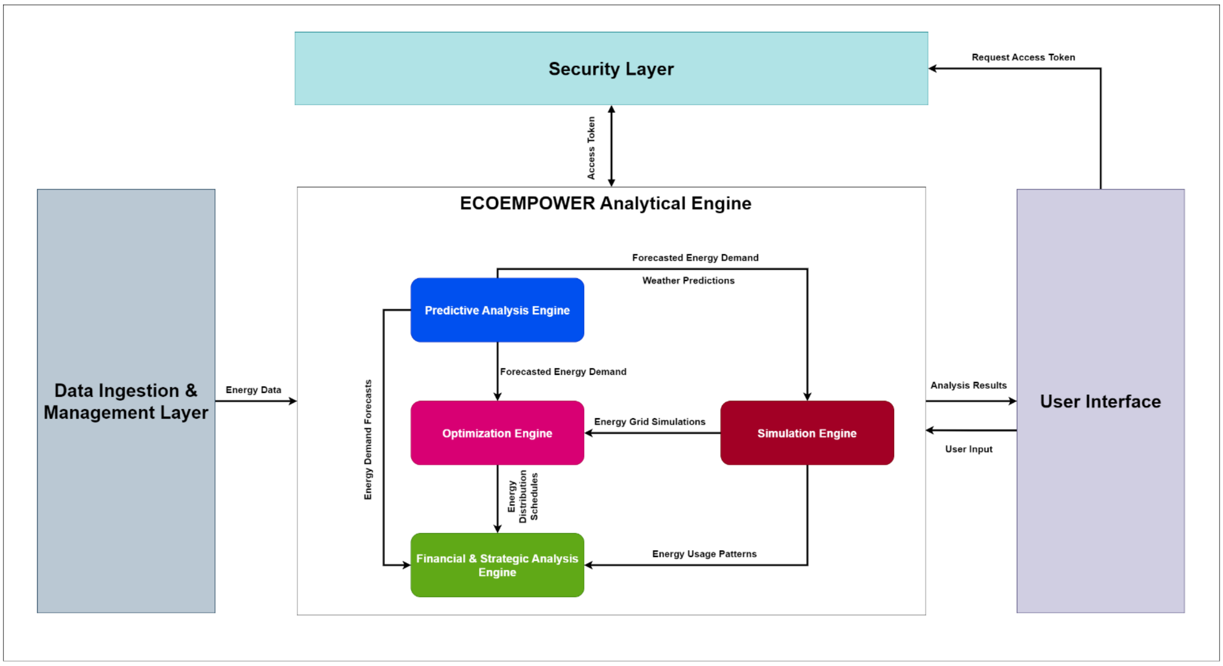

Figure 5.3 – Analytical engine within the ECOEMPOWER platform

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 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 Layer functions as a sophisticated backend engine of the ECOEMPOWER Analytical Layer, to deliver accurate and timely energy demand and weather condition forecasts. This engine can perform data analysis methodologies and is designed to underpin proactive energy management strategies.

Advanced Predictive Algorithms: This subcomponent of the Predictive Analysis Layer employs cutting-edge statistical and ML algorithms to analyze historical and current data, extrapolating patterns to predict future conditions. The algorithms are selected for their robustness in handling time-series data, capturing seasonality, and adapting to new trends, ensuring the forecasts are both accurate and relevant.

Data Integration: To enhance the precision of predictions, this layer can integrate data from external weather services and other pertinent sources. The integration process is streamlined to ensure data fluidity, enabling the predictive models to adjust to live environmental inputs dynamically.

Forecast Dissemination: Essential to this layer is the generation of forecast reports. These reports are tailored to provide stakeholders with actionable insights, summarizing complex predictive data into coherent, decision-ready formats. Automation extends to the scheduling and distribution of these reports, ensuring information is delivered promptly to inform energy management decisions.

Precision Tuning and Validation: The technical design can include mechanisms for ongoing tuning and validation of predictive models to maintain high accuracy levels. Continuous back-testing against actual outcomes could allow for model refinement, ensuring the Predictive Analysis Layer evolves in line with changing data patterns and remains a reliable source for forecasting.

Integration with Analytical Dashboard: The Predictive Analysis Layer is architecturally aligned to feed its outputs directly into an analytical dashboard, part of the UI Layer. This ensures that predictive insights are accessible through an intuitive interface, fostering an interactive environment where users can visualize and comprehend future energy and weather scenarios.

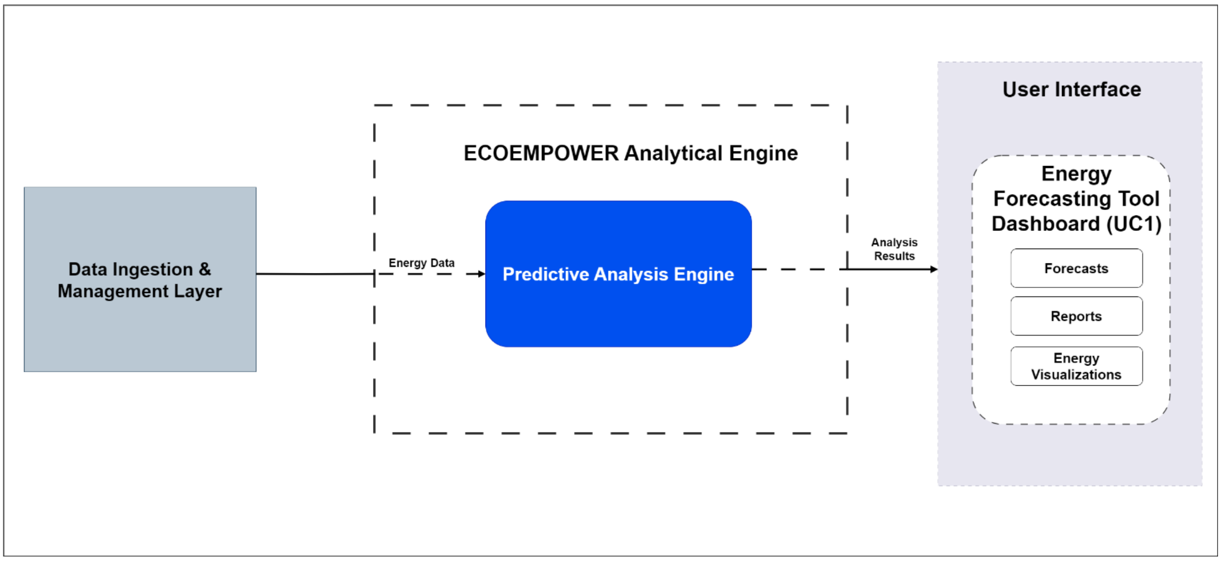

Figure 5.4 – Predictive analysis engine within the ECOEMPOWER platform

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 the complex algorithms 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 conceptualized as a symbiotic system where the Predictive Analysis Engine provides the computational power and analytical depth, while the Forecasting Tool delivers the visualization and user interaction capabilities. Together, they form a comprehensive forecasting service within the ECOEMPOWER Platform.

5.2.5 Simulation Engine

The Simulation Engine is a sophisticated backend component of the ECOEMPOWER Analytical Layer, dedicated to emulating the behavior of energy systems within diverse scenarios. Its function is critical for exploring the impact of various energy strategies, allowing for the analysis and fine-tuning of energy distribution based on simulated conditions. By providing a backend system to test and predict energy flows and consumption patterns, the Simulation Engine enables ECs to anticipate and plan for future demands. This proactive approach is instrumental in enhancing the efficiency and resilience of energy systems, fostering the integration of renewable energy sources, and ultimately contributing to the sustainability goals of the community.

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 operates as an integral backend engine within the ECOEMPOWER Analytical Layer, designed to provide a virtual representation of energy systems for scenario analysis and strategic planning. It is the embodiment of advanced simulation methodologies, combining historical data analysis with hypothetical scenario testing to offer a robust planning tool for energy management.

Dynamic Energy System Modeling: At the core of the Simulation Engine lies the dynamic energy system modeling subcomponent. This module employs complex algorithms to simulate the behavior of various energy assets, including generation sources, storage systems, and consumption patterns across different scenarios. These simulations are essential for understanding the potential impacts of changes in energy policy, market conditions, or technological advancements on the energy system.

Scenario Analysis and Testing: A crucial feature of the Simulation Engine is its ability to perform scenario analysis and testing. This facilitates the examination of 'what-if' situations, allowing energy managers to assess the outcomes of different strategic decisions before implementation. By providing a sandbox environment for testing, the Simulation Engine aids in risk mitigation and strategic planning.

Result Visualization and Interaction: A key aspect of the Simulation Engine is the visualization of simulation results. It is designed to interface with the UI Layer, facilitating the presentation of complex simulation data in a clear and interactive format. This enables stakeholders to visualize potential energy system behaviors and make informed decisions based on simulated outcomes.

Customization and Flexibility: Recognizing the diverse needs of ECs, the Simulation Engine is built with customization and flexibility in mind, ensuring that the simulations are tailored and relevant.

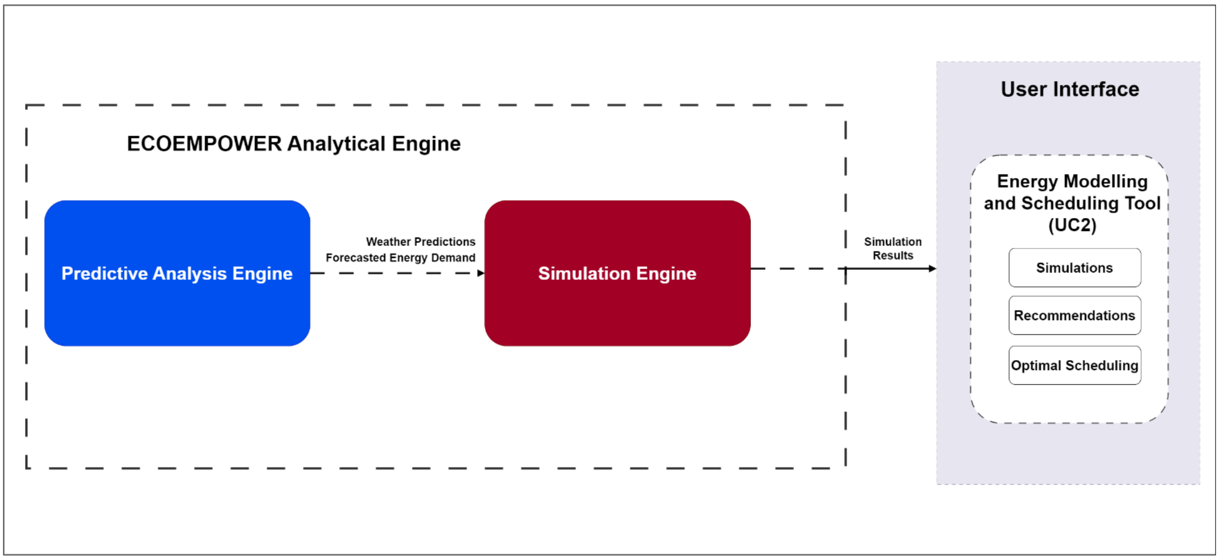

Figure 5.5 – Simulation engine within the ECOEMPOWER platform

The Simulation Engine forms the backbone of the Energy Modeling and Scheduling Tool, functioning as the backend processor that underpins energy system analysis within the ECOEMPOWER Platform. This engine is the nexus where complex simulation models are developed and executed, providing detailed insights into the potential performance of various energy system configurations.

In this symbiotic relationship, the Simulation Engine operates as the technical powerhouse, using historical data and projected trends to emulate energy system behaviors under a multitude of scenarios. Its capabilities are not limited to mere prediction; they extend to encompass a thorough exploration of the consequences of different energy strategies, allowing for a deep understanding of potential system performance.

On the front end, the Energy Modeling and Scheduling Tool is the user interface, presenting sophisticated simulations of the Simulation Engine in an accessible and interactive dashboard. This dashboard is integral for stakeholders who seek to engage with the simulation data, offering customization options and interactive elements to visualize different energy models and scenarios.

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

Complementing the Simulation Engine, the Optimization Engine stands as a key backend engine focused on the efficient utilization of energy resources. It leverages advanced mathematical models to devise optimal power dispatch schedules that align with both current and forecasted energy demands. The engine operates on the principle of minimizing losses and maximizing the use of renewable resources, thus not only bolstering energy efficiency but also reinforcing the environmental stewardship of ECs. Through its optimization capabilities, the engine plays a vital role in ensuring that energy management strategies are both cost-effective and eco-friendly, paving the way for a seamless transition to greener community grids.

5.2.6.1 Requirements

Functional Requirements:

1. **Resource Optimization Algorithms**: The engine must utilize optimization algorithms to determine the most efficient resource allocation and power dispatch strategies.
2. **Demand-Response Integration**: The engine could be capable of integrating demand-response signals to adjust power distribution, ensuring system stability and efficiency.
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 functions as a core backend engine within the ECOEMPOWER Analytical Layer, specifically tasked with the efficient allocation and scheduling of energy resources. As the practical application arm of the platform's analytical capabilities, this engine integrates operational data with predictive insights to formulate optimal energy distribution strategies.

Resource Allocation and Efficiency: Central to the Optimization Engine is its resource allocation and efficiency module. Utilizing sophisticated optimization algorithms, this module processes data related to energy production, storage capabilities, and consumption demands to formulate the most effective distribution strategies. The goal is to balance the supply-demand equation, ensuring energy is used optimally across the community's infrastructure.

Demand-Response Coordination: An essential function of the Optimization Engine is coordinating demand-response actions. This involves analysis of consumption patterns and the initiation of automated control strategies to adjust power usage in response to supply conditions. Potentially, with the right infrastructural support, it could be used to help stabilize the grid and that could lead to potential cost savings and increased system reliability.

Integration with Predictive Analytics: The Optimization Engine is designed to work hand-in-hand with the Predictive Analysis Engine, taking the forecasts and predictions as inputs for its optimization algorithms. This ensures that optimization is not only reactive but also proactive, considering forecasted trends to optimize future energy use.

Interface with Energy Modeling and Scheduling Tool: On the front end, the Energy Modeling and Scheduling Tool provides an interactive platform for users to engage with the optimized schedules generated by the Optimization Engine. This tool visualizes the optimized strategies in a user-friendly format, allowing stakeholders to understand and interact with the scheduling recommendations, make adjustments, and provide feedback.

Adaptability and Scalability: The design of the Optimization Engine is inherently adaptable and scalable, capable of handling the varying needs and sizes of different ECs. It is engineered to accommodate new types of energy resources and technologies, ensuring the platform remains at the forefront of energy optimization as the sector evolves.

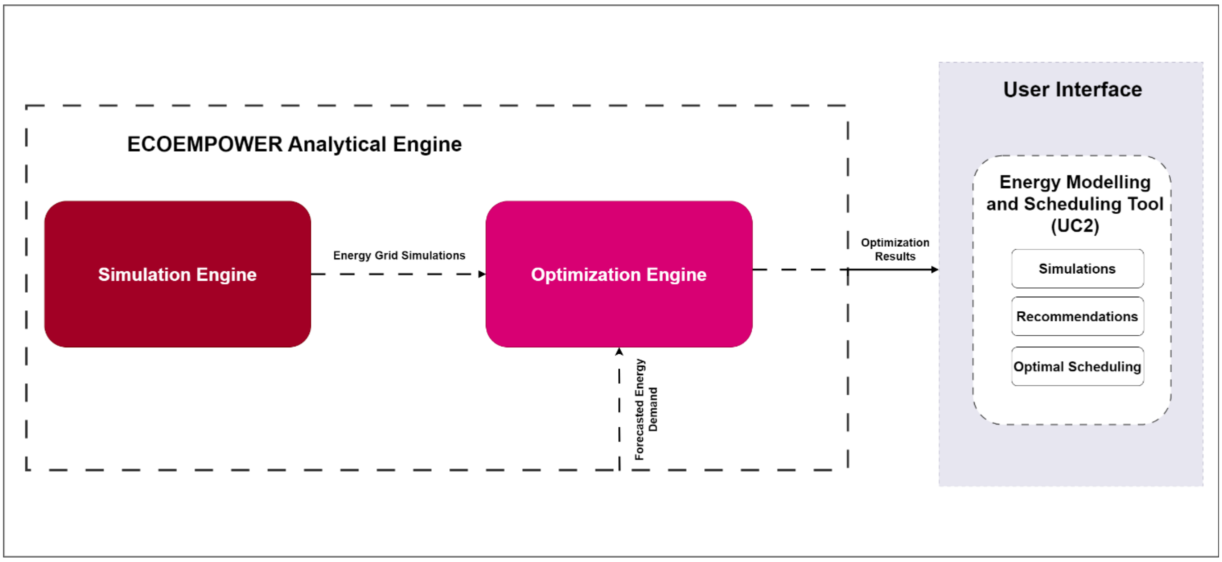

Figure 5.6 – Optimization engine within the ECOEMPOWER platform

The Optimization Engine serves as a crucial 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 tandem with the Simulation Engine to provide a comprehensive energy management solution.

In this collaborative framework, the Simulation Engine lays the groundwork by modeling various energy scenarios and predicting system behaviors. It generates a rich dataset of potential outcomes based on different energy strategies. The Optimization Engine then takes these insights and applies advanced optimization algorithms to them, identifying the most effective energy distribution and usage strategies. This synergy allows for the assessment of numerous scenarios not just in terms of feasibility but also in terms of efficiency and optimization.

On the front end, the Energy Modeling and Scheduling Tool acts as a visual and interactive interface for both engines. While the Simulation Engine provides the tool with various modeled scenarios, the Optimization Engine supplies optimized schedules and resource allocation plans. The tool then presents these complex strategies in an accessible and user-friendly manner. Users can interact with this data to understand the implications of different energy models and optimized schedules, enabling them to make informed decisions based on comprehensive analyses.

This interconnectedness ensures that the Optimization Engine is not just a standalone processor but an integral part of a larger ecosystem within the ECOEMPOWER Platform. It enhances the value of the simulated data by adding a layer of practical, actionable optimization, which is crucial for real-world applications. The Optimization Engine, in essence, transforms theoretical models into tangible, optimized strategies, bridging the gap between simulation and practical implementation in energy management.

5.2.7 Financial and Strategic Analysis Engine

The Financial and Strategic Analysis Engine, functioning as a key backend component of the ECOEMPOWER Analytical Layer, is specifically developed for the in-depth assessment of the economic impact and strategic implications of various energy management strategies. This engine plays a crucial role in elucidating the financial and strategic aspects of energy decisions, employing a combination of advanced analytical methodologies and scenario-based planning.

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 most important functionality of this engine is its capability to conduct comprehensive economic evaluations, using sophisticated cost-benefit analysis models. These models are adept at quantifying the financial outcomes of different energy strategies, taking into account a wide range of variables, including initial investments, operational costs, potential savings, and revenue generation. Additionally, the engine is equipped to simulate various scenarios, providing a multi-faceted view of potential financial and strategic outcomes under different conditions.

The Financial and Strategic Analysis Engine integrates data from various sources within the ECOEMPOWER Platform, including energy consumption patterns, pricing data, and market trends. This integration enables the engine to offer data-driven insights, supporting stakeholders in aligning their energy strategies with broader financial sustainability and long-term viability objectives.

To effectively communicate its findings, the engine interfaces with analytical dashboards and reporting tools within the UI Layer. This integration ensures that the complex financial analyses and strategic recommendations are presented in an understandable and actionable format, facilitating informed decision-making among EC stakeholders.

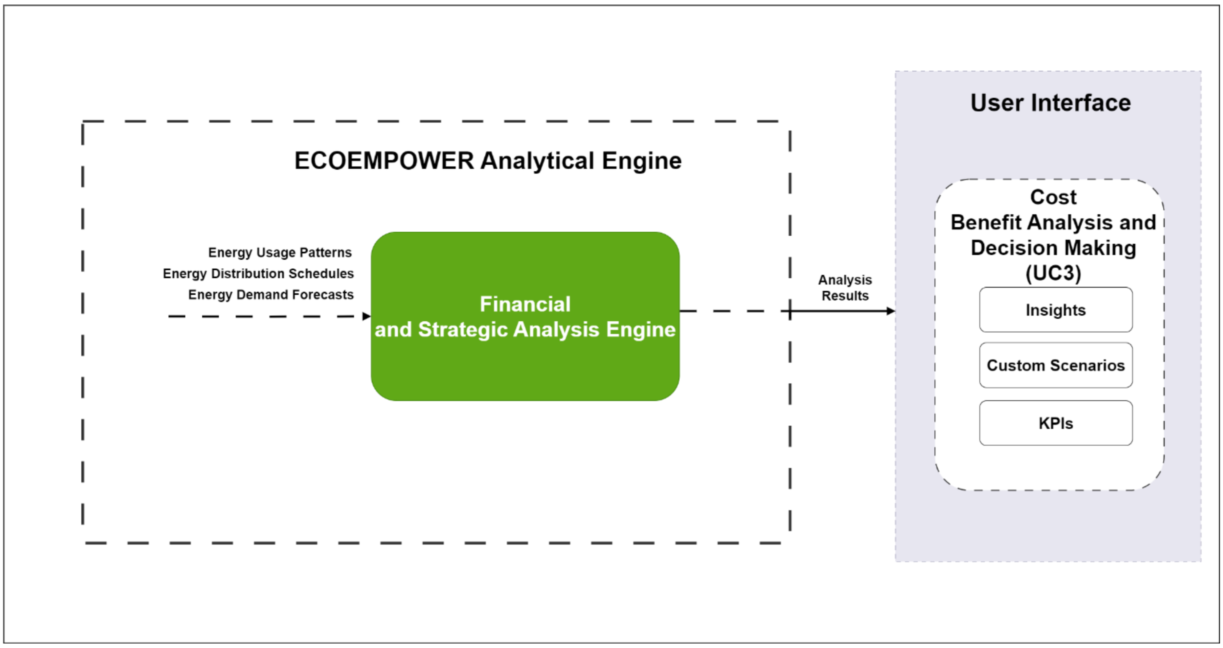

Figure 5.7 – Financial and strategic engine within the ECOEMPOWER platform

5.2.8 UI Layer

The UI Layer is crafted to provide an engaging and intuitive experience for users. It achieves this through advanced data visualization and user customization options, making complex energy data accessible and understandable. An effective UI layer is crucial as it bridges the gap between sophisticated energy management systems and end-users, enhancing user engagement, simplifying interactions, and ultimately leading to more effective management and monitoring of energy resources.

5.2.8.1 Requirements

Functional Requirements:

1. **Intuitive and Responsive Design**: The UI should be designed to be intuitive 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 of the ECOEMPOWER Platform is engineered as a sophisticated frontend, seamlessly integrating with the platform's various backend engines and the Security Layer to deliver an intuitive and interactive experience to users. This layer is a critical component in making complex energy data and analytical results accessible and actionable for end-users, thereby playing a pivotal role in the effective management and monitoring of energy resources.

Integration with ECOEMPOWER Analytical Engine: The UI Layer is intricately designed to connect with the ECOEMPOWER Analytical Engine, which includes the Predictive Analysis, Simulation, Optimization, and Financial and Strategic Analysis Engines. It retrieves processed data and analysis results from these engines and displays them in a user-friendly format. For each specific UC or tool within the platform, the UI Layer presents relevant data visualizations and interactive elements, allowing users to engage with the information, configure settings, and make informed decisions based on the analytical insights provided.

Connection with the Security Layer/Keycloak: The UI layer integrates tightly with the Security Layer, particularly with Keycloak for authentication and authorization. This integration ensures that users can securely access the platform and that data privacy and integrity are maintained. The UI Layer supports single sign-on (SSO) and role-based access controls, ensuring that users only access data and functionalities relevant to their roles and permissions.

Responsive and Adaptive Design: In line with its functional requirements, the UI Layer is developed with a focus on responsiveness and adaptability. It is designed to provide a consistent and efficient user experience across various devices, from desktop computers to smartphones. This adaptability is crucial for accommodating users in different contexts, whether they are in an office setting or on the move.

Advanced Data Visualization: The UI Layer utilizes sophisticated visualization tools to present complex energy data and analytics in a clear and engaging manner. Interactive charts, graphs, and dashboards are employed to make the data comprehensible to users with varying levels of technical expertise. This approach is essential for translating the advanced computations and predictions from the backend engines into actionable insights that users can understand and utilize.

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.

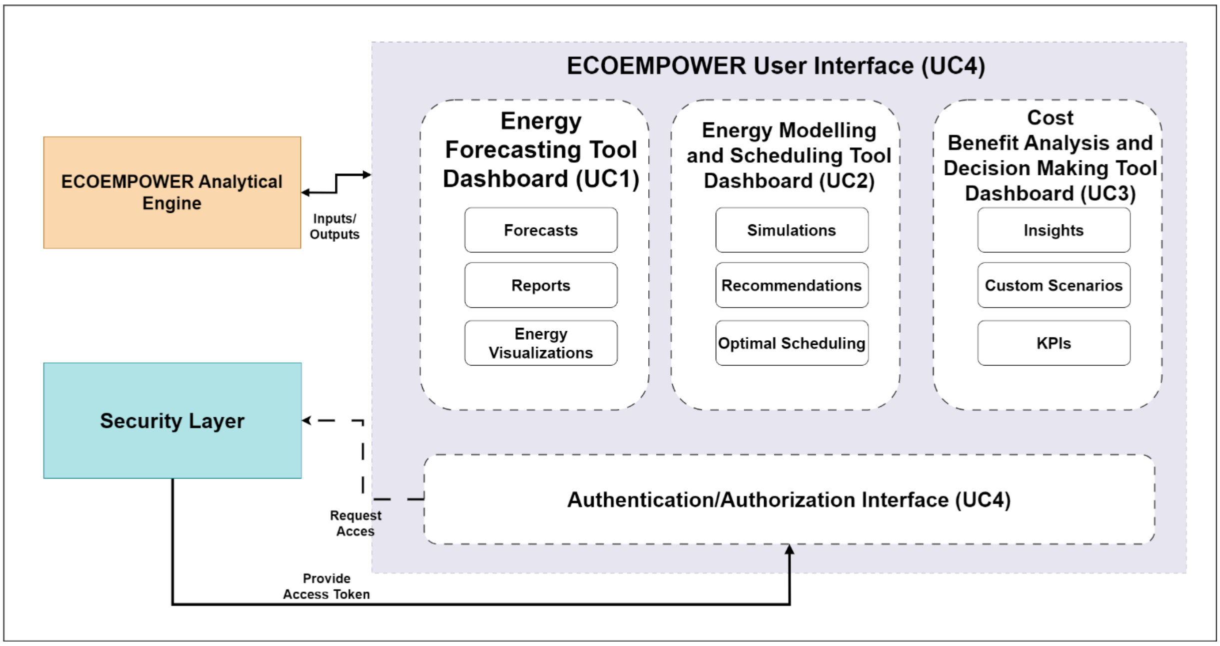

Figure 5.8 – UI layer of the ECOEMPOWER platform

5.3 Preliminary Platform Mockups

In this section, we delineate the preliminary platform mockups for the ECOEMPOWER Platform, drawing on the foundational 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 underpinned by a methodical approach, incorporating 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.

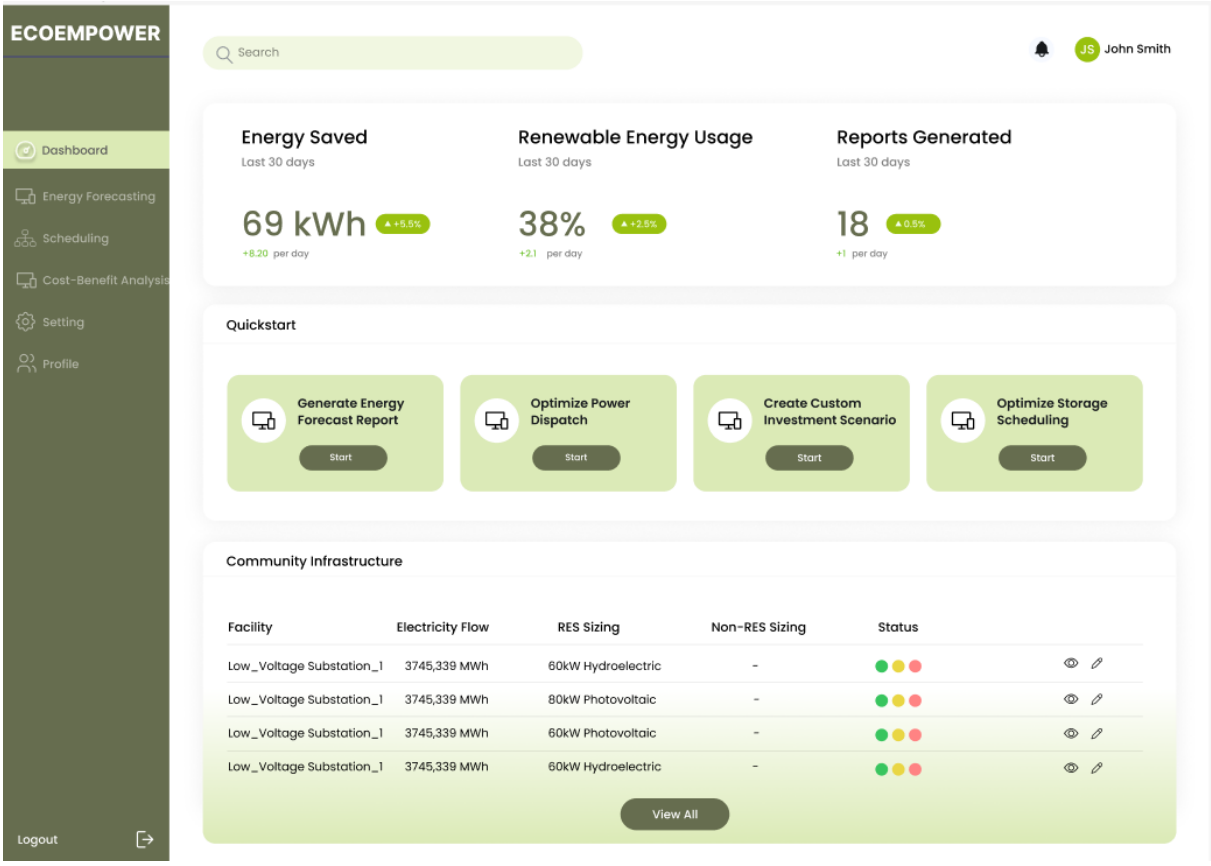

Figure 5.9 – Preliminary mock-up of the main ECOEMPOWER dashboard

The above preliminary mockup offers a conceptualized vision of the main dashboard for the ECOEMPOWER Platform. This interface really incorporates a modular approach and user-centric design. In this dashboard there are:

- Central to the dashboard is the prominent display of essential KPIs that articulate the tangible 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.

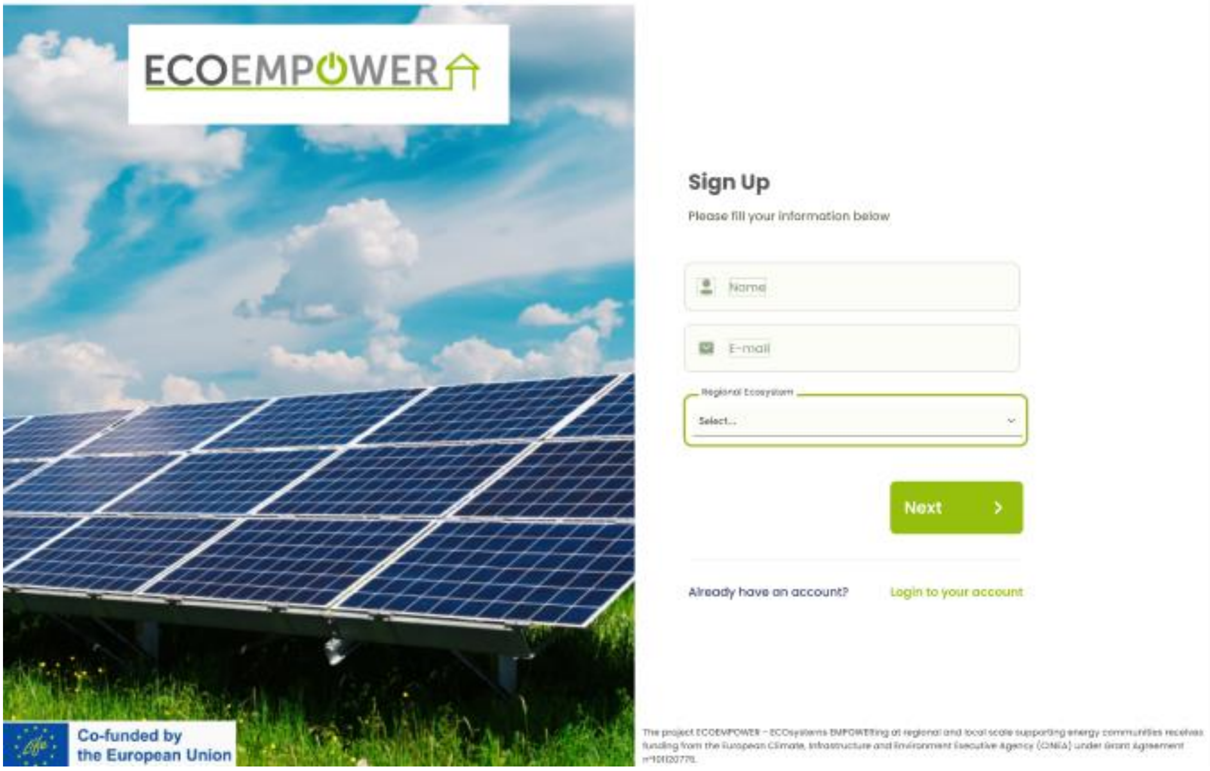

Figure 5.10 – Registration mock-up

The Registration mockup for the ECOEMPOWER Platform, is meticulously designed to streamline the user access process while adhering to the highest standards of data protection compliance, as mandated by GDPR. This UI serves 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. It will play a crucial role in managing 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.

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 are built into the registration process, instilling trust and safeguarding user rights.

Figure 5.11 – Illustrative example of the potential outcomes generated by the energy forecasting tool

In Figure 5.11, 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.

As we look forward to the next phases of the ECOEMPOWER project, our next steps 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 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.