SYNERGY

D6.2 1st Version of the EaaS Tool Suite for Energy Retailers and Aggregators

Big Energy Data Value Creation within SYNergetic enERGY-as-a-service Applications through trusted multi party data sharing over an AI big data analytics marketplace

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Abbreviations and Acronyms

Acronym	Description
AMI	Advanced Metering Infrastructure
API	Application Programming Interface
APM	Aggregator Portfolio Manager
BaU	Business as Usual
BW	Blockchain Wallet
CSE	Customer Segmentation Engine
D-1	Day before the physical trade/generation takes place (energy markets)
DDP	Distributed Data Protocol
DER	Distributed Energy Resource
DMP	Daily Market Prices
DR	Demand response
DSM	Demand Side Management
DSO	Distribution System Operator
DSS	Decision Support System
EaaS	Energy as a Service
EC	European Commission
EMS	Energy Management System
EU	European Union
FCM	Flexibility Contracts Manager
FMS	Flexibility Marketplace Search Engine
FSR	Flexibility Settlement and Remuneration Component
IRR	Investment Return Rate
KPI	Key Performance Indicator
LV	Low Voltage
M&V	Measurement and Verification
ML	Machine Learning
MPOT	Market Positioning Optimization Tool
O&M	Operations and Maintenance

Acronym	Description
PEAE	Personalized Energy Analytics Engine
POT	PPA Optimization Tool
PPA	Power Purchase Agreement
PPFE	Portfolio Pattern Forecasting Engine
PV	Photovoltaics
SaaS	Software as a Service
SHIE	Smart Home Integration Engine
TSO	Transmission System Operator
UI	User interface
UX	User experience
VPP	Virtual Power Plant
WMPDSS	Wholesale Market Participation Decision Support System
WP	Work Package

Executive summary

The current deliverable D6.2 "1st Version of the EaaS Tool Suite for Energy Retailers and Aggregators" reports the current status of the developments being performed under Tasks 6.1, 6.2, 6.3 and 6.4, each one in charge of the design and implementation of the applications composing the tool suite to be delivered by WP6. This deliverable is a follow up of the previous D6.1 "Detailed functionality specifications and design of the EaaS Tool Suite", consists on the release of the first version of the applications, and is accompanied by this report, where details on the current status of development for each application and its features are provided. The applications composing the tool suite are:

- **Portfolio Analytics and Management Application**: application implementing necessary features to allow retailers and aggregators position themselves to provide better and added value services. By exploiting all available data, in order to analyse in detail what is the composition of their portfolio of customers and how those behave, the target users will gain useful insights towards segmentation of customers and towards enabling novel strategies to address the energy requirements of the portfolio, such as the implementation of dynamic price-based Demand Side Management strategies and the optimal operation on short and long-term energy markets.

- **Personalized Energy Analytics Application**: application focusing on the provision of services to prosumers (customers of the retailers and aggregators targeted by the *Portfolio Analytics and Management Application*). The proposed services follow two main lines: providing enhanced information about energy usage, and providing advanced services for optimum operation of smart appliances.

- **Flexibility Analytics and Consumer-Centric DR Optimization Application**: application implementing necessary features to allow DER aggregators position themselves to provide better and added value services, by analysing in detail what is the flexibility potential of their portfolio, and by facilitating the optimal placement of the flexible assets in different strategies.

- **DR Smart Contract Monitoring, Handling, Settlement and Remuneration Platform**: application implementing all necessary features to allow DER Aggregators and Flexible Asset

Managers to come into a common marketplace and negotiate the enrolment of the flexibility assets in different flexibility services through a contractual process.

Within this context, the scope of the current deliverable includes for each one of the applications:

- Overview, including a summary of the application objectives, features and target users

- Implemented functionalities, detailing the current status of development for each of the features documented in D6.1 "Detailed functionality specification and design of the EaaS Tool Suite for Energy Retailers and Aggregators", including an overview of the implemented user interfaces

- Technology stack and implementation tools, detailing the libraries used under the hood to implement the different modules of the applications

- API documentation, describing how the interaction among different components and with the SYNERGY Platform is being implemented

- Installation instructions

- Assumptions and restrictions, providing an overview of the requirements imposed to retailers and aggregators willing to integrate with and make use of the applications

- Licensing and access details

- Planned features for the next release (M24, December 2021, prior to the start of the first demo run of the demo cases)

The current deliverable is the second of three deliverables to be delivered by WP6. Follow-up deliverable D6.3 (due to M42) will consist on the release and companion documentation of the final version of the applications specified in D6.1.

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1   Introduction

1.1   Purpose of the document

The current deliverable, D6.2 "1ˢᵗ Version of the EaaS Tool Suite for Energy Retailers and Aggregators", provides an overview of the status of the implementation work undertaken on WP6. This work package is responsible for the delivery of Energy as a Service applications for electricity retailers and aggregators, as well as applications aiming at personalized energy analytics and energy efficiency optimization based on human-centric automation features for electricity consumers and prosumers.

The purpose of this document is to provide details on the status of implementation for each one of the four applications composing the toolsuite, including an overview of the features and its current development status, as well as additional technical and licensing-related aspects and plans for the next months.

1.2   Scope of the document

This document accompanies the release of the first version of the applications composing the *EaaS Tool Suite for Energy Retailers and Aggregators*, and therefore contains details for each one of the four applications composing the tool suite, namely the *Portfolio Analytics and Management Application*, the *Personalized Energy Analytics Application*, the *Flexibility Analytics and Consumer-Centric DR Optimization Application* and the *DR Smart Contract Monitoring, Handling, Settlement and Remuneration Platform*. These applications are built taking advantage of the features offered by the *SYNERGY Integrated Platform* beta release [1] mainly in the following terms:

- data ingestion through the variety of protocols enabled by the *SYNERGY Integrated Platform*

- data homogenization, provided by the mapping of the diversity of data sources to the *SYNERGY Common Information Model* [2]

- workflow analytics, both configured specifically for each one of the applications, or taking advantage of the existing pre-trained analytics offered out-of-the-box by the *SYNERGY Integrated Platform* [3]

- access on demand to results of those analytics

For each of those applications, an overview on the current status and next planned actions is provided.

Development plans and documentation provided for all energy applications developed within WP5 *Advanced Grid-level Analytics for Optimized Network and Asset Management Services and Applications*, WP6 *Portfolio-level Analytics for Energy-as-a-Service (EaaS) Applications for Electricity Retailers and Aggregators* and WP7 *Building/District-level Analytics for Optimized Energy Performance Management* have been designed in a coherent manner with the feature release plans of the *SYNERGY Integrated Platform*, and aligned in order to assure that the relevant milestones of the project are met according to the project-wise development plan. In this context, the next release of the applications described in this document has been internally scheduled by M24 (prior to the start of the first demo run of the demo cases).

1.3 Structure of the document

This document consists of seven chapters, including chapter 1 for the introduction to the deliverable, chapter 6 for the conclusions drawn during its writing and chapter 7 for the consulted references. The core of deliverable D6.2 is provided in chapters 2 to 5, where the status of development of applications and their components are detailed. These chapters provide an overview for each one of the four applications being developed within WP6. For each application, the following details are provided:

- Overview, including a summary of the application objectives, features and target users

- Implemented functionalities, detailing the current status of development for each of the features documented in D6.1 "Detailed functionality specification and design of the EaaS Tool Suite for Energy Retailers and Aggregators" [4], including an overview of the implemented user interfaces

- Technology stack and implementation tools, detailing the libraries used under the hood to implement the different modules of the applications

- API documentation, describing how the interaction among different components and with the SYNERGY Platform is being implemented

- Installation instructions

- Assumptions and restrictions, providing an overview of the requirements imposed to retailers and aggregators willing to integrate with and make use of the applications

- Licensing and access details

- Planned features for the next release (M24, December 2021, prior to the start of the first demo run of the demo cases)

2 Portfolio Analytics and Management Application

2.1 Overview

The *Portfolio Analytics and Management Application* implements necessary features to allow retailers and aggregators position themselves to provide better and added value services. By exploiting all available data, in order to analyse in detail what is the composition of their portfolio of customers and how those behave, the target users will gain useful insights towards segmentation of customers and towards enabling novel strategies to address the energy requirements of the portfolio, such as the implementation of dynamic price-based Demand Side Management strategies – as means to minimise deviations between customer demand and energy allocated in the wholesale market – and the optimal operation on short and long-term energy markets.

2.2 Implemented functionalities

The functionalities of the *Portfolio Analytics and Management Application* have been split in 5 components according to their nature.
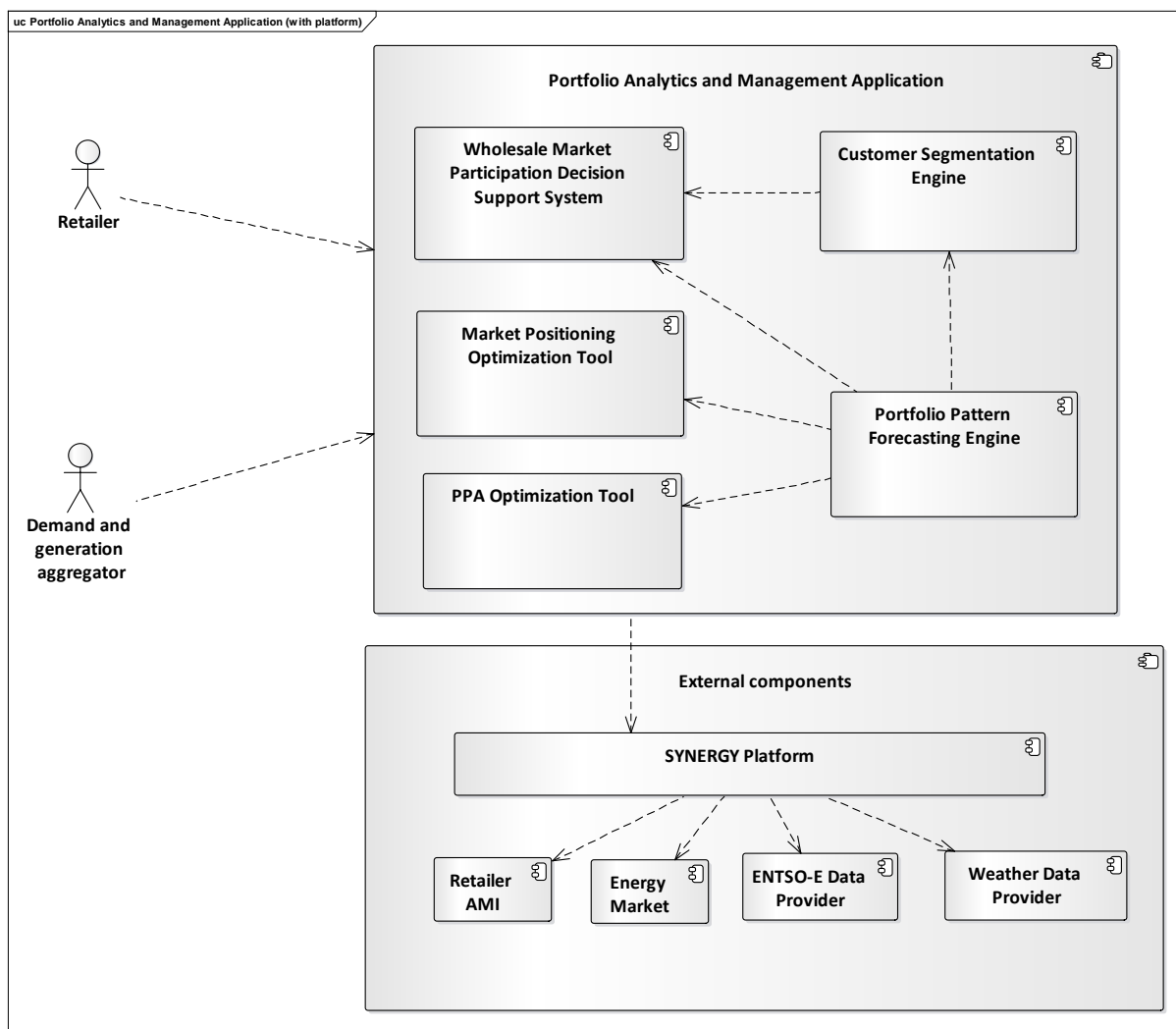
Figure 1: Portfolio Analytics and Management Application components and addressed actors

The following table summarizes the current status of all the features to be provided by the application.

Table 1: Portfolio Analytics and Management Application - Implemented functionalities

Feature	Status	Notes
PPFE_1 Next 6 hours portfolio demand forecast	Partially implemented	Algorithm implemented as SYNERGY platform pre-trained analytics. Integration with application is pending. User interface for feature is ready
PPFE_2 Day-ahead portfolio demand forecast	Partially implemented	Algorithm implemented as SYNERGY platform pre-trained analytics. Integration with application is pending. User interface for feature is ready
PPFE_3 Long-term portfolio demand forecast	Partially implemented	Algorithm implemented as independent program. Integration with application is pending. User interface for feature is ready
PPFE_4 Next 6-hours portfolio exported	Partially implemented	Algorithm implemented as SYNERGY platform pre-trained analytic. Integration with application is pending.

Feature	Status	Notes
energy forecast		User interface for feature is ready
PPFE_5 Day-ahead portfolio exported energy forecast	Partially implemented	Algorithm implemented as SYNERGY platform pre-trained analytic. Integration with application is pending. User interface for feature is ready
PPFE_6 Long-term portfolio exported energy forecast	Partially implemented	Algorithm currently implemented as independent program, its registration as pre-trained analytic in the SYNERGY platform is pending. User interface for feature is ready
CSE_1 Elasticity profiles	Implemented	Elasticity profiles are calculated for customers exposed to dynamic tariff prices. For 6 different time frames (00-08, 08-16, 16-24h weekday/weekend) specific elasticity scores (kWh/€) are computed In a second stage, K-means clustering in conjunction with the elbow method are applied to classify all customers by identifying patterns according to their elasticity scores. Cluster centroids, together with cluster composition, are stored for further usage. For each cluster, relevant average energy-related KPIs are computed
CSE_2 Socioeconomic profiling	Implemented	Static available socioeconomic characteristics of the customers (zip code and type of contract have been considered at current stage in order to demonstrate this feature) are used to build groups For each group, relevant average energy-related KPIs are computed
CSE_3 Demand profiling and classification	Implemented	Demand profiles are calculated for customers, considering 6 different time frames (00-08, 08-16, 16-24h weekday/weekend) average demands (kWh) are computed In a second stage, K-means clustering in conjunction with the elbow method are applied to classify all customers by identifying patterns according to their demand scores. Cluster centroids, together with cluster composition, are stored for further usage. For each cluster, relevant average energy-related KPIs are computed
CSE_4 Exported energy profiling and classification	Implemented	Exported energy profiles are calculated for customers, considering 6 different time frames (00-08, 08-16, 16-24h weekday/weekend) average exported energies (kWh) are computed In a second stage, K-means clustering in conjunction with the elbow method are applied to classify all customers by identifying patterns according to their exported energy scores. Cluster centroids, together with cluster composition, are stored for further usage. For each cluster, relevant average energy-related KPIs are computed
WMPDSS_1 Wholesale market deviations forecast	Partially implemented	This feature depends on feature PPFE_1. User interface for feature is ready
WMPDSS_2 Adjustments for intra-day market participation	Partially implemented	This feature depends on feature WMPDSS_1. User interface for feature is ready

Feature	Status	Notes
WMPDSS_3 Dynamic tariff calculation	Partially implemented	This feature depends on feature WMPDSS_1 and WMPDSS_2. User interface for feature is ready
WMPDSS_4 Communication of dynamic tariffs to customers	Partially implemented	This feature depends on feature WMPDSS_3. User interface for feature is ready
WMPDSS_5 Simulation of dynamic tariffs	Partially implemented	This feature depends on feature WMPDSS_3. User interface for feature is ready
MPOT_1 Day-ahead price forecast	Partially implemented	Integration with application is pending. User interface for feature is ready
MPOT_2 Intra-day price forecast	Partially implemented	Integration with application is pending. User interface for feature is ready
MPOT_3 Continuous intra-day price forecast	Partially implemented	Integration with application is pending. User interface for feature is ready
MPOT_4 Indicators summary	Partially implemented	Integration with application is pending. User interface for feature is ready
POT_1 Long-term day-ahead price forecast	Implemented	Calculated as part of PPA optimization program
POT_2 PPA optimization	Implemented	Based on the defined scenario characteristics, the optimum characteristics for a PPA are computed, including size of the PV Power Plant, PPA price and relevant expected effects for the portfolio (self-consumption rates, cost savings…). Implemented as optimization program with interfaces with the SYNERGY Platform for data retrieval

2.2.1 Login

The user interface is provided in the form of a web application (Figure 2). Login is implemented as an integration with the SYNERGY Platform's Security, Authentication and Authorization mechanisms through Keycloak (Figure 3), an open-source identity service provider implementing a set of well-known authentication and authorization protocols.
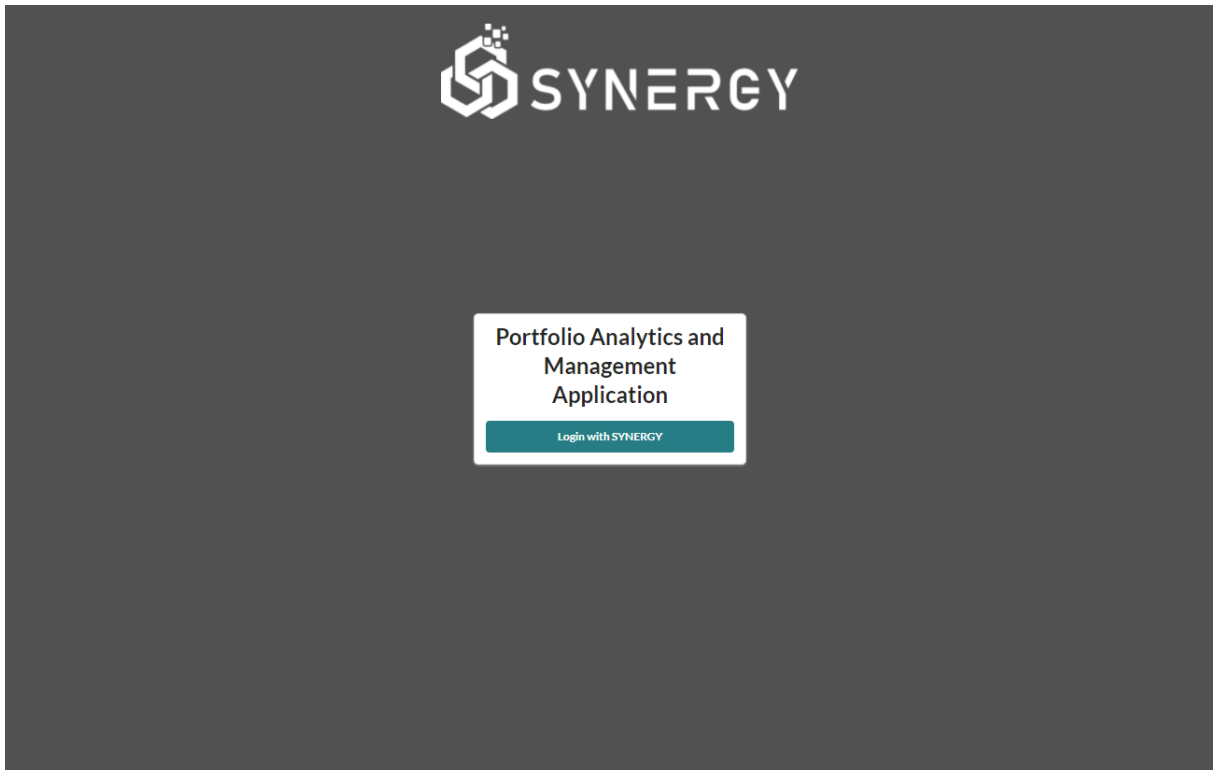

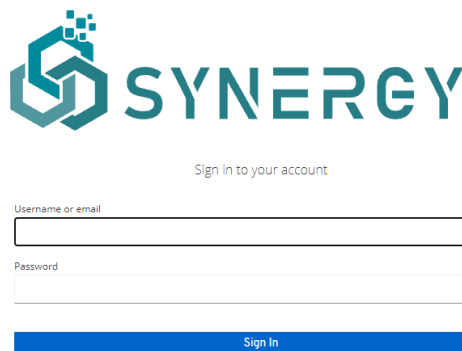*Figure 2: Portfolio Analytics and Management Application - Login*

Figure 3: Portfolio Analytics and Management Application - Login (ii)

2.2.2 Dashboard

The *Dashboard* of the Portfolio Analytics and Management Application (Figure 4) represents relevant indicators for the user, including recent aggregated portfolio demand (and short-term forecast), as well as demand share per relevant groups of customers (contract type and region).
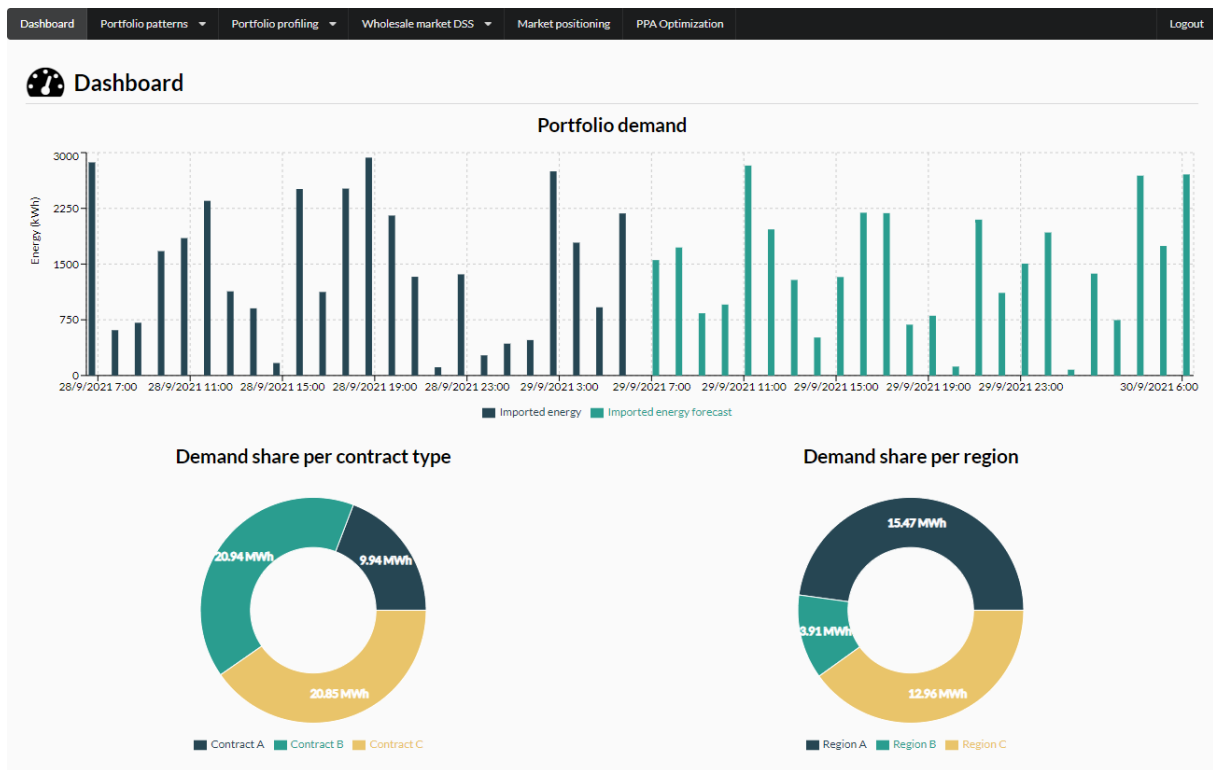

Figure 4: Portfolio Analytics and Management Application - Dashboard

2.2.3 Portfolio patterns

The *Portfolio Patterns* section contains several subsections that enable the navigation and drilling through both historical and relevant forecasted data. The following subsections are provided:

- Customers: gives access to detailed information about the energy usage measurements available for specific customers (Figure 5),

- Historical data: gives access to aggregated information about the energy usage measurements available for the complete portfolio of customers, or for specific region-based groups (Figure 6),

- Short-term forecast: gives access to next 6 hours forecast of energy usage measurements for the complete portfolio of customers, or for specific region-based groups (Figure 7),

- Long-term forecast: gives access to next 15 years forecast of energy usage measurements for the complete portfolio of customers, or for specific region-based groups (Figure 8).
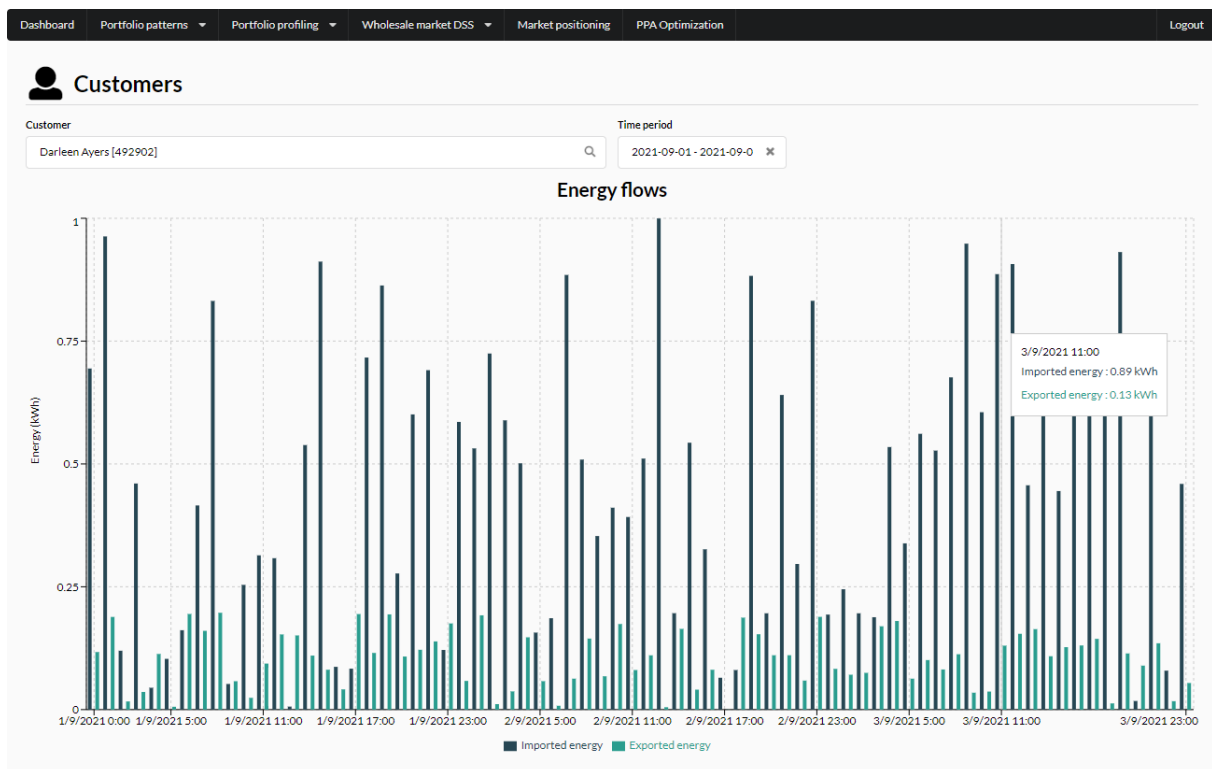

Figure 5: Portfolio Analytics and Management Application - Customers
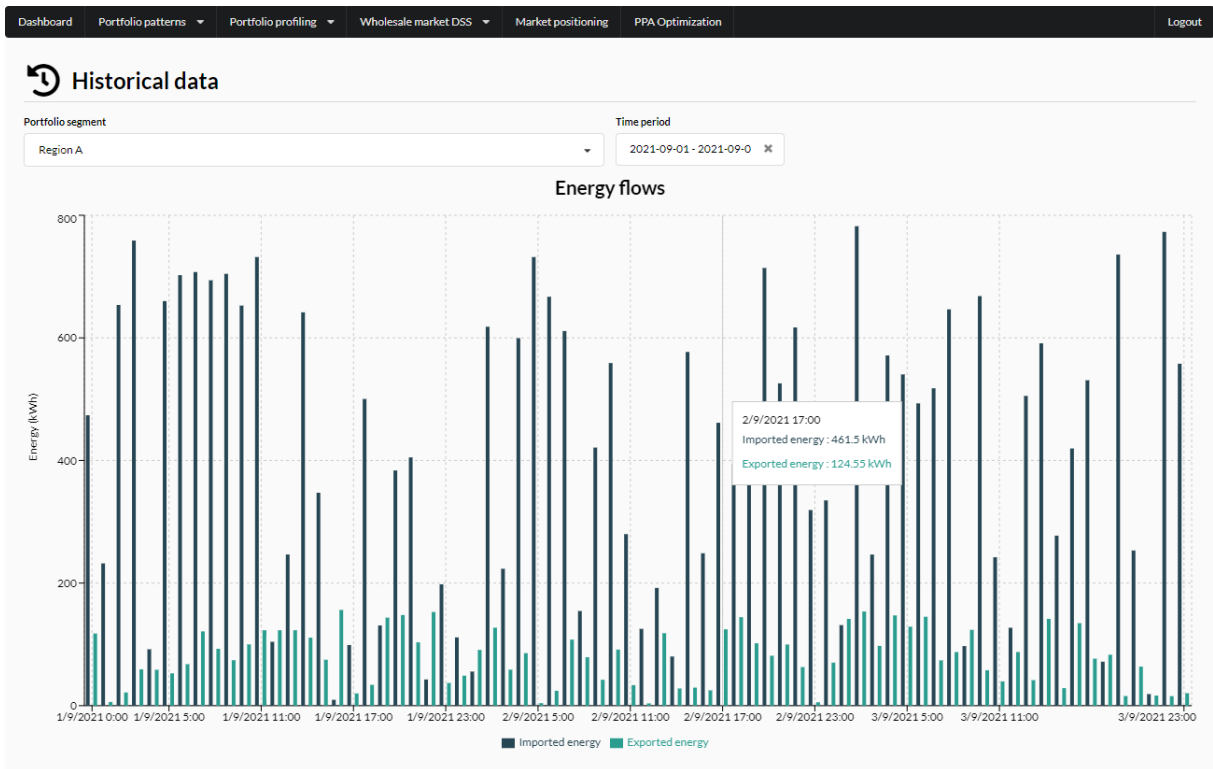
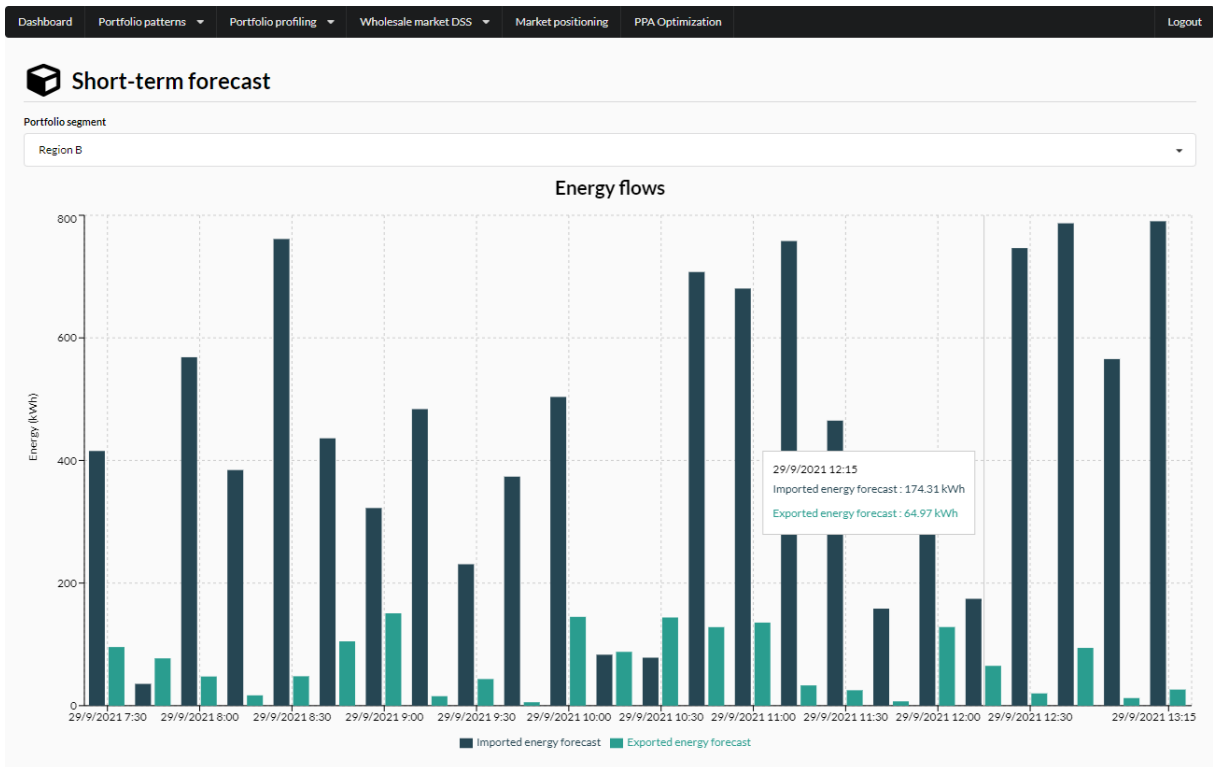*Figure 6: Portfolio Analytics and Management Application - Historical data*

Figure 7: Portfolio Analytics and Management Application - Short-term forecast
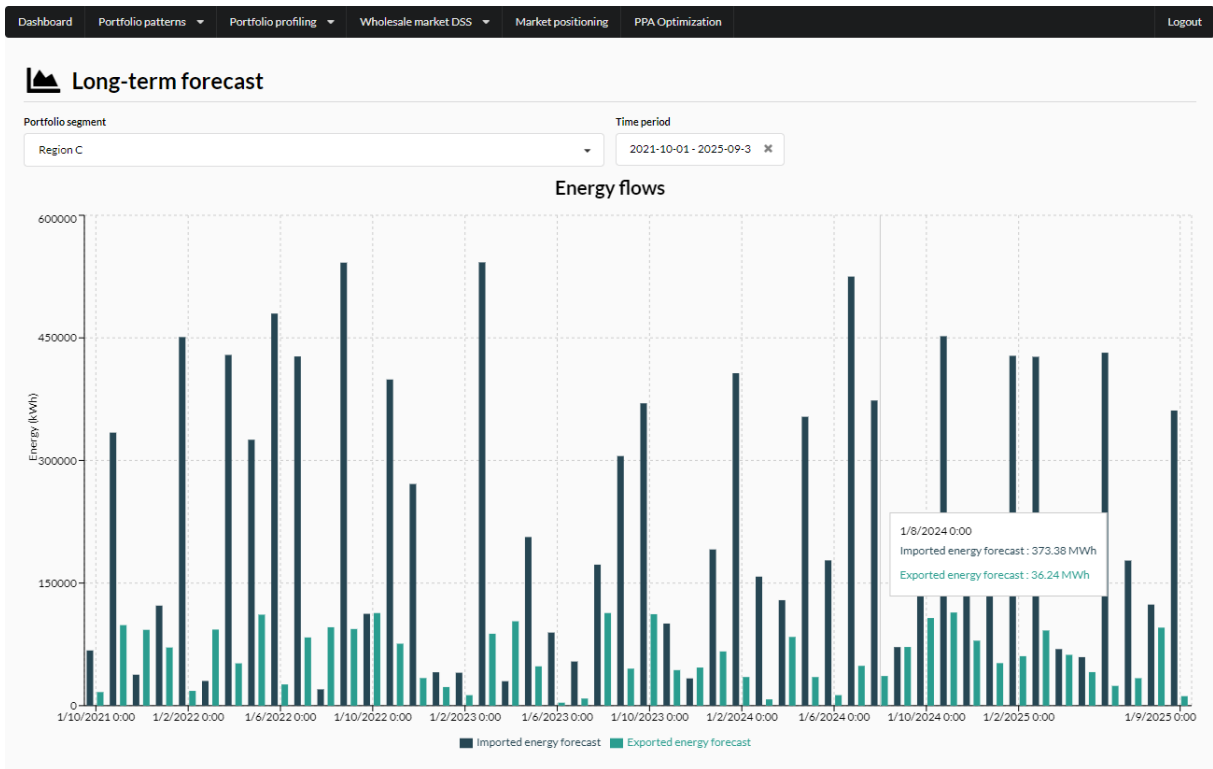
Figure 8: Portfolio Analytics and Management Application – Long-term forecast

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2.2.4 Portfolio profiling

The *Portfolio Profiling* section provides access to the results of the different segmentation analytics that are enabled by the application, through different specific subsections.

- Elasticity profiling: gives access to the details of the clusters identified according to the elasticity scores computed for each customer (Figure 9 and Figure 10),

- Demand temporal distribution profiling: gives access to the details of the clusters identified according to the average temporal distribution of the demand over dayweeks/weekends and different hourly ranges of the customers (Figure 11 and Figure 12),

- Socioeconomic profiling: gives access to the details of the clusters identified according to socioeconomic characteristics of the customers. Current version uses contract type and postal codes to build the groups (Figure 13, Figure 14 and Figure 15).
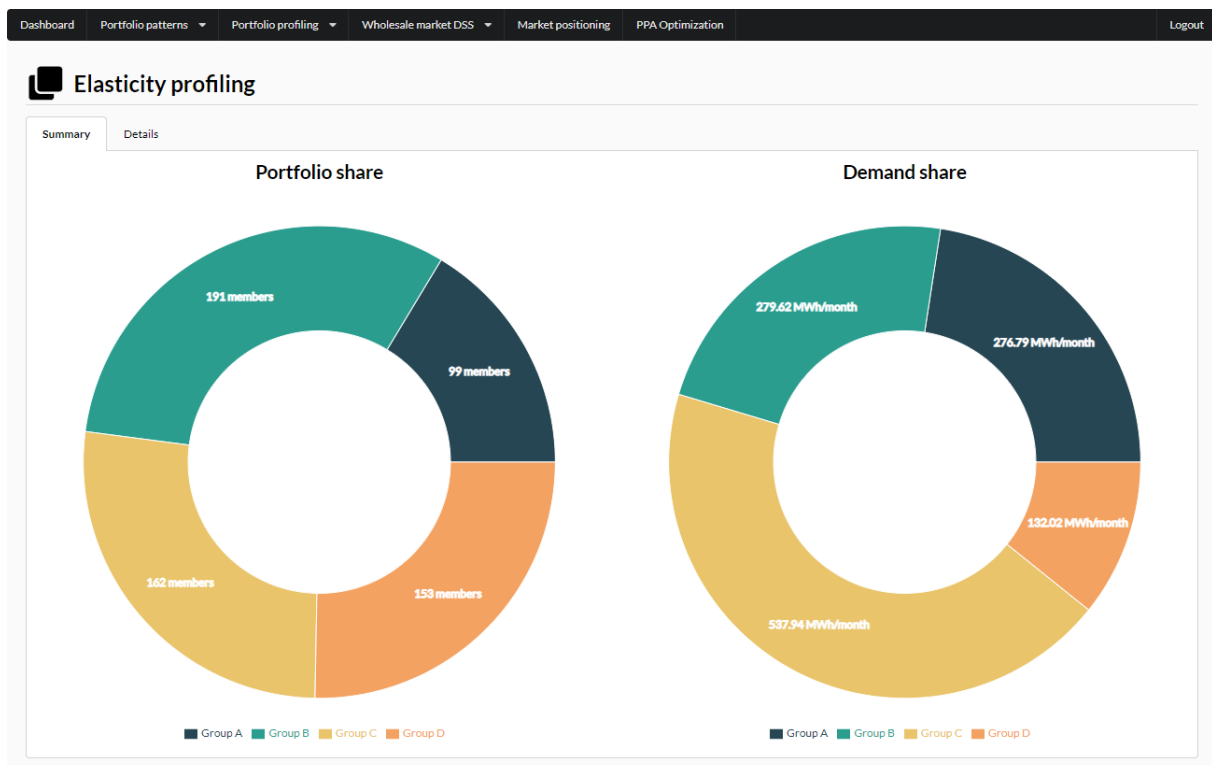

Figure 9: Portfolio Analytics and Management Application - Elasticity profiling
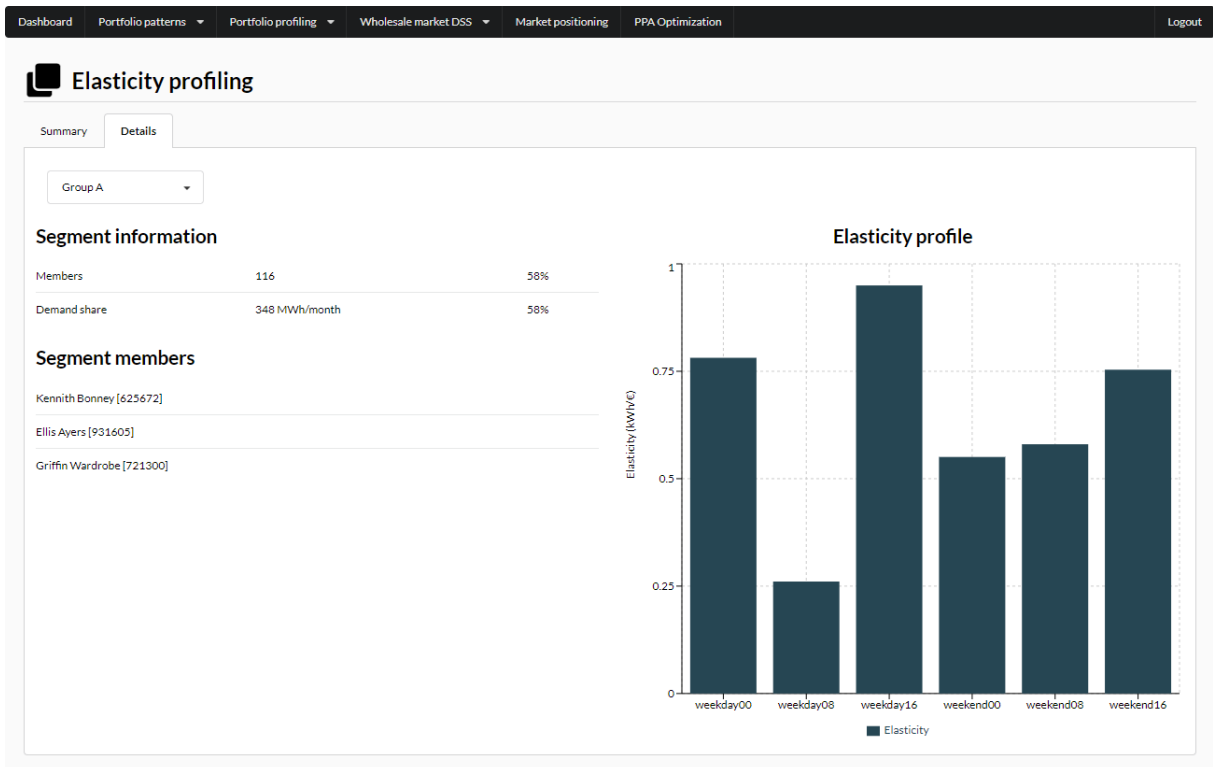
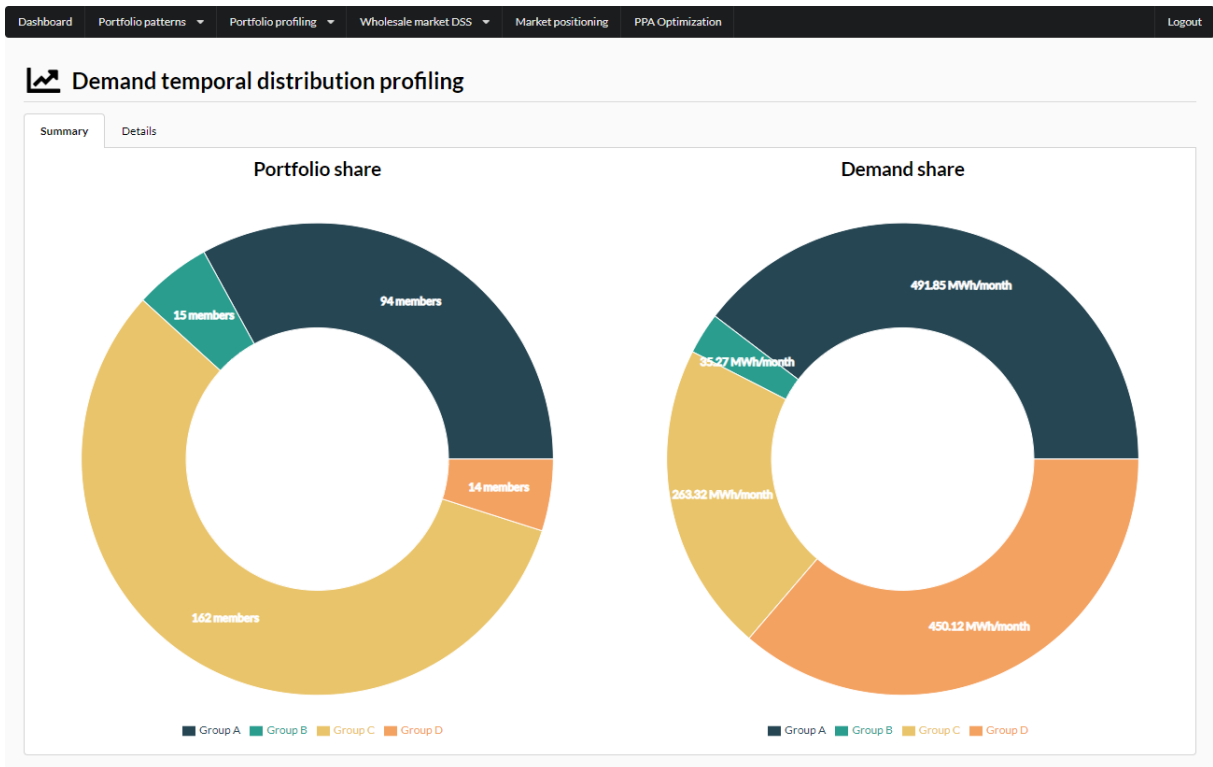*Figure 10: Portfolio Analytics and Management Application - Elasticity profiling (ii)*

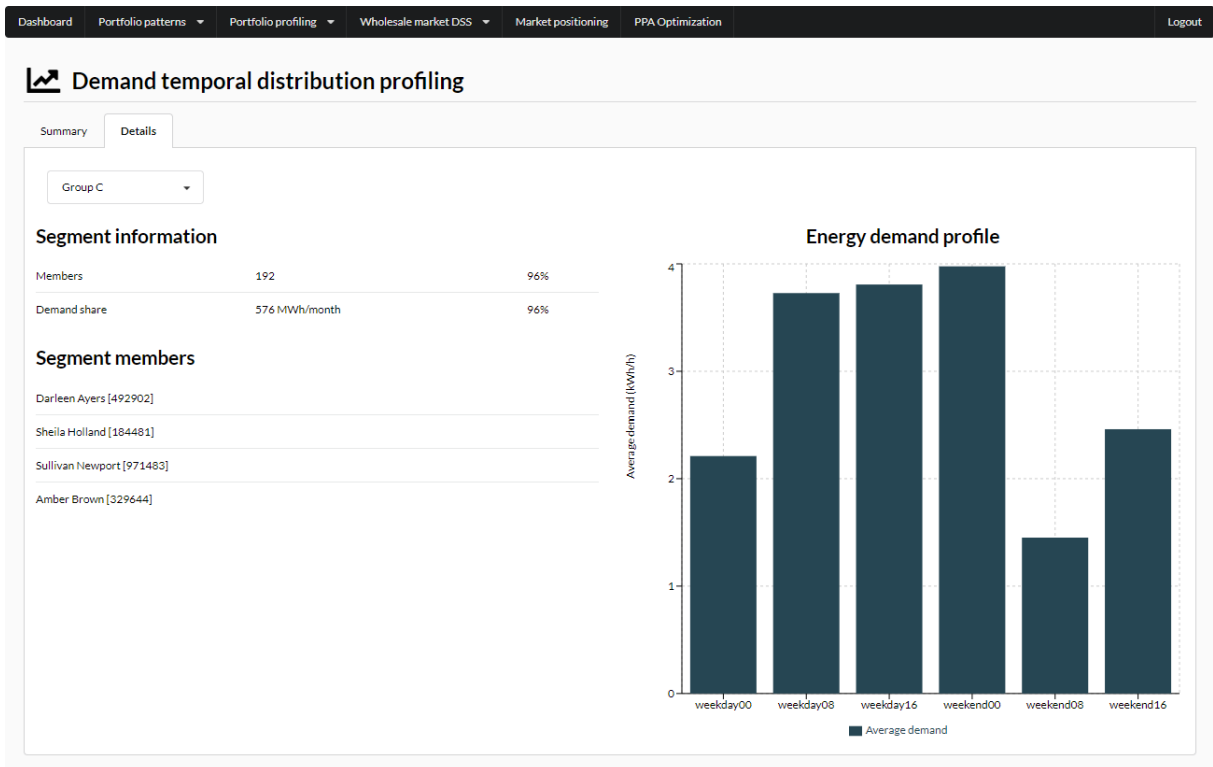*Figure 11: Portfolio Analytics and Management Application - Demand temporal distribution profiling*

Figure 12: Portfolio Analytics and Management Application - Demand temporal distribution profiling (ii)
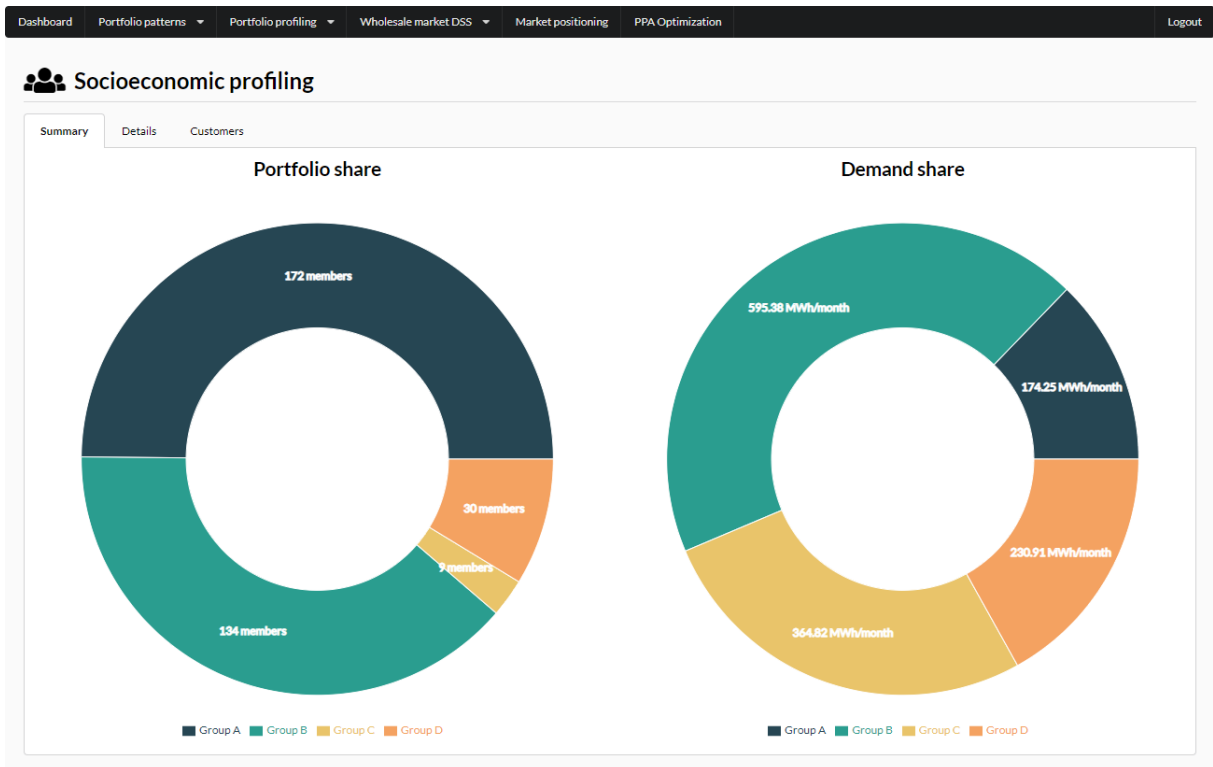

Figure 13: Portfolio Analytics and Management Application - Socioeconomic profiling
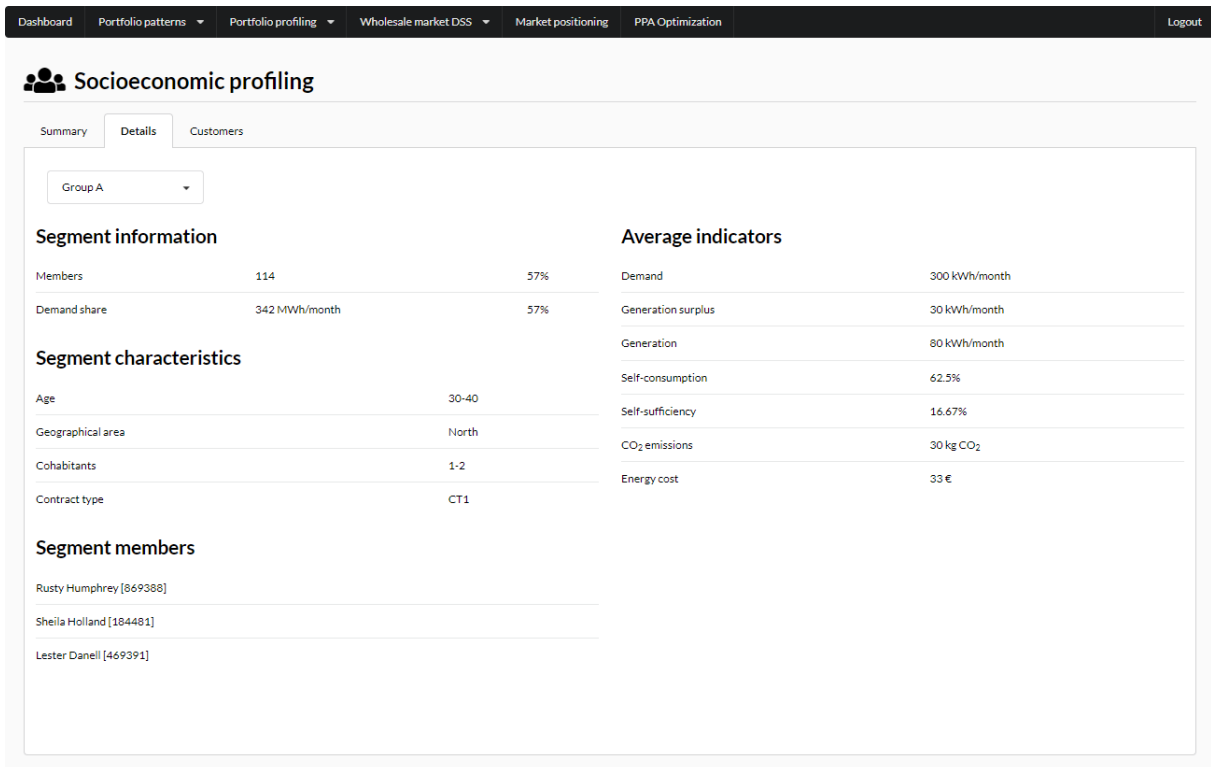
Figure 14: Portfolio Analytics and Management Application - Socioeconomic profiling (ii)
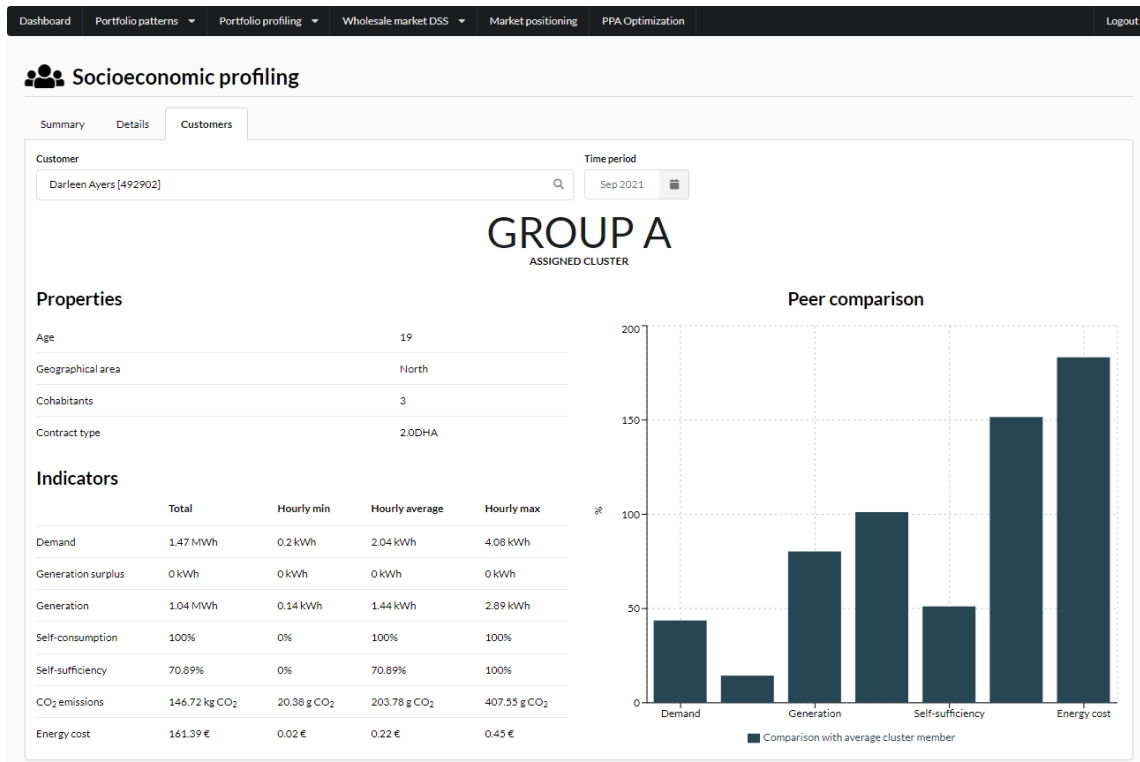

Figure 15: Portfolio Analytics and Management Application - Socioeconomic profiling (iii)

2.2.5 Wholesale market DSS

The *Wholesale Market DSS* section contains several subsections that provide access to the historical data and relevant forecasts used to address the wholesale market and handle the estimated deviations. The following subsections are provided:

- Historical deviations: displays the past energy demand deviations of the different groups of the portfolio, or of the portfolio as a whole. Energy demand deviations are presented as the difference between the day-ahead forecast that was provided for a specific date, and the actual demand reported by the metering devices (Figure 16),

- Intraday deviations: displays the expected energy demand deviations for the current day, according to the evolution of considered factors – mainly, real time demand and generation data as reported by TSO (Figure 17),

- Optimum dynamic tariff prices: displays the results of the optimum dynamic tariff price calculation algorithm, which matches the expected intraday deviations with the elasticity profiling of the customers to provide the optimum price change that would correct the deviation. Upon selection of the aggregator/retailer operator, additional statisics are displayed showing details on the share of energy shift expected to be covered by each segment of customers (Figure 18),

- Dynamic tariff prices simulation: allows retailers and aggregators to simulate what-if scenarios. By changing the tariff price, its effects over the expected intraday deviation are displayed (Figure 19).

This project has received funding from the European Union's Horizon 2020 Research and Innovation programme under Grant Agreement No 872734.
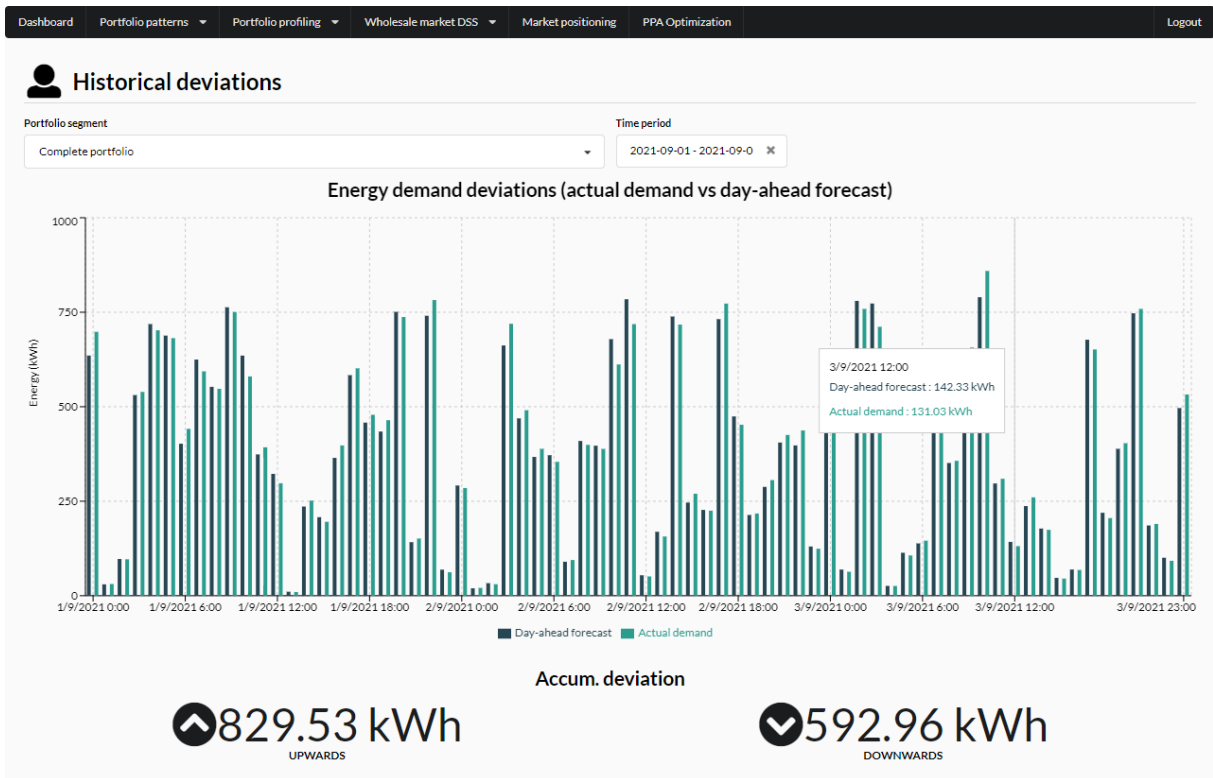
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Figure 16: Portfolio Analytics and Management Application - Wholesale Market Historical deviations
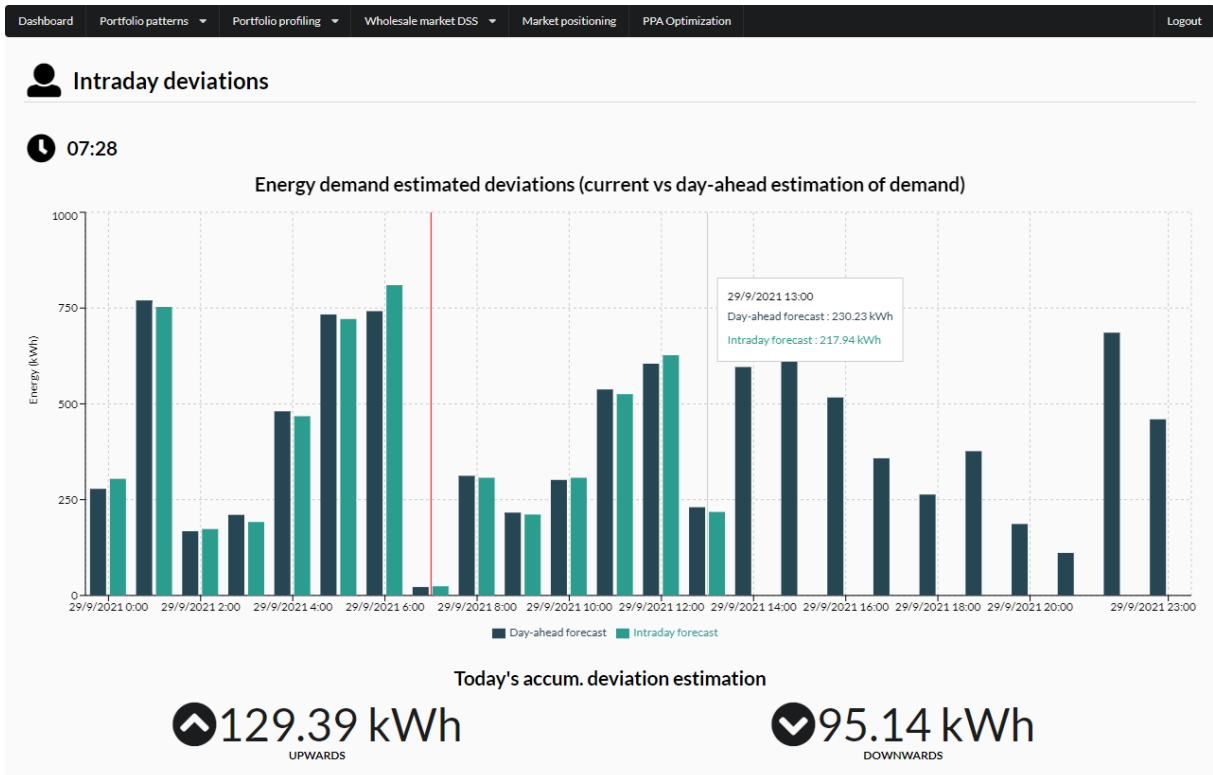
Figure 17: Portfolio Analytics and Management Application - Wholesale Market Intraday deviations

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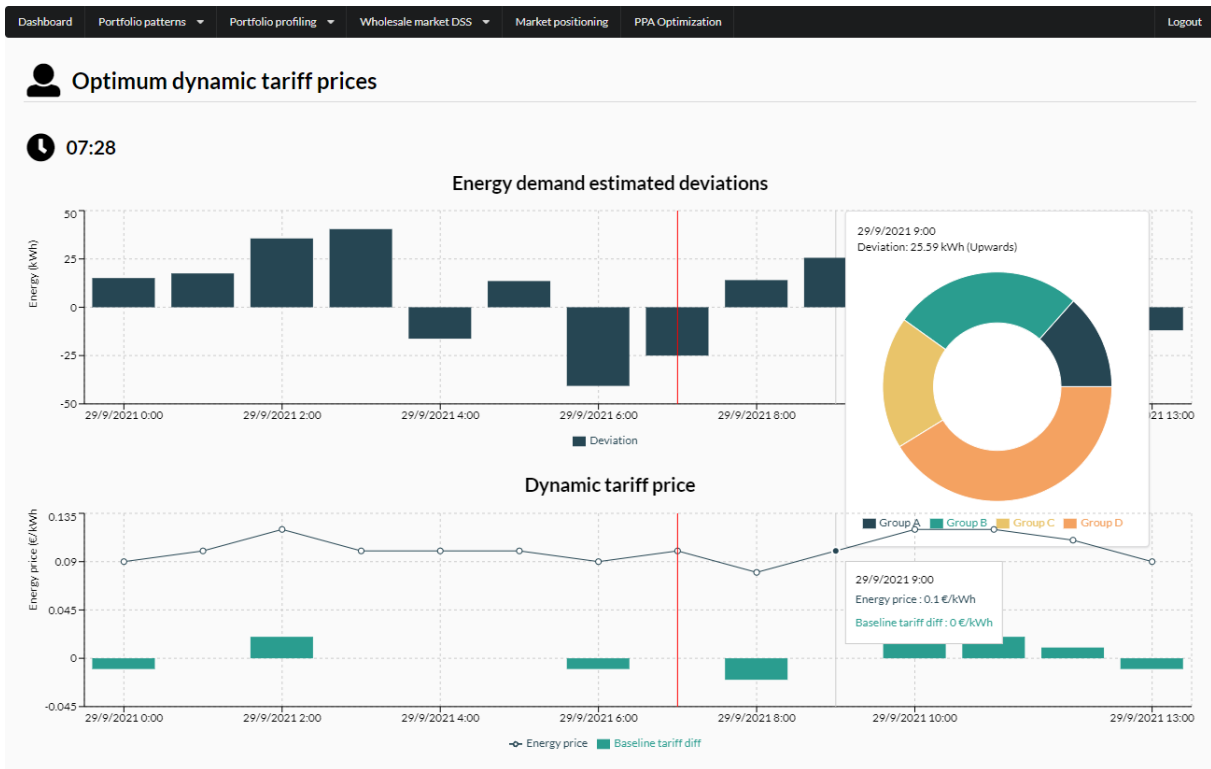*Figure 18: Portfolio Analytics and Management Application - Optimum dynamic tariff prices*
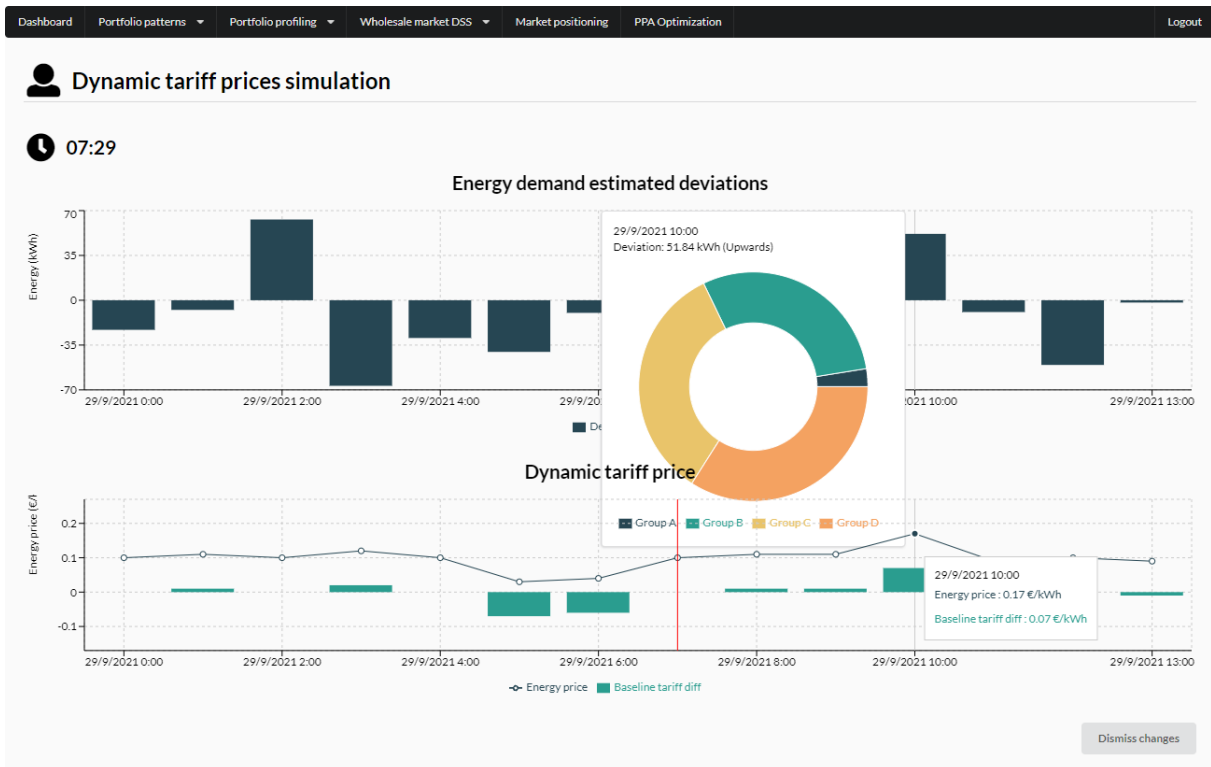
Figure 19: Portfolio Analytics and Management Application - Dynamic tariff prices simulation

2.2.6   Market Positioning Optimization

The Market Positioning Optimization section (Figure 20) gives access to the results of the corresponding component for the portfolio of RES Plants present in the portfolio of the generation aggregators. The information gets updated automatically on a day-ahead basis (i.e. results up to the next day are accessible in this site)
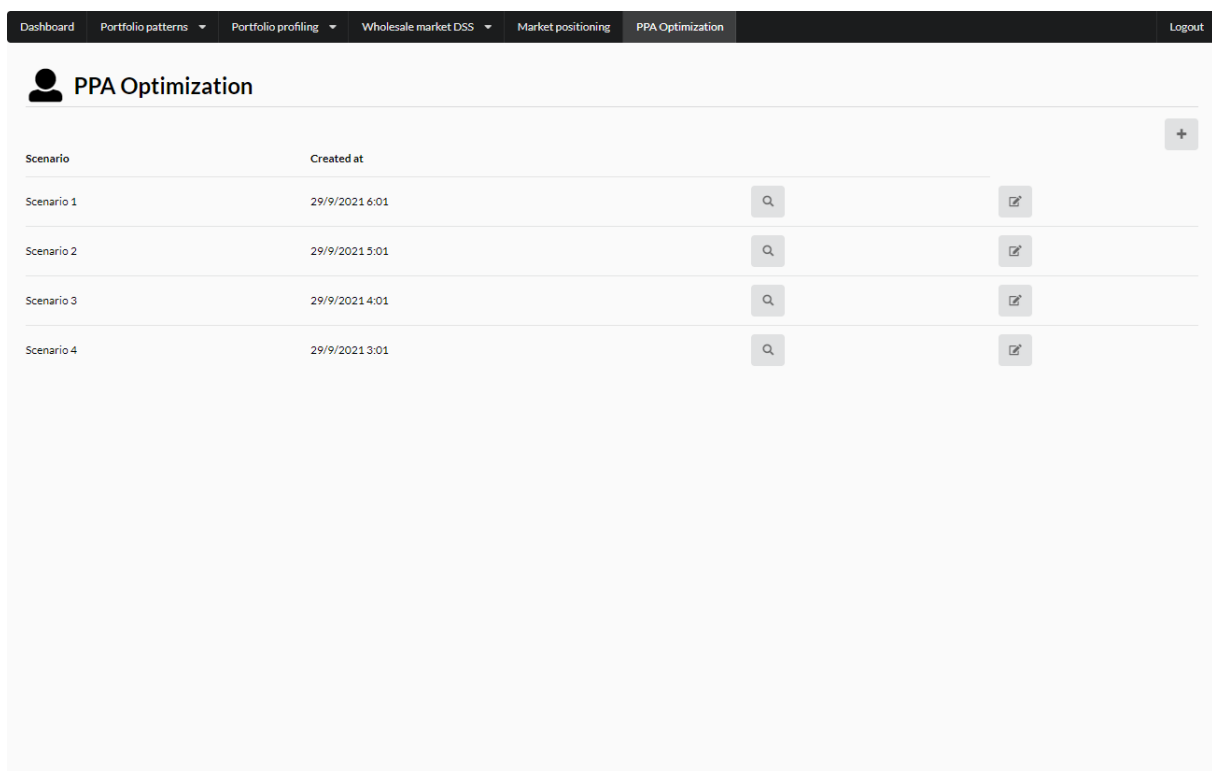
Figure 20: Portfolio Analytics and Management Application - Market Positioning

2.2.7 PPA optimization

The *PPA Optimization* section gives access to the features offered by the corresponding component. This component facilitates the decision support related to the agreement of PPAs among a retailer and a RES owner/aggregator by optimizing the relevant parameters for a particular context – or scenario – defined by the user. In this context, retailer/aggregator operator can configure new optimization scenarios or navigate through the previously defined ones (Figure 21), define or edit the characteristics of the scenario to be optimized (Figure 22) and access the details of the resulting optimum PPA parameters (Figure 23).

Figure 21: Portfolio Analytics and Management Application - PPA Optimization

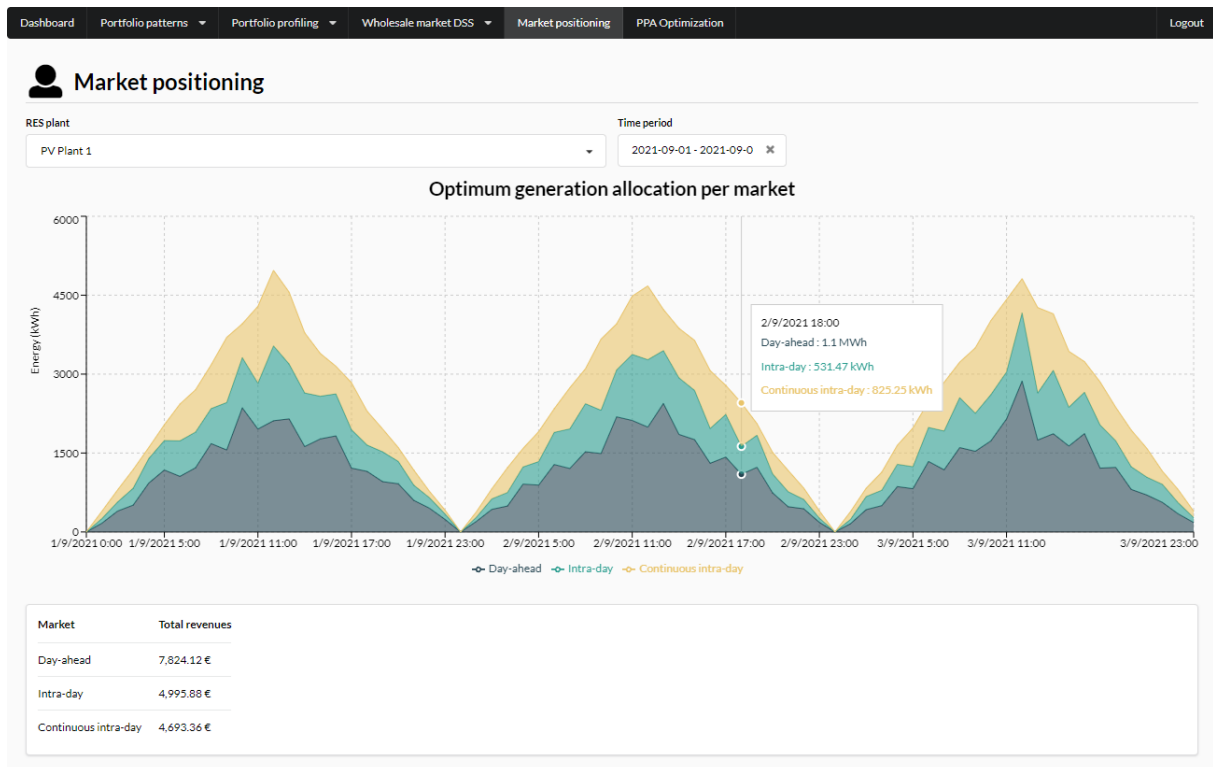*Figure 22: Portfolio Analytics and Management Application - PPA Optimization (ii)*

Figure 23: Portfolio Analytics and Management Application - PPA Optimization (iii)
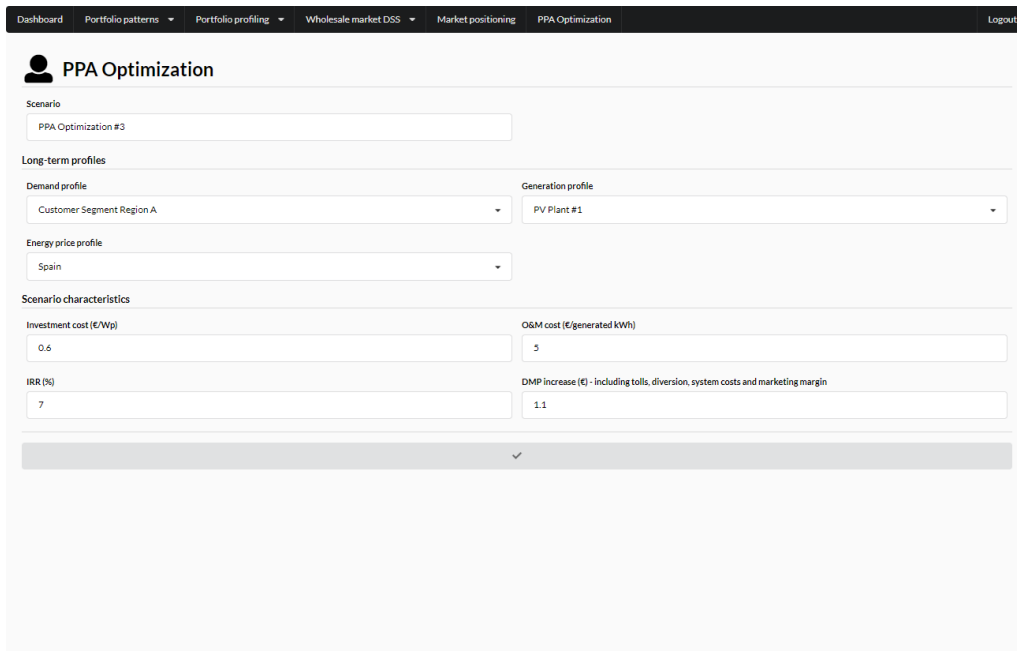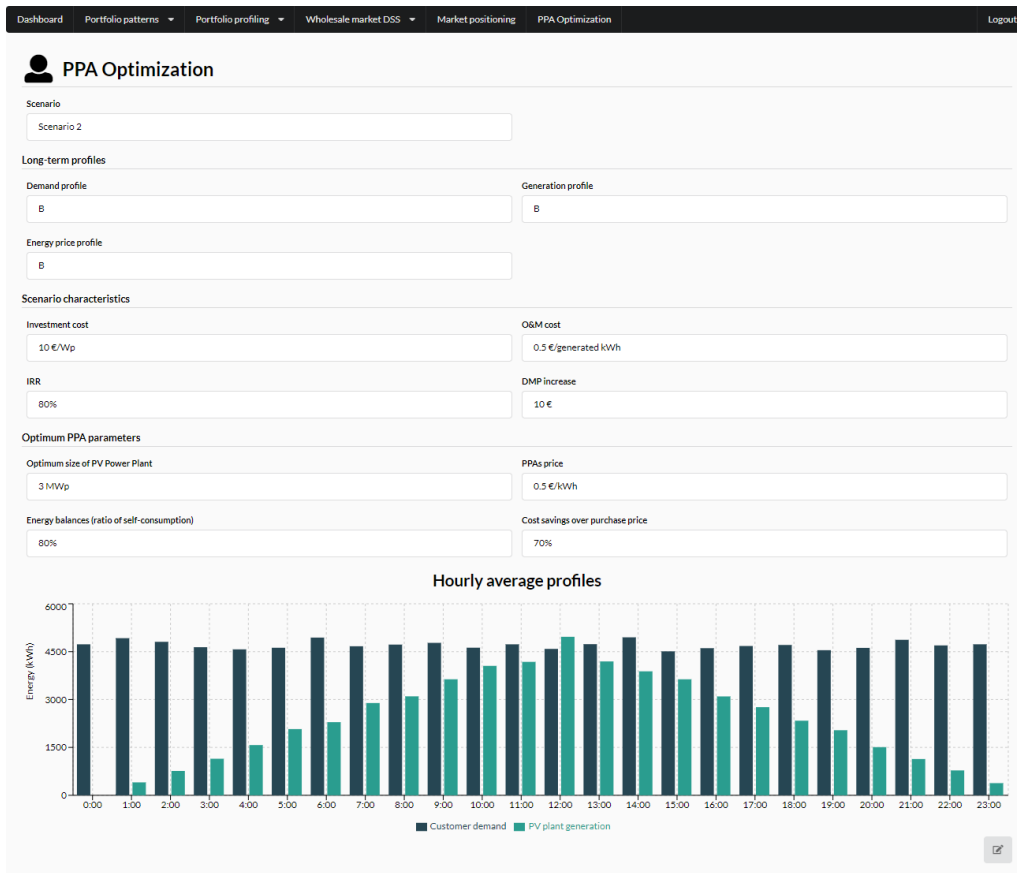
2.3 Technology stack and implementation tools

The following table summarizes the set of libraries used for the development of the Portfolio Analytics and Management Application. In summary, Meteor framework has been used to build the main backend and frontend including SYNERGY Platform integration, while other specific components have been built using python ML libraries.

Table 2: Portfolio Analytics and Management Application - Technology stack

Library	Version	License	Purpose
meteor-base	1.4.0	MIT License	User interface. Packages every Meteor app needs to have.
mobile-experience	1.1.0	MIT License	User interface. Packages for a great mobile UX.
mongo	1.10.1	MIT License	User interface. The database Meteor supports right now.
static-html		MIT License	User interface. Define static page content in .html files.
reactive-var	1.0.11	MIT License	User interface. Reactive variable for tracker.
tracker	1.2.0	MIT License	User interface. Meteor's client-side reactive programming library.
session	1.2.0	MIT License	User interface.
accounts-password	1.7.0	MIT License	User interface.
standard-minifier-js	2.6.0	MIT License	User interface. JS minifier run for production mode.
es5-shim	4.8.0	MIT License	User interface. ECMAScript 5 compatibility for older browsers.
Ecmascript	0.15.0	MIT License	User interface. Enable ECMAScript2015+ syntax in app code.
shell-server	0.5.0	MIT License	User interface. Server-side component of the 'meteor shell' command.
aldeed:collection2	3.0.0	MIT License	User interface.
underscore	1.0.10	MIT License	User interface.
react-meteor-data		MIT License	User interface.
alanning:roles		MIT License	User interface.
semantic:ui		MIT License	User interface.
jquery		MIT License	User interface.
flemay:less-autoprefixer		MIT License	User interface.
matb33:collection-hooks		MIT License	User interface.
mizzao:user-status		MIT License	User interface.

Library	Version	License	Purpose
etraid:accounts-openid		Proprietary	User interface.
@babel/runtime	^7.12.5	MIT License	User interface.
@popperjs/core	^2.6.0	MIT License	User interface.
bcrypt	^5.0.0	MIT License	User interface.
etra-forms	^1.0.4	Proprietary	User interface.
etra-ui-components	^2.0.0	Proprietary	User interface.
etraid_formats	^1.0.16	Proprietary	User interface.
html-react-parser	^1.2.4	MIT License	User interface.
i18next	^20.1.0	MIT License	User interface.
i18next-browser-languagedetector	^6.1.0	MIT License	User interface.
i18next-http-backend	^1.2.0	MIT License	User interface.
jquery	^3.4.1	MIT License	User interface.
lodash	^4.17.15	MIT License	User interface.
luxon	^1.26.0	MIT License	User interface.
meteor-node-stubs	^1.0.0	MIT License	User interface.
moment-timezone	^0.5.33	MIT License	User interface.
popper.js	^1.16.1	MIT License	User interface.
prop-types	^15.7.2	MIT License	User interface.
react	^16.14.0	MIT License	User interface.
react-dom	^16.14.0	MIT License	User interface.
react-i18next	^11.8.11	MIT License	User interface.
react-icons	^4.2.0	MIT License	User interface.
react-live-clock	^5.0.16	MIT License	User interface.
react-moment	^1.1.1	MIT License	User interface.
react-month-picker	^2.2.0	MIT License	User interface.
react-router-dom	^5.2.0	MIT License	User interface.
react-semantic-ui-datepickers	^2.13.0	MIT License	User interface.
recharts	^2.0.9	MIT License	User interface.
recompose	^0.30.0	MIT License	User interface.
semantic-ui-react	^1.1.1	MIT License	User interface.
simpl-schema	^1.10.2	MIT License	User interface.
styled-components	^5.2.1	MIT License	User interface.
pandas	1.3.3	BSD 3-Clause "New" or "Revised" License	Business logic.
sklearn	0.24.2	BSD 3-Clause "New" or "Revised" License	Business logic.

This project has received funding from the European Union's Horizon 2020 Research and Innovation programme under Grant Agreement No 872734.

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Library	Version	License	Purpose
requests	2.26.0	Apache License 2.0	Business logic.
numpy	1.21.2	BSD 3-Clause "New" or "Revised" License	Business logic.
pymongo	3.12.1	Apache License 2.0	Business logic.
iso8601	0.1.16	MIT License	Business logic.
statsmodels	0.12.2	BSD License (BSD License)	Business logic.
investpy	1.0.6	MIT License	Business logic.
yfinance	0.1.63	Apache License 2.0	Business logic.
flask-restplus	0.13.0	BSD License (BSD-3-Clause)	API
flask	1.1.2	BSD License (BSD-3-Clause)	API
werkzeug	0.16.1	BSD License (BSD-3-Clause)	API
python-ddp	0.1.5	MIT License	API

2.4   API documentation

2.4.1   Integration with SYNERGY Platform via REST API

The majority of the analytics required by the application have been configured as *analytic workflows* that are executed by the SYNERGY Platform. In order to have access to the results of such analytics, different *data retrieval queries* have been configured, all of them exposing specific REST endpoints. Authentication mechanisms are implemented within the SYNERGY Platform in order to ensure that only authorized parties (components of the *Portfolio analytics and Management application* in this context) are granted access.

Table 3: Portfolio Analytics and Management Application - Integration with SYNERGY Platform

Data Retrieval Query	Type	Implementer	Purpose
[DEV-WP6] CUSTOMERS - PRE Elasticity	HTTP GET	SYNERGY Platform	Customer data ready for elasticity profiling analysis.
[DEV-WP6] SOCIOECONOMIC - Avg Monthly KPIs	HTTP GET	SYNERGY Platform	Monthly KPIs for each socioeconomic cluster.
[DEV-WP6] _MERGED_ - Monthly Avg Energy Data	HTTP GET	SYNERGY Platform	Monthly KPIs per customer.
[DEV-WP6] _MERGED_ - Hourly/WD Avg Energy Data	HTTP GET	SYNERGY Platform	Data ready for temporal energy usage profiling per customer.
[DEV-WP6] CUSTOMERS - KPIs	HTTP GET	SYNERGY Platform	Hourly KPIs per customer.
[DEV-WP6] Socioeconomic groups	HTTP GET	SYNERGY Platform	Socioeconomic profiling clusters.
[DEV-WP6] PORTFOLIO - Agg Energy	HTTP	SYNERGY	Aggregated data for complete customer

Data Retrieval Query	Type	Implementer	Purpose
Data	GET	Platform	portfolios.
[DEV-WP6] CUSTOMERTYPE - Agg Energy Data	HTTP GET	SYNERGY Platform	Aggregated data per customer type.
[DEV-WP6] REGION - Agg Energy Data	HTTP GET	SYNERGY Platform	Aggregated data per region.
[DEV-WP6] CUSTOMER - Energy Data	HTTP GET	SYNERGY Platform	Raw measurements per customer.
[DEV-WP6] _MERGED_ - Energy Data	HTTP GET	SYNERGY Platform	Raw measurements per customer
[DEV-WP6] _MERGED_ - Contracts	HTTP GET	SYNERGY Platform	Contract information per customer.
[DEV-WP6] PORTFOLIO - Segments	HTTP GET	SYNERGY Platform	Basic KPIs per region.
[DEV-WP6] CUSTOMERS - Socioeconomic groups	HTTP GET	SYNERGY Platform	Customer basic data socioeconomic profiling.

2.4.2   PPA optimization component API

The PPA optimization component has been integrated with the application backend using the Distributed Data Protocol (DDP).

Table 4: Portfolio Analytics and Management Application - Integration with PPA optimization component

Endpoint	Type	Implementer	Purpose
unsolvedPPAOptimizationScenarios	publication	backend	Publishes any PPA optimization scenario that has not been solved yet. PPA optimization component receives the details of the unsolved scenarios reactively, as soon as they get registered by the end user.
ppaOptimization.scenarios.result	method	backend	This method can be used to update any existing optimization scenario with new results. It is used by the PPA optimization component to post back the results of the optimization.

2.5   Installation instructions

All the components of the application have been packaged as a set of docker images. These docker images are available from a private repository at docker hub. This kind of packages facilitate the deployment in any platform supporting this technology (e.g. Kubernetes). Due to the nature of the software, being offered in the form of SaaS, no installation procedure is required by final users.

Table 5: Porfolio Analytics and Management Application - Installation instructions

Image	Tag	Purpose
etraid/synergy_portfolioanalyticsui	0.0.23	Application main backend and frontend.
etraid/synergy_ppaoptimization	0.0.5	PPA optimization component.

2.6   Assumptions and restrictions

The architecture of the Portfolio analytics and Management application relies on the services provided by the SYNERGY Platform, specifically in the features related to data ingestion and data analytics.
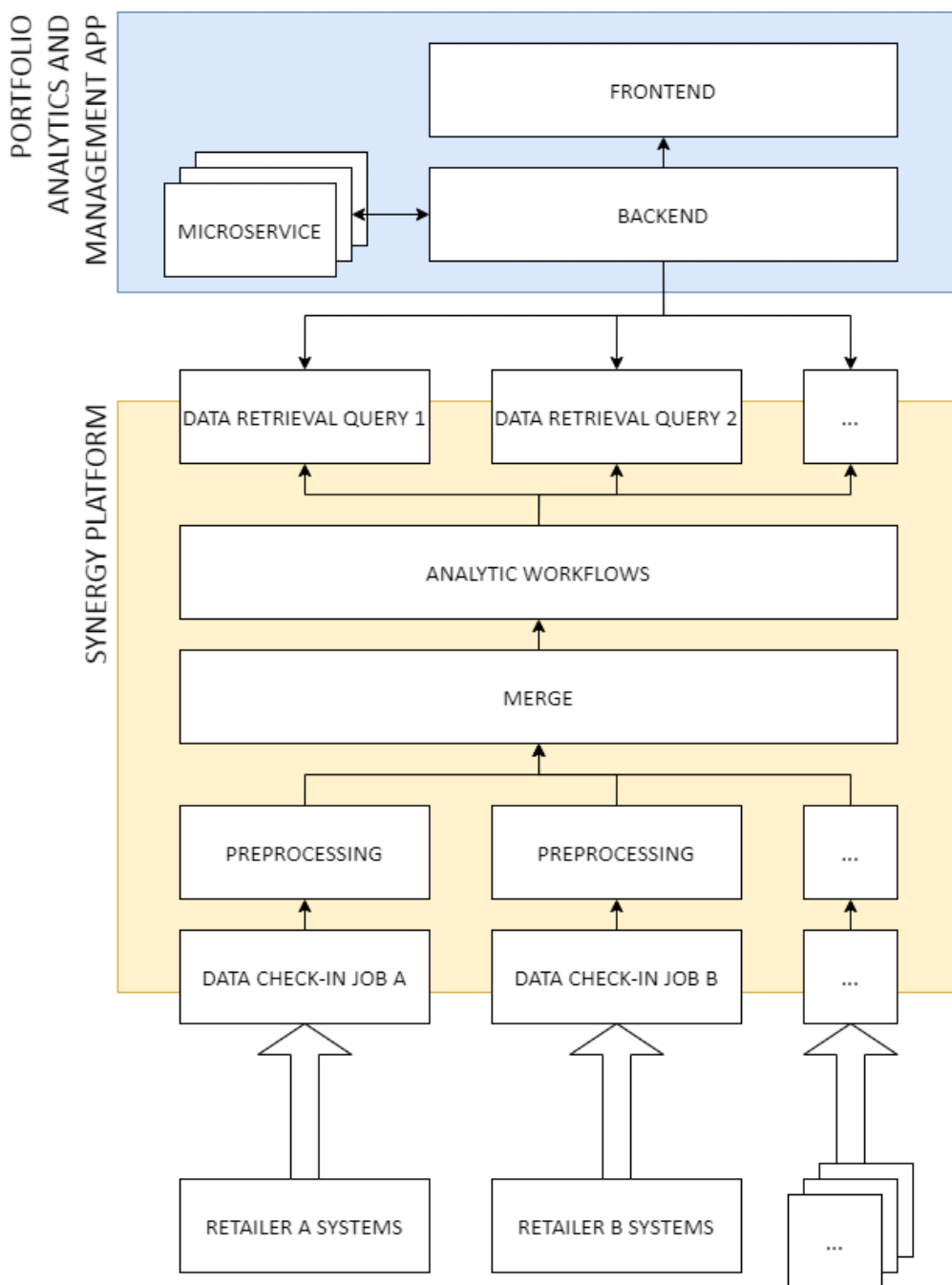
Figure 24: Portfolio Analytics and Management Application - Integration approach

In order to be able to use the application, the following configuration steps need to be taken for every new aggregator/retailer that wishes to integrate with the application:

- Retailers and aggregators are required to be registered as users of the SYNERGY Platform,

- Retailers and aggregators are required to configure the necessary data check-in jobs, so required datasets get accessible through the platform.

Table 6: Portfolio Analytics and Management Applications - Required input datasets

Dataset	Content	Description
Contracts	Contract id Customer name Supply point address Contracted tariff Contracted capacity	Basic customer contractual information.
Smart meter data	Contract id Timestamp Total energy imported Total energy exported	Time series of energy imported/exported counters at customer's supply point, on an hourly basis.
Generation data	Contract id Timestamp Total energy exported	Whenever available, time series of energy exported counters at customer's RES connection point, on an hourly basis.
Tariffs	Timestamp Price	Time series of active energy prices per tariff.

- Retailers and aggregators are required to grant access to application manager to the required datasets, so those can be incorporated to the application workflows, by signing the appropriate contracts within the SYNERGY Platform,

- Application manager configures the preprocessing step which ensures that existing datasets from any retailer and aggregator are transformed from the SYNERGY CIM (that is followed in the SYNERGY Platform) to the specific application's schema.

2.7   Licensing and access

The licensing and IPR of each component that consist of the *Portfolio Analytics and Management Application* are provided in the following table.

Table 7: Portfolio Analytics and Management Application - Licensing Details

Component	Licensing details
Portfolio Pattern Forecasting Engine	ETRA I+D is the owner of all intellectual property rights of this component. All rights are reserved.
Customer Segmentation Engine	ETRA I+D is the owner of all intellectual property rights of this component. All rights are reserved.
Wholesale Market Participation DSS	ETRA I+D is the owner of all intellectual property rights of this component. All rights are reserved.
Market Positioning Optimization Tool	URBENER is the owner of all intellectual property rights of this component. All rights are reserved.
PPA Optimization Tool	CUERVA is the owner of all intellectual property rights of this component. All rights are reserved.

A demo version of the application is accessible at https://portfolioanalytics.synergy-bigdata.eu/[1]

2.8   Planned features for next release

The next release of the application is scheduled for M24 (end of December 2021), prior to the start of the first demo run of the demonstration cases. Work scheduled for the next release includes:

- Finalization of the pending integrations, as detailed in section 2.2,

- Revision of the behaviour of the application with source datasets that update dynamically,

- Taking benefit of upcoming features of the SYNERGY Platform (e.g. query parameters on data retrieval queries for datasets that are results of analytic workflows) to enhance performance of the application.

---

[1] Demo credentials are available on request

3 Personalized Energy Analytics Application

3.1 Overview

The *Personalized Energy Analytics Application* focuses on the provision of services to prosumers (customers of the retailers and aggregators targeted by the *Portfolio Analytics and Management Application*). The proposed services follow two main lines:

- Providing enhanced information about the energy usage habits, and hints that encourage better behaviours towards more sustainable (both economic and environmentally) energy demand patterns. These features will be implemented by the *Personalized Energy Analytics Engine* component,

- Providing advanced services for optimum operation of smart appliances towards enabling a proper balance between comfort and energy-savings. These features will be implemented by the *Smart Home Integration Engine* component.

3.2 Implemented functionalities

The functionalities of the *Personalized Energy Analytics Application* have been split in 2 components according to their nature.
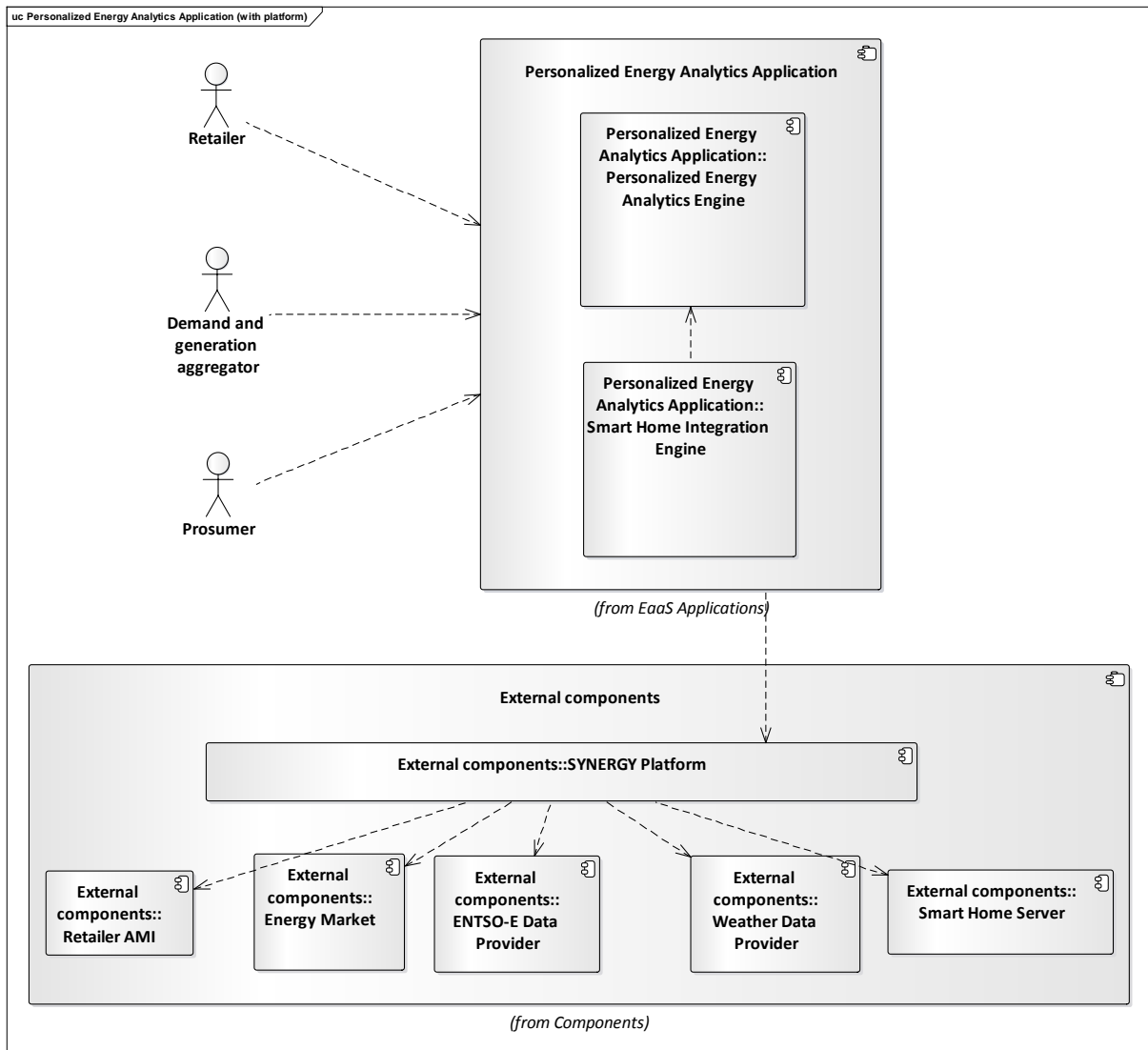
Figure 25: Personalized Energy Analytics Application components and addressed actors

The following table summarizes the current status of all the features to be provided by the application.

Table 8: Personalized Energy Analytics Application - Implemented functionalities

Feature	Status	Notes
PEAE_1 Active power histograms per supply point	Implemented	Analytic workflows have been configured in the SYNERGY Platform computing histograms per contract (supply point) on a monthly basis

Feature	Status	Notes
PEAE_2 Energy demand time distribution	Implemented	Analytic workflows have been configured in the SYNERGY Platform computing average demand on 6 different time frames (00-08, 08-16, 16-24h weekday/weekend) per contract (supply point) on a monthly basis
PEAE_3 Self-consumption	Implemented	Analytic workflows have been configured in the SYNERGY Platform computing self-consumption ratios per contract (supply point) on an hourly, daily and monthly basis
PEAE_4 Self-sufficiency	Implemented	Analytic workflows have been configured in the SYNERGY Platform computing self-sufficiency ratios per contract (supply point) on an hourly, daily and monthly basis
PEAE_5 Comparison of demand between relevant time periods	Implemented	Demand KPI differences across relevant time periods can be accessed in the User Interface
PEAE_6 Customer peer comparison	Implemented	Socioeconomic profiling is used as the basis to feed the personalized report on peer comparison, which is accessible in the User Interface
PEAE_7 Demand and production forecasts	Partially implemented	Algorithm implemented as SYNERGY platform pre-trained analytic. Integration with application is pending. User interface for feature is ready.
PEAE_8 Deviation of demand and production against forecasts/baseline	Partially implemented	This feature depends on feature PEAE_7. User interface for feature is ready.
PEAE_9 Provide alternative options for energy behaviour changes	Partially implemented	Relying segmentation is implemented. Still pending decision tables to translate indicators to human-readable texts. User interface for feature is ready.
PEAE_10 Target-monitoring	Partially implemented	Analytic workflow has been configured in the SYNERGY Platform filtering those values that violate the configured thresholds User interface for configuration on demand of such thresholds is pending
SHIE_1 Comfort profiles	Partially implemented	Algorithm implemented as independent program, its integration in the SYNERGY Platform as pre-trained analytic is pending. User interface for feature is ready.
SHIE_2 Automatic control schedules for HVAC devices	Partially implemented	Schedules based on usage patterns are provided. Consideration of comfort-profiles depends on feature SHIE_1. User interface for feature is ready.
SHIE_3 Automatic control schedules for lighting devices	Partially implemented	Schedules based on usage patterns are provided. Consideration of comfort-profiles depends on feature SHIE_1. User interface for feature is ready.
SHIE_4 Automatic control schedules for DHW devices	Partially implemented	Schedules based on usage patterns are provided. Consideration of comfort-profiles depends on feature SHIE_1. User interface for feature is ready.
SHIE_5 Control signals communication to customers	Partially implemented	Computed schedules get stored in an application database. Implementation of an API for external access is pending

Feature	Status	Notes
SHIE_6 Control signals communication to flexibility assets	Partially implemented	Computed schedules get stored in an application database. Implementation of an API for external access is pending
SHIE_7 Detect presence and absence	Not implemented	This feature is pending for next release.

3.2.1 Login

The user interface is designed in such a way that it can be properly used from smartphones, either as a website or as a specific app (Figure 26). Login is implemented as an integration with the SYNERGY Platform's Security, Authentication and Authorization mechanisms through Keycloak, an open-source identity service provider implementing a set of well-known authentication and authorization protocols.
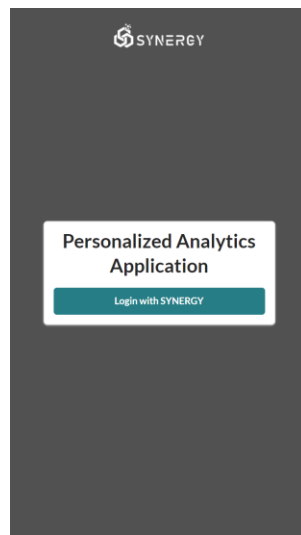
Figure 26: Personalized Energy Analytics Application - Login

3.2.2 Dashboard

First section displays a *Dashboard* with basic energy usage indicators and projections relative to the current month – demand, generation, cost, and energy flows (Figure 27).
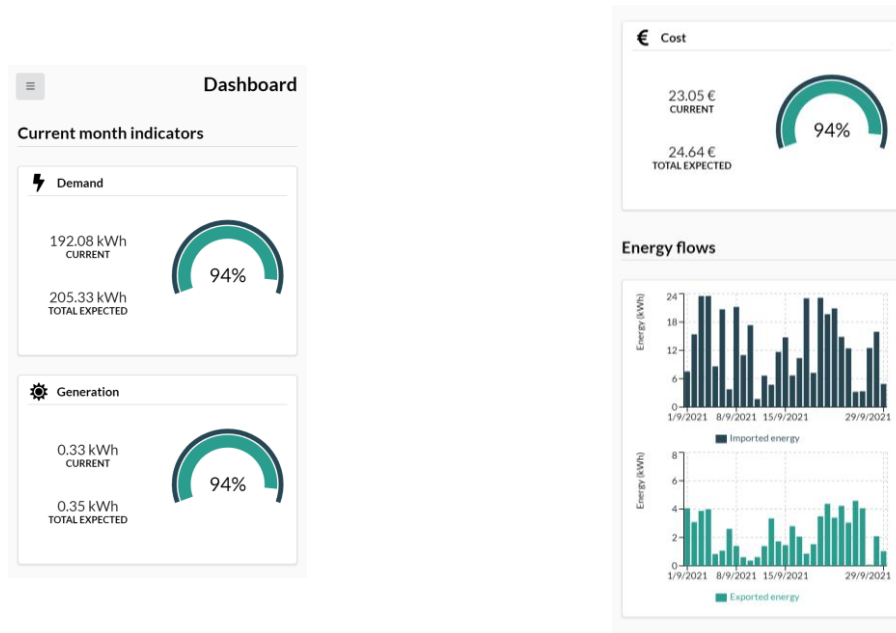
Figure 27: Personalized Energy Analytics Application - Dashboard

3.2.3 Energy indicators and drill-in

The *Energy indicators* section allows users to navigate and get insights on their energy-usage data. By selecting a date range, a number of indicators are displayed, including for each of them the absolute values and charts with the relevant time series. Additionally, the *Period comparison* site displays similar information, but in this case the end user can select a period in the past with which the presented information will be compared. Finally, the *Contracted Power Analysis* site provides a histogram-based representation of the distribution of the active power of the customer, which is crosschecked with the contracted capacity in order to provide hints with regards to the appropriateness of the contracted capacity (Figure 28).
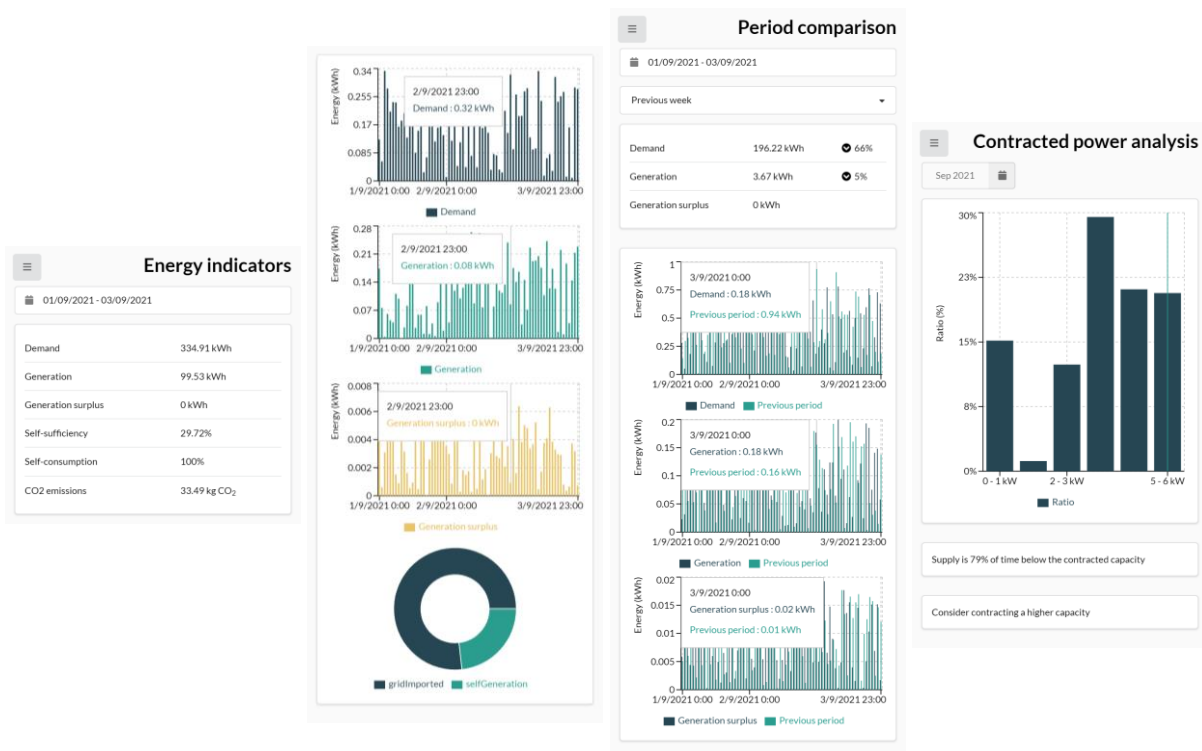
Figure 28: Personalized Energy Analytics Application - Energy indicators and drill-in

This project has received funding from the European Union's Horizon 2020 Research and Innovation programme under Grant Agreement No 872734.

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3.2.4   Peer-comparison

The *Peer comparison* section (Figure 29) allows users to get indications on how they compare themselves to similar users, according to a number of indicators. Presented information is based in the socioeconomic profiling performed by the *Portfolio Analytics and Management application*.
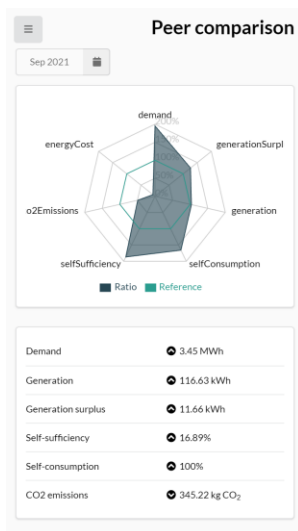
Figure 29: Personalized Energy Analytics Application - Peer comparison

3.2.5 Alerts and tips

The *Alerts* section (Figure 30) displays an ordered list of the alerts triggered by this component to the user. In the case of the app, the application will trigger a notification to the users so they become aware of the alert as soon as possible.

The *Tips* section (Figure 30) provides tips, hints and relevant milestones or warnings achieved by the user with regards to the energy usage patterns. Those tips are automatically produced by the component on a periodic basis (e.g., every week), by comparing recent data with relevant previous periods and with the customer's peers.
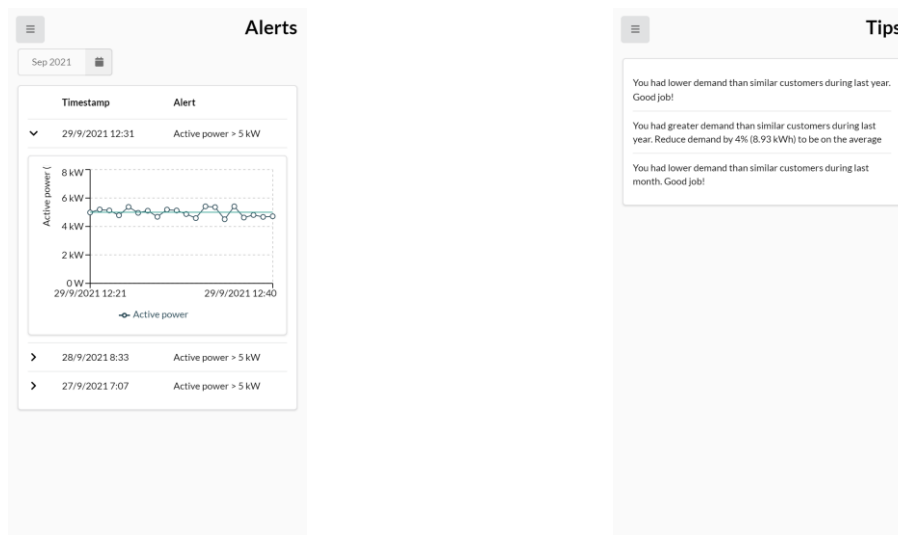
Figure 30: Personalized Energy Analytics Application - Alerts and tips

3.2.6 Smart home

The *Smart Home Dashboard* section displays in a glance the current status for all sensors/systems integrated in the smart home service of the customer. This information gets complemented by the *Monitoring* site, which gives access to the history of data retrieved by the smart assets (Figure 31).
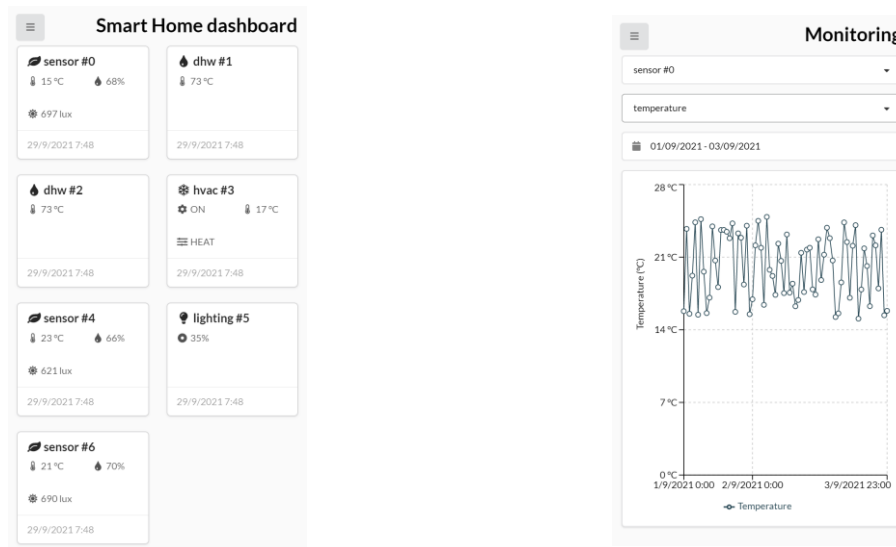
Figure 31: Personalized Energy Analytics Application - Smart Home dashboard and monitoring

The *Smart Asset Scheduling* section (Figure 32) gives access to optimum schedules of the smart assets (HVAC, lighting or DHW) owned by the customer. The user is free to change the proposed schedules by editing or adding new commands to its smart asset schedules (Figure 33 and Figure 34).
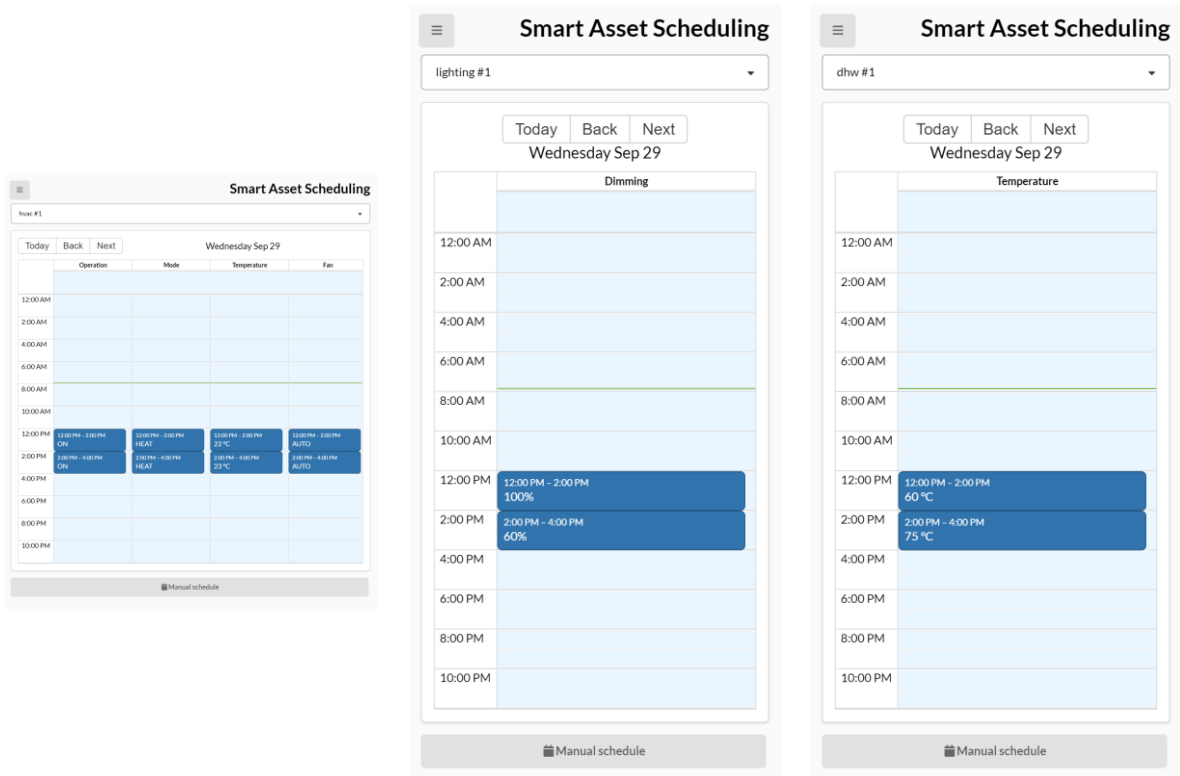
Figure 32: Personalized Energy Analytics Application - Smart Asset Scheduling
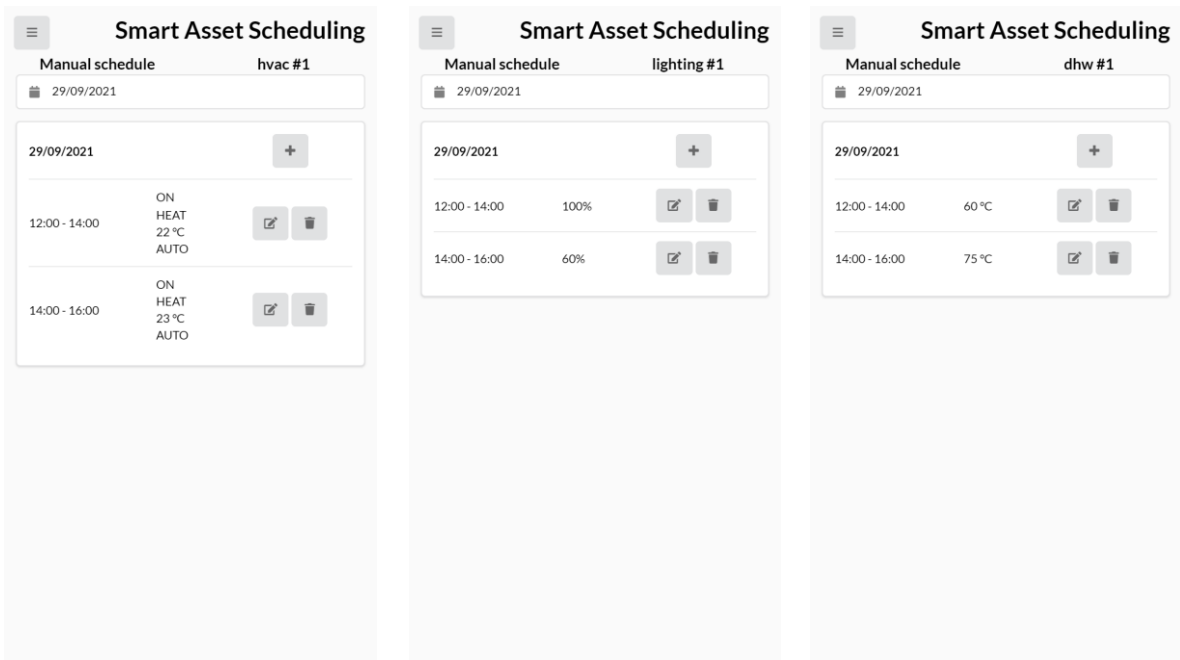
Figure 33: Personalized Energy Analytics Application - Smart Asset Scheduling (edition)
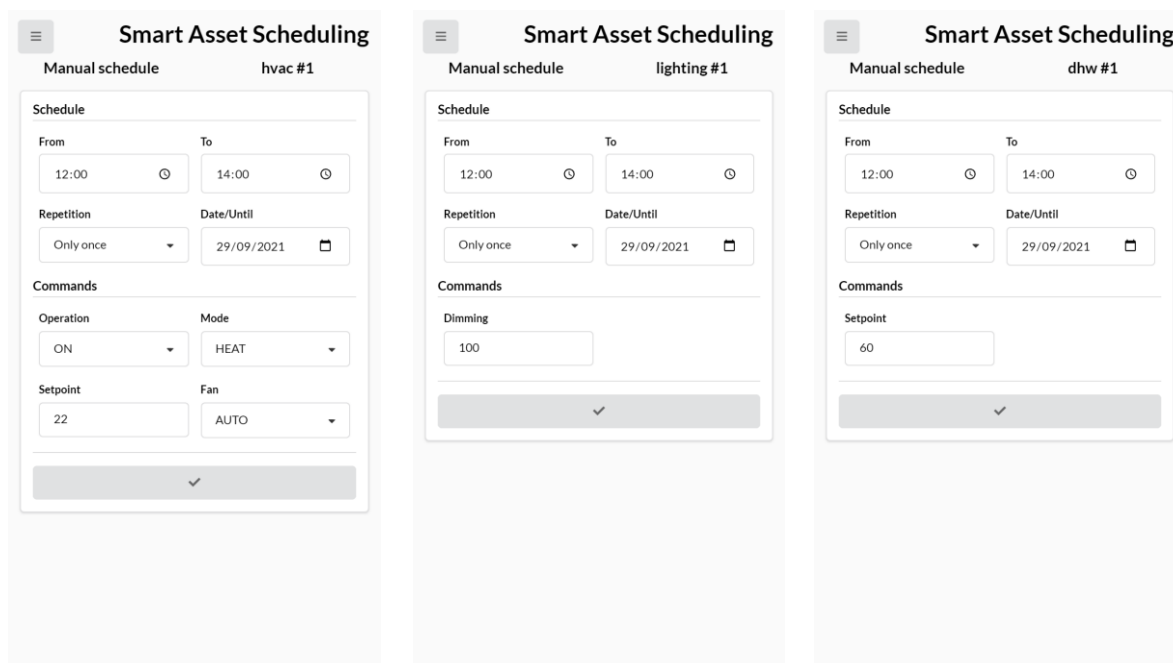
Figure 34: Personalized Energy Analytics Application - Smart Asset Scheduling (manual schedule details)

3.3 Technology stack and implementation tools

The following table summarizes the set of libraries used for the development of the Personalized Energy Analytics Application. In summary, Meteor framework has been used to build the main backend and frontend including SYNERGY Platform integration.

Table 9: Personalized Energy Analytics Application - Technology stack

Library	Version	License	Purpose
meteor-base	1.4.0	MIT License	User interface. Packages every Meteor app needs to have.
mobile-experience	1.1.0	MIT License	User interface. Packages for a great mobile UX.
mongo	1.11.0	MIT License	User interface. The database Meteor supports right now.
static-html		MIT License	User interface. Define static page content in .html files.
reactive-var	1.0.11	MIT License	User interface. Reactive variable for tracker.
Tracker	1.2.0	MIT License	User interface. Meteor's client-side reactive programming library.
session	1.2.0	MIT License	User interface.
accounts-password	1.7.0	MIT	User interface.

Library	Version	License	Purpose
		License	
standard-minifier-js	2.6.0	MIT License	User interface. JS minifier run for production mode.
es5-shim	4.8.0	MIT License	User interface. ECMAScript 5 compatibility for older browsers.
ecmascript	0.15.1	MIT License	User interface. Enable ECMAScript2015+ syntax in app code.
shell-server	0.5.0	MIT License	User interface. Server-side component of the `meteor shell` command.
aldeed:collection2	3.0.0	MIT License	User interface.
underscore	1.0.10	MIT License	User interface.
react-meteor-data		MIT License	User interface.
alanning:roles		MIT License	User interface.
semantic:ui		MIT License	User interface.
jquery		MIT License	User interface.
flemay:less-autoprefixer		MIT License	User interface.
matb33:collection-hooks		MIT License	User interface.
mizzao:user-status		MIT License	User interface.
etraid:accounts-openid		Proprietary	User interface.
@babel/runtime	^7.12.5	MIT License	User interface.
@popperjs/core	^2.6.0	MIT License	User interface.
bcrypt	^5.0.0	MIT License	User interface.
etra-forms	^1.0.10	Proprietary	User interface.
etra-ui-components	^2.0.1	Proprietary	User interface.
etraid_formats	^1.0.16	Proprietary	User interface.
html-react-parser	^1.2.6	MIT License	User interface.
i18next	^20.2.2	MIT License	User interface.
i18next-browser-languagedetector	^6.1.0	MIT License	User interface.
i18next-http-backend	^1.2.2	MIT License	User interface.
jquery	^3.4.1	MIT License	User interface.

Library	Version	License	Purpose
lodash	^4.17.21	MIT License	User interface.
luxon	^1.26.0	MIT License	User interface.
meteor-node-stubs	^1.0.0	MIT License	User interface.
popper.js	^1.16.1	MIT License	User interface.
prop-types	^15.7.2	MIT License	User interface.
react	^16.14.0	MIT License	User interface.
react-big-calendar	^0.33.2	MIT License	User interface.
react-dom	^16.14.0	MIT License	User interface.
react-i18next	^11.8.13	MIT License	User interface.
react-modal-promise	^0.7.2	MIT License	User interface.
react-month-picker	^2.2.0	MIT License	User interface.
react-router-dom	^5.2.0	MIT License	User interface.
react-semantic-ui-datepickers	^2.13.0	MIT License	User interface.
recharts	^2.0.9	MIT License	User interface.
recompose	^0.30.0	MIT License	User interface.
semantic-ui-calendar-react	^0.15.3	MIT License	User interface.
semantic-ui-react	^1.1.1	MIT License	User interface.
simpl-schema	^1.10.2	MIT License	User interface.
styled-components	^5.2.3	MIT License	User interface.

3.4   API documentation

3.4.1   Integration with SYNERGY Platform via REST API

The majority of the analytics required by the application have been configured as *analytic workflows* that are executed by the SYNERGY Platform. In order to access to the results of such analytics, different *data retrieval queries* have been configured, all of them exposing specific REST endpoints.

Authentication mechanisms are implemented within the SYNERGY Platform in order to ensure that only authorized parties (components of the *Personalized Energy Analytics application* in this context) are granted access.

Table 10: Personalized Energy Analytics Application - Integration with SYNERGY Platform

Data Retrieval Query	Type	Implementer	Purpose
[DEV-WP6] _MERGED_ - Monthly Avg Energy Data	HTTP GET	SYNERGY Platform	Monthly KPIs per customer.
[DEV-WP6] CUSTOMERS - KPIs	HTTP GET	SYNERGY Platform	Hourly KPIs per customer.
[DEV-WP6] Socioeconomic groups	HTTP GET	SYNERGY Platform	Socioeconomic profiling clusters.
[DEV-WP6] CUSTOMER - Energy Data	HTTP GET	SYNERGY Platform	Raw measurements per customer.
[DEV-WP6] _MERGED_ - Energy Data	HTTP GET	SYNERGY Platform	Raw measurements per customer
[DEV-WP6] _MERGED_ - Contracts ii	HTTP GET	SYNERGY Platform	Contract information per customer.
[DEV-WP6] CUSTOMERS - Socioeconomic groups	HTTP GET	SYNERGY Platform	Customer basic data socioeconomic profiling.

3.5   Installation instructions

All the components of the application have been packaged as a set of docker images. These docker images are available from a private repository at docker hub. This kind of packages facilitate the deployment in any platform supporting this technology (e.g. Kubernetes).

Table 11: Personalized Energy Analytics Application - Installation instructions

Image	Tag	Purpose
etraid/synergy_personalizedanalyticsui	0.0.19	Application main backend and web-based frontend.

End-users will be required to download and install the application on their mobile phones (targeted systems are Android and iOS). At the current stage of development, only test versions of the app are being created, so no public access to it is yet provided. Nevertheless, for reference a web-based demo version of the application is published, as detailed under section 3.7.

3.6   Assumptions and restrictions

The Personalized Energy Analytics relies on data provided by retailers and aggregators to the Portfolio Analytics and Management application. Therefore, same assumptions and restrictions as described in section 2.6 apply.

3.7   Licensing and access

The licensing and IPR of each component that consist of the *Personalized Energy Analytics Application* are provided in the following table.

Table 12: Personalized Energy Analytics Application – Licensing Details

Component	Licensing details
Personalized Energy Analytics Engine	ETRA I+D is the owner of all intellectual property rights of this component. All rights are reserved.
Smart Home Integration Engine	ETRA I+D is the owner of all intellectual property rights of this component. All rights are reserved.

A demo version of the application is accessible at https://personalizedanalytics.synergy-bigdata.eu/[2]

3.8   Planned features for next release

The next release of the application is scheduled for M24 (end of December 2021), prior to the start of the first demo run of the demonstration cases. Work scheduled for the next release includes:

- Finalization of the pending integrations, as detailed in section 3.2,

- Revise the behaviour of the application with source datasets that update dynamically,

- Take benefit of upcoming features of the SYNERGY Platform (e.g. query parameters on data retrieval queries for datasets that are results of analytic workflows, or capability to acquire pretrained analytics developed by third parties in the SYNERGY Marketplace) to enhance performance of the application.

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[2] Demo credentials are available on request

4 Flexibility Analytics and Consumer-Centric DR Optimization Application

4.1 Overview

The *Flexibility Analytics and Consumer-Centric DR Optimization Application* implements the necessary features to allow aggregators to provide better and added value flexibility related services. By exploiting all available data, in order to analyse in detail what is the flexibility potential of their portfolio, the application facilitates the optimal placement of the flexible assets in different Demand Side Management strategies as triggered by 3rd party electricity stakeholders requesting for ancillary services. There are two main components that consist of the overall application: (a) The Aggregator Portfolio Manager to facilitate aggregators to continuously have a clear picture and management of their portfolio's performance, in order to be able to deliver the required flexibility to network operators and (b) the VPP Configuration Engine to trigger the optimal strategies over the portfolio assets on the basis of flexibility requests triggered by 3rd party entities (i.e., network operators).

4.2   Implemented functionalities

The functionalities of the *Flexibility Analytics and Consumer-Centric DR Optimization Application* have been split in 2 components according to their nature.
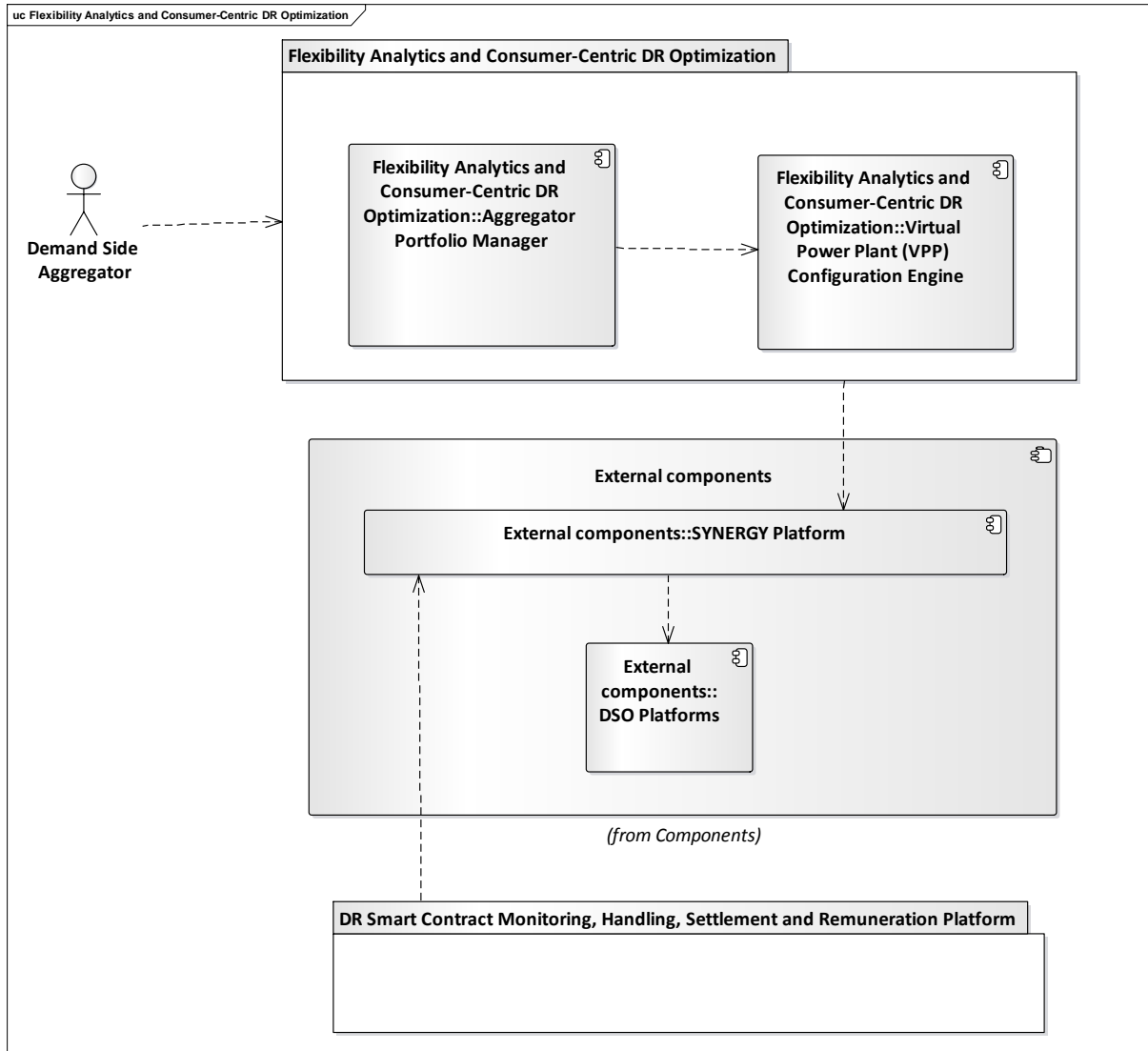
Figure 35: Flexibility Analytics and Consumer-Centric DR Optimization Application components and addressed actors

The list of features implemented in the 1st version of the Flexibility Analytics and Consumer-Centric DR Optimization Application is presented in the following table.

Table 13: Flexibility Analytics and Consumer-Centric DR Optimization Application - Implemented functionalities

This project has received funding from the European Union's Horizon 2020 Research and Innovation programme under Grant Agreement No 872734.

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Feature	Status	Notes
APM_1 – Multi dimensional flexible source classification based on operational parameters	Implemented	The end user of the tool may set groups of assets based on flexible asset operational characteristics
APM_2 – Multi dimensional flexible source classification based on spatial parameters	Implemented	The end user of the tool may set groups of assets based on spatial/location based parameters
APM_3 – Multi dimensional flexible source classification based on temporal parameters	Implemented	The end user of the tool may set groups of assets based on temporal criteria
APM_4 – User-defined classification of flexibility sources	Partially Implemented	User interface for feature is ready. Pending some testing of the analytics process for the execution of the classification functionality.
VPP_1 – Provision of ancillary services to TSOs/DSOs	Implemented	The app receives DR strategies from 3rd party entities (DSOs/TSOs) following standardized business templates
VPP_2 – Flexible source clustering to VPPs	Partially Implemented	User interface for feature is ready. Pending some testing of the analytics process for the execution of the VPP functionality.

A more detailed view on the different functionalities implemented as part of the 1st version of the Flexibility Analytics and Consumer-Centric DR Optimization Application is provided.

4.2.1 Login

At first, the SYNERGY SSO authorization process applies where the user is prompted to provide personal account credentials (as in any other application of SYNERGY project) as depicted in Figure 36.
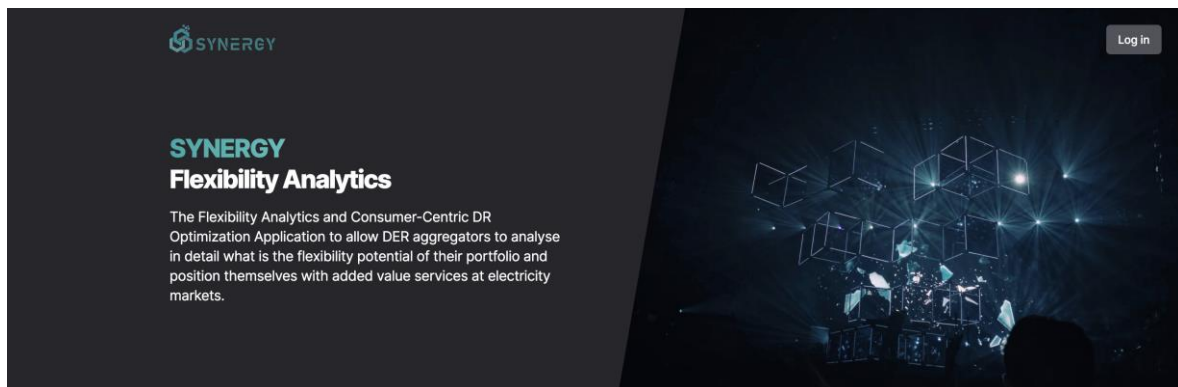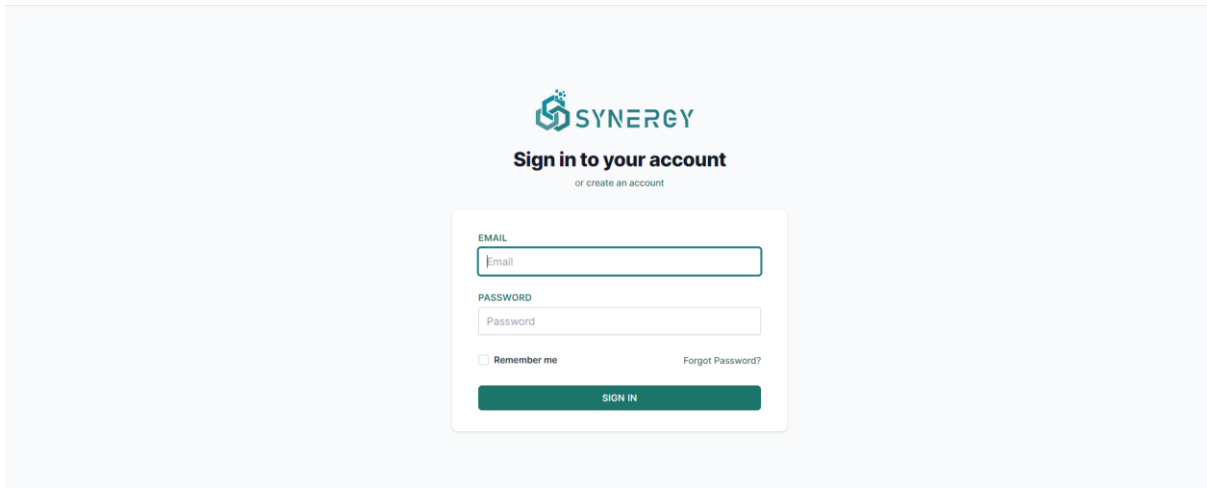
Figure 36: SYNERGY Flexibility Analytics Login Page

As part of the authorization process, the user may log into the application through the username/password of the SYNERGY Platform's Security, Authentication and Authorization mechanisms that allow for single sign-on (Figure 37).

Figure 37: SYNERGY Flexibility Analytics – SSO authentication

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4.2.2 Aggregator Portfolio Management

Once entering into the application (overview section), the business stakeholder (aggregator) has access on the list of assets of the portfolio. Following a multi-dimensional characterization of the different flexible assets, the end user of the application is prompted to define operational related criteria e.g., spatial filtering, operational characteristics-based filtering in order to search over the assets of the portfolio as in Figure 38.
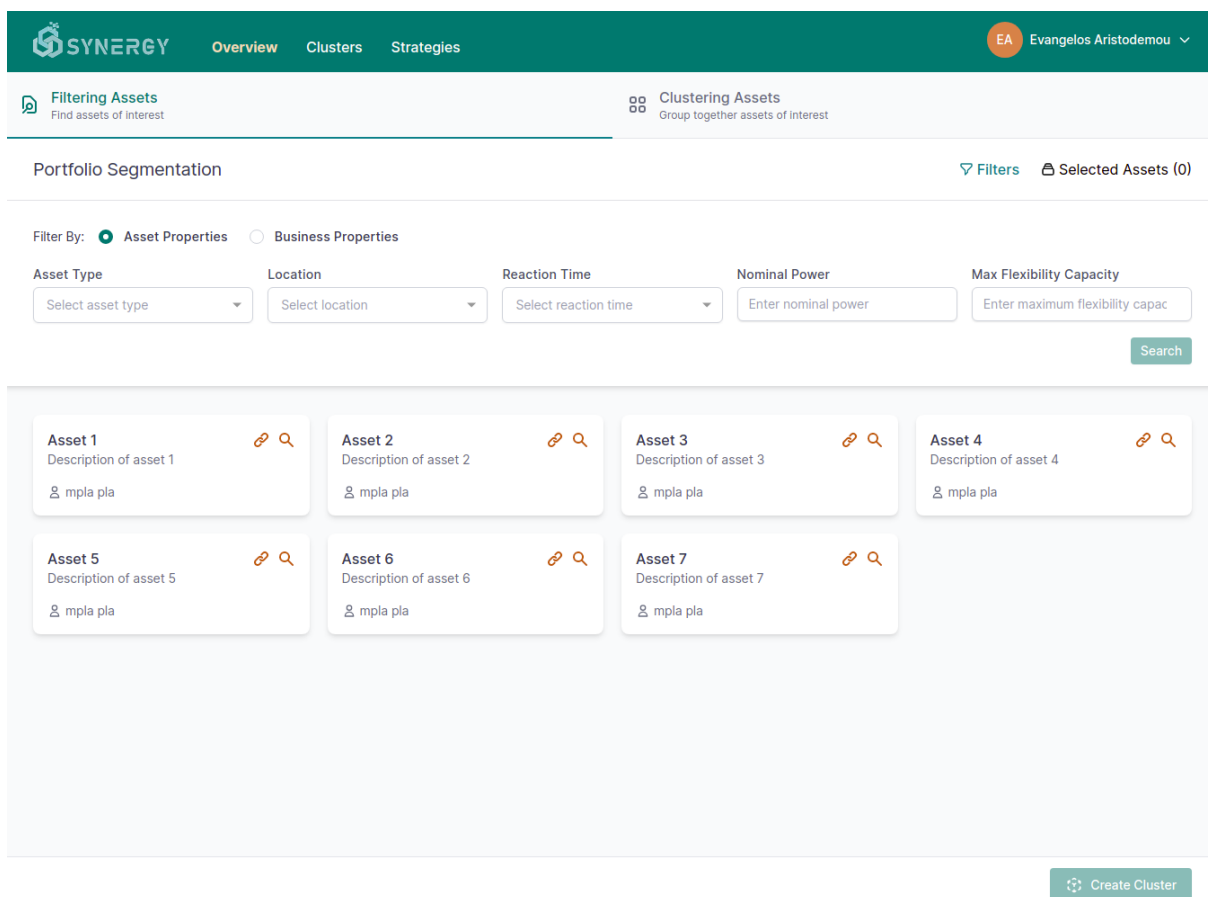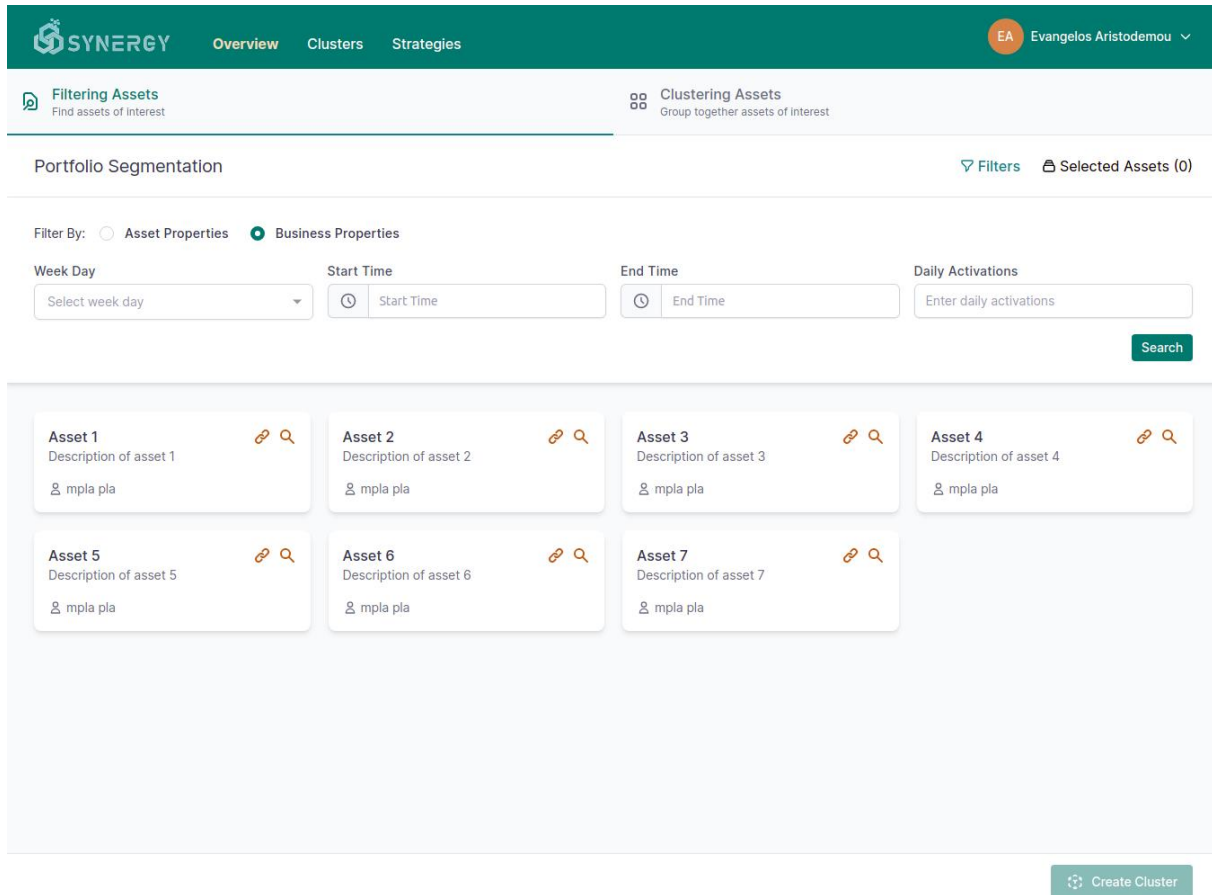
Figure 38: SYNERGY Flexibility Analytics – Assets Search – operational parameters

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In addition, and by taking into account the participation of the aggregator into different contractual agreements, business related criteria re considered as part of the filtering process e.g., active business period, contractual limitations etc (Figure 39).

Figure 39: SYNERGY Flexibility Analytics – Assets Search – business parameters

Following the execution of filtering process, the end user of the tool may select the specific set of assets to define a cluster/group for further analysis as shown in Figure 40.

Figure 40: SYNERGY Flexibility Analytics – Asset Selection

Once selecting the list of assets, the end user of the application may provide the name and a short description of the cluster as in Figure 41.
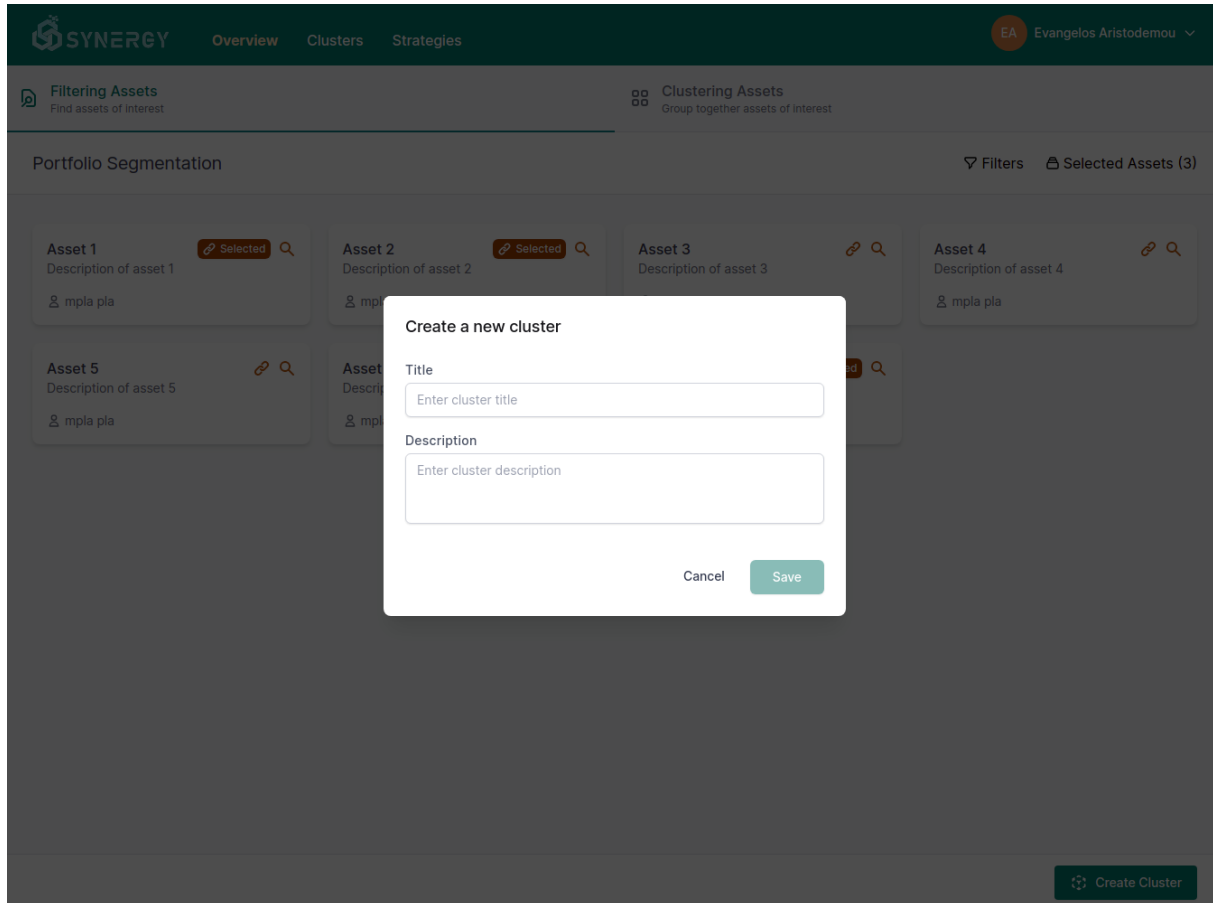
Figure 41: SYNERGY Flexibility Analytics – Group Definition

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In addition, the business actor of the tool may select an asset in order to get insights about the flexibility related characteristics. Information about asset static characteristics (e.g. nominal power, flexibility capacity) as well as time series related information is available through the visualization as depicted in Figure 42.
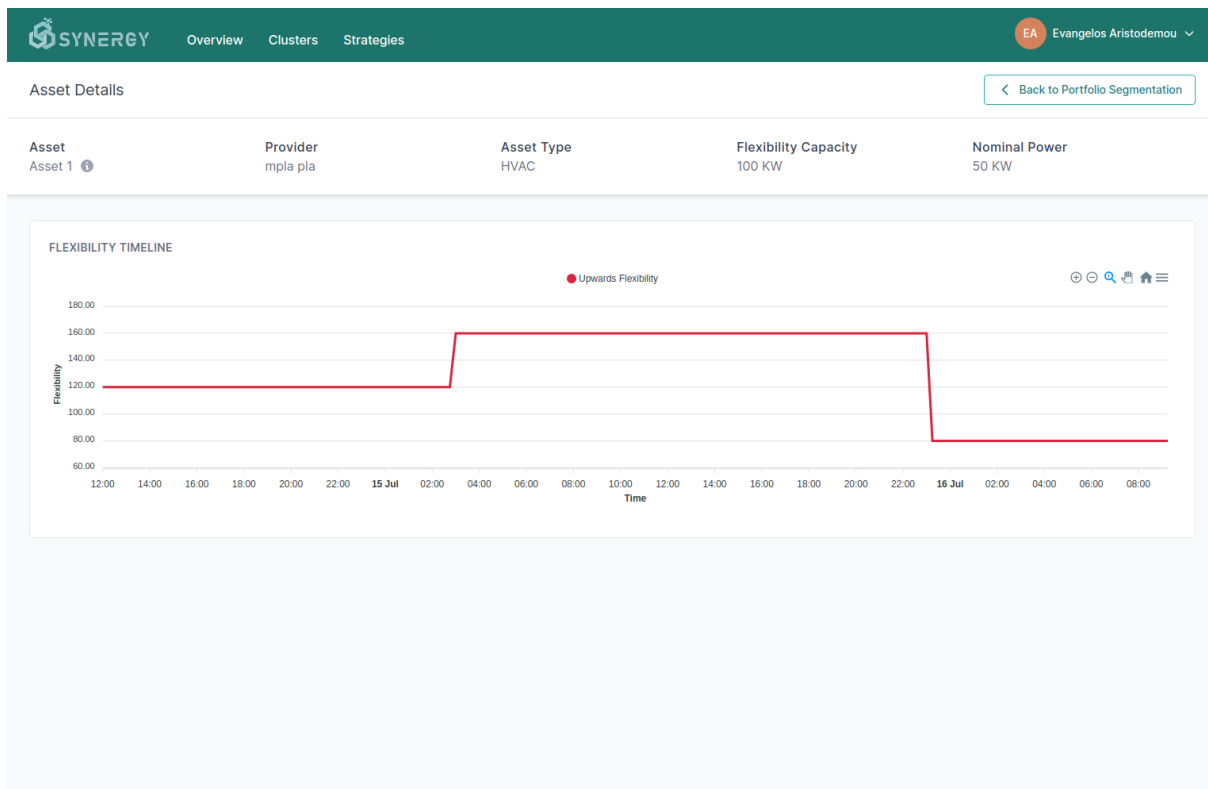
Figure 42: SYNERGY Flexibility Analytics – Asset Details

The list of clusters/ groups defined by the business actor is available through a dedicated view. The user of the tool may view the list of assets participating at a specific group, edit or delete the group as presented in Figure 43.
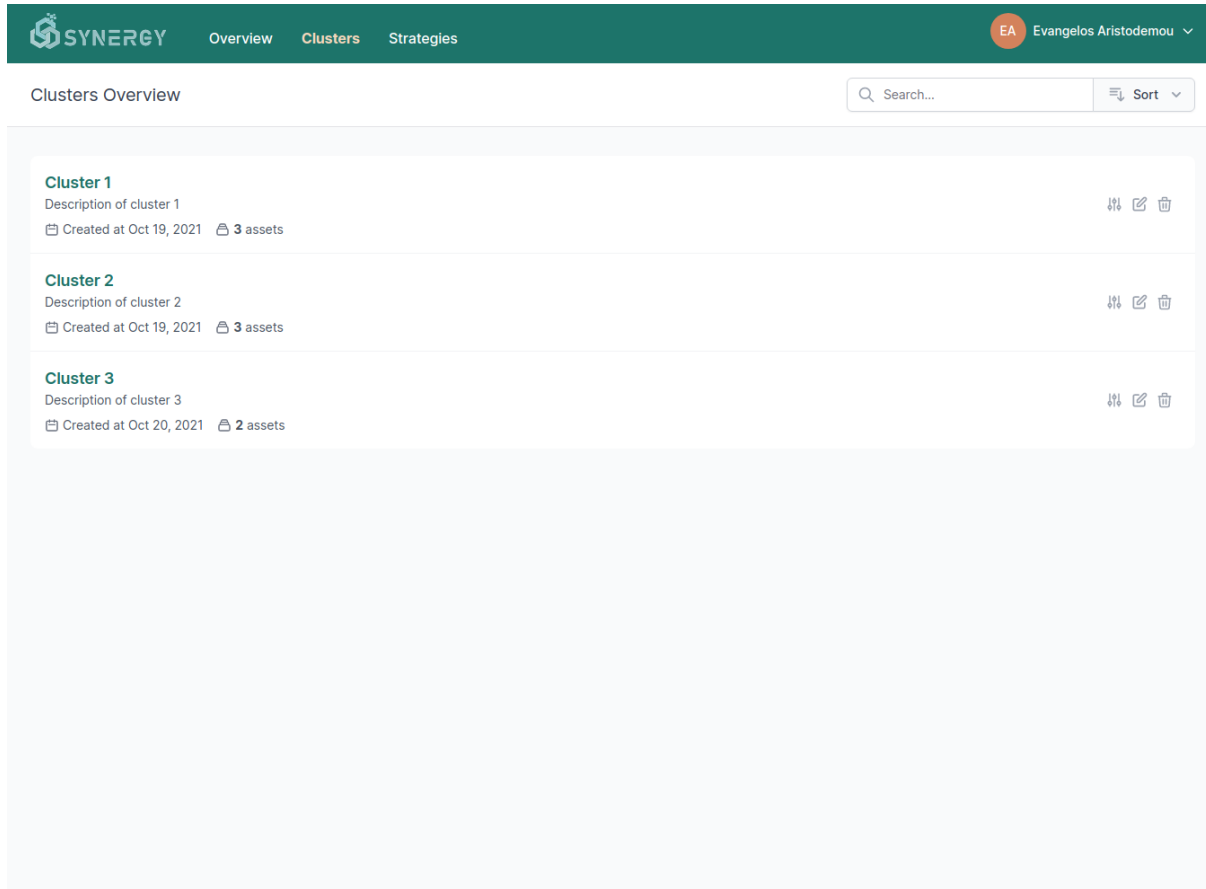
Figure 43: SYNERGY Flexibility Analytics – Clusters Overview

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Through the edit functionality, the user may reshuffle/edit the list of assets that are part of a specific group (Figure 44).
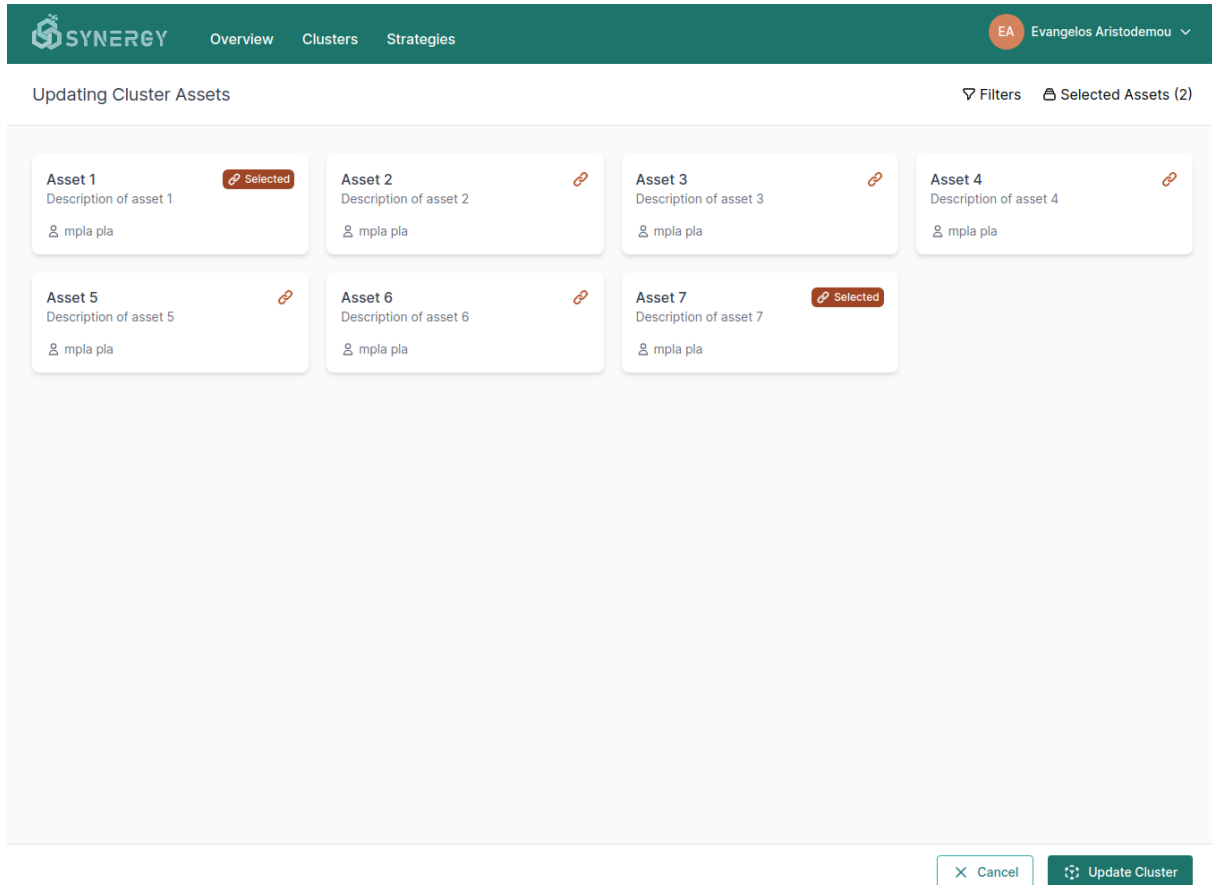
Figure 44: SYNERGY Flexibility Analytics – Edit Cluster

Also, the user may edit the group metadata information (e.g., name, description) as in Figure 45.
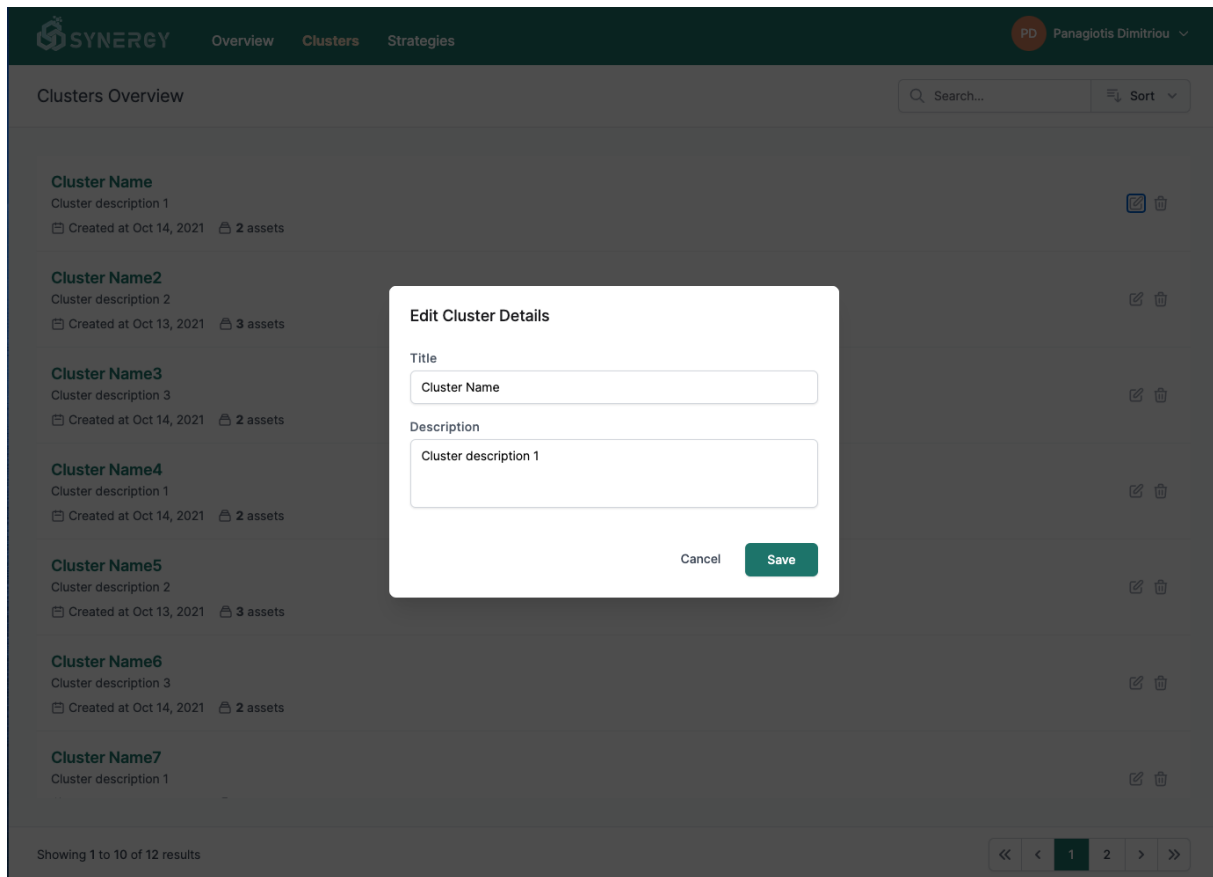
Figure 45: SYNERGY Flexibility Analytics – Edit Cluster Parameters

Furthermore, the user may select a specific group and further drill into the details of the assets. Time series flexibility related information of each asset of the group is available. In addition, a tabular visualization provides insights about the performance of the assets of the group for the aggregate period. Key metrics, i.e., total flexibility potential, maximum flexibility potential, etc. are presented through this specific view of the application as shown in Figure 46.
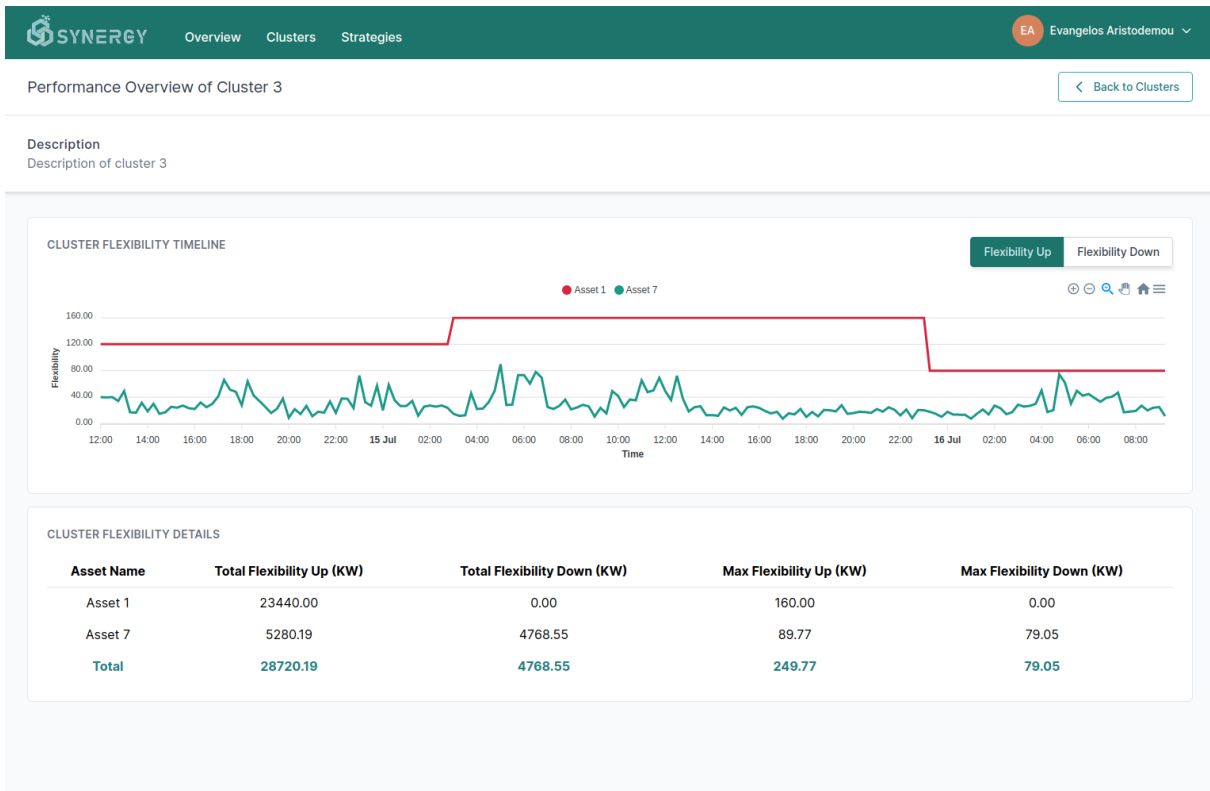
Figure 46: SYNERGY Flexibility Analytics – Cluster performance

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4.2.3 Aggregator VPP Management

Complementary to the aggregator portfolio management functionality as presented in the previous section, the aggregators have access to a number of visualizations related to the analysis performed by the VPP component.

An overview of the different strategies (Strategies Tab) is available (Figure 47), where the business stakeholder has access to the full list of events triggered by 3rd party entities (i.e., network operators). A filtering feature is provided to facilitate aggregators to search for flexibility strategies under specific criteria (i.e. active or closed strategies).
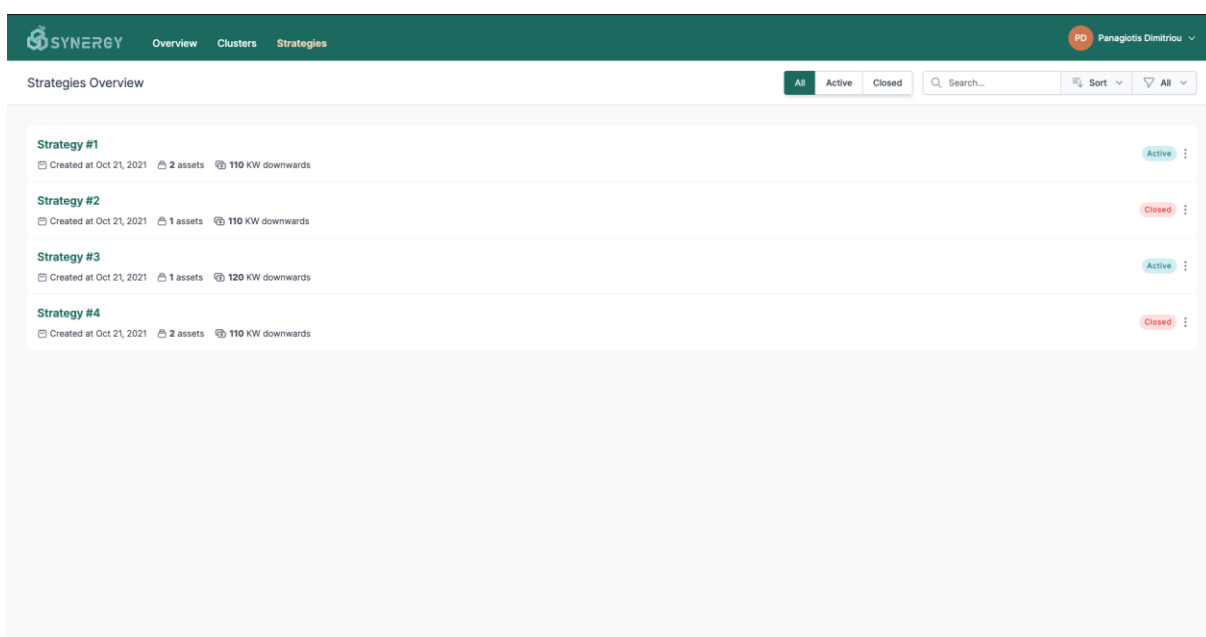
Figure 47: SYNERGY Flexibility Analytics –Strategies List

The end user of the application may then select one of the strategies in order to get insights about:

- The campaign request parameters as triggered by the 3rd party network operator. Information about the requested flexibility at each specific time step of the campaign is presented.

- The flexibility related parameters for the pool of assets selected for activation in this specific campaign; results of VPP optimization process. Information about the requested flexibility per asset at each specific time step of the portfolio strategy is presented.

The different views of the application are presented in the following figures (Figure 48 and Figure 49).
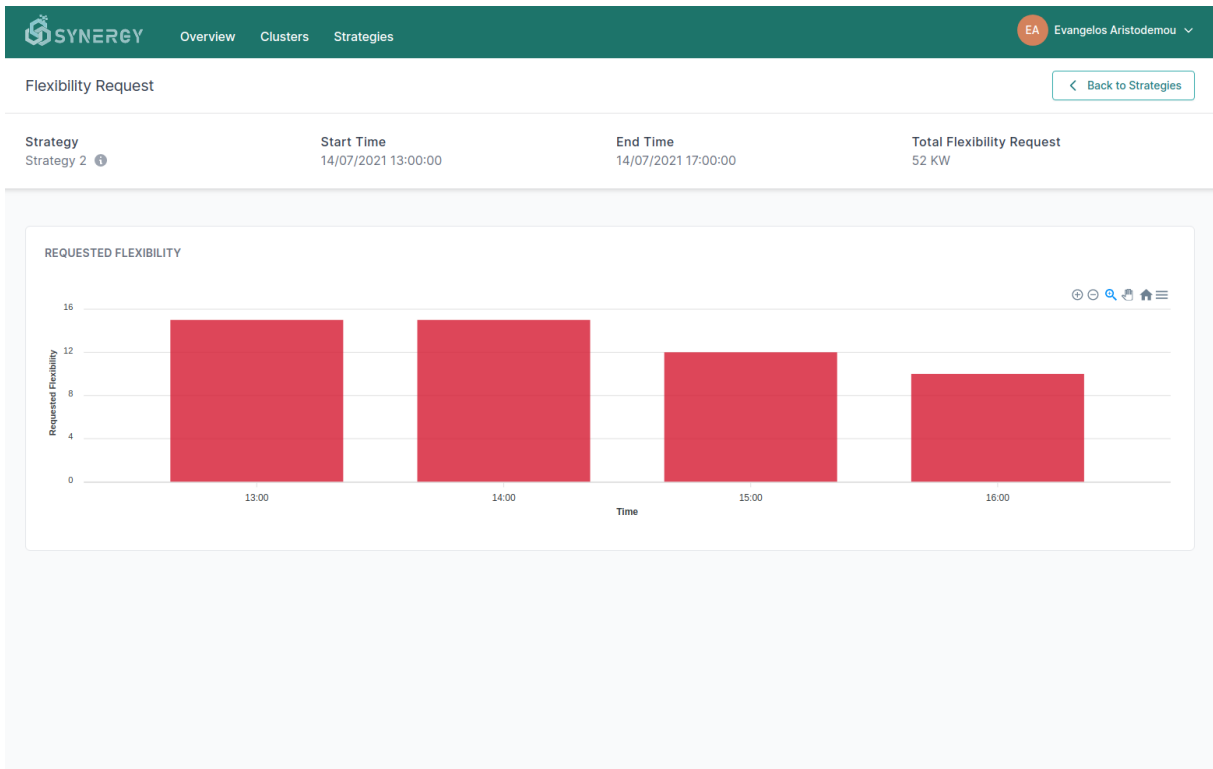
Figure 48: SYNERGY Flexibility Analytics – 3rd party flexibility request details
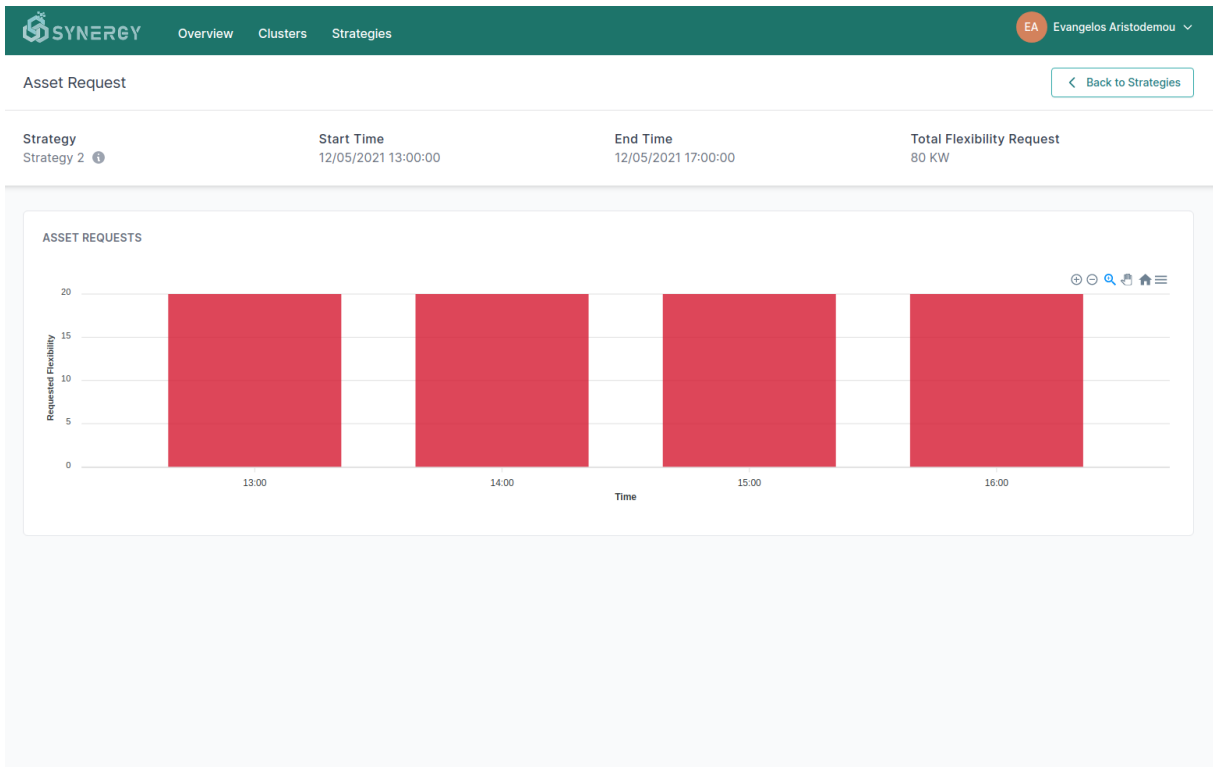
Figure 49: SYNERGY Flexibility Analytics – portfolio flexibility request details

In addition, the user can also drill into the history of closed campaigns and retrieve information associated with the performance of assets under each specific campaign (Figure 50). A timeseries graph is available showing the activation details of the different flexible assets under the specific business requests. Furthermore, a table is available to present in more details the performance of the assets enrolled under a specific campaign.
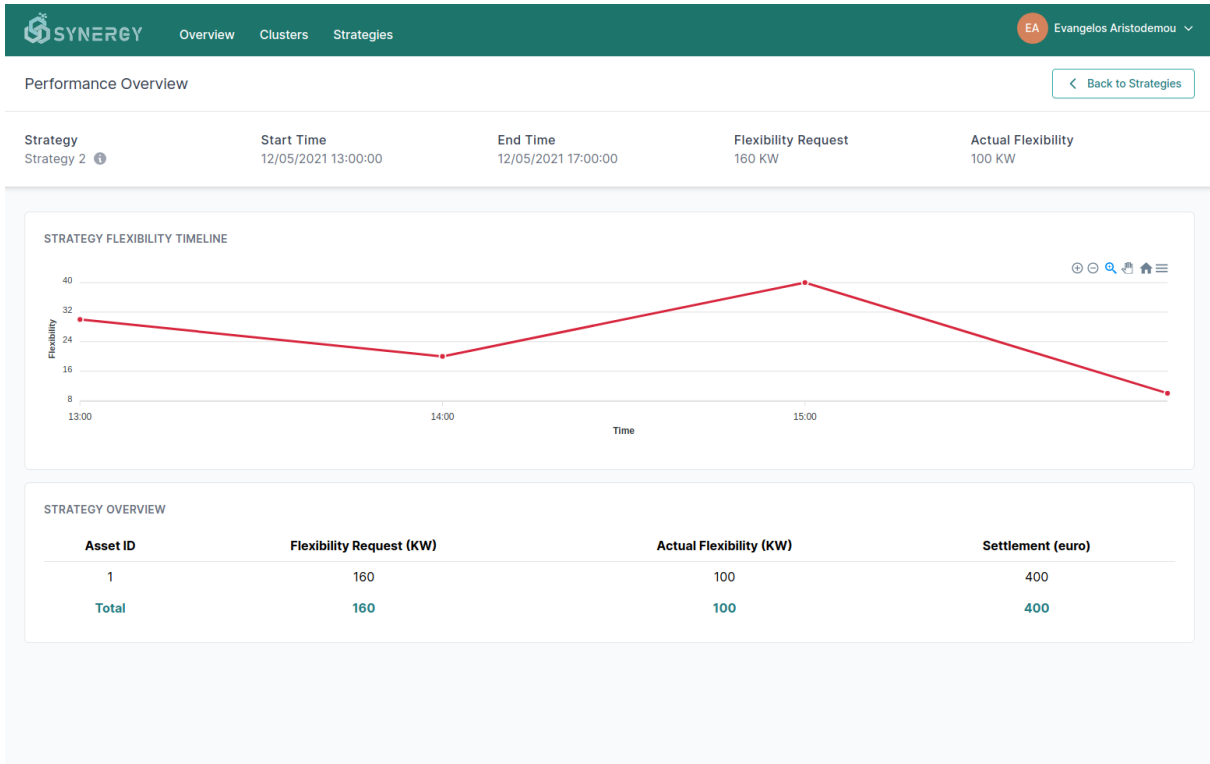
Figure 50: SYNERGY Flexibility Analytics – Strategy Performance

As a side functionality, the end user of the tool (from the management section of the strategies list) may also remove one or more strategies from the campaigns overview list as in Figure 51.
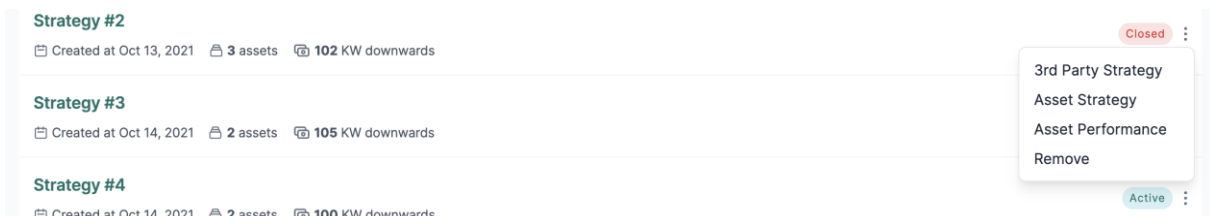
Figure 51: SYNERGY Flexibility Analytics – Remove VPP Strategy

4.3   Technology stack and implementation tools

In order to provide its intended functionalities, the Flexibility Analytics and Consumer-Centric DR Optimization Application is built on state-of-the-art technologies, namely: (a) in the back-end layer, the Nest (NodeJS) web framework as the core framework for delivering efficient, reliable and scalable server-side applications and Flask (Python) framework for specific processes (b) in the front-end layer, VueJS to present the results of the optimization process; (c) in the data storage layer, PostgreSQL (as the relational database) to store the configuration parameters and the results of the Flexibility Analytics and Consumer-Centric DR Optimization Application. In addition, an Elasticsearch engine is deployed to handle the flexibility time series results required for the analysis.

Table 14: Flexibility Analytics and Consumer-Centric DR Optimization Application - Technology stack

Library	Version	License	Purpose
Elasticsearch	7.10	Elastic License	Data Storage
PostgreSQL	12.2	PostgreSQL License (similar to BSD/MIT)	Data Storage
Nest NodeJS Web Framework	12	MIT License	Business logic
Vue.js	2.6.11	MIT	User interface
TailwindCSS	1.9.0	MIT	User interface
TypeORM	-	MIT	Business logic
Flask	1.1.1	BSD 3-Clause	Business logic
Flask RESTful extension	0.3.8	BSD 3-Clause	Business logic
Flask CORS support	3.0.8	MIT	Business logic
Vault	-	Mozilla Public License 2.0	Data Storage

Note: data analytics and optimization libraries used in the Flexibility Analytics and Consumer-Centric DR Optimization Application are aligned with the frameworks and libraries that are supported in the Data Analytics Services Bundle in the SYNERGY Cloud Platform.

4.4   API documentation

4.4.1   Integration with SYNERGY Platform via REST API

The datasets required for the functionality of the application are available from the SYNERGY Platform. In addition, the majority of the analytics required by the application have been configured as analytic workflows that are executed by the SYNERGY Platform. In order to have access to the available

datasets and the results of analytics, different data retrieval queries have been configured, all of them exposing specific REST endpoints. On the other hand, the results of the Flexibility Analytics and Consumer-Centric DR Optimization Application (Aggregate FlexOffer, Flexible assets FlexOrder) are made available to the SYNERGY platform for further exploitation by 3rd party applications.

Table 15: Flexibility Analytics and Consumer-Centric DR Optimization Application - Integration with SYNERGY Platform

Data Retrieval Query	Type	Implementer	Purpose
[DEV-WP6] – FLEX_ASSET - CONFIGURATION	HTTP GET	SYNERGY Platform	Flexible Asset configuration parameters (type, location etc.)
[DEV-WP6] – FLEX_ASSET-CONTRACT	HTTP GET	SYNERGY Platform	Flexible Asset contractual parameters
[DEV-WP6] – FLEX_ASSET - PROFILE	HTTP GET	SYNERGY Platform	Flexible Asset flexibility profiling datasets
[DEV-WP6] – FLEX_ASSET-DSO_REQUEST	HTTP GET	SYNERGY Platform	3rd party (DSOs) Flexibility request/order
[DEV-WP6] – FLEX_ASSET-SETTLE	HTTP GET	SYNERGY Platform	Flexible Asset flexibility settlement details
[DEV-WP6] – FLEX_ASSET-FLEX_OFFER	HTTP POST	SYNERGY Platform	Aggregate flexibility offers to 3rd party entities
[DEV-WP6] – FLEX_ASSET-FLEX_STRATEGIES	HTTP POST	SYNERGY Platform	Flexible Assets flexibility orders/strategies

Note: Also, authentication mechanisms are implemented within the SYNERGY Platform in order to ensure that only authorized parties (Flexibility Analytics and Consumer-Centric DR Optimization Application users in this context) are granted access.

4.5   Installation instructions

All the components of the application have been packaged as a set of docker images. These docker images are available from the private repository at docker hub. This kind of packages facilitate the deployment in any platform supporting this technology (e.g., Kubernetes). Due to the nature of the software, being offered in the form of SaaS, no installation procedure is required by final users.

Table 16: Flexibility Analytics and Consumer-Centric DR Optimization Application - Installation instructions

Image	Tag	Purpose
suite5/flexibility-analytics-app-backend	latest	The latest version of the Flexibility Analytics and Consumer-Centric DR Optimization Application backend
suite5/flexibility-analytics-app-frontend	latest	The latest version of the Flexibility Analytics and Consumer-Centric DR Optimization Application front end

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Image	Tag	Purpose
suite5/flexibility-analytics-app-search	latest	The latest version of Flexibility Analytics and Consumer-Centric DR Optimization Application search feature

4.6 Assumptions and restrictions

The overall functionality of the Flexibility Analytics and Consumer-Centric DR Optimization Application relies on the datasets and services provided by the SYNERGY Platform, specifically in the features related to data ingestion and data analytics.

In order to be able to use the application, following configuration steps need to be taken for every new aggregator that wishes to integrate with the Flexibility Analytics and Consumer-Centric DR Optimization Application:

- Aggregators are required to be registered as users of the SYNERGY Platform.

- Aggregators are required to configure the necessary data check-in jobs, so required datasets get accessible through the platform.

- Aggregators to grant access over the datasets to the application manager, so these datasets to be incorporated to the application workflows, by signing the appropriate contracts within the SYNERGY Platform.

- Application manager configures the necessary pre-processing steps – which ensures that existing datasets from any aggregator are transformed (from the SYNERGY CIM in accordance with D3.1 [2]) to meet a common data model required for the execution of the analytics services by the application.

4.7 Licensing and access

The licensing and IPR of each component that consist of the *Flexibility Analytics and Consumer-Centric DR Optimization Application* are provided in the following table.

A demo version of the application is accessible at https://flexibility-analytics.synergy-bigdata.eu[3].

4.8 Planned features for next release

The next release of the application is scheduled for M24 (end of December 2021), prior to the start of the first demo run of the demonstration cases. Work scheduled for the next release includes:

- Final testing and deployment of asset classification feature as part of Aggregator Portfolio Management Module.

- Final testing and deployment of asset optimization feature as part of VPP Management Module.

- Development and deployment of the reconfiguration (automatic and manual) of VPPS as part of the enhanced functionality of the VPP Management Module.

- Also, during the following months, the application will take benefit of upcoming updates on the SYNERGY Platform to perform end to end integration.

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[3] Demo credentials are available on request

5 DR Smart Contract Monitoring, Handling, Settlement and Remuneration Platform

5.1 Overview

The DR Smart Contract Monitoring, Handling, Settlement and Remuneration Platform is the component that implements all necessary features to allow aggregators and flexible asset managers to come into a common marketplace and negotiate the enrolment of the flexibility assets in different flexibility services through a contractual process. Apart from the contractual part, the settlement and remuneration of the different flexible assets for their participation in the flexibility services is supported and in order to ensure transparency on the different processes running in the marketplace, a blockchain based implementation is considered. The components that consist of the DR Smart Contract Monitoring, Handling, Settlement, and Remuneration Platform are: (a) the Flexibility Marketplace Search Engine to facilitate aggregators to search from a pool of flexibility sources with specific characteristics that fit to their business objectives, (b) the Flexibility Contracts Manager to manage the contractual process among aggregators and flexibility asset managers, (c) the Flexibility Settlement & Remuneration Engine to enable fair settlement and remuneration of the flexibility assets for participation in flexibility services, (d) the Blockchain Wallet to act as the user registry and management layer to enable end user's interaction with the Blockchain-enabled smart contract monitoring, handling, settlement and remuneration platform.

5.2 Implemented functionalities

The functionalities of the *DR Smart Contract Monitoring, Handling, Settlement and Remuneration Platform* have been split in 2 different components according to their nature.
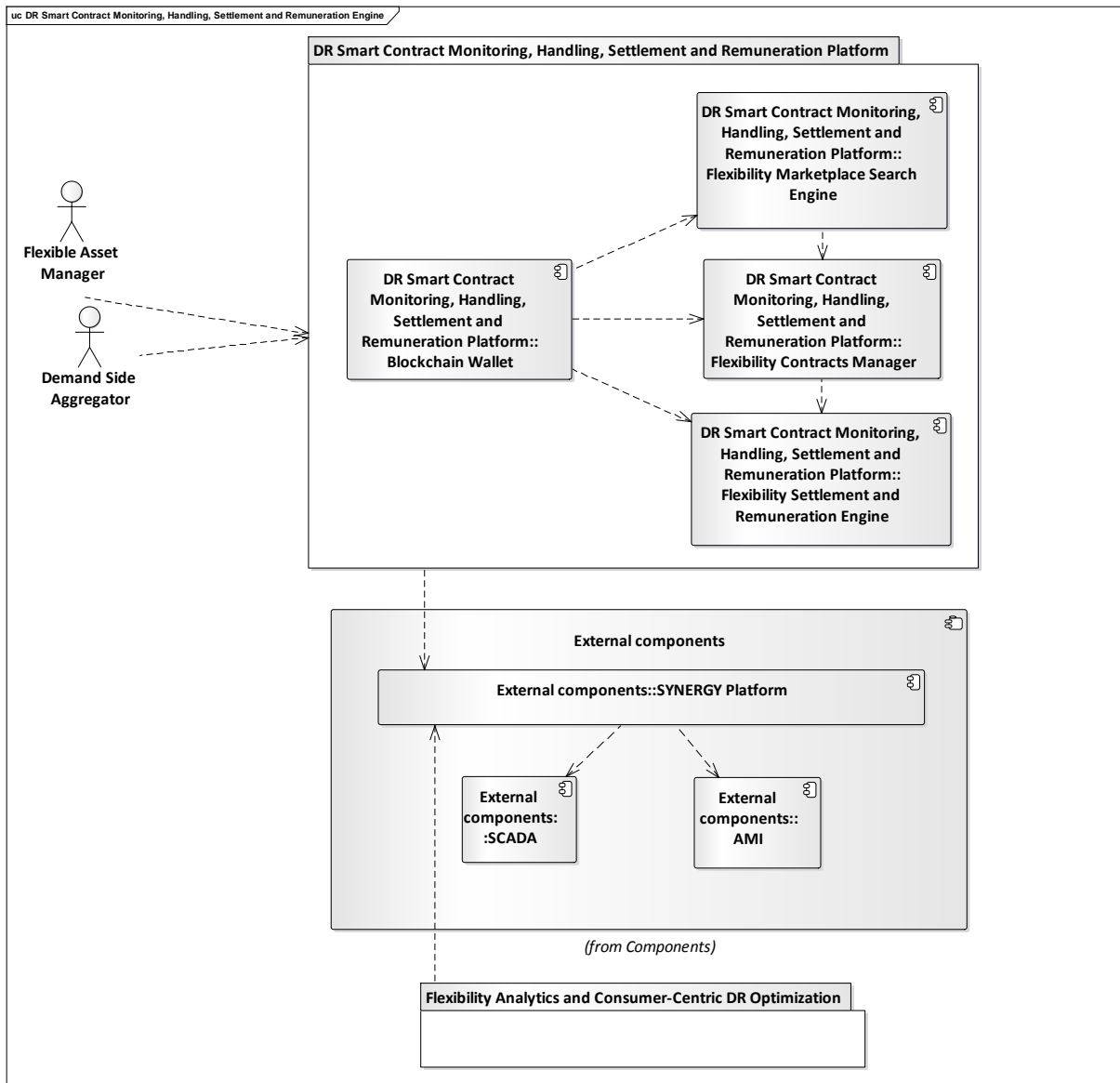
Figure 52: DR Smart Contract Monitoring, Handling, Settlement and Remuneration Application components and addressed actors

The list of features implemented in the 1st version of the *DR Smart Contract Monitoring, Handling, Settlement and Remuneration Platform* is presented in the following table.

Table 18: DR Smart Contract Monitoring, Handling, Settlement and Remuneration Platform - Implemented functionalities

Feature	Status	Notes
FMS_1 – Prosumers to report assets availability settings in the marketplace	Implemented	The flexible asset managers are able to set availability and constrains via the application.
FMS_2 – Aggregators to search for the available flexibility sources in the marketplace	Implemented	The flexible asset aggregators are able to search the details of the assets available on the marketplace.
FCM_1 – Aggregators to offer draft contracts to the prosumers for their available flexibility	Implemented	The flexible asset aggregators are able to set contractual offers to the flexible asset managers about assets available on the marketplace.
FCM_2 – Prosumers to be able to accept/reject/negotiate contractual terms	Implemented	The negotiation over the terms of a defined contract template is enabled as part of the functionality of the application.
FCM_3 – Aggregators to provide counteroffers during the negotiation phase	Implemented	The flexible asset aggregators are able to set updates on the contractual offers as part of the negotiation process.
FSR_1 – Flexibility Settlement on the basis of an accurate Performance Measurement and Verification Process	Partially Implemented	User interface for this feature is ready. The Performance Measurement and Verification algorithm still under development.
FSR_2 – Flexibility Remuneration for the provided flexibility under a specific contract	Implemented	The remuneration feature on the basis of settlement results and taking into account contractual terms has been implemented
WM_1 – Authorisation based user's registration in the marketplace	Implemented	Authorization service is implemented following the approach adopted in SYNERGY project.

Note: the data analytics used in the DR Smart Contract Monitoring, Handling, Settlement and Remuneration Platform Application are aligned with the frameworks and libraries that are supported in the Data Analytics Services Bundle in the SYNERGY Integrated Platform.

A more detailed view on the different functionalities implemented as part of the 1st version of the Smart Contract Monitoring, Handling, Settlement and Remuneration Platform Application is provided.

5.2.1 Login

As stated above, there are two different stakeholders (flexible assets managers/aggregators) accessing the flexibility marketplace but the same login process applies for both entities participating in it as presented in Figure 53.
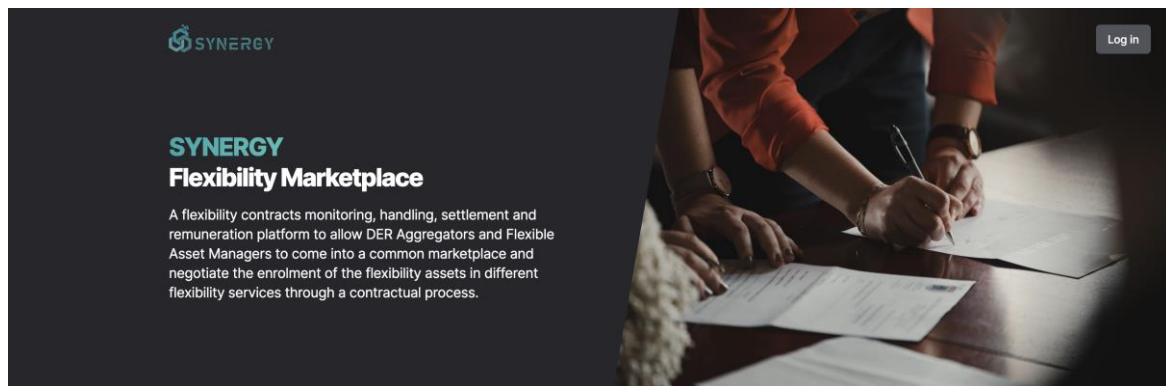
Figure 53: SYNERGY Flexibility Marketplace – Login Credentials

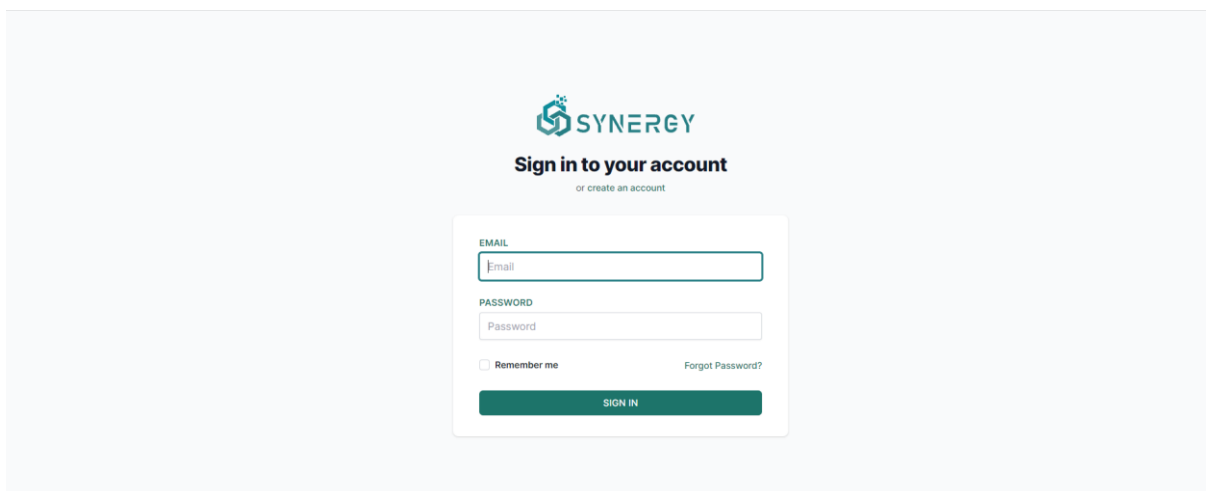At first, the authorization process applies where the end users of the application are prompted to provide credentials (single sign-on credentials as provided in the SYNERGY Platform - Figure 54).

Figure 54: SYNERGY Flexibility Marketplace – SSO Page

Once logged into the application, the user is prompted to provide the private key and wallet password for the Ethereum wallet that has been generated in the SYNERGY Platform in order to be able to proceed with any contract related action via the application as depicted in Figure 55.
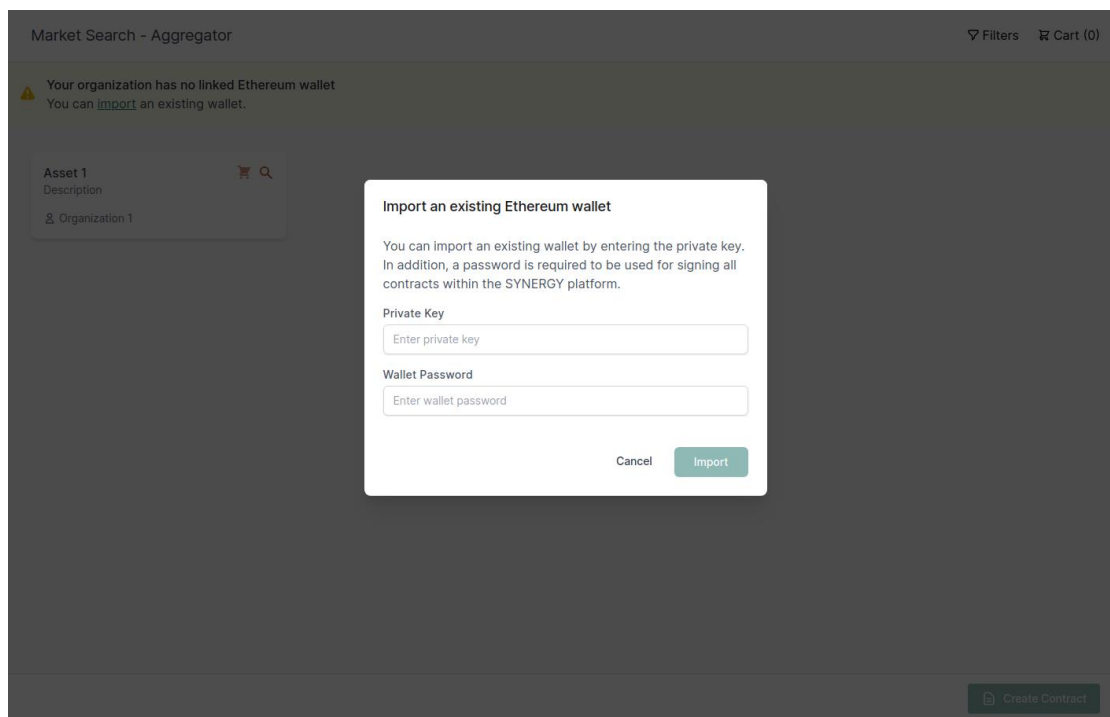
Figure 55: SYNERGY Flexibility Marketplace –Ethereum Password provision

5.2.2 Flexibility Marketplace Search

Once entering the application, the dedicated views per stakeholder are accessible. Starting with the flexible asset owner, the stakeholder of the application will get access on the list of flexible assets; that have been pre-configured to be visible in the flexibility marketplace. A filtering section is available to facilitate the owner to select the appropriate, multiple flexibility assets. Filtering criteria are available based on the type of the asset, the location, and different energy/flexibility related characteristics as depicted in the following Figure 56.
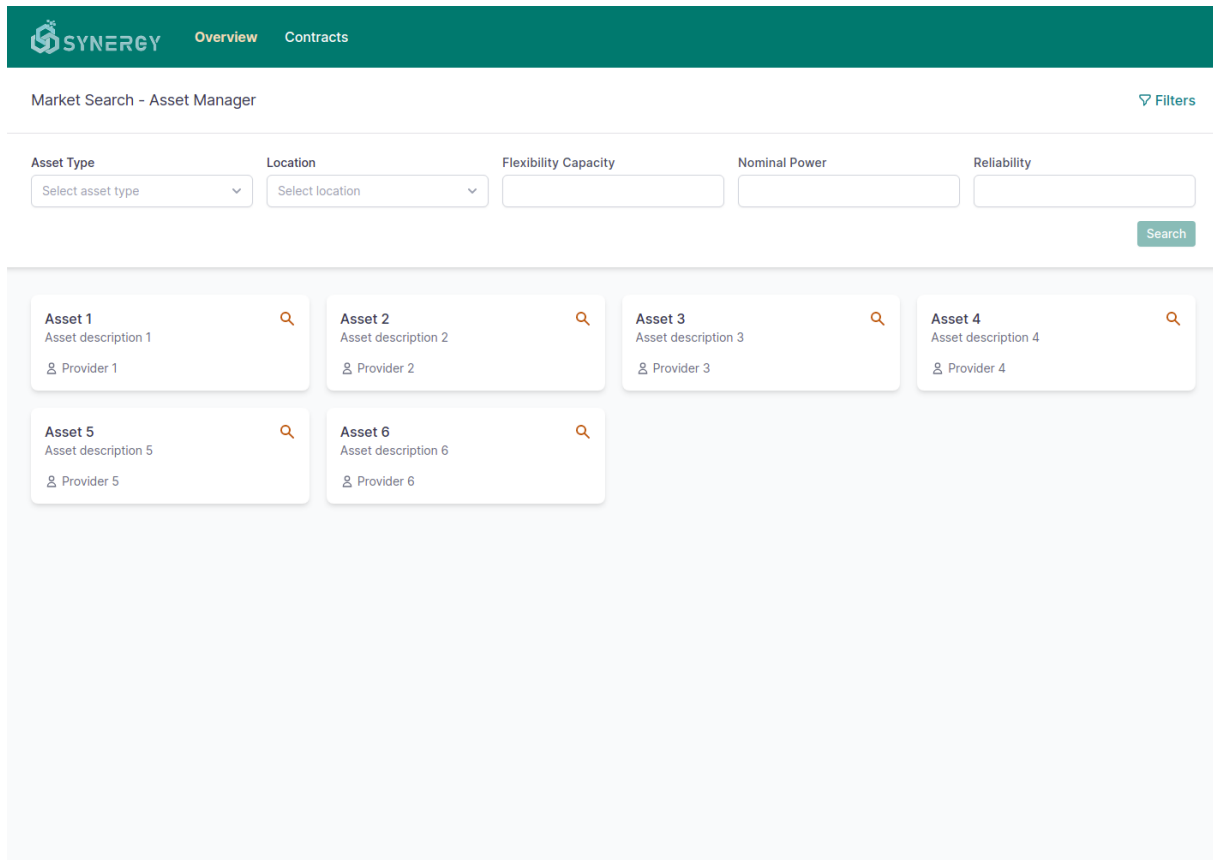
Figure 56: SYNERGY Flexibility Marketplace – Flexible Asset Manager Overview

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By selecting a specific asset, the flexible assets owner may receive details about the flexibility potential of this asset (Figure 57). In addition, the end user of the application has access on the marketplace configuration parameters where (s)he is prompted to set time schedules for the marketplace availability - Figure 58.
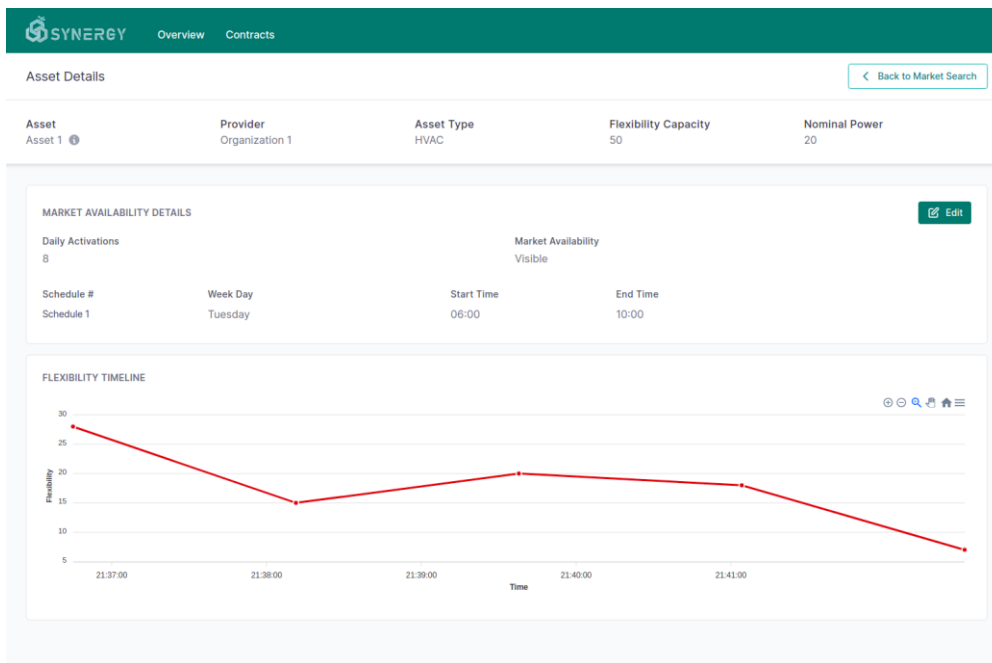
Figure 57: SYNERGY Flexibility Marketplace – Asset Manager – Asset Details
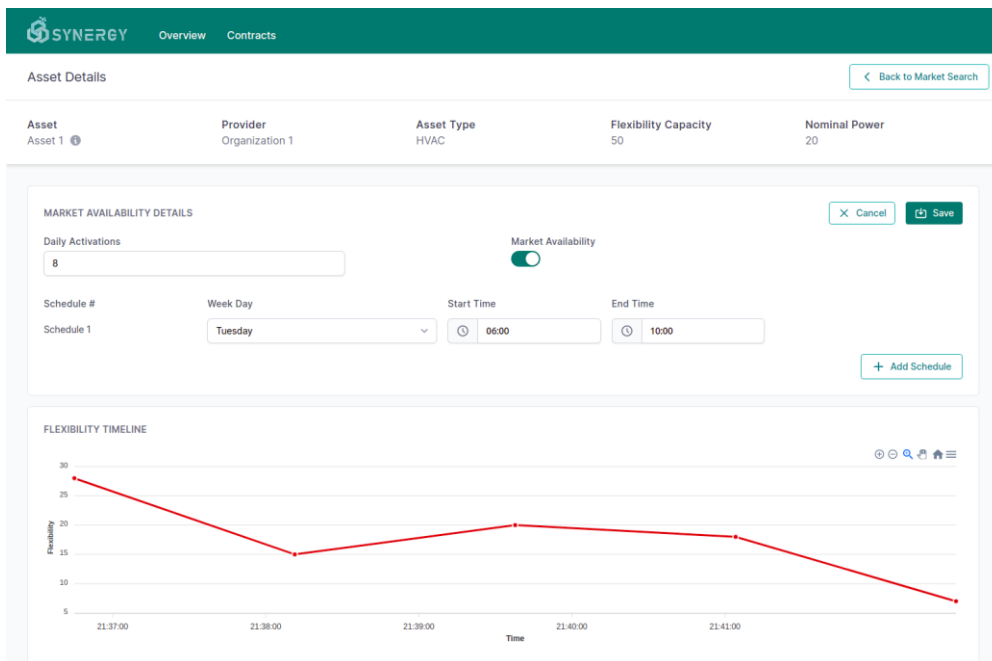
Figure 58: SYNERGY Flexibility Marketplace – Asset Manager – Marketplace Availability Settings

On the other side, the aggregator has access on the application and the overview of the assets configured to participate in the marketplace. By placing asset related criteria, (s)he gets a list of available assets that meet any organizational priorities as presented in Figure 59.
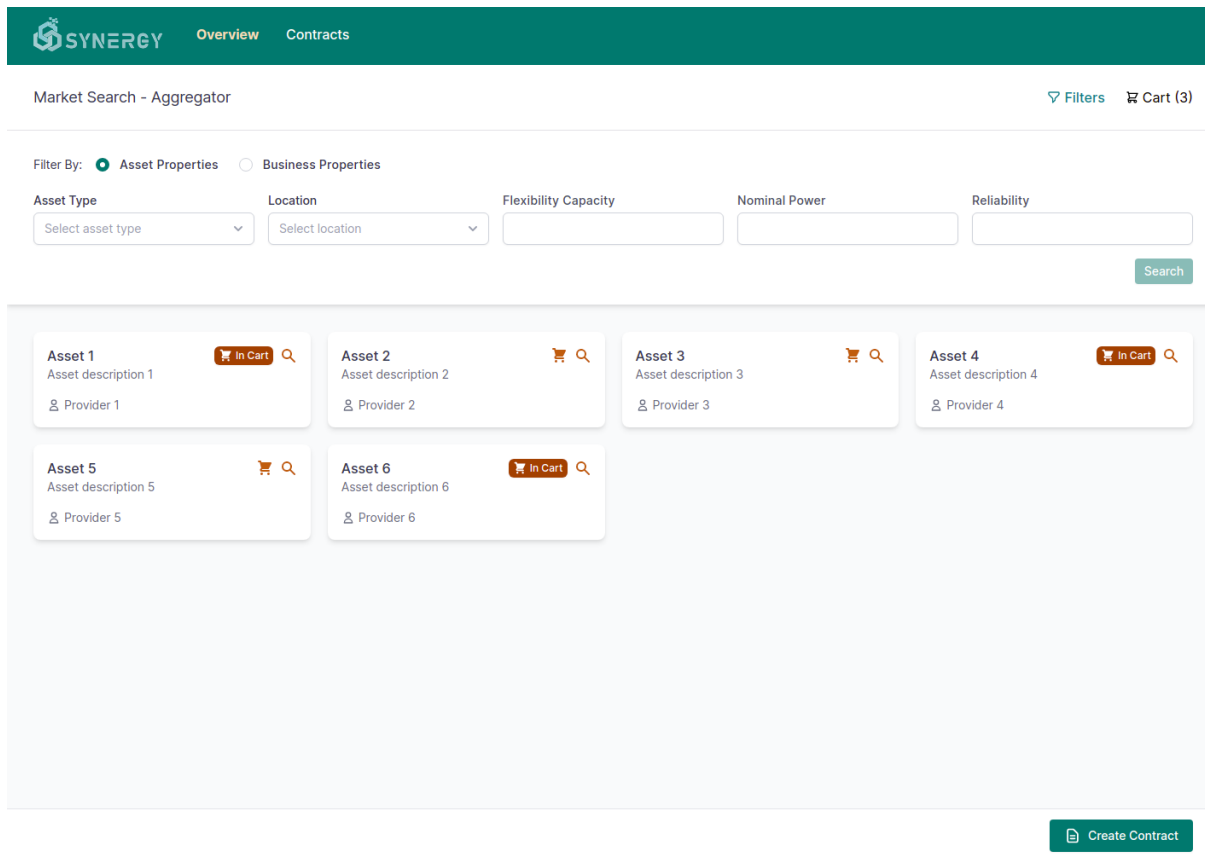
Figure 59: SYNERGY Flexibility Marketplace – Aggregator – Operational Settings

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Moreover, availability related criteria may be defined by the aggregator in order to filter assets that best fit to its business needs and preferences (Figure 60).
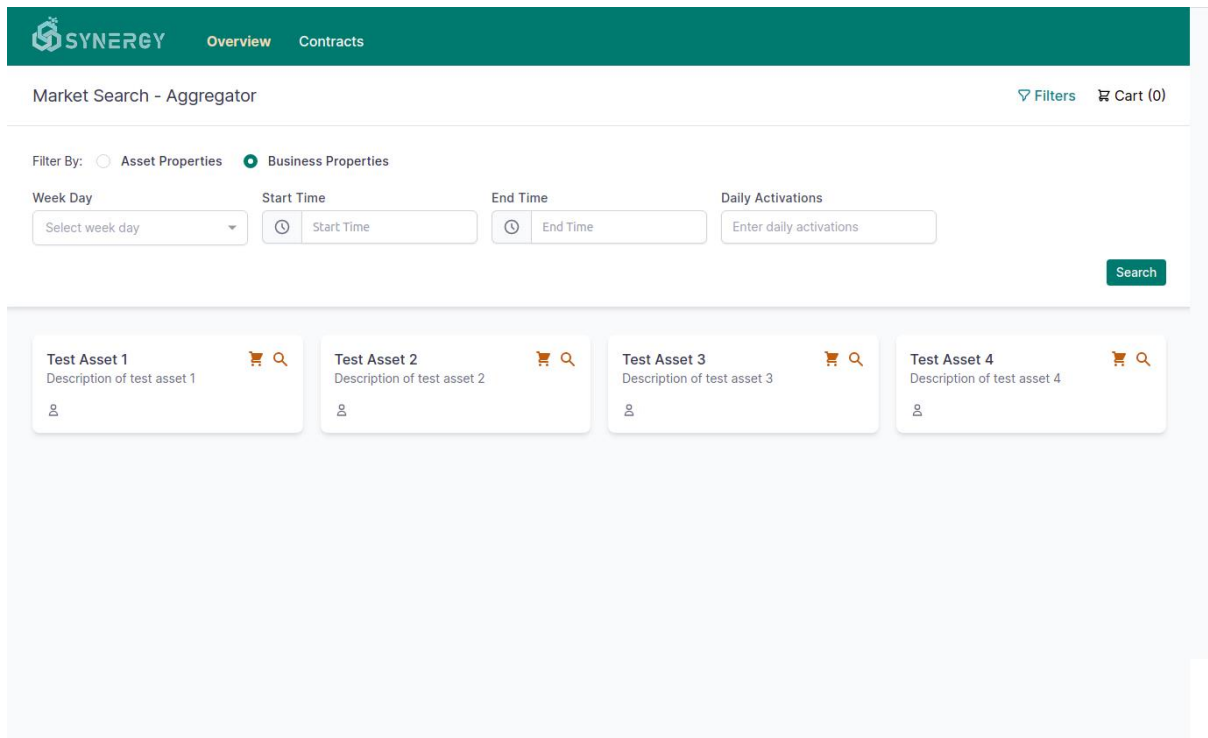
Figure 60: SYNERGY Flexibility Marketplace – Aggregator – Business Settings

Similar to the flexible asset manager, the aggregator may drill into the details of each asset getting insights about its nominal characteristics, flexibility related parameters as well as its market availability as depicted in Figure 61.
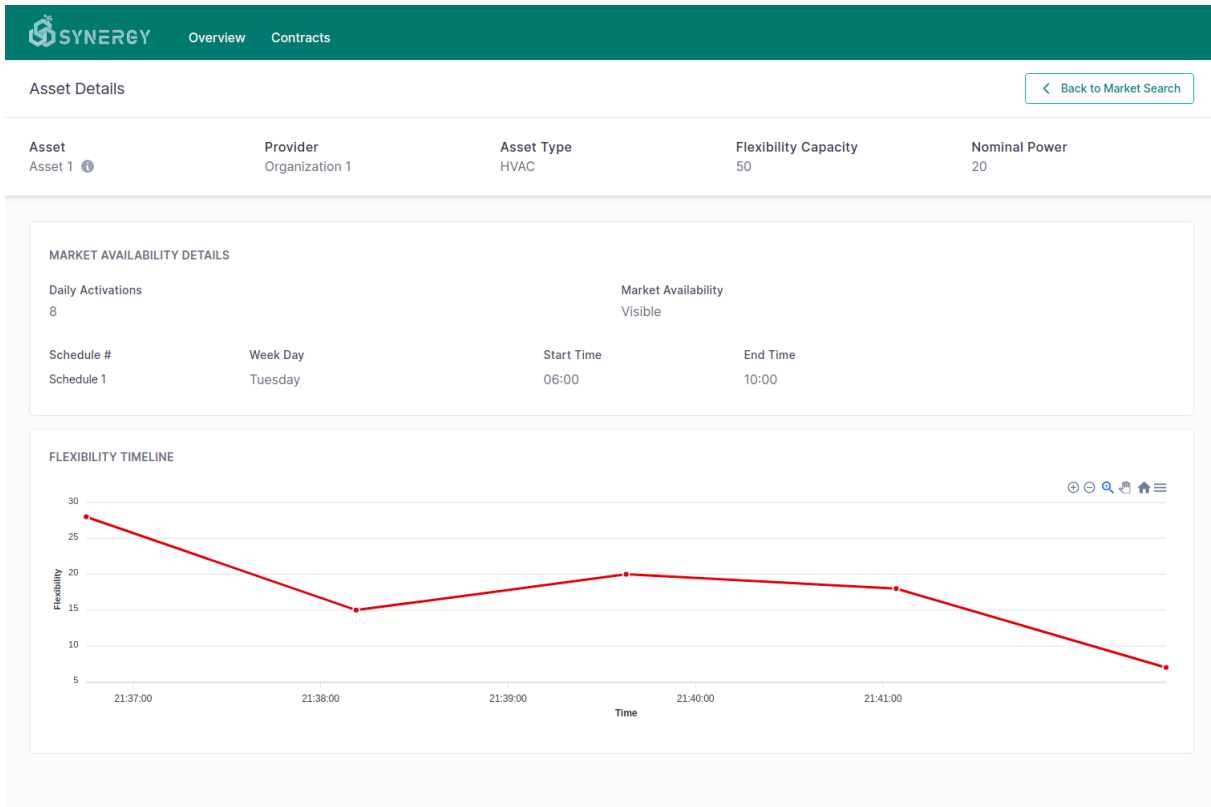
Figure 61: SYNERGY Flexibility Marketplace – Aggregator – Asset Details

5.2.3 Flexibility Marketplace Contracts Management

As a next step, the aggregator may select from the assets of interest for enrolment at a specific contractual offer. One or more assets may be added in the cart to set a group offer - Figure 62.
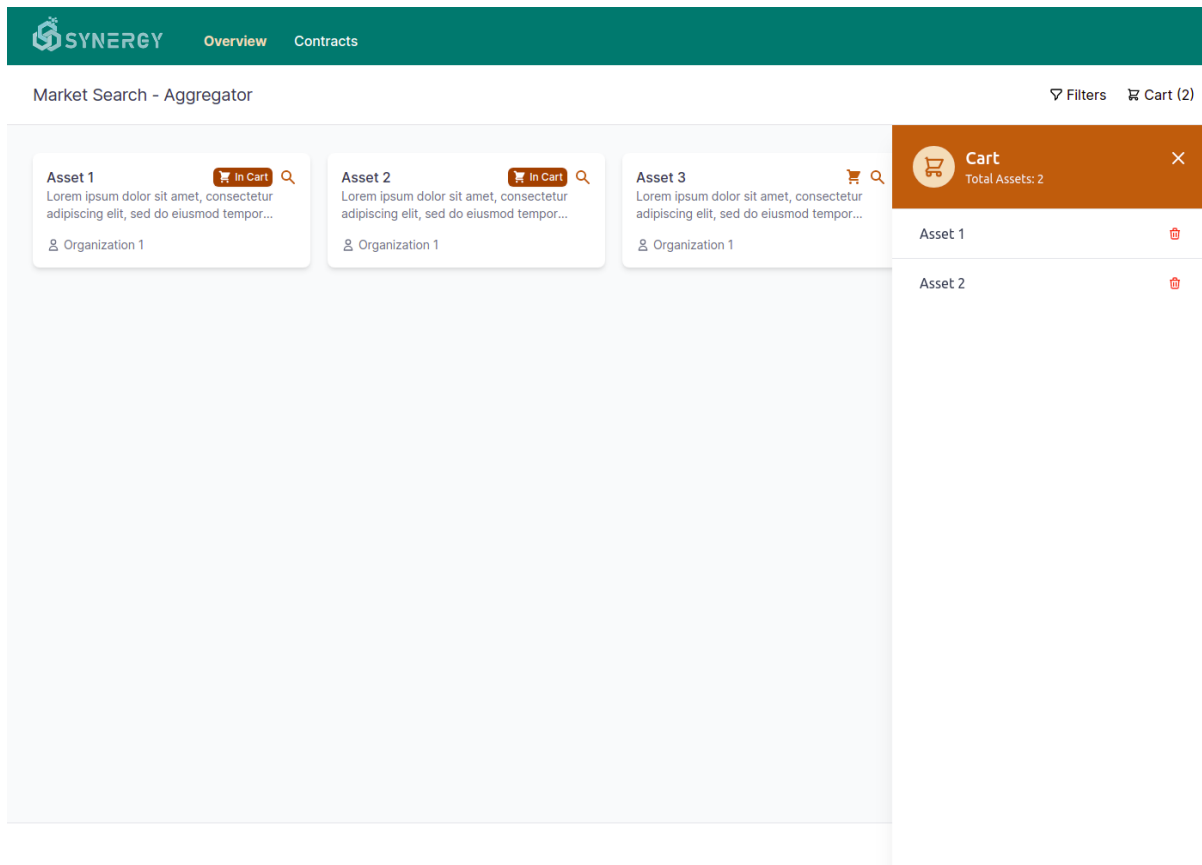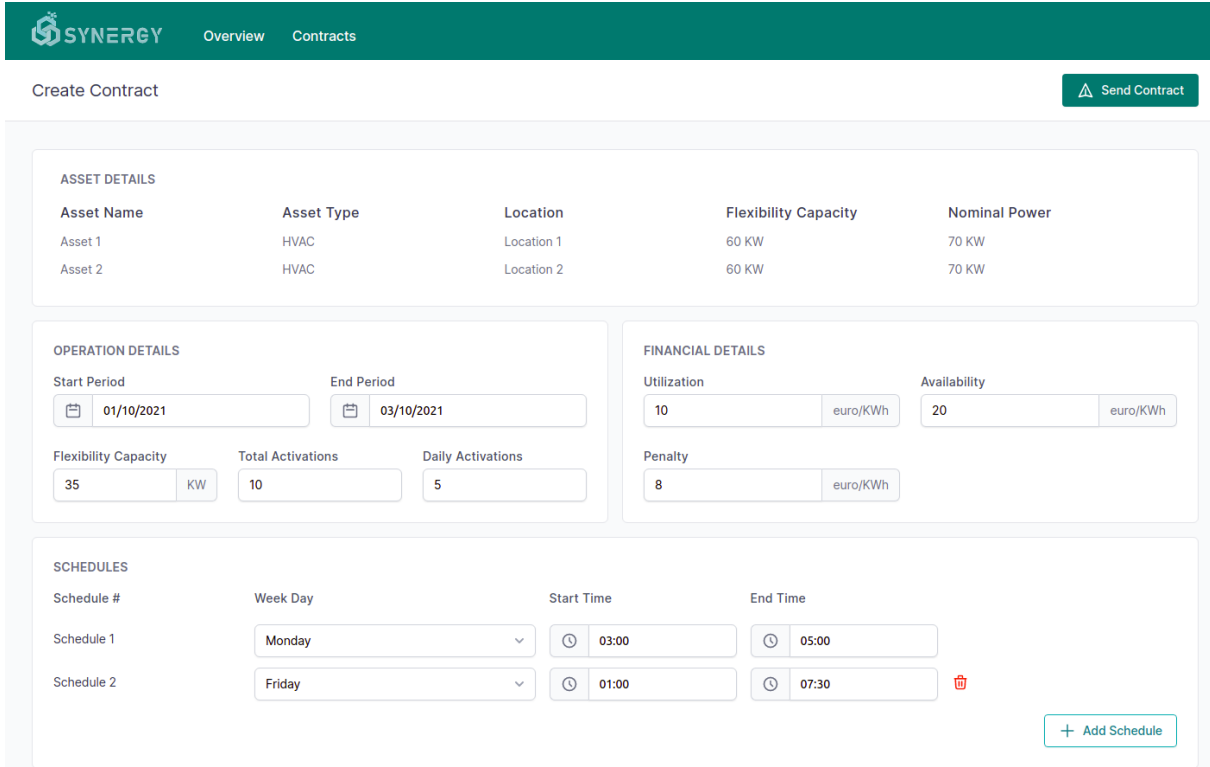
Figure 62: SYNERGY Flexibility Marketplace – Aggregator – Asset Cart

Then, by selecting the assets to enrol in a campaign, the user is prompted to specify the contract related values as part of the offer template. More specifically information about the duration of the contract, the availability of the assets during the contractual period as well as financial parameters are specified as in Figure 63.
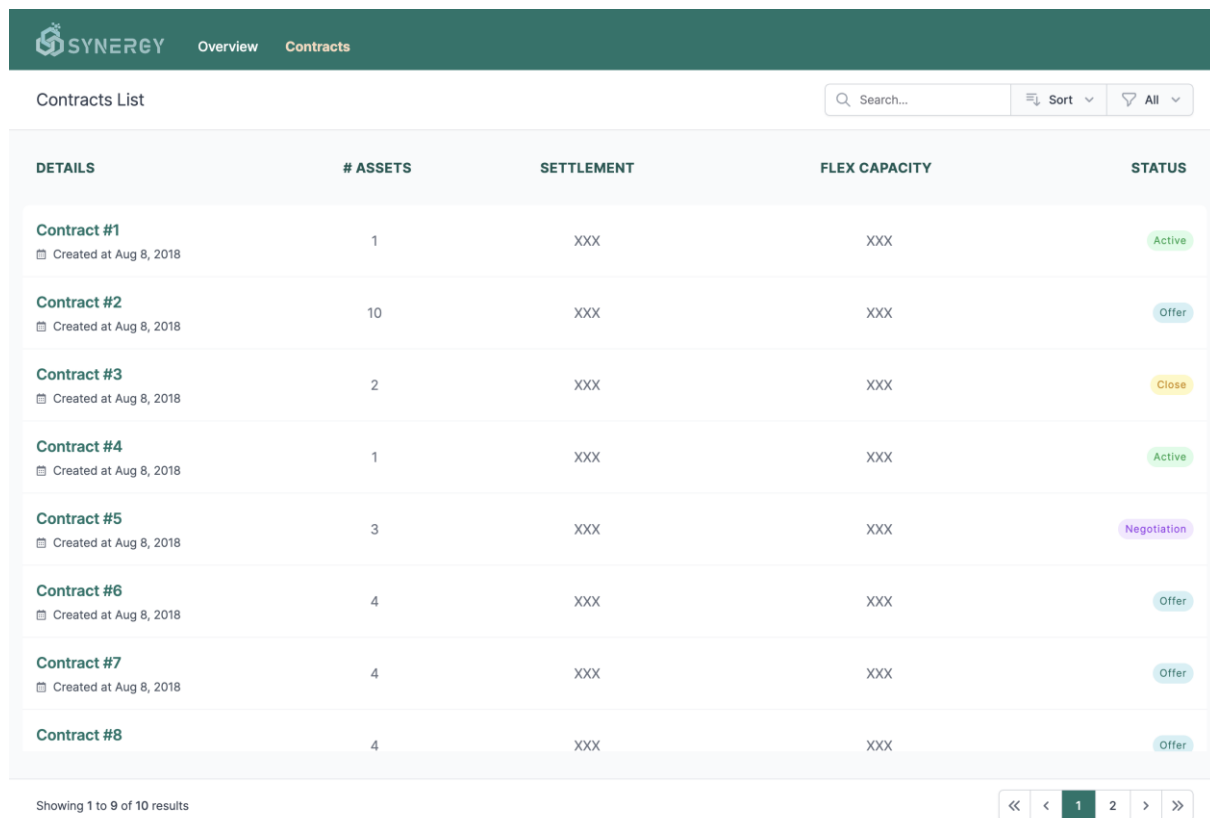
Figure 63: SYNERGY Flexibility Marketplace – Aggregator – Contract Offer

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Once the contractual offer is established, then the negotiation process starts. The flexible asset manager may access the list of available offers to get insights about the parameters of the new contractual offer as shown in Figure 64.
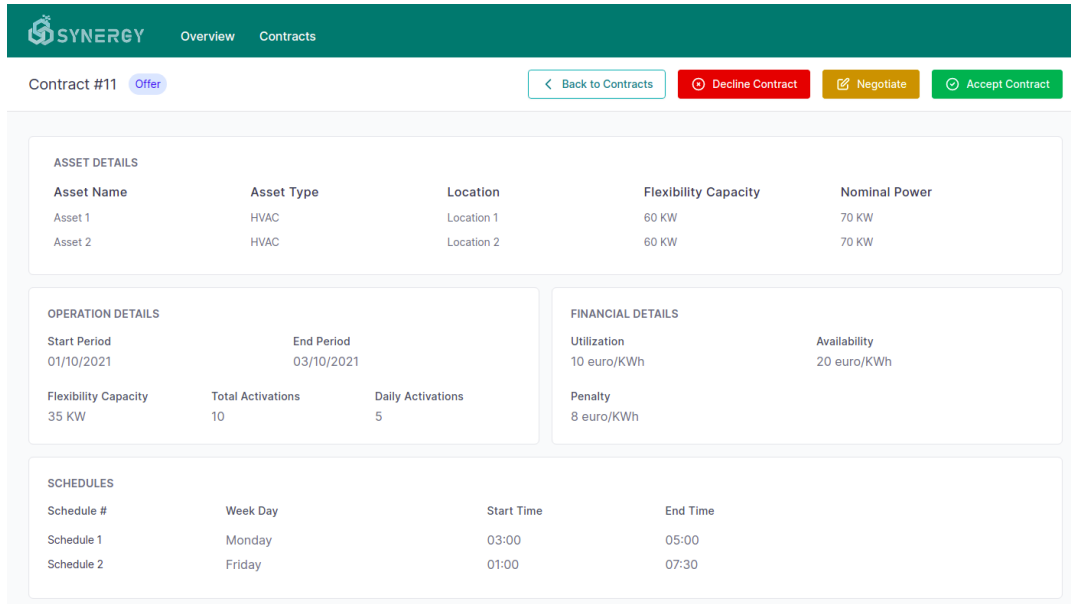
Figure 64: SYNERGY Flexibility Marketplace – List of Contracts

The user is prompted to review the contract offer terms and further accept, reject or negotiate specific terms - Figure 65.

Figure 65: SYNERGY Flexibility Marketplace – Aggregator – Contract Acceptance/ Rejection/ Negotiation

In case of acceptance or rejection, the negotiation process is over. In case of negotiation, updates over specific parameters apply and this counter offer is then available to the aggregator for negotiation (Figure 66).

Figure 66: SYNERGY Flexibility Marketplace – Negotiation Process

At any step of the process, any updates on the contractual parameters are registered into the blockchain, thus the business actor is prompt to provide the Ethereum wallet credentials - Figure 67.
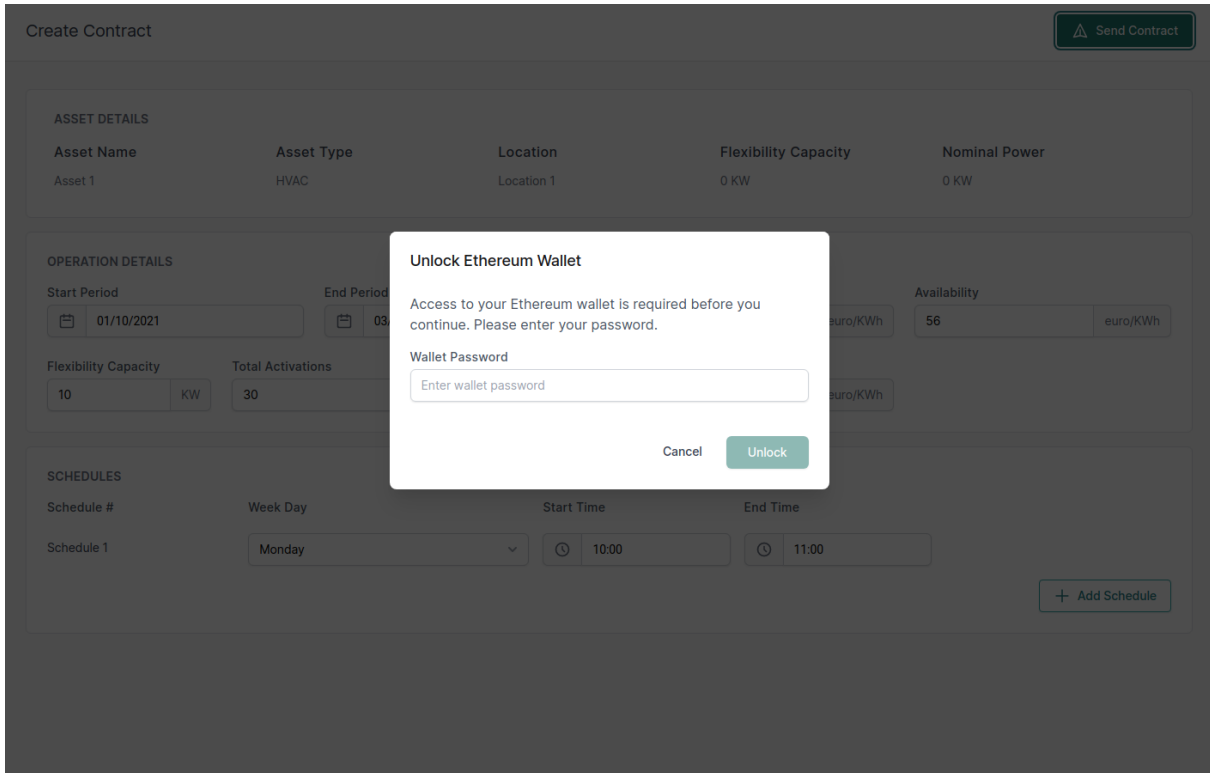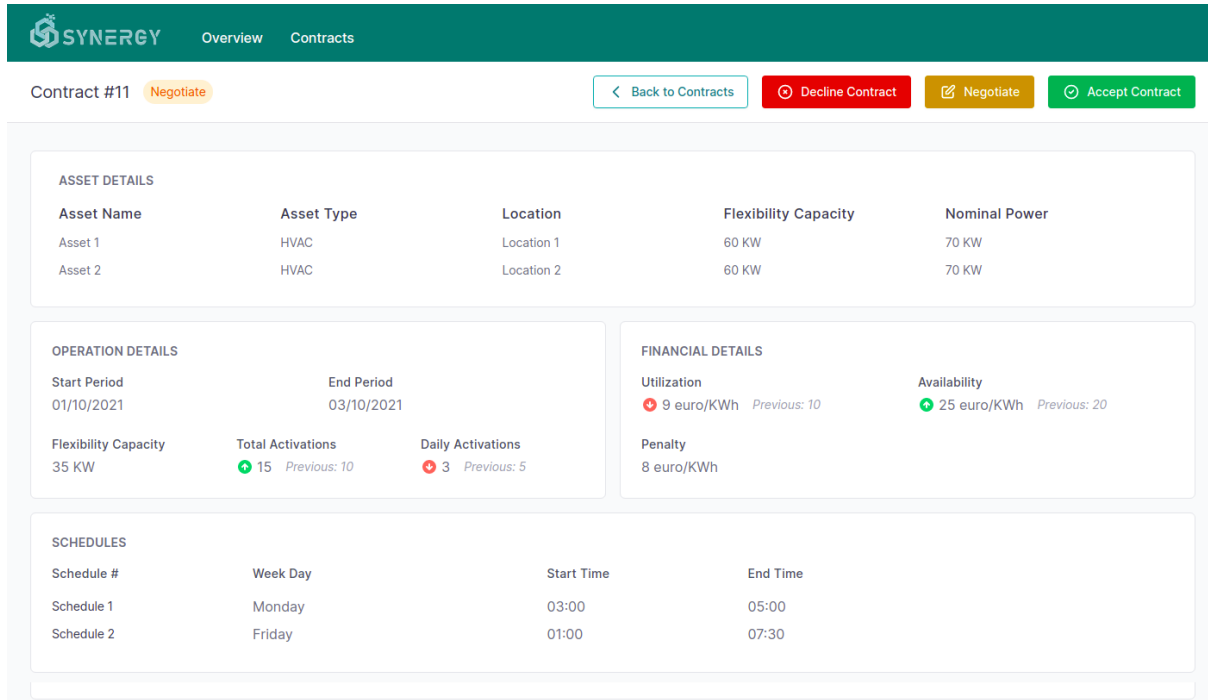

Figure 67: SYNERGY Flexibility Marketplace – Contract Registry Updates

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In addition, the updates on the contractual parameters are visible through the contract template in order to log the most recent modifications as presented in Figure 68.

Figure 68: SYNERGY Flexibility Marketplace – Contract Parameters Negotiation Updates

Also, once a contract has been signed, both actors may access it in the list of available contracts and download the contract parameters in a PDF file that follows a standardized template as depicted in the following Figure 69.

Figure 69: SYNERGY Flexibility Marketplace – Contract Template Download

5.2.4 Flexibility Marketplace Settlement and Remuneration

From the list of contracts, the business actor may select the settlement and remuneration tab in order to get insights about the performance of each contract/each asset of contract. A timeseries graph is provided highlighting: (a) the activation time for a flexibility request, (b) the flexibility order as triggered by the aggregator, and (c) the flexibility offered as calculated by the settlement component. We have to point out that the same visualization is available for both actors enrolled in the business process (aggregators and flexible assets managers) for transparency reasons as depicted in Figure 70.
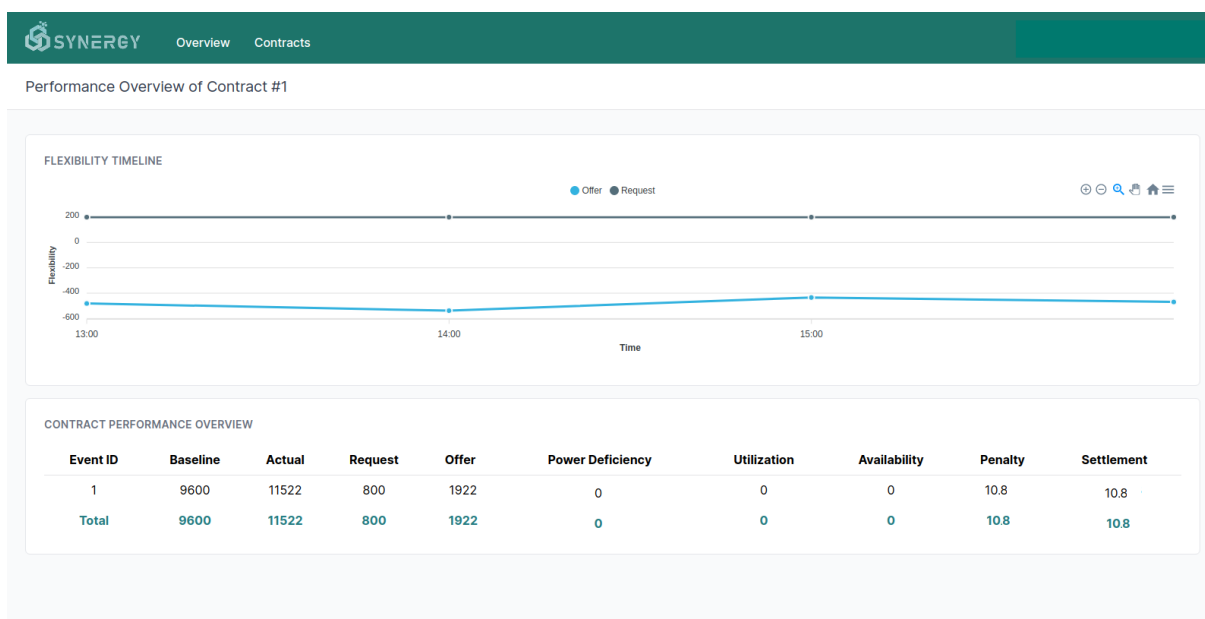
Figure 70: SYNERGY Flexibility Marketplace – Contracts Settlement Graph

In addition, a table is available, providing the details of the settlement process (per request and in total) for the contractual agreement. Along with the settlement information, information associated with the remuneration process (utilization, availability and penalty) is also accessible via the application.

5.3 Technology stack and implementation tools

In order to provide its intended functionalities, the DR Smart Contract Monitoring, Handling, Settlement and Remuneration Platform is built on state-of-the-art technologies, namely: (a) in the back-end layer, the Nest (NodeJS) web framework as a mature framework for delivering efficient, reliable and scalable server-side applications, (b) in the front-end layer, VueJS to present the results of

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the optimization process; (c) in the data storage layer, depending on the applicable data assets' licenses (that determine whether local storage will be eventually allowed), PostgreSQL (as the relational database for the management of the flexible assets and contracts related properties), Elasticsearch (as the indexing engine to facilitate efficient clustering and segmentation of data). On the other hand, the contract and settlement and remuneration results will be stored in the Ethereum blockchain, based on Truffle framework and set up in the SYNERGY Platform.

The detailed list of technologies used for the development of the DR Smart Contract Monitoring, Handling, Settlement and Remuneration Platform is presented in the following table.

Table 19: DR Smart Contract Monitoring, Handling, Settlement and Remuneration Platform - Technology stack

Library	Version	License	Purpose
Elasticsearch	7.10	Elastic License	Data Storage
PostgreSQL	12.2	PostgreSQL License (similar to BSD/MIT)	Data Storage
Nest NodeJS Web Framework	12	MIT License	Business Logic
Vue.js	2.6.11	MIT	User interface
TailwindCSS	1.9.0	MIT	User interface
Ethereum	1.9.24	LGPL-3.0 License	Blockchain
TypeORM	-	MIT	Business Logic
Flask	1.1.1	BSD 3-Clause	Business Logic
Flask RESTful extension	0.3.8	BSD 3-Clause	Business Logic
Flask CORS support	3.0.8	MIT	Business Logic
Vault	-	Mozilla Public License 2.0	Data Storage

5.4   API documentation

5.4.1   Integration with SYNERGY Platform via REST API

The datasets required for the functionality of the application are available from the SYNERGY Platform. In addition, the majority of the analytics required by the application have been configured as analytic workflows that are executed by the SYNERGY Platform. In order to access to the available datasets and the results of analytics, different data retrieval queries have been configured, all of them exposing specific REST endpoints. On the other hand, the datasets from the DR Smart Contract Monitoring,

Handling, Settlement and Remuneration Platform (contract details, settlement and remuneration details) are made available to the SYNERGY platform for further exploitation by 3rd party applications.

Table 20: DR Smart Contract Monitoring, Handling, Settlement and Remuneration Platform - Integration with SYNERGY Platform

Data Retrieval Query	Type	Implementer	Purpose
[DEV-WP6] – FLEX_ASSET - CONFIGURATION	HTTP GET	SYNERGY Platform	Flexible Asset configuration parameters.
[DEV-WP6] – FLEX_ASSET - PROFILE	HTTP GET	SYNERGY Platform	Flexible Asset flexibility profiling datasets.
[DEV-WP6] – FLEX_ASSET- FLEX_STRATEGIES	HTTP GET	SYNERGY Platform	Flexible Assets flexibility orders/strategies.
[DEV-WP6] – FLEX_ASSET- BASELINE	HTTP GET	SYNERGY Platform	Flexible Assets baseline energy profile data.
[DEV-WP6] – FLEX_ASSET- ENERGY--METER	HTTP GET	SYNERGY Platform	Flexible Assets actual metering data.
[DEV-WP6] – FLEX_ASSET- CONTRACT	HTTP POST	SYNERGY Platform	Flexible Asset contractual parameters.
[DEV-WP6] – FLEX_ASSET- SETTLE	HTTP POST	SYNERGY Platform	Flexible Asset flexibility settlement details.

Note: Also, authentication mechanisms to ensure that only authorized parties (DR Smart Contract Monitoring, Handling, Settlement and Remuneration Platform) are granted access are available in the SYNERGY Platform.

5.5 Installation instructions

All the components of the application have been packaged as a set of docker images. These docker images are available from a private repository at docker hub. This kind of packages facilitate the deployment in any platform supporting this technology (e.g., Kubernetes). Due to the nature of the software, being offered in the form of SaaS, no installation procedure is required by final users.

Table 21: DR Smart Contract Monitoring, Handling, Settlement and Remuneration Platform - Installation instructions

Image	Tag	Purpose
suite5/flexibility-contracts-app-backend	latest	The latest version of the DR Smart Contract Monitoring, Handling, Settlement and Remuneration Platform backend
suite5/flexibility-contracts-app-frontend	latest	The latest version of the DR Smart Contract Monitoring, Handling, Settlement and Remuneration Platform front end
suite5/flexibility-contracts-app-search	latest	The latest version of the DR Smart Contract Monitoring, Handling, Settlement and Remuneration Platform search feature

5.6   Assumptions and restrictions

The overall functionality of the DR Smart Contract Monitoring, Handling, Settlement and Remuneration Platform relies on the datasets and services provided by the SYNERGY Platform, specifically in the features related to data ingestion and data analytics.

In order to be able to use the application, following configuration steps need to be taken for every new aggregator that wishes to integrate with the DR Smart Contract Monitoring, Handling, Settlement and Remuneration Platform:

- Aggregators are required to be registered as users of the SYNERGY Platform.

- Flexible asset owners are required to be registered as users of the SYNERGY Platform.

- DR Smart Contract Monitoring, Handling, Settlement and Remuneration Platform is required to configure the necessary data check-in jobs, so required datasets get accessible through the platform.

- DR Smart Contract Monitoring, Handling, Settlement and Remuneration Platform manager to grant access over specific datasets to the application manager, so these datasets to be incorporated to the application workflows, by signing the appropriate contracts within the SYNERGY Platform.

- Application manager configures the pre-processing steps – which ensures that existing datasets are transformed from the SYNERGY CIM to meet a common data model required for the execution of the analytics services by the application.

5.7   Licensing and access

The licensing and IPR of each component that consist of the DR Smart Contract Monitoring, Handling, Settlement and Remuneration Platform are provided in the following table.

Table 22: DR Smart Contract Monitoring, Handling, Settlement and Remuneration Platform - Licensing Details

Component	Licensing details
Flexibility Marketplace Search Engine	Suite5 is the owner of all intellectual property rights of this component. All rights are reserved.
Flexibility Contracts Manager	Suite5 is the owner of all intellectual property rights of this component. All rights are reserved.
Flexibility Settlement & Remuneration	Suite5 is the owner of all intellectual property rights of this component. All rights are reserved.
Blockchain Wallet Component	Suite5 is the owner of all intellectual property rights of this component. All rights are reserved.

A demo version of the application is accessible at https://flexibility-contracts.synergy-bigdata.eu[4].

5.8   Planned features for next release

In the following, a summary of the planned features for the next release of the DR Smart Contract Monitoring, Handling, Settlement and Remuneration Platform (planned for M24) is provided:

- Implement feature FCM_4 – Aggregators and prosumers to receive notifications about the status of the contractual process – as part of the *DR Smart Contract Monitoring, Handling, Settlement and Remuneration Platform.*

- Finalize feature FSR_1 – Flexibility Settlement on the basis of an accurate Performance Measurement and Verification Process – by testing and deploying the Performance Measurement and Verification Mechanism.

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[4] Demo credentials are available on request

6 Conclusions

Deliverable D6.2, entitled "1st Version of the EaaS Tool Suite for Energy Retailers and Aggregators", consists on the release of the first version of the applications composing this tool suite and this companion report providing an overview of the current status of development, technical details and planned features for the next release, has been internally scheduled by M24 (prior to the start of the first demo run of the demo cases).

In general terms, the foreseen milestones with regards to the development of the applications along the lifetime of the project include:

- Release of stable version of the applications, ready for the demonstration phase, by M24,

- Continuous evaluation, feedback retrieval and implementation of enhancements along the execution of the first phase of the demonstration (M24 to M33),

- Support and bug fixing during the execution of the second phase of the demonstration (M34 to M42).

The work on the applications will continue along the project implementation and progress will be reported in the next WP6 report, D6.3 "Final Version of the EaaS Tool Suite for Energy Retailers and Aggregators", due to M42. This next deliverable will accompany the release of the final version of the applications, delivered together with the corresponding documentation.

7 References

[1] SYNERGY Consortium, «D3.4 SYNERGY Integrated Platform & Open APIs - Beta Release».

[2] SYNERGY Consortium, «D3.1 SYNERGY Common Information Model».

[3] SYNERGY Consortium, «D4.2 SYNERGY Baseline Data Analytics - Draft Release».

[4] SYNERGY Consortium, «D6.1 Detailed functionality specification and design of the EaaS Tool Suite for Energy Retailers and Aggregators».

[5] SYNERGY Consortium, «SYNERGY GA - ANNEX 1,» 2019.