BD4OPEM

Big Data for OPen innovation Energy Marketplace

Deliverable 7.4
Pilot 3 – Turkish pilot description and results

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Abbreviations and Acronyms

Acronym	Description
AC	Alternative Current
AMR	Automatic Meter Reading
AST2 / AST	Transformer name codes in Field 1
ASM	A Java based Module / Framework
BESS	Battery Energy Storage System
BRP	Balance Responsible Party
CHP	Combined Heat and Power Plant /System
DAM	Day-ahead market
DC	Direct current
DSO	Distribution System Operator
EV	Electric Vehicle
EMS	Energy Management System
ESS	Energy Storage System
GIS	Geographical Information System
KPI	Key performance Indicator
LV	Low Voltage (level)
MV	Medium Voltage (level)
MDMS	Meter Data Management System
OPF	Optimal Power flow
P2P	Peer to Peer (Energy Trading)
PCS	Power convertion system / two way inverter
PQ	Power quality
PV	Photo voltaic (Panel)
RES	Renewable energy Sources
SGAT	Transformer name codes in Field 1
Tx	Task x
TBYK	Transformer name codes in Field 1
TSO	Transmission System Operator
UC	Use Case
UPS	Uninterruptable power Supply

Acronym	Description
V2G	Vehicle to Grid
WPx	Work Package x

1 Executive summary

This deliverable document all the work performed within Task 7.4 (T7.4), related to the Turkish demonstration site (Pilot 3) of the BD4OPEM project. It follows the methodology of implementation described in Deliverable 7.1 (D7.1) "Large Scale pilots' methodology" [1]

The services implemented in this pilot are the following:

Service ID	Name of service (name of approach when relevant)	Service developer
S1.3	Predictive maintenance in electrical power systems (Predictive maintenance applied to smart meters)	JSI
S1.3	Predictive maintenance in electrical power systems (Multiple asset maintenance schedule prediction in critical grids)	VUB
S3.1	Grid disturbance simulations (Congestions forecast for day ahead)	UPC
S3.1	Grid disturbance simulations (P1-related disturbances)	JSI
S5.1	Flexibility forecast (UPC approach)	UPC
S5.1	Flexibility forecast (JSI approach)	JSI
S5.2	Flexibility aggregated services for BRPs	UPC
S5.3	Flexibility aggregated services for DSOs (Flexibility-based AC OPF)	UPC
S5.3	Flexibility aggregated services for DSOs (Flexibility services for DSOs based on neural networks)	JSI
S7.1	P2P trading	ATOS
S8.1	Asset and investment planning	UPC
S8.2	Asset estimation optimization for microgrid	VUB

First, each service is presented succinctly and the use cases (UCs) are being reminded, based on Work Package 4 (WP4) inputs. The results of each service implemented in this pilot are then shown, but those results may vary in terms of quality, depending on the quality of data collected on the pilot site. This is why a data quality assessment has also been performed in order to bring insight and explanation on why those results were found.

2 Introduction

2.1 Purpose and intended audience

The BD4OPEM project aims to design, develop, and deploy a Marketplace in order to provide innovative energy services for the reliable operation of the smart grid. These energy services will be provided through a marketplace, acting as an open, modular data analysis toolbox and facilitating data exchange and advanced usage. In this way, the data coming from the diverse energy domain sources will be put at the disposal of advanced energy service developers through a marketplace.

The main objective of WP7 is to oversee the implementation and demonstration of the services developed in the previous WPs. Through this implementation, the aim is to prove two points:

- That the tools developed are compliant with the given objectives and, if not, analyse and identify the reason for the difference and provide recommendations about the tool optimization to reach better results.
- That the Marketplace platform and the Analytics toolbox permits flexibility, replicability, and scalability of the services between data providers and service users with adapted features.

Overall, this work package consists in providing the input for the analysis of the impact of the whole system developed during BD4OPEM project and giving recommendation to optimise its use and management. It is as well the opportunity to gather feedbacks from different demonstration sites and their respective leaders upon the platform, the services, and the customer experience.

This document describes the results of the implementation of the services for the Turkish demonstration site. The main audience of this document is:

- WP7 partners themselves, to know the results of the project for the Turkish demonstration site
- WP9 partners for the description of the processes and methodology which can be used in the latter exploitation of the platform.
- Future data providers or service users that want to interface with the BD4OPEM platform.
- Future algorithm developers or service providers that want to propose their own services to OEDAS.

2.2 Relationship with other BD4OPEM tasks

This deliverable is related to different tasks within the BD4OPEM project:

- T7.1, Pilot Methodology and preparation of large-scale pilots, as this implementation is a first demonstration of the methodology described in this task.
- T7.2, T7.3, T7.5, as they are similar tasks.
- T7.6, in which the results of each demonstration site are tested and validated
- WP9, which will be able to use the results of each demonstration site for exploitation and replication purposes.

2.3 Structure

This document is divided into three main sections:

- The final description of the demonstration site, with the global perimeter, the specifics of the pilot and a recap table of the services implemented in this demonstration
- The services results for this demonstration site, with a reminder of the use cases, a data assessment and the services implementation conclusions
- A monitoring of project KPIs

Then a final part will conclude with lessons learned from the pilot and from the service developers' perspectives.

Finally two annexes will detail the storylines of each service as well as the results of services testing in the Marketplace.

3 Final description of the Turkish demonstration site

3.1 Global perimeter

The Turkish pilot in BD4OPEM project is OEDAŞ, Osmangazi Elektrik Dağıtım A.Ş. [2] which is one of the 21 DSOs in Turkey. It is the second Distribution System Operator (DSO) of Turkey with highest photovoltaic (PV) penetration. In total, 2.79 million people living in 5 provinces are energised with OEDAŞ distribution services.

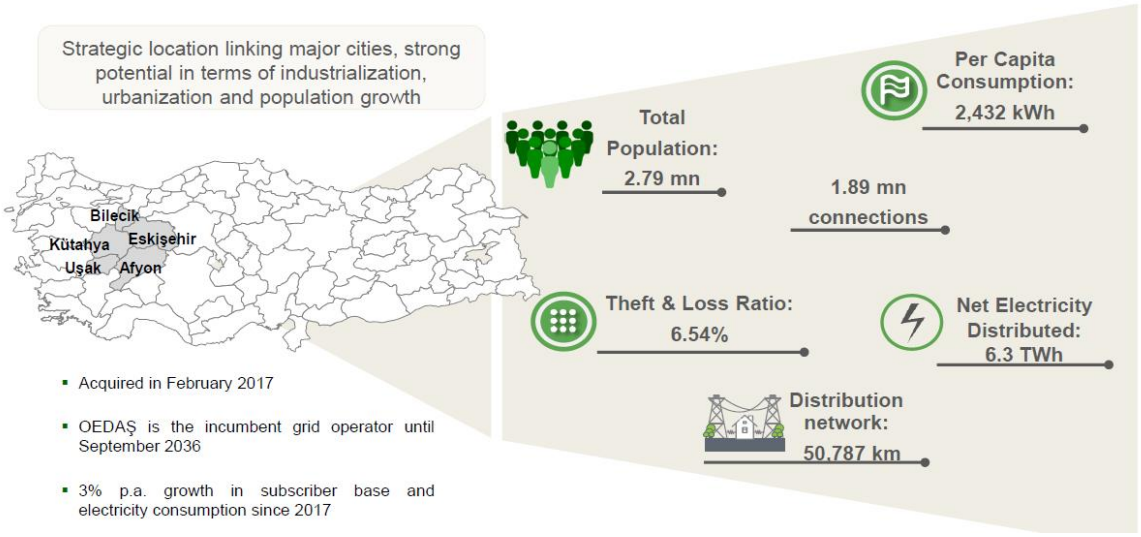

Figure 1: OEDAŞ Company Overview

For most of the services OEDAŞ will use this Medium Voltage (MV) Feeder Pilot area with 11 Substations in Filed 1 (see Figure 2) and 1 Low Voltage (LV) Transformer area as seen in Figure 3 and Figure 5

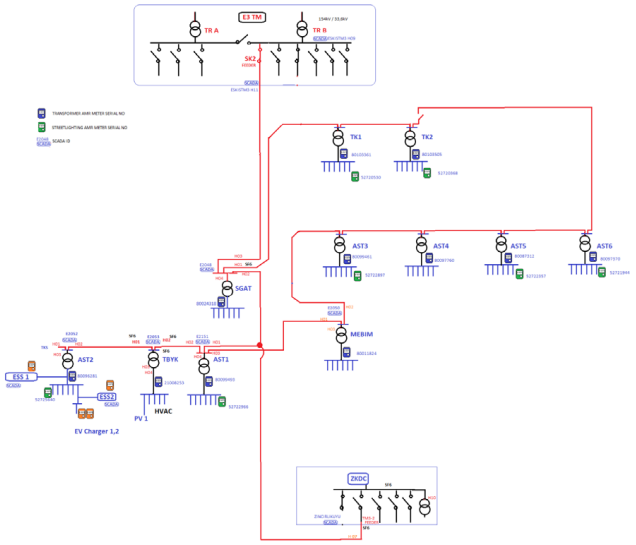

Figure 2: Single Line Diagram of OEDAŞ demonstration site Field 1

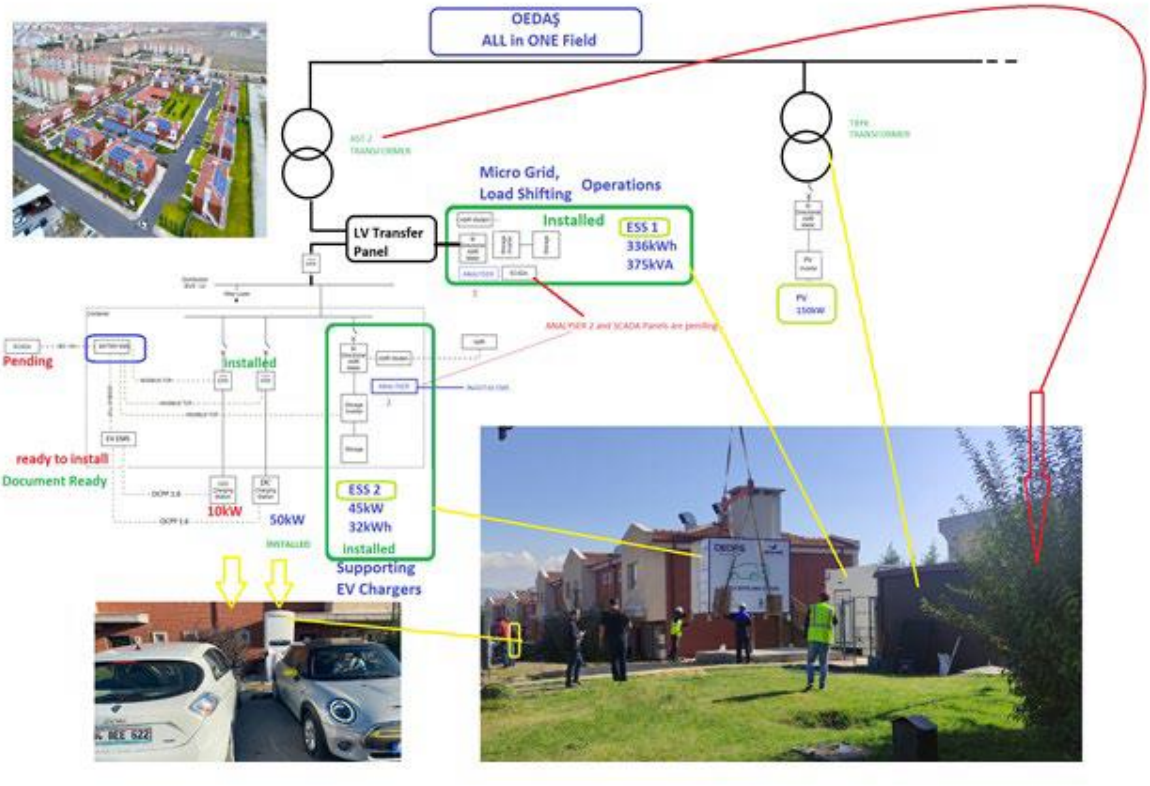

Figure 3: Description of the LV Demonstration site of Field 1

You can see the PV Penetration area in MV level of Field 2 at Figure 4 below,

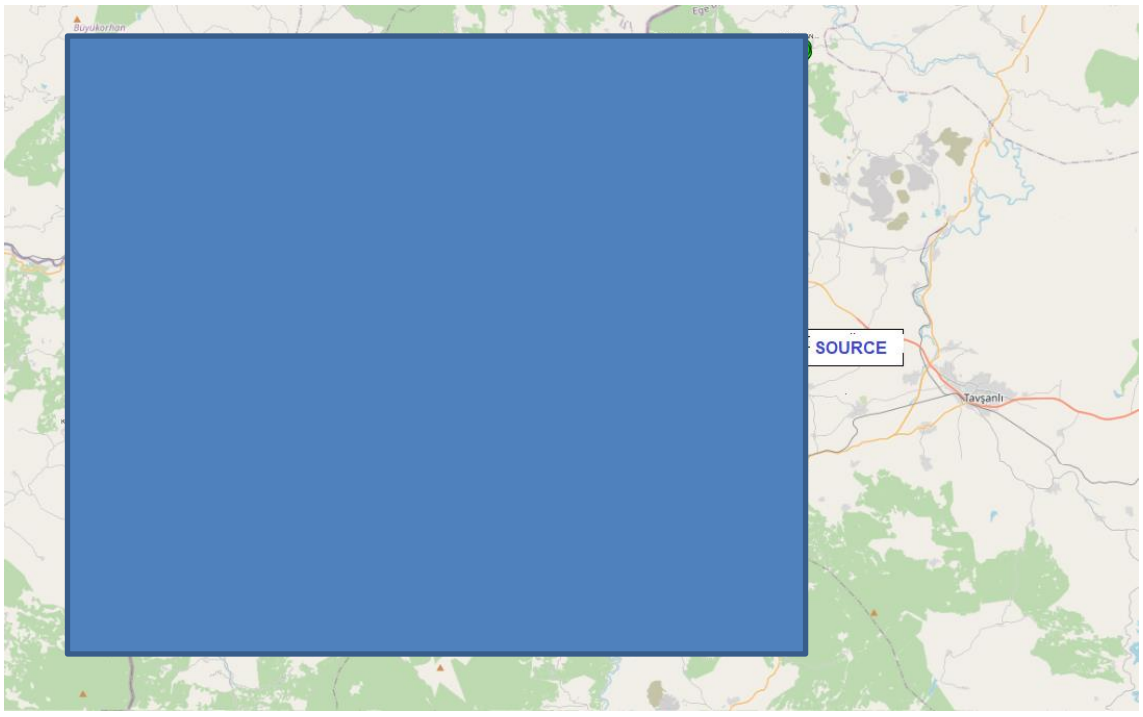

Figure 4: Field 2 PV Penetration area with voltage disturbances

3.2 Specifics of the pilots (update from D7.1)

Data Sources

The LV demonstration site is composed of (see Figure 5):

Figure 5: GIS screen of LV transformer area in Field 1

- The "AST2" Transformer and "TBYK" photovoltaic (PV) power plant's Transformer,
- Energy Storage System ESS1(375kW 336kWh) with off-grid and load shifting capability,
- ESS2 (45kW 32kWh) supporting Electric Vehicle (EV) Chargers Load,
- 50kW Direct Current (DC) EV Charger and 10kW Vehicle to Grid (V2G) EV Charger.

Because of legal requirements OEDAŞ tried to use middleware solution to share the limited part of the OEDAŞ's original data sets of internal services (AMR, EMS, GIS, etc.) of assets. OEDAŞ provided (Geographical Information System) GIS data, NAR/Aril Automatic Meter Reading (AMR) Systems Metering data of Transformers and street lighting.
Data collection development from Inavitas Energy Management system (EMS) was in progress as well as Analyser and Flexible assets analyser data integration (to get some measurements such as consumption, production etc.). But finally this data was manually downloaded and shared with related partners by using a data lake. Figure 6 is a view of the dashboard interface of Inavitas EMS analyser reading system.

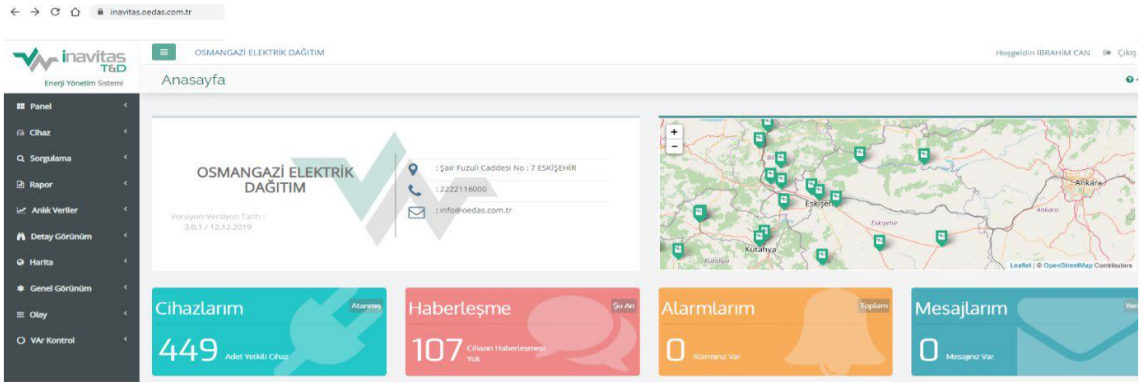

Figure 6: EMS Screen

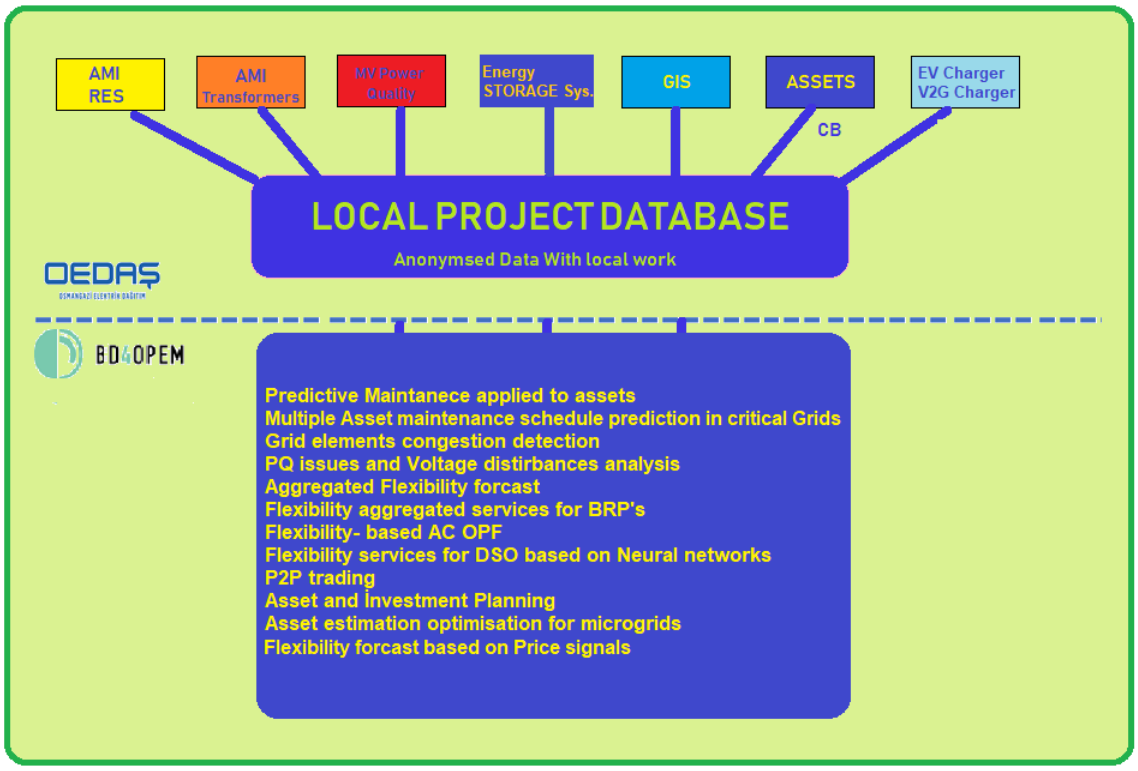

Figure 7: OEDAŞ Data Sources

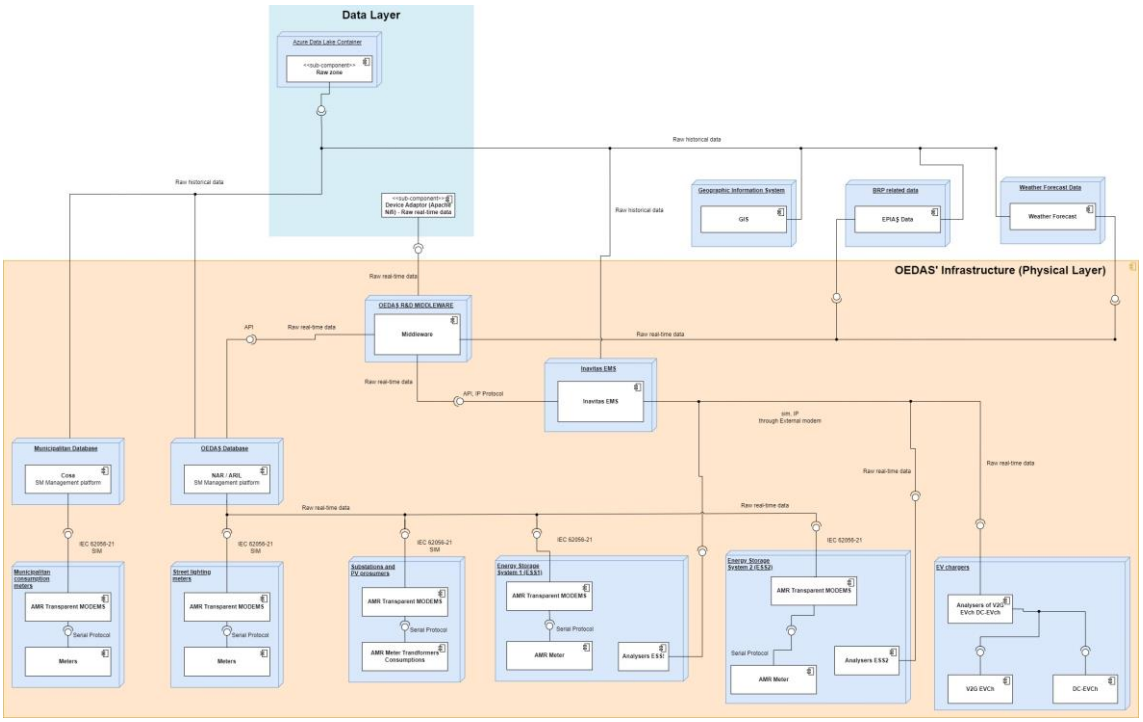

Figure 8: BD4OPEM architecture – Physical layer OEDAS (Pilot Turkey)

For more information about the physical layer and its integration in the BD4OPEM architecture, please refer to D2.4 [3]

3.3 Recap table of services to be implemented

During the project timeline OEDAŞ decided to be ready for future problems with the help of services in Table 1 according to data availability.

Table 1: OEDAŞ BD4OPEM Services

Service ID	Name	Algorithm Developer
S1.3	Predictive maintenance in electrical power systems	JSI
S1.3	Predictive maintenance in electrical power systems	VUB
S3.1	Grid disturbance simulations	UPC
S3.1	Grid disturbance simulations	JSI
S5.1	Flexibility Forecast	UPC
S5.1	Flexibility Forecast	JSI
S5.2	Flexibility aggregated services for BRPs	UPC
S5.3	Flexibility aggregated services for DSOs	UPC
S5.3	Flexibility aggregated services for DSOs	JSI
S7.1	P2P trading	ATOS
S8.1	Asset and investment planning	UPC
S8.2	Asset estimation optimization for microgrids	VUB

4 Services results for the Turkish demonstration site

4.1 S1.3 – Predictive maintenance in electrical power systems results

4.1.1 JSI approach: Predictive maintenance applied to smart meters

4.1.1.1 Introduction of the service

Name: Predictive maintenance in electrical power systems
Category: Operation and maintenance
Task: T4.1
Location on the grid: LV grid

The service results are presented in a document accessible through the service results web page as explained in the previous Section. The results table of the content is presented in Figure 9. The report is split into six main sections, namely Introduction, Input data overview, Classification model, Classification results, Conclusions and Service documentation. The Introduction provides a brief introduction into the service while the documentation section provides brief documentation about the service usage.

4.1.1.2 Data assessment

The data needed depends on the equipment maintained. In Table 2 is provided an example for data AMR Transformer Meter and Feeder Analysers.

Table 2: Data assessment table for S1.3.

Data source needed	BD4OPEM Ontology	Data quality assessment	Impact of the quality on the service
AMR metering historical management	Smart meter	Adequate	High
Feeder Analyser measurements	Performance measurements	Available	High
Weather parameters	Weather measurements	Available	High
Failure times and reason	Failure data	Not adequate	High

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Predictive maintenance service

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Figure 9: Report of the results

The following data has been provided for the service:

- Transformer station AST2 profile for a period of almost 2 years
- Feeder data for a period of almost 2 years
- Weather data for the same period
- Failure data for the circuit breaker in the same period

Site layout

In the Figure 10 below the site layout is presented. We can see the transformer station AST2 denoted with yellow hexagon to which additional two transformers are connected, TBYK and AST1. Through the transformer SGAT, the SK2 feeder, denoted as well with the yellow hexagon, is connected. The two network equipment are monitored through the SCADA system.

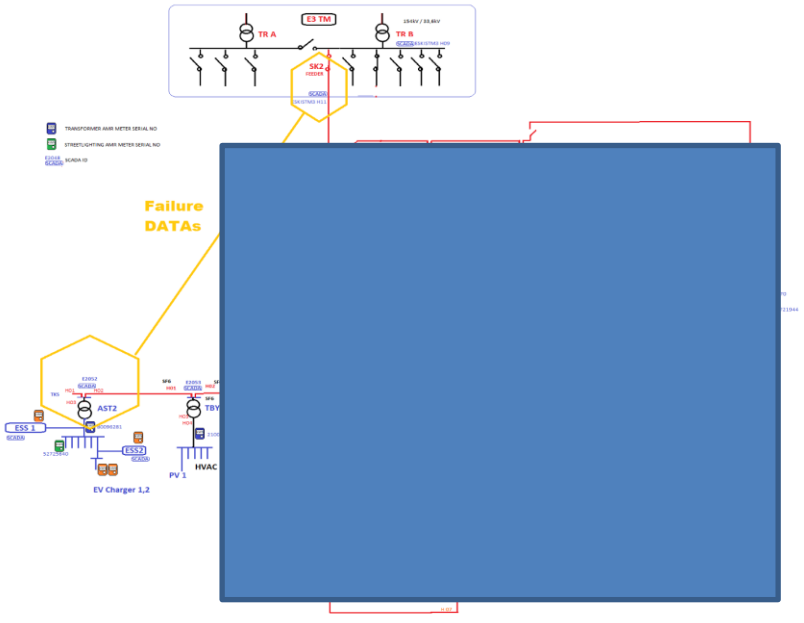


Figure 10: Failures in Filed 1 Single Line Diagram

Failures

In the figure below three failures in the network are collected. Two failures are related to the AST2 transformer circuit breakers and the third to the circuit breaker SK2. See Figure 10.The times of the break are reported exactly.

Failure Code NO	Grid Asset	Failure reason	Failure Start	Failure Finish	Energy Cut off point	Layer	Failure Reasun	Location	Failure Duration (min)	İstasyon	Cell of Station
10419866	1030540865-Circuit Breaker	Temporary Failure	06.11.2020 16:42:00	06.11.2020 16:46:03	1030540865	CB	CB Cut off	AST2 Transformer	4	TOKI SOGUTONU	TR1 GELIS
10436496	1000716862-Circuit Breaker	Temporary Failure	20.12.2020 12:09:28	20.12.2020 12:43:28	1000716862	CB	CB Cut off	E3 TM SK2 Feeder	34	ESKISEHIR TM 3	SAKARYA 2
10626910	1030540865-Circuit Breaker	Temporary Failure	17.11.2021 18:35:19	17.11.2021 19:36:37	1030540865	CB	CB Cut off	AST2 Transformer	61	TOKI SOGUTONU	TR KORUMA HUCRESI

Figure 11 Failure data set

AST2 profile data

In the Figure 12 below the transformer ASK2 profile is shown. The time span and the measured quantity are reported in the plot title. It can be seen that the pattern of consumption has changed significantly in the beginning of the year 2020, after April that year the consumption seems to be regular. According to the failures as were reported in the previous section the data at the time of failures is available.

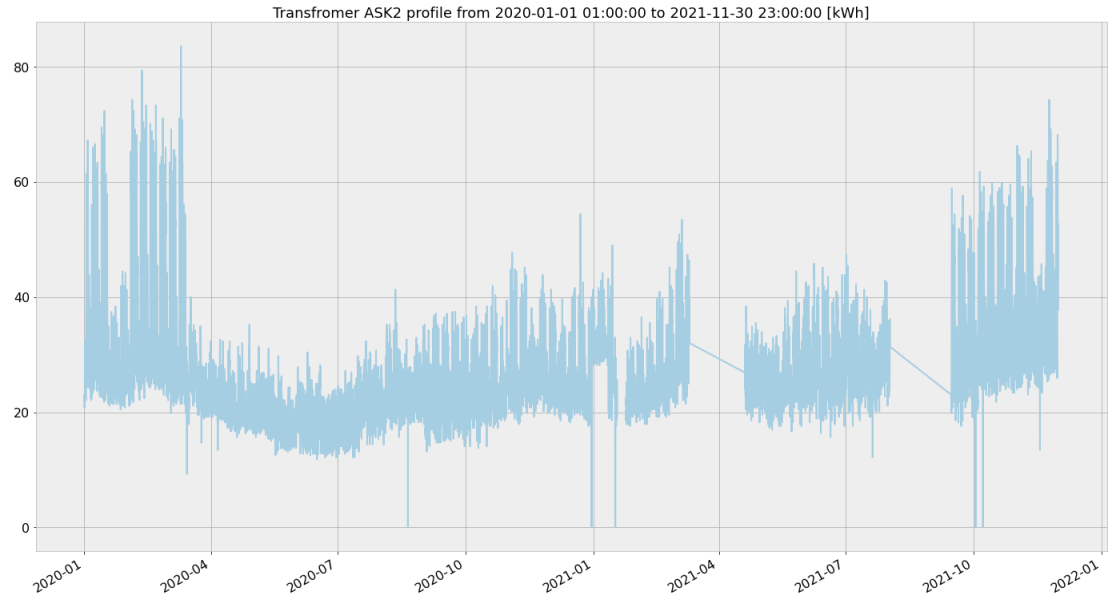


Figure 12: AST2 Transformers Profile

Feeder measurement data

The feeder data is more extensive, containing more information about the consumption at the feeder. The data provides currents and voltages for all three phases and active and reactive power for consumption and production. The data is presented below in the table.

time	CB_Ia	CB_Ib	CB_Ic	CB_MVArh-plus	CB_MVArh-minus	CB_MWh-plus	CB_MWh-minus	CB_Vab	CB_Vbc	CB_V
2020-01-01 00:00:00	261.449	259.697	258.794	0.0	0.979	14.657	0.0	35.467	35.508	35.2
2020-01-01 00:15:00	256.027	254.795	252.262	NaN	NaN	NaN	NaN	35.014	35.061	34.8
2020-01-01 00:30:00	252.287	251.129	249.126	NaN	NaN	NaN	NaN	35.013	35.054	34.8
2020-01-01 00:45:00	249.235	248.512	245.634	NaN	NaN	NaN	NaN	35.014	35.045	34.9
2020-01-01 01:00:00	245.448	244.328	241.178	0.0	1.172	14.502	0.0	35.106	35.156	34.8
...	...	...	...	...	...	...	...	...	...	
2021-12-31 22:45:00	16.373	16.470	16.938	NaN	NaN	NaN	NaN	35.477	35.501	35.2
2021-12-31 23:00:00	16.542	16.794	17.055	0.0	0.416	0.928	0.0	35.437	35.466	35.2
2021-12-31 23:15:00	16.597	16.640	17.120	NaN	NaN	NaN	NaN	35.447	35.484	35.2
2021-12-31 23:30:00	16.341	16.496	16.770	NaN	NaN	NaN	NaN	35.532	35.555	35.3
2021-12-31 23:45:00	16.318	16.379	16.473	NaN	NaN	NaN	NaN	35.629	35.639	35.4

70176 rows × 10 columns

Figure 13 SK2 Feeders Circuit breaker's Measurement Data Set

Below the power production and generation at the feeder is presented. It can be seen that the consumption has drastically changed in late October 2020. The consumption after this time seems regular. The regular data covers all three failures.

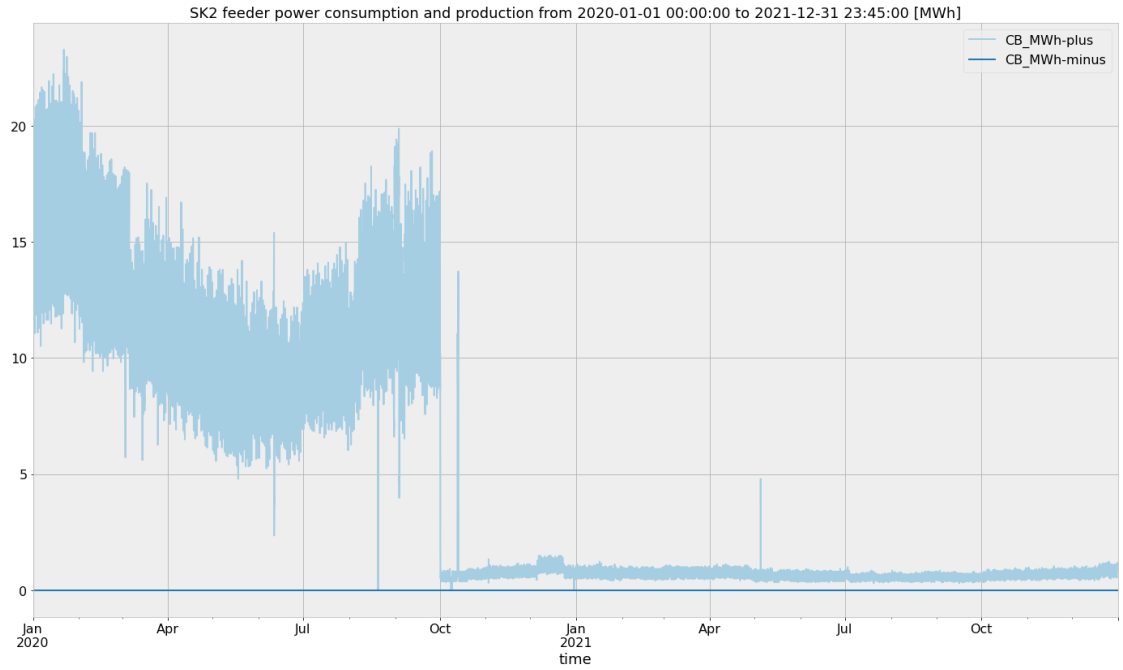


Figure 14: SK2 Feeder's Power Consumption

Weather data

The weather data is from the same region as the transformer station and the feeder. The most important weather parameters are the following:

- sealevelpressure,
- temperature,
- precipitation,
- snowfraction,
- winddirection,
- windspeed,
- relativehumidity,
- gni_backwards: direct radiation.

The temperature profile is presented in Figure 15.

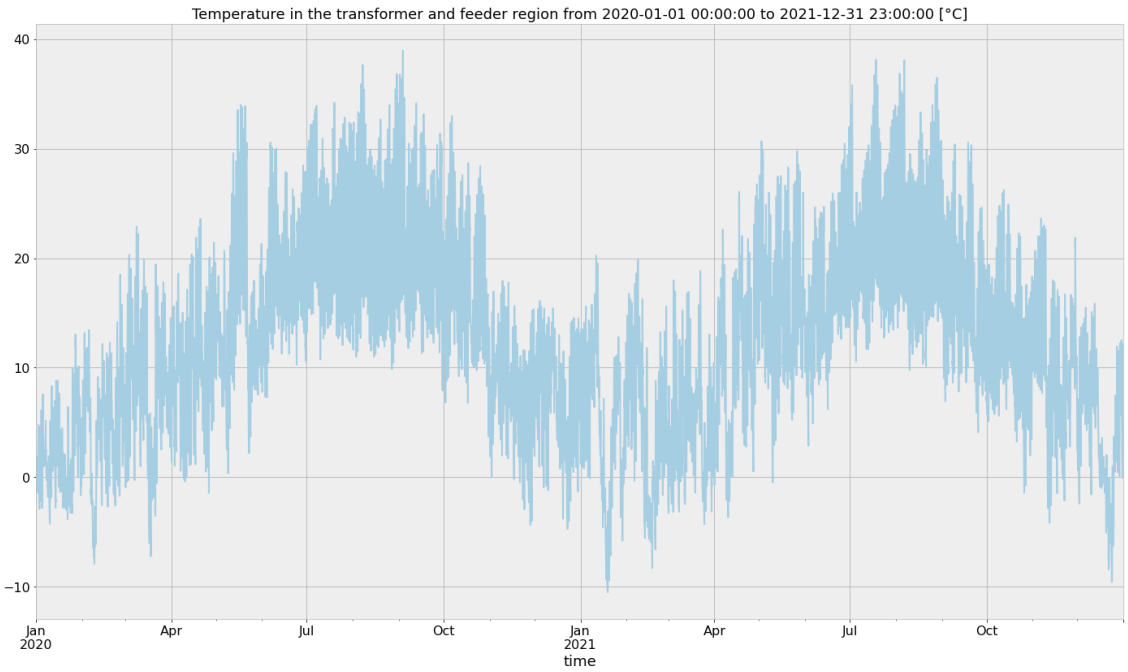


Figure 15: Temperature of the Field 1

Table 3: Use case table for S1.3.

Use case	Description
UC1	Use classification and prediction of the grid related equipment state to detect possible future failures of the equipment

4.1.1.3 Use Case 1

The classification model has been prepared on the data available. Since there were only three failures recorded, all three failures have been addressed as a single case based on similar data. The data for the second failure at SK2 circuit breaker is different and richer as it for at the first and third case. All three cases have been analysed together with a combination of both datasets, the profile obtained at the ASK2 transformer station and the data obtained at SK2 circuit breaker.

The model has been based on the following data:

- the profile at the AST2 transformer station
- the profile at SK2 circuit breaker
- the weather data and the variables measured as explained in weather data section.

The model has been prepared based on daily features in the dataset. The features have been extracted in the same manner from both profiles, from each measured variable, and from all considered weather variables. All in all, the extraction resulted in 731 days, each day with 325 extracted features from 11 electrical and 7 weather variables. The days with NaNs have been dropped, resulting in 597 available days with full data.

The features considered were basic statistics like mean, standard deviation, variance, min and max value, skewness and median, extended with autocorrelation, correlations between the variables, number of peaks, peak width, correlation with a cylinder function of variable width, etc. A small example of features is provided below:

```
Index(['TR_consumption-sum', 'TR_consumption-mean', 'TR_consumption-median',
       'TR_consumption-std', 'TR_consumption-var', 'TR_consumption-min',
       'TR_consumption-max', 'TR_consumption-skew', 'TR_consumption-0.25',
       'TR_consumption-0.5',
       ...
       'CB_Vca-number_of_peaks', 'CB_Vca-shannon_entropy',
       'CB_Vca-corr-sealevelpressure', 'CB_Vca-corr-temperature',
       'CB_Vca-corr-precipitation', 'CB_Vca-corr-snowfraction',
       'CB_Vca-corr-winddirection', 'CB_Vca-corr-windspeed',
       'CB_Vca-corr-relativehumidity', 'CB_Vca-corr-gni_backwards'],
      dtype='object', length=325)
```

The target was a simple vector of 0's on the days without failures and 1's on a day with a failure. All in all, the model has three days with failure. During the modelling we made sure that all the target days have a full set of features with no NaNs.

Validation of the model

Since the target group is very limited a spicy Leave-One-Out cross-validator with XGBoost Classifier is used for the dataset validation. The average score of the cross-validation is very high, almost 0.995. Accuracy reports a proportion of correct predictions (both true positives and true negatives) among the total number of cases examined. In general, such high score is a good indicator that the model can be used for potential future failure cases analysis. The caveat of the analysis is a potential overfitting and misleading results when there is high imbalance between the observed classes, as is in our case between days without failures and days with a failure.

Average Score: 0.9949748743718593

Classification results

One of the most important results of classification with this little number of failures is better understanding which features lead to good classification. The XGBoost

framework provides insights into features importance through three type of feature importance:

- **importance per cover**: A high cover value means that the feature is used in splits that affect a large number of instances. This can be important when the dataset is imbalanced or when you're interested in the model's performance across a diverse set of samples
- **importance per weights**: A higher weight implies that a feature is used more frequently in making splits in the trees, and thus is considered more important for the model's decisions. However, this doesn't account for the effectiveness of these splits,
- **importance per gains**: A higher gain means that a feature, on average, better contributes to the model by creating more informative splits, or by reducing impurity. This is often considered a more meaningful metric than weight, as it takes into account the quality of the splits.

Understanding the features and their importance can lead to better detection of potential dates and conditions in these dates that could lead to failures.

XGBClassifier(base_score=None, booster=None, callbacks=None,
colsample_bylevel=None, colsample_bynode=None,
colsample_bytree=None, device=None, early_stopping_rounds=None,
enable_categorical=False, eval_metric='mlogloss',
feature_types=None, gamma=None, grow_policy=None,
importance_type=None, interaction_constraints=None,
learning_rate=None, max_bin=None, max_cat_threshold=None,
max_cat_to_onehot=None, max_delta_step=None, max_depth=None,
max_leaves=None, min_child_weight=None, missing=nan,
monotone_constraints=None, multi_strategy=None, n_estimators=None,
n_jobs=None, num_parallel_tree=None, random_state=None, ...)

The importance per gains provides meaningful information on which features are most important in building a decision tree and for the splits in the tree. The top five features are the following:

- CB_MVArh-minus-max_conv_10: convolution between reactive power consumed at the circuit breaker and 10 hour cycling signal
- CB_MWh-plus-max_conv_12: convolution between power consumed at the circuit breaker and 12 hours cylindric signal
- CB_MVArh-minus-above_mean: the sum of reactive power consumptions above the mean in a day
- TR_consumption-autocorr: autocorrelation of a transformer station power consumption
- CB_Ia-pct_change: sum of a pandas pct_change(), the function is used to compute the percentage change between the current and a prior element in a DataFrame or Series computed for phase A current

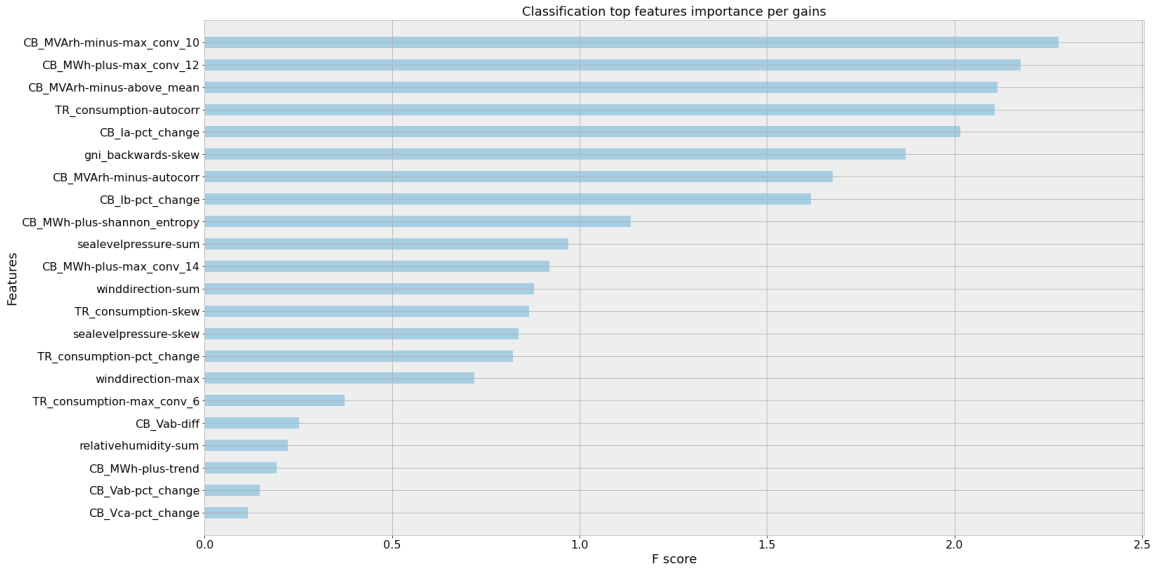


Figure 16: Classification of parameters

The analysis below provides basic statistics for the top five features. The differences between the failure and ordinary days could be understood as follows:

- **CB_MVArh-minus-max_conv_10**: this feature is the top in importance according to the gain metric. It shows notable differences between failure and ordinary days in mean, median, and maximum values. The convolution with a 10-hour cylindric signal on reactive power consumption at the circuit breaker might be capturing patterns specific to failure events. The higher values on ordinary days could suggest a regular pattern disrupted during failure days.
- **CB_MWh-plus-max_conv_12**: this feature also ranks high in importance and exhibits differences in mean and maximum values between failure and ordinary days. The 12-hour convolution with power consumption could be detecting cyclical patterns that differ on days when failures occur. The larger standard deviation on ordinary days might indicate more variability in normal conditions.
- **CB_MVArh-minus-above_mean**: the sum of reactive power consumptions above the mean shows a higher average on failure days. This suggests that on failure days, there are more instances where reactive power consumption is significantly above the average, possibly indicating instability or unusual conditions in the power system.
- **TR_consumption-autocorr**: autocorrelation of transformer station power consumption is lower on failure days. This could mean that the regularity of consumption patterns is disrupted during failures, leading to lower autocorrelation values.
- **CB_Ia-pct_change**: phase A current shows a minor average percentage change on failure days but with a much higher standard deviation and maximum on ordinary days. This might suggest that phase a current is more stable on failure days or that ordinary days include more significant fluctuations, which could be part of regular operational variations.

The differences in these statistics between failure and ordinary days suggest that failures are associated with disruptions in regular patterns of power consumption and reactive power flow. But it has to be noted that the number of failure days is very low and that the analysis is therefore limited. Domain knowledge is critical in interpreting these results and it is crucial to remember that while these features are

important for the model's predictions, the correlation in general does not imply causation.

Table 4: Failure parameters

	Failure Day Mean	Failure Day Median	Failure Day Std	Failure Day Max	Ordinary Day Mean	Ordinary Day Median	Ordinary Day Std	Ordinary Day Max
CB_MVArh-minus-max_conv_10	5.673468	5.735632	0.352405	5.990654	6.948974	7.261411	1.348134	9.155133
CB_MWh-plus-max_conv_12	2.476123	2.126779	0.700695	3.282810	3.066359	2.977694	0.770071	9.170709
CB_MVArh-minus-above_mean	14.666667	14.000000	1.154701	16.000000	12.277778	12.000000	2.165639	18.000000
TR_consumption-autocorr	0.596591	0.489523	0.251527	0.883937	0.769474	0.801534	0.133367	0.944740
CB_Ia-pct_change	-0.003243	-0.000268	0.005388	0.000000	0.080657	0.049117	0.500238	11.085703

The importance of the features per weights and per cover indicate that also the weather features can play certain roles in classification, like sea level pressure radiation and wind direction besides features extracted from daily circuit breaker reactive power consumption and circuit breaker and transformer power consumption.

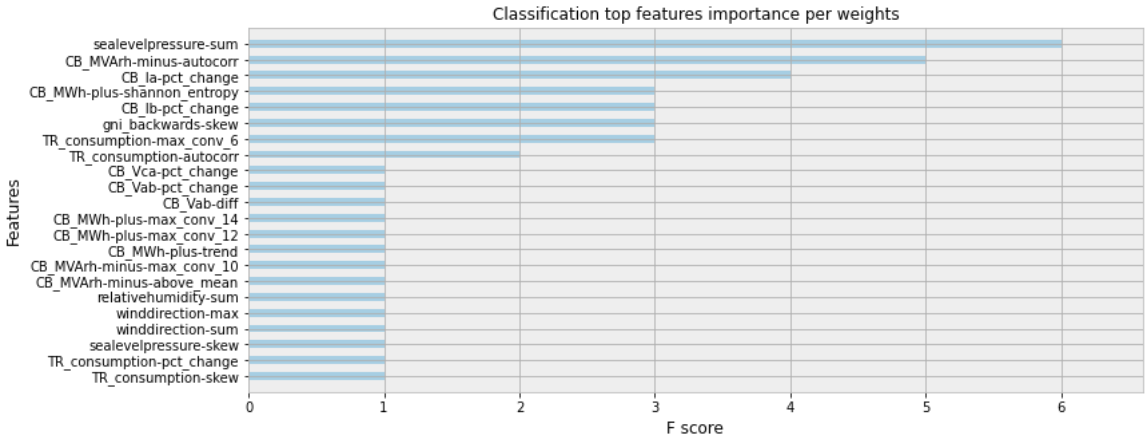


Figure 17: Classification of futures per weights

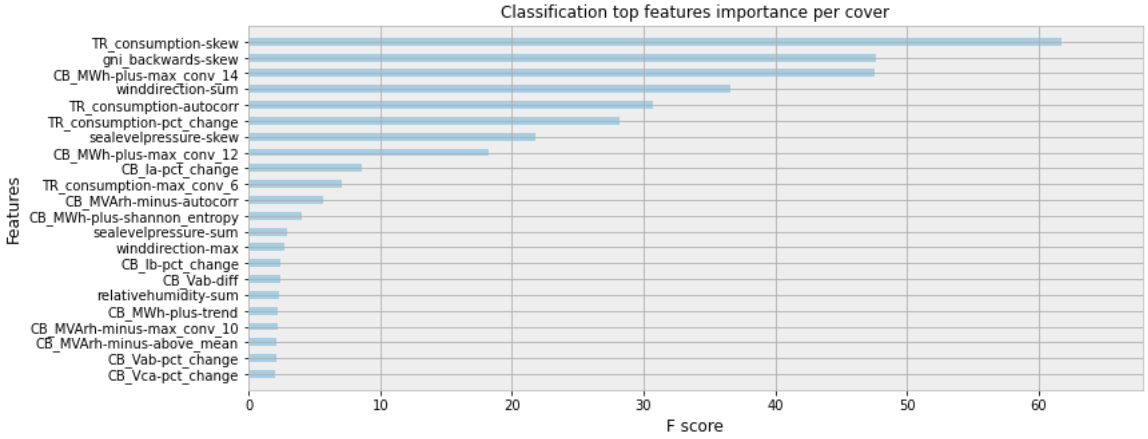


Figure 18: Classification of futures per cover

Looking into failure days:

After features analysis we can take a look at power consumptions at ordinary and failure days. At first the average of ordinary of ordinary and failure at ASK2 transformer station will be presented and then the consumptions at SK2 circuit breaker.

Comparing the ASK2 transformer station profiles at ordinary and failure days indicate that the failure days have more volatile consumption. The peak pressure seems to be higher, the peak time is longer than ordinary. It has to be noted that volatility could be also related to much smaller sample size of the failure days.

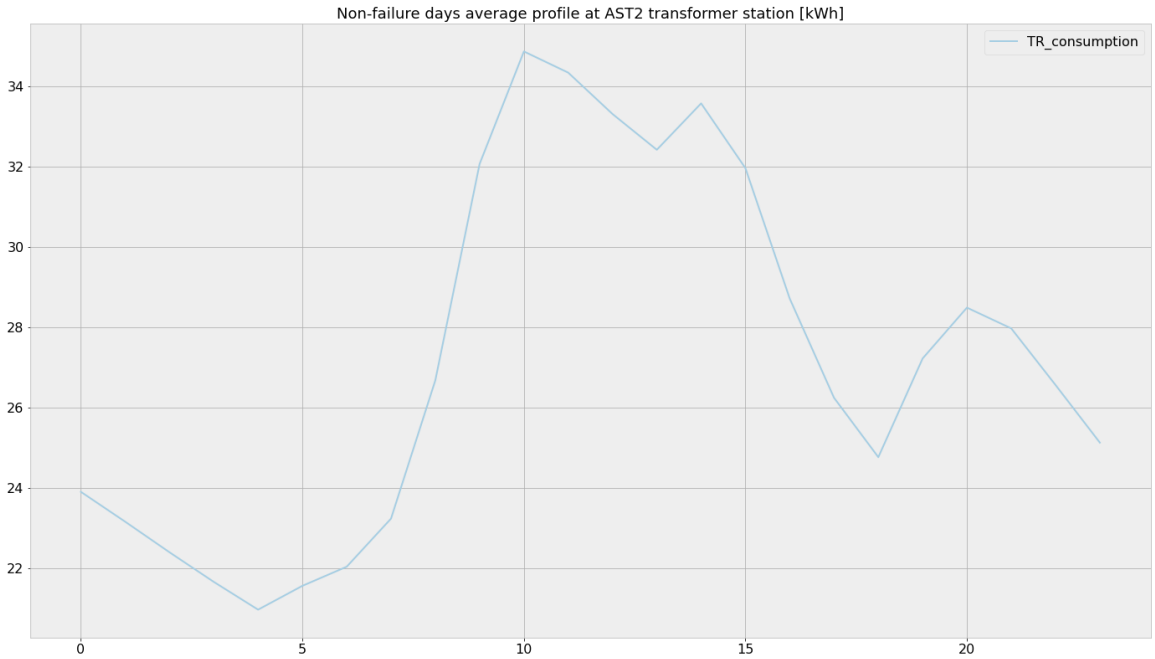


Figure 19: Failure days AST2 Transformers load profile

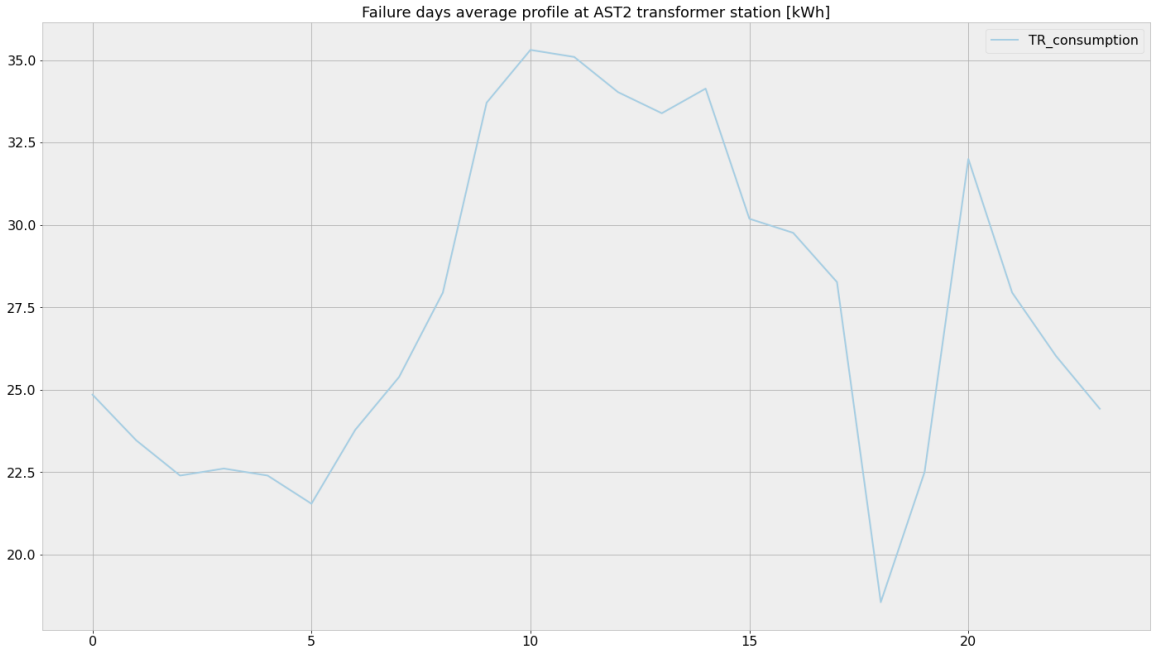


Figure 20: Failure days AST2 Transformers load profile

The average power consumption at SK2 circuit breaker at ordinary and failure days are presented below. Again, the failure days exhibit more volatile consumption and

the peak pressure is higher than on ordinary days. The overall consumption is higher on failure days with more steady power consumption.

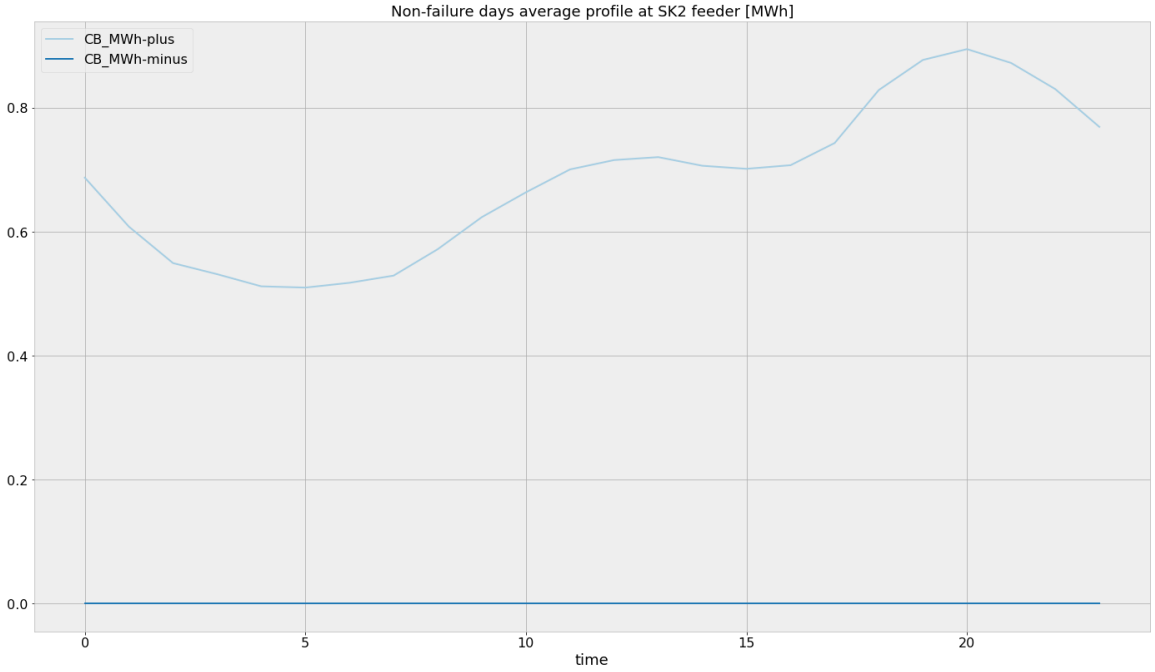


Figure 21 SK2 Feeders CB analyser data load profile

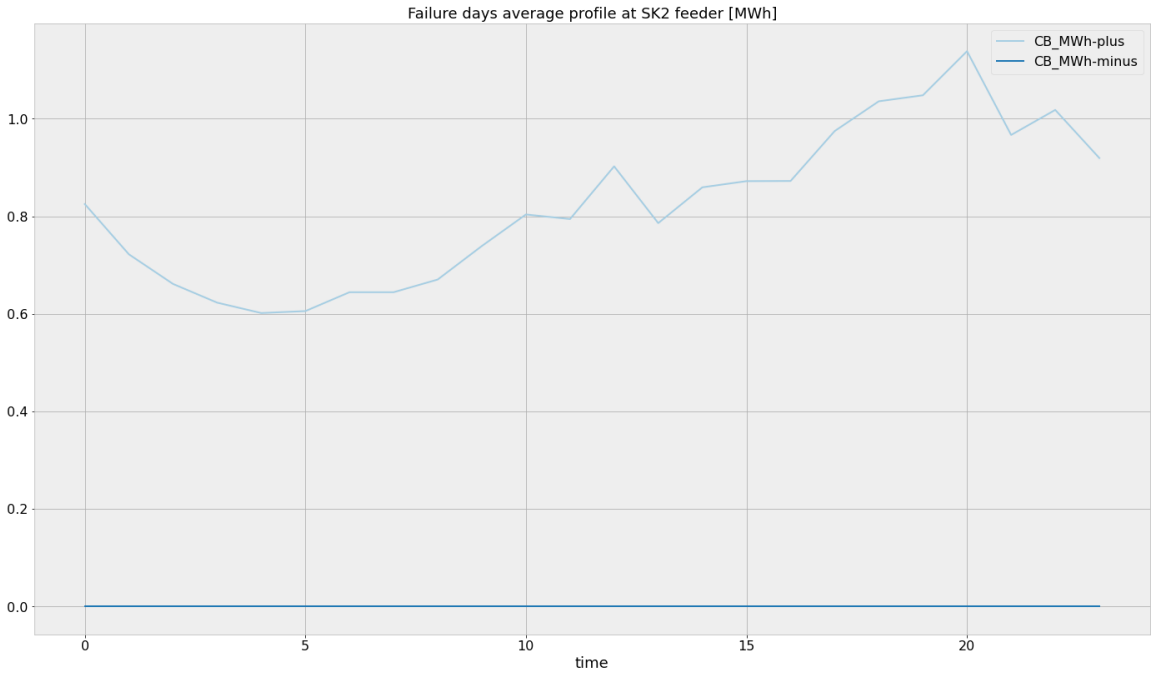


Figure 22: Failure days SK2 Feeders CB analyser data load profile

4.1.1.4 Service conclusions

The predictive maintenance through classification shows its potential already in relatively simple classification features and day profiles analysis. The main problem for the predictive maintenance is a prolonged collection of failure data and regular and careful collection of accompanying measurement data used for features engineering.

More features enable developing a classification model(s) that could be used on multiple parallel cases of data and equipment. The model should be designed with both fine grain characteristics - be capable to treat a specific class of equipment like circuit breaker - and robustness - be suitable to cover broader classes of same equipment avoiding overfitting - in mind.

Extensive, regular and careful collection of base features data can enable good forecasting of the features and consequently, potential classification of the features data to failure days.

Interpreting the failures models and related features importance undoubtedly requires close cooperation between the domain knowledge owners and machine and deep learning data analytics. Only in this way the proper feature engineering can be implemented and most important features collected and extracted.

Service usage

The service is used as follows. At the marketplace interface the proper dataset needs to be contracted from the data provider. The service user needs to then contract the service and while doing so, select predictive maintenance by classification as a service option. After the service provider will activate the service contract the service will run through the "ASM" (Java based platform) framework, execute all the cells in the notebook and write the report to the user service space which the user can access through service user interface

4.1.2 VUB approach: Multiple asset maintenance schedule prediction in critical grids

4.1.2.1 Introduction of the service

Name: Predictive maintenance in electrical power systems
Category: Operation and maintenance
Task: T4.2
Location on the grid: LV grid

The purpose of the service is to find the optimal maintenance schedule for multiple and different assets in one (part of the) grid by using the specific characteristics and limitations of each asset in the grid as well as the grid limitations itself in a fully combined way. To fulfil the demand side, the grid is composed of multiple assets producing (i) electricity and (ii) heat, both at a certain cost. For safety purposes, assets undergo several maintenances throughout the year and this during their whole lifetime. The service aims at finding an optimal maintenance schedule in regards with the production cost and safety measures. To do so, a Multiple Integer Linear Program (MILP) is introduced, and results are presented through a result-oriented user interface (UI).

Table 5: Use cases for the S1.3 service

Use case	Description
Maintenance scheduling	As a grid operator you want to plan the maintenances of each of your assets in a way that it has a minimal impact on the grid operations and in the most economical way. While as a maintenance operator you want to

	plan the maintenances in advance so for employee and spare parts planning.

4.1.2.2 Use Case 1

Once all the data is contracted and provided to the algorithm developers, the data is being processed to return an optimal maintenance scheduler for the different assets. Provided these assets may have specific requirements and or scheduled maintenance (periodically), this information must be given to the service provider.

Based on all the information acquired, an optimal scheduling scheme will be returned to the maintenance operator, see Figure 23. This interactive visualization allows the operator to analyse the type of maintenance, the required duration and gives in a glance the best timing to perform the latter.

Furthermore, in case the operator is only interested in specific assets, the operator can (un)check the boxes next to the asset of intrest.

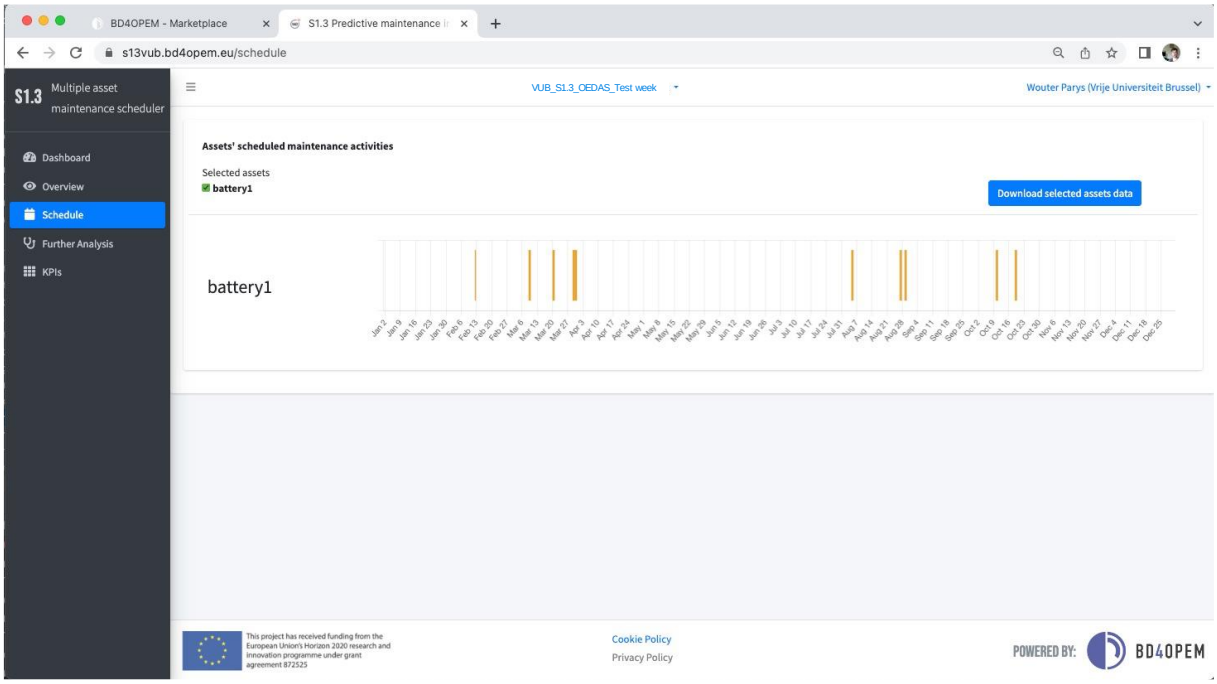


Figure 23: Maintenance activities per asset

Each type of maintenance activity will be linked to a certain cost imposed by the change in energy flows induced by the changed asset availability. Therefore the grid operator may wish to know how the scheduling of his maintenances may affect the total operational cost. This is shown in Figure 24. Here an overview of the different activities per asset is displayed, combined with the cost pre-optimization and the one post-optimization. Thus, allowing the maintenance operator to compare the total gain in EUR by the automated scheduling.

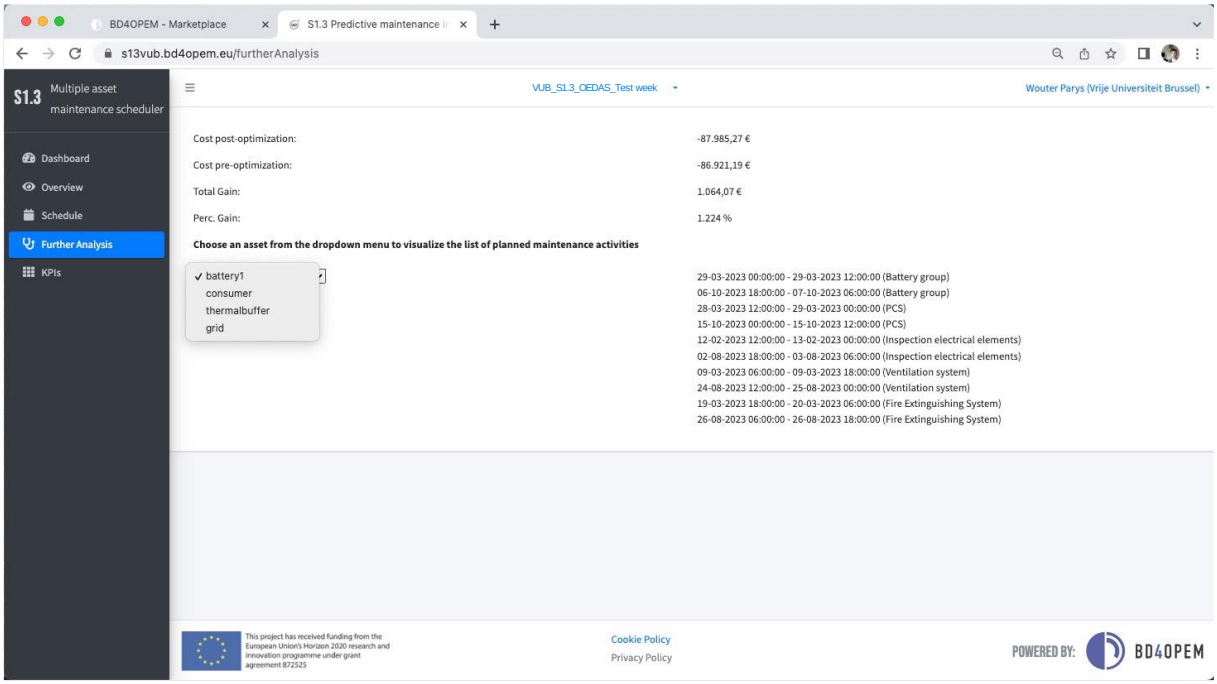


Figure 24: Further analysis with cost overview

Pilot Deployment

The service is initially built for a microgrid including build-in functionalities for coping with heat and electricity demand together (e.g. CHPs(Combined Heat and Power Plant) and heat pumps) as well thermal assets only (e.g. steam and hot water boilers). But mainly with the focus on providing the full energy demand in the cheapest way possible while including all the constraints in terms of services and maintenances. The Turkish pilot case is deviating from this case in the sense that it involves a part of a distribution grid instead of a microgrid. The business case is different as well the involved assets, so the tool had to be expanded specifically for the Turkish pilot case.

Description of pilot set-up

The set-up of the service in this pilot is adapted to the specific use case:

- The power input/output of the different assets (PV, battery…) and the consumption (smart meter data) data is used after the data harmonisation process.
- The service configuration (e.g. defining all the specific maintenances for all the different assets in the system) is a manual process and done together by the service provider and the service user.
- In the set-up of the Turkish demonstration site there is only 1 asset with specific maintenance requirements (with shut down)
    - Battery (field 1) of 336 kWh
- For this one asset, 5 different maintenances are described:
    - Battery group:
        - Follow up on EMS on a daily basis – no shut down
        - Checking the ambient temperature values on a weekly basis and checking the doors of the battery cabinets – no shut down
        - The following maintenance should be done every 6 months;
            I. Performing a physical examination
            II. Environmental inspection
            III. Performing a functional examination
            IV. Detailed examination
    - PCS (6 Months)
        - Temperature and dust control
        - Cleaning the cabinet

        - Checking the fuse and SC SPDs
        - Control of fans
    - Inspection of Electrical Elements (6 Months)
        - Visual inspection of wiring, AC and DC connection
        - Control of overcurrent protection devices and switches
        - UPS functionality check
    - Ventilation System (6 Months)
        - Checking the air filters
        - Checking the evacuation system
        - Checking the heating cooling system
    - Fire Extinguishing System (6 Months)
        - Visual inspection of the FM200 system
        - Inspecting mounting fasteners, straps and related hardware to detect loose, damaged or broken parts
        - Inspecting all electrical connections and performing electrical continuity tests

This results in two rather simple pilot specific configuration files that are needed to run the service:

- CSV 1: asset configuration

```
asset_name,type,min,max,eff,ratio,include
battery2,battery,0,,0.90,,True
```

- CSV 2: maintenance configuration

```
asset,maintenance_name,opt,min,max,dur,last
battery2,Battery group,182,152,212,8,120
battery2,PCS,182,152,212,8,120
battery2,Inspection electrical elements,182,152,212,8,120
battery2,Ventilation system,182,152,212,8,120
battery2,Fire Extinguishing System,182,152,212,8,120
```

Specific adaptations for pilot set-up

The service searches for the best moment in time to execute the shutdowns of the assets for maintenance purposes.

- Because of the DSO structure instead of the microgrid structure of the pilot it was not possible to describe the full economical system of the assets inside of the grid in which the battery has a place, so the top-down approach is revisited to a bottom-up approach. Instead of modelling the consumption and production of the battery based on external parameters, we start from the current battery use and distract the periods of high value and low value for the battery (periods when the battery is used a lot are considered as economic valuable periods for the battery to be not in maintenance and the other way around). In this way the service only relies on the historical asset (e.g. battery) profile to find the optimal maintenance schedule
- Based on previous remark there is a necessity for multiple years of data to create a good statistical expected battery power profile on which the maintenances can be modelled. In the use case, only a limited amount of data is available, which results in a high susceptibility to over-fitting. The service however will generate working results.

Results for Turkish pilot

Figure 25 shows the set-up of the smart maintenance scheduler for the Turkish pilot.

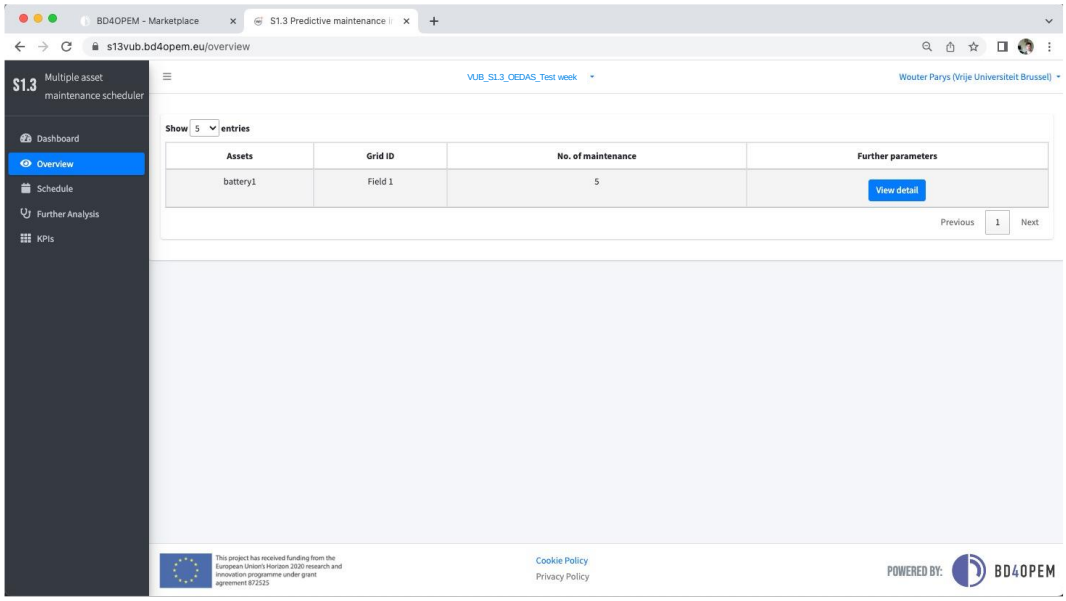


Figure 25: Asset overview included in optimisation

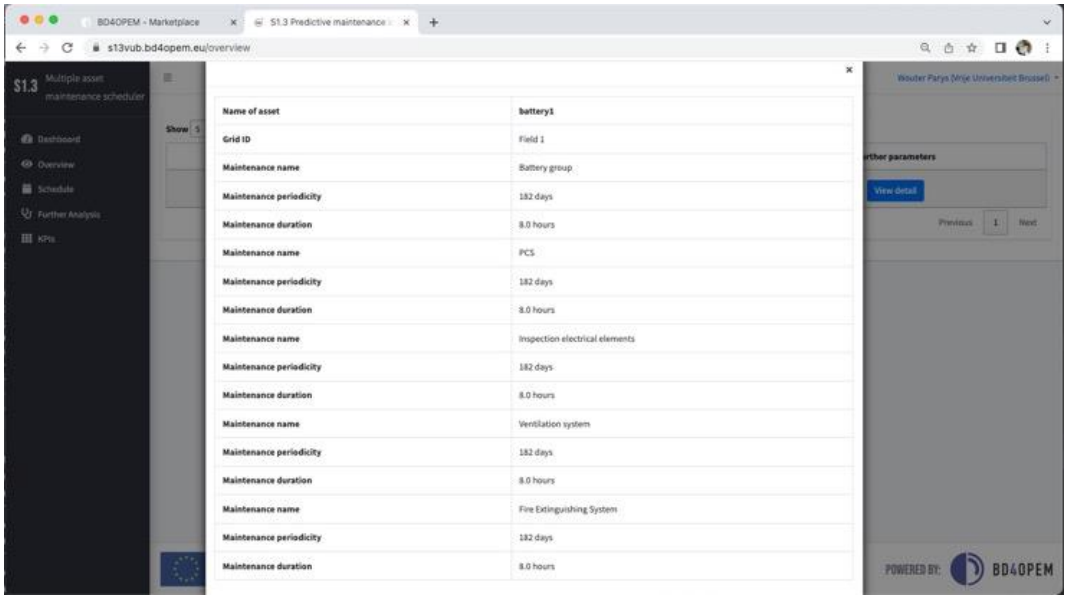


Figure 26: Pop-out window with asset details (shows all the maintenance types per asset)

Figure 27 and Figure 28 show the results and the impact of the smart scheduler.

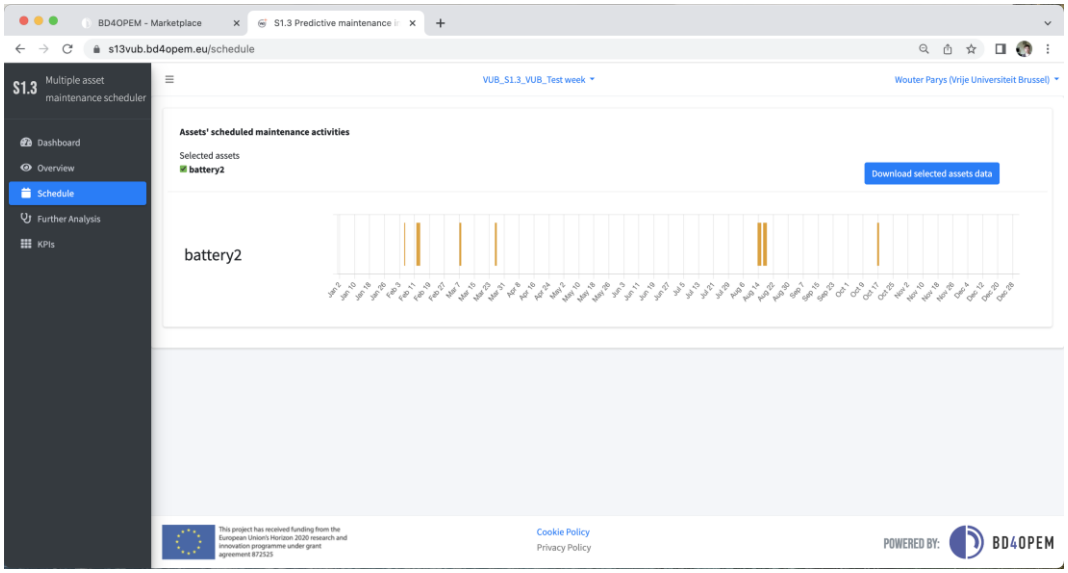


Figure 27: Results – most ideal combined maintenance schedule

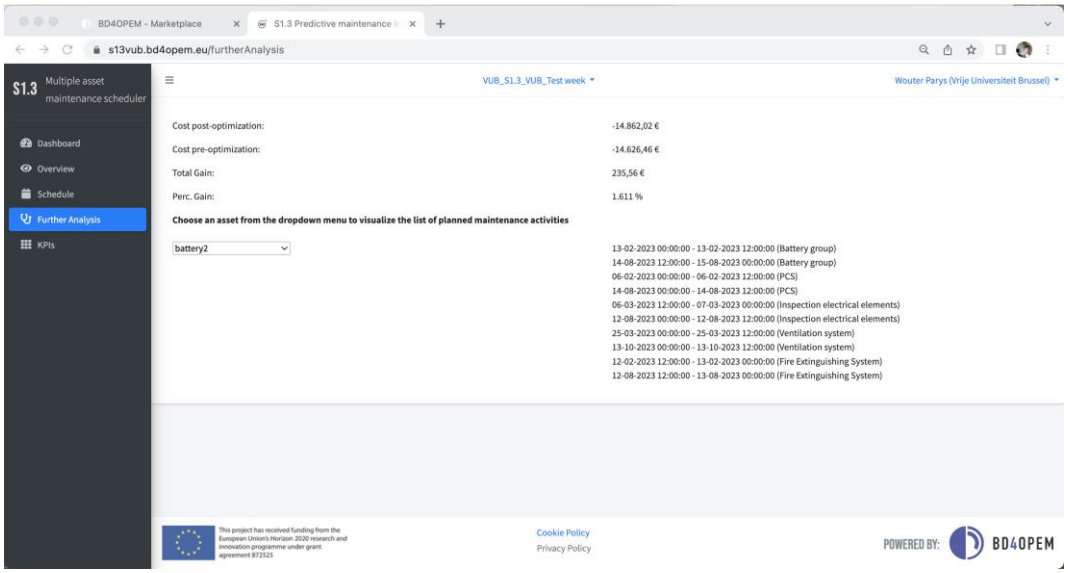


Figure 28: Cost comparison before and after smart scheduling

As stated earlier, the input for the smart scheduling is the expected battery use and the expected benefit by using the battery. A combined profile is generated which is considered as the positive impact value of using the battery at a specific moment in time. When a maintenance with a battery outage is planned in a certain time window, the lost revenue is related to the expected positive impact value.

Figure 29 shows the result of the smart planning algorithm in relation to the expected battery use. Maintenances are planned at the most economic beneficiary timeslots while still considering grid, energy and maintenance constraints. In this specific pilot set-up, the ideal moments to plan the outage is mainly related to the periods of low expected battery use, which is clearly envisioned by comparing the 'smart' planned outages with the not-smart planned outages. The latter still consider all the grid, energy and maintenance constraints, but do not consider economic parameters, which is the specific added value of the smart scheduling algorithm of this service in combination with the full automation.

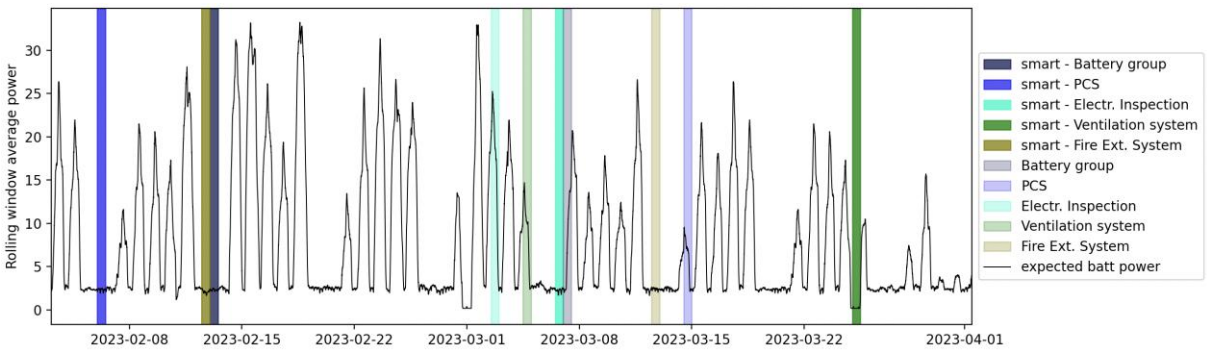


Figure 29: Maintenance periods with and without smart planning algorithm

4.1.2.3 Data assessment

Table 6 shows the data needs for the service S1.3 in the Turkish pilot and adopts the impact of potential bad data quality.

Table 6: Data assessment for the S1.3 service

Data source needed	BD4OPEM ontology	Data quality assessment	Impact of the quality on the service
Historical data: electricity prices	Retail electricity price	Excellent	N/A
Historical data: Electric consumption	Energy meter data	Good	Limited impact (better historical data could improve the future energy consumption forecast)
Battery data: Power	Energy meter data: Charged or discharged power [kW] or Energy [kWh]	Sufficient	Data quality is sufficient. Longer contiguous time series would improve the future battery use forecast

4.1.2.4 Service conclusions

Currently the service is based on partial battery data of 2022 to plan the maintenances for 2023. When data builds up and data is available for multiple years, the algorithm will generate more useful and accurate results.

During the service testing, the grid operator provided valuable feedback and was also interested in the applicability of the service for their own network (by e.g. monitoring the needs for their battery storage systems to be in maintenance etc.).

Other feedback during the demo is:

- It would give more benefits for grid operator to be able to compare their assets on one figure instead of having them the one under the other (remark concerning the UI).

- Difference between the types of maintenances should be more clear by using for example different colours.

4.2 S3.1 – Grid disturbance simulations results

4.2.1 UPC approach: Congestions forecast for day ahead

4.2.1.1 Introduction of the service

Name: Grid Disturbance Simulations.
Category: Operation and maintenance.
Task: T4.1
Location on the grid: MV grid, LV Grid

This service predicts possible congestion scenarios for the day-ahead operation planning on a low-voltage and/or medium-voltage grid by applying machine learning techniques (e.g., Linear Regression, Neural Networks). The output contains information such as the location and time of possible congestions in the grid and suggests improvements by means of swapping between phases at connections or consumers where problems occur.

Table 7: Use Cases for the S3.1 service

Use case	Description
UC1	**As a:** DSO analyst, **I want to:** generate a congestion management plan for the next day **So that I can:** gain insights into congestion management and the efficiency of flexibility sources. **Acceptance criteria:** The system displays flexibility source values, congestion percentages, and detailed flexibility insights for selected days.
UC2	**As a:** DSO analyst, **I want to:** evaluate the grid I managed before and after my dispatch of flexibility. **So that I can:** directly assess the impact of the flexibility request on line loading and voltage improvements. **Acceptance criteria:** The system displays snapshots of the grid pre and post-flexibility request for any chosen hour and allows downloading of these images, along with the power injection of flexibility sources per bus throughout the day.

4.2.1.2 Use Case 1

Reviewing the forecasted demand, the service offers the deterministic forecasted demand for aggregated sources, the total amount of power in the grid for each hour, as shown in Figure 30. This is an interesting result as the analyst can know where is going to be the peak hour in a first glance to the service UIs, which in this execution there are two peaks at 11:00h and 19:00. It is also possible to check and analyse the forecasted demand for each of the loads in the grid, with the help of the dropdown in the right. The analyst can select a specific load, which can be of more interest to the DSO, for any particular reason. In Figure 31, we can observe the profile of the load SGAT in a day-ahead. This can be done with any other load. Additionally, the analyst can download the table in excel form, as seen in Figure 32, of the results for all the loads in case they wish to generate more detailed reports.

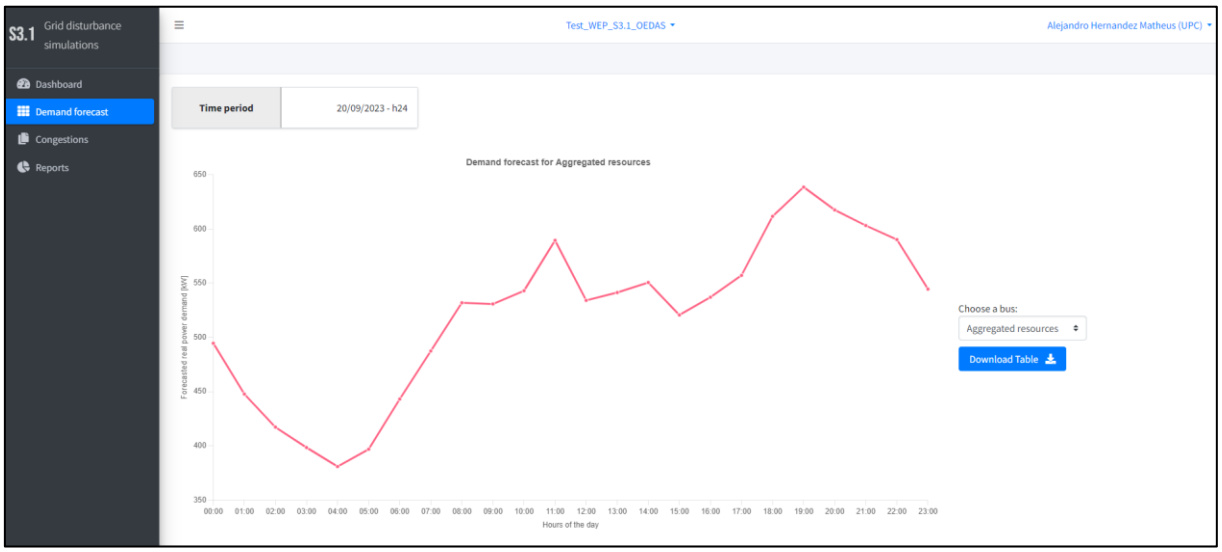


Figure 30: Aggregated demand

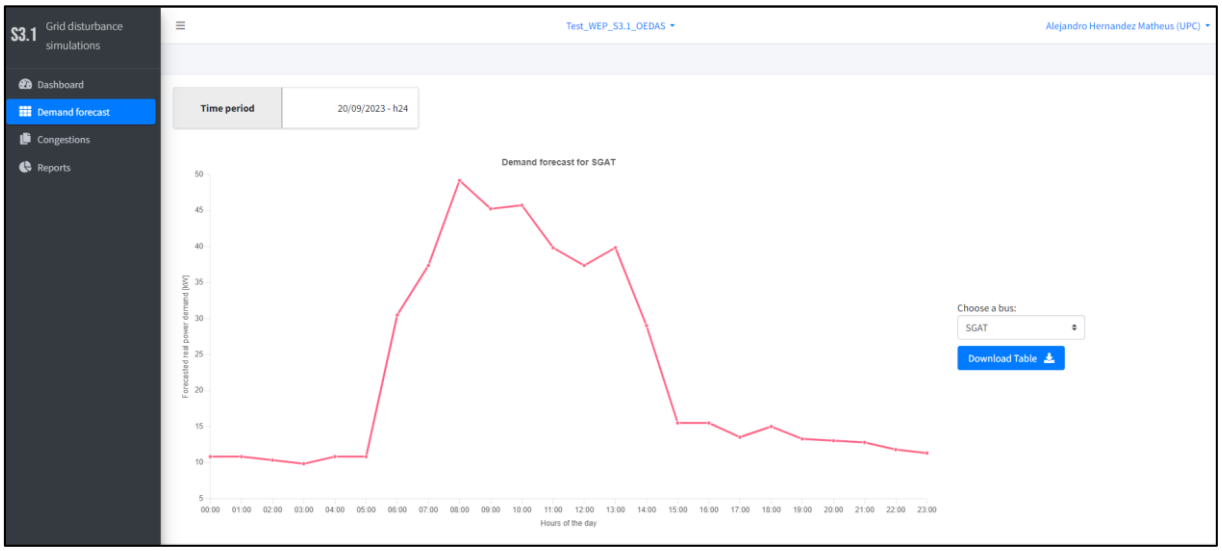
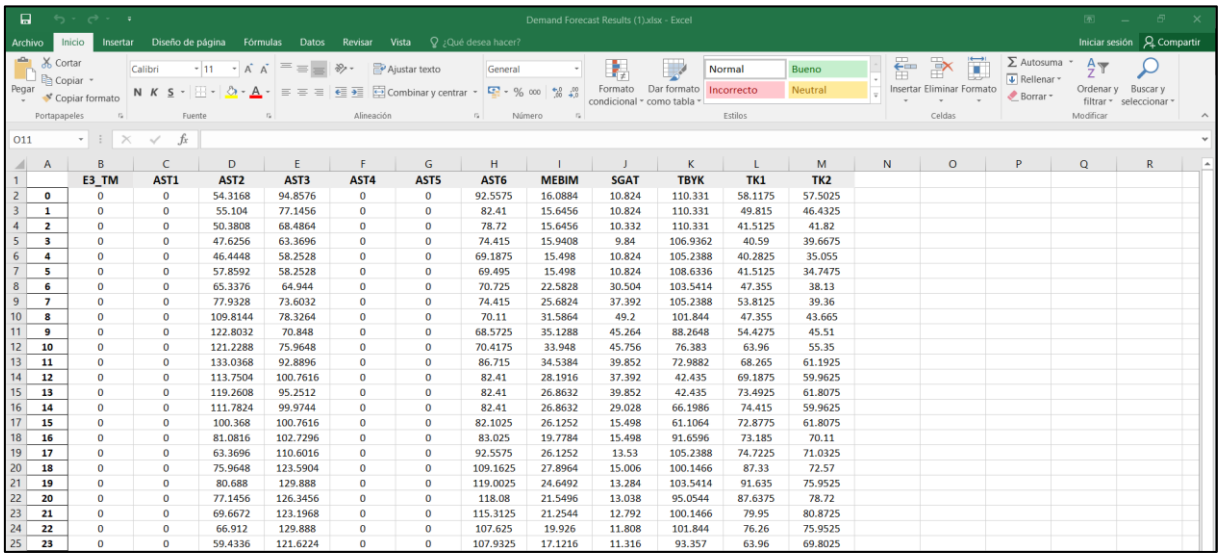


Figure 31: Forecast Demand for Load SGAT



		E3_TM	AST1	AST2	AST3	AST4	AST5	AST6	MEBIM	SGAT	TBYK	TK1	TK2
2	0	0	0	54.3168	94.8576	0	0	92.5575	16.0884	10.824	110.331	58.1175	57.5025
3	1	0	0	55.104	77.1456	0	0	82.41	15.6456	10.824	110.331	49.815	46.4325
4	2	0	0	50.3808	68.4864	0	0	78.72	15.6456	10.332	110.331	41.5125	41.82
5	3	0	0	47.6256	63.3696	0	0	74.415	15.9408	9.84	106.9362	40.59	39.6675
6	4	0	0	46.4448	58.2528	0	0	69.1875	15.498	10.824	105.2388	40.2825	35.055
7	5	0	0	57.8592	58.2528	0	0	69.495	15.498	10.824	108.6336	41.5125	34.7475
8	6	0	0	65.3376	64.944	0	0	70.725	22.5828	30.504	103.5414	47.355	38.13
9	7	0	0	77.9328	73.6032	0	0	74.415	25.6824	37.392	105.2388	53.8125	39.36
10	8	0	0	109.8144	78.3264	0	0	70.11	31.5864	49.2	101.844	47.355	43.665
11	9	0	0	122.8032	70.848	0	0	68.5725	35.1288	45.264	88.2648	54.4275	45.51
12	10	0	0	121.2288	75.9648	0	0	70.4175	33.948	45.756	76.383	63.96	55.35
13	11	0	0	133.0368	92.8896	0	0	86.715	34.5384	39.852	72.9882	68.265	61.1925
14	12	0	0	113.7504	100.7616	0	0	82.41	28.1916	37.392	42.435	69.1875	59.9625
15	13	0	0	119.2608	95.2512	0	0	82.41	26.8632	39.852	42.435	73.4925	61.8075
16	14	0	0	111.7824	99.9744	0	0	82.41	26.8632	29.028	66.1986	74.415	59.9625
17	15	0	0	100.368	100.7616	0	0	82.1025	26.1252	15.498	61.1064	72.8775	61.8075
18	16	0	0	81.0816	102.7296	0	0	83.025	19.7784	15.498	91.6596	73.185	70.11
19	17	0	0	63.3696	110.6016	0	0	92.5575	26.1252	13.53	105.2388	74.7225	71.0325
20	18	0	0	75.9648	123.5904	0	0	109.1625	27.8964	15.006	100.1466	87.33	72.57
21	19	0	0	80.688	129.888	0	0	119.0025	24.6492	13.284	103.5414	91.635	75.9525
22	20	0	0	77.1456	126.3456	0	0	118.08	21.5496	13.038	95.0544	87.6375	78.72
23	21	0	0	69.6672	123.1968	0	0	115.3125	21.2544	12.792	100.1466	79.95	80.8725
24	22	0	0	66.912	129.888	0	0	107.625	19.926	11.808	101.844	76.26	75.9525
25	23	0	0	59.4336	121.6224	0	0	107.9325	17.1216	11.316	93.357	63.96	69.8025

Figure 32: Table of demand forecast in excel form

4.2.1.3 Use Case 2

For the analysis of the of the congestions, this tool offers a congestion where the analyst can see the forecast current, in kilo Ampers (kA), for each of the lines in the distribution grid. As seen in Figure 33, the figure shows the behaviour for the first line of the grid. The limit of the line, calculated with the required data to contract the service, is also shown for the analyst to know if there is going to be a congestion.

Figure 33: Line 15 forecast

Additionally, in the report tab, the analyst can observe line by line the probability of congestions and this value translated to kA. Also, the report shows the number of total congestions in the grid, which for this particular case is 0.

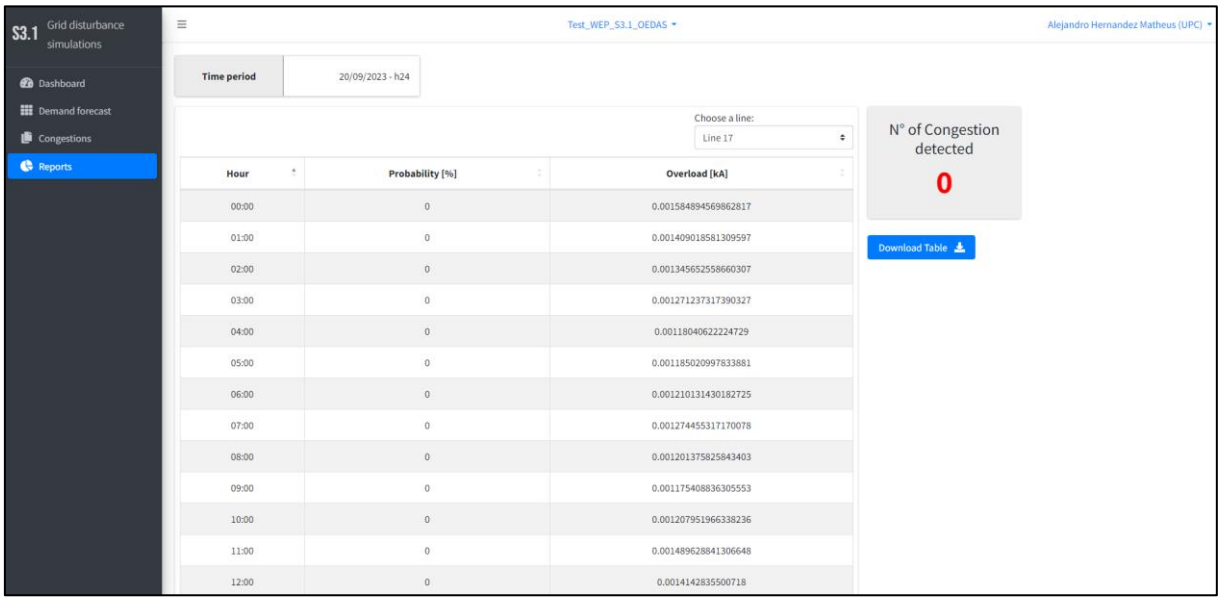


Figure 34: Report tab

4.2.1.4 Data assessment

The data required to establish the service mainly comprehends topology and grid parameters of the grid, as well historical measurements from either transformers or loads within the grid. The specific data files for this service can be observed in Table 8.

Table 8: Data assessment

Data source needed	BD4OPEM ontology	Data quality assessment	Impact of the quality on the service
Grid Topology	Service_parameters	Some missing connections points	High
Historical measurements	Smart_Meter	Data lacking for some months	High

4.2.1.5 Service conclusions

The results of the service are highly useful for DSOs. This type of information is especially useful in highly congested grids. However, it is very sensitive to the input data. Also, the fact that the machine learning models are trained with a fixed topology, it is an important drawback to be used on grids that change their topologies often. In the case of the Turkish pilot, there are not many congestions historically. As a matter of fact, it is difficult to measure congestions in lines, which is an opportunity area for this service. The approach could be different by exploring congestions in voltages. Additionally, it is a very data intensive service, so adding features and prediction variables adds more complexity to its execution.

Additionally, some feedback raised during the testing of the service is as follows:

- The forecast figures could benefit from actual measurements of the loads, to help the analyst with past days investigations.
- Lines results should be given in Amperes (A), instead of kilo Amperes (kA)

- Information about the conductor should be given, as this helps the analyst with the decision making. This also applies to transformers with different cooling systems.
- In the Report Tables, the maximum thermal limit should be given, to provide reference.

4.2.2 JSI approach: PQ-related disturbances

Name: Grid disturbance simulations.
Category: Operation and maintenance.
Task: T4.1
Location on the grid: MV grid

Due to load fluctuations and intermittent power generation at various locations, distribution systems are susceptible to line and transformer overloads. In addition, excessive simultaneous energy consumption in a specific part of the network can lead to an undervoltage problem. On the other hand, excessive simultaneous generation can lead to an overvoltage problem. This service aims to solve the above problems by performing the MV grid simulations and identifying possible solutions to improve power quality (PQ).

Table 9: Use cases for the S3.1 service

Use case	Description
UC1	As DSO you want to analyse MV grid to increase ingestion capabilities for RES.
UC2	As DSO you want to analyse MV grid to improve voltage profiles at the end-user
UC3	As DSO you want to analyse MV grid to minimize investment costs for reinforcing the grid

4.2.2.1 Use Cases

As a DSO, the primary objective is to improve the capabilities of the existing medium-voltage grid to increase the feed-in of renewable energy with minimal investment costs while complying with PQ requirements or addressing potential existing PQs. Most critical are the voltage levels at different points of the MV grid (substations). In the worst-case scenario, the largest voltage fluctuations are expected at the ends that have high loads or RES generation. An example of such node is shown in Figure 35 (cyan curve), which has high penetration of PV systems with limited self-consumption. These distributed energy is transferred through the MV system to other consumers in the grid. The result is high fluctuation of voltages, especially towards upper limit. The upper limit is 10% above nominal voltage.

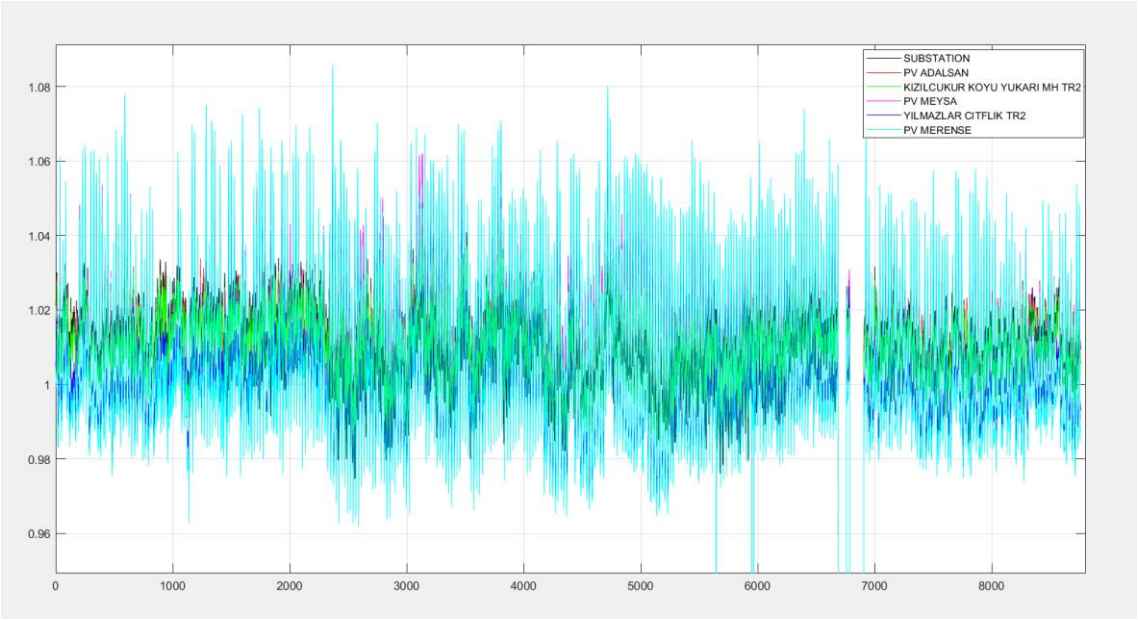


Figure 35: Selected normalized voltage profiles at different nodes on OEDAS selected MV Grid.

During the analysis of the MV grid, we found many potential PQ issues on the selected grid, which is shown by the voltage profile histogram in Figure 36. The worst-case voltages are already close to the PQ limits.

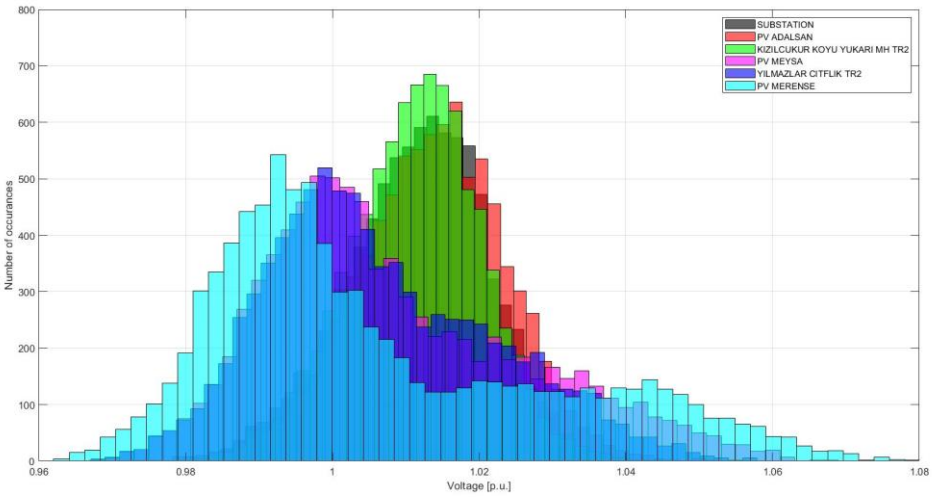


Figure 36: Voltage profiles - histogram

Few solutions were proposed:

1) Replace cable to PV Merense with a larger cross-section. The zero sequence resistance changed from 0.1093 Ω/km to 0.0882 Ω/km.

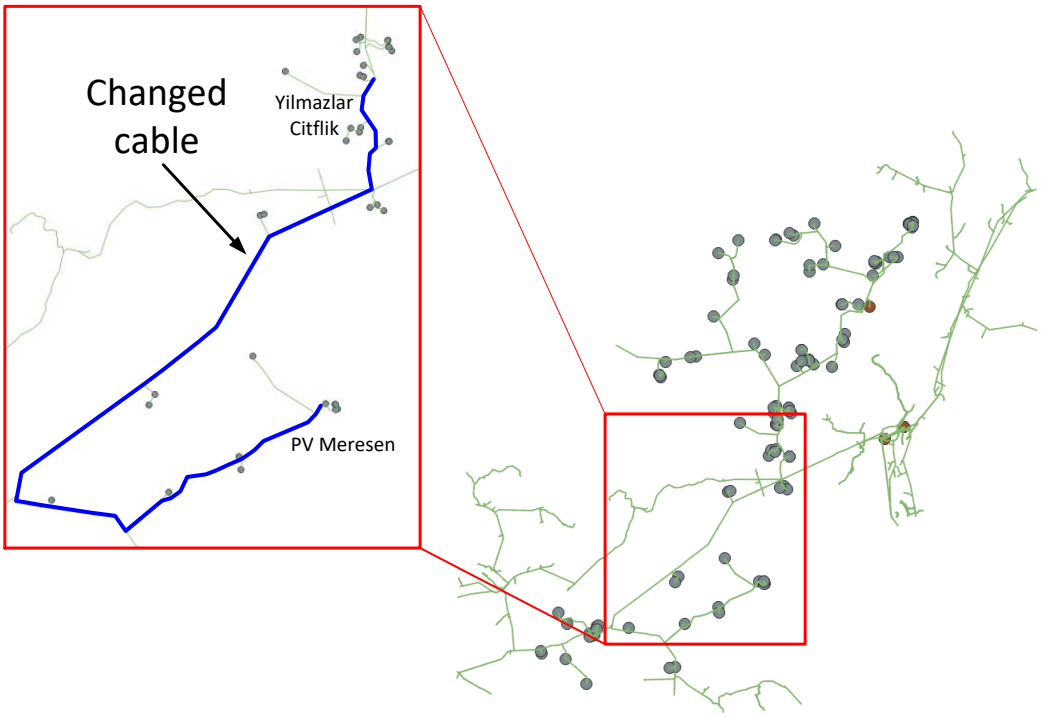


Figure 37: Grid topology with proposed cable change to improve PQ related parameters.

The improved voltage histogram is shown in the following Figure 38:

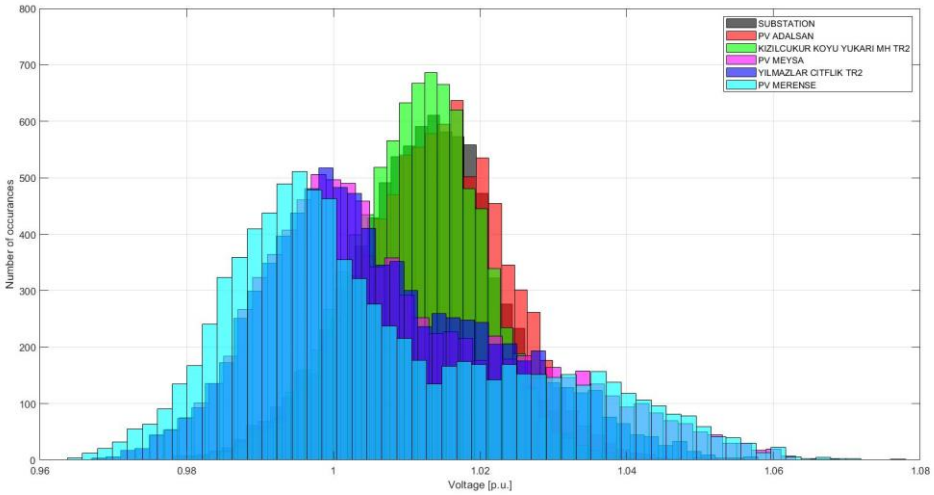


Figure 38: Improved histogram after cable change towards PV Merense.

2) Similar to the previous scenario, replace the cable to PV Merense with a larger cross-section. The zero sequence resistance changed from 0.1093 Ω/km to 0.0711 Ω/km.

The improved voltage histogram is shown in the following Figure 39:

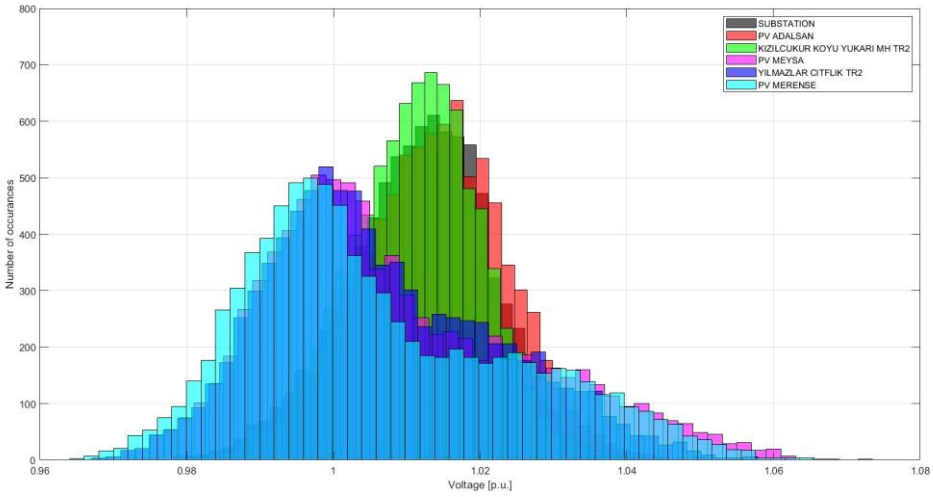


Figure 39: Improved histogram after cable (resistance) change towards PV Merense.

3) New line to PV Merenese, paralel to existing one

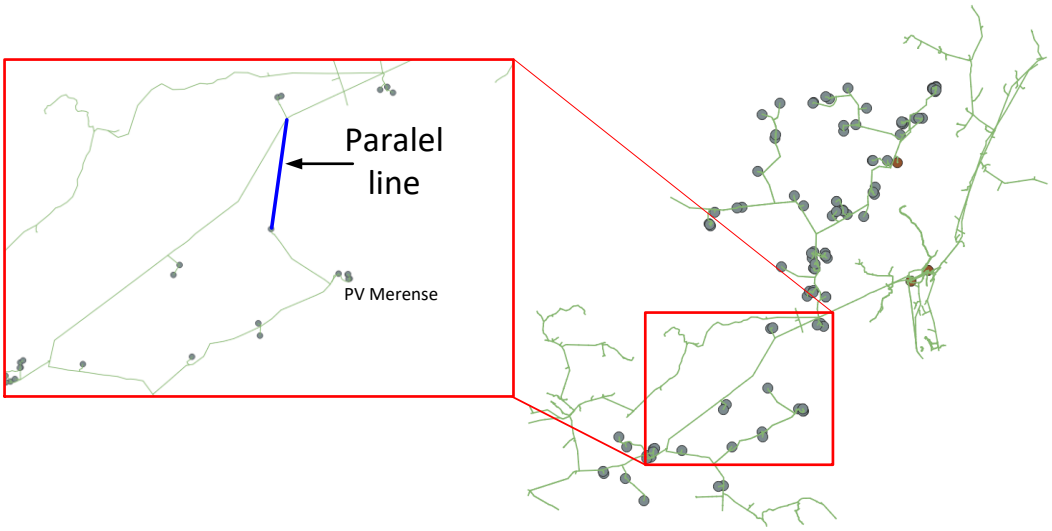


Figure 40: Grid topology with a new line to improve PQ-related parameters.

The improved voltage histogram is shown in the following Figure 41

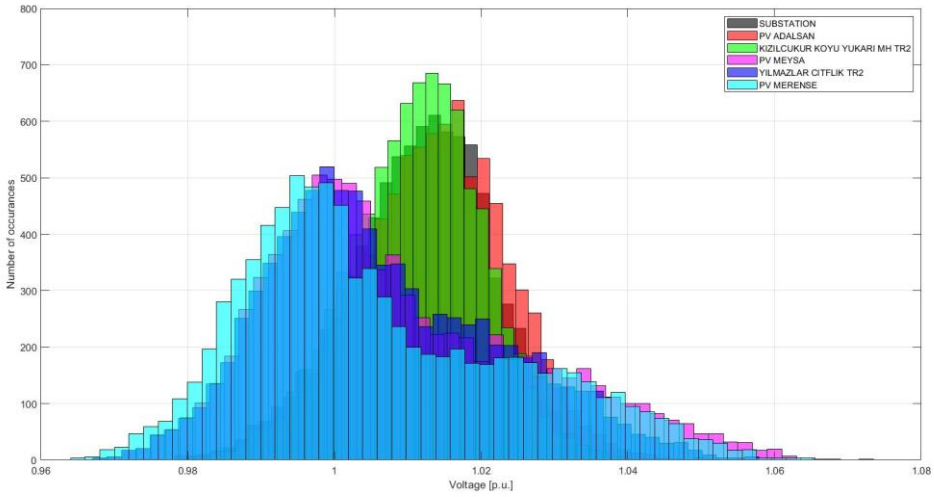


Figure 41 Improved histogram after cable change towards PV Merense.

4.2.2.2 Data assessment

Table 10: Data Assessment

Data source needed	BD4OPEM ontology	Data quality assessment	Impact of the quality on the service
Grid Topology	Service_parameters	Good	High
Historical measurements	Smart_Meter	Some missing values for substations measurements, estimations had to be done	High

4.2.2.3 Service conclusions

The service addresses challenges arising from load fluctuations, intermittent power generation, and potential disturbances, aiming to improve voltage profiles.

The results of the service are useful for DSOs to efficiently plan the investment costs for reinforcing the grid. DSOs can use the information provided by the service to:

- Identify the specific areas of the grid that are most in need of reinforcement.
- Prioritize investment in grid reinforcement projects.
- Select the most cost-effective grid reinforcement solutions.
- Assess the impact of different reinforcement options on the grid.

In addition, DSOs can use the service to plan for the future integration of renewables. The service can help DSOs to:

- Identify the impact of different renewable energy scenarios on the grid.
- Develop strategies for integrating renewables into the grid in a reliable and cost-effective manner.

- Ensure that the grid is prepared for the increased variability and uncertainty associated with renewable energy generation.

Overall, the service can help DSOs to improve the reliability, quality, and efficiency of their electricity grids, while also supporting the integration of renewable energy.

4.3 S5.1 – Flexibility Forecast results

4.3.1 UPC approach: Flexibility forecast

Introduction of the service

Name: Flexibility forecast
Category: Flexibility and demand response
Task: T4.3
Location on the grid: LV grid and/or MV grid

This service aims to forecast the available flexibility within an aggregator's portfolio in order to know how much flexibility can be activated in a specific time horizon. The objective is to provide the aggregator with a tool to estimate flexibility and provide this service to different stakeholders, such as the Distribution System Operator (DSO) or the Balance Responsible Party (BRP) in later stages and services.

Table 11: Use cases for the S5.1 service

Use case	Description
UC1	**As a:** aggregator, you want to know in advance the flexibility available on the grid. **I want to:** know in advance the flexibility available on the grid. **So that I can:** so I can optimise my portfolio **Acceptance Criteria:** When I run the Flexibility forecast service I obtain the hourly flexibility forecast for the next day.

4.3.1.1 Use Case 1

The aggregator selects the assets it wants to take into account and run the model. They can then access the prediction of the available flexibility for the next day hour by hour with the "forecast" section. Figure 42 shows the graph on the UI representing the forecast, with the KPIs used to interpret the curve on the right. It is obvious that there is for instance a prediction of constant availability during the day. The analyst can download the graph (it will be downloaded as in Figure 43) and the data as an excel file (as in Figure 44)

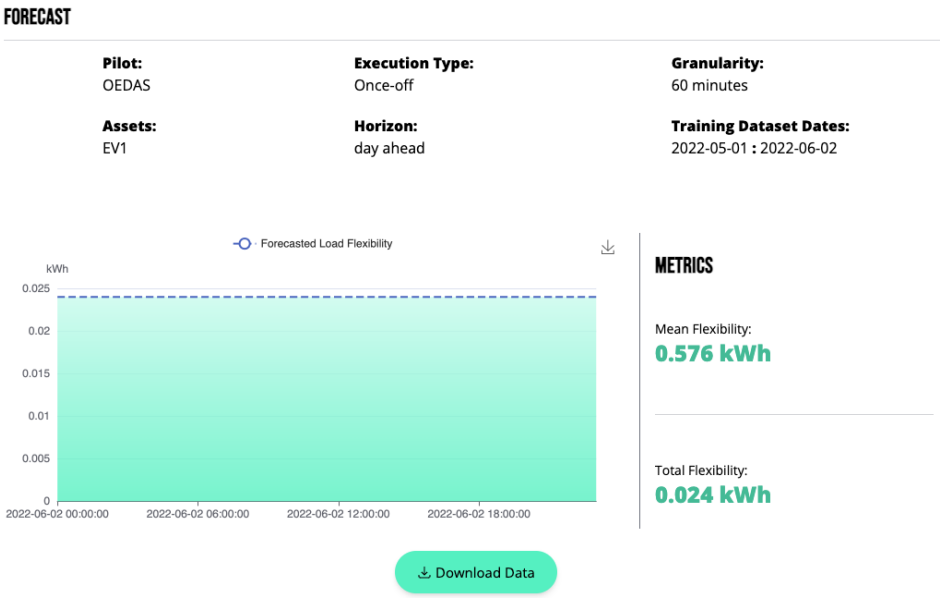


Figure 42: Forecast 24h ahead of Flexibility Availability ("Forecast" section of the UI)

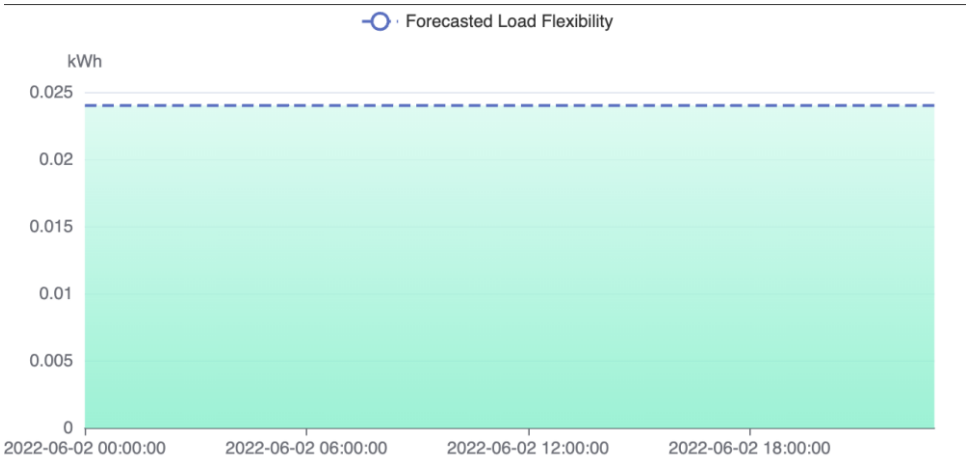
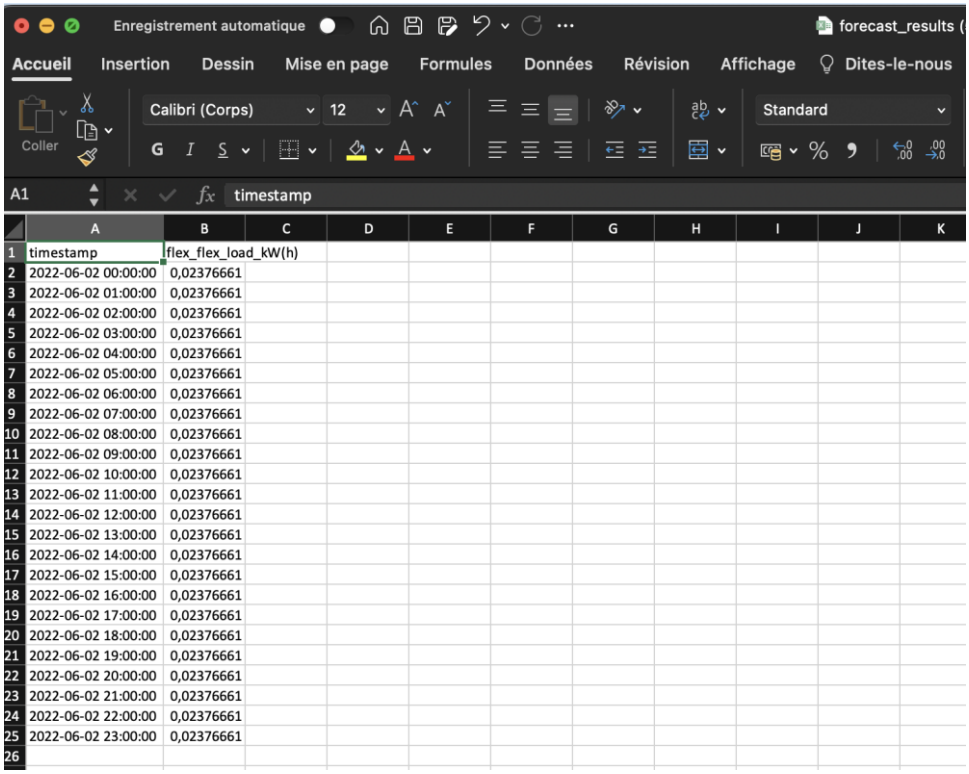


Figure 43: Plot downloaded from the UI



	A	B	C	D	E	F	G	H	I	J	K
1	timestamp	flex_flex_load_kW(h)									
2	2022-06-02 00:00:00	0,02376661									
3	2022-06-02 01:00:00	0,02376661									
4	2022-06-02 02:00:00	0,02376661									
5	2022-06-02 03:00:00	0,02376661									
6	2022-06-02 04:00:00	0,02376661									
7	2022-06-02 05:00:00	0,02376661									
8	2022-06-02 06:00:00	0,02376661									
9	2022-06-02 07:00:00	0,02376661									
10	2022-06-02 08:00:00	0,02376661									
11	2022-06-02 09:00:00	0,02376661									
12	2022-06-02 10:00:00	0,02376661									
13	2022-06-02 11:00:00	0,02376661									
14	2022-06-02 12:00:00	0,02376661									
15	2022-06-02 13:00:00	0,02376661									
16	2022-06-02 14:00:00	0,02376661									
17	2022-06-02 15:00:00	0,02376661									
18	2022-06-02 16:00:00	0,02376661									
19	2022-06-02 17:00:00	0,02376661									
20	2022-06-02 18:00:00	0,02376661									
21	2022-06-02 19:00:00	0,02376661									
22	2022-06-02 20:00:00	0,02376661									
23	2022-06-02 21:00:00	0,02376661									
24	2022-06-02 22:00:00	0,02376661									
25	2022-06-02 23:00:00	0,02376661									
26											

Figure 44: Plot downloaded from the UI

The "model info" section can also provide insights for the aggregator to better understand the data and compare possible future models (metrics available) as it is presented above.

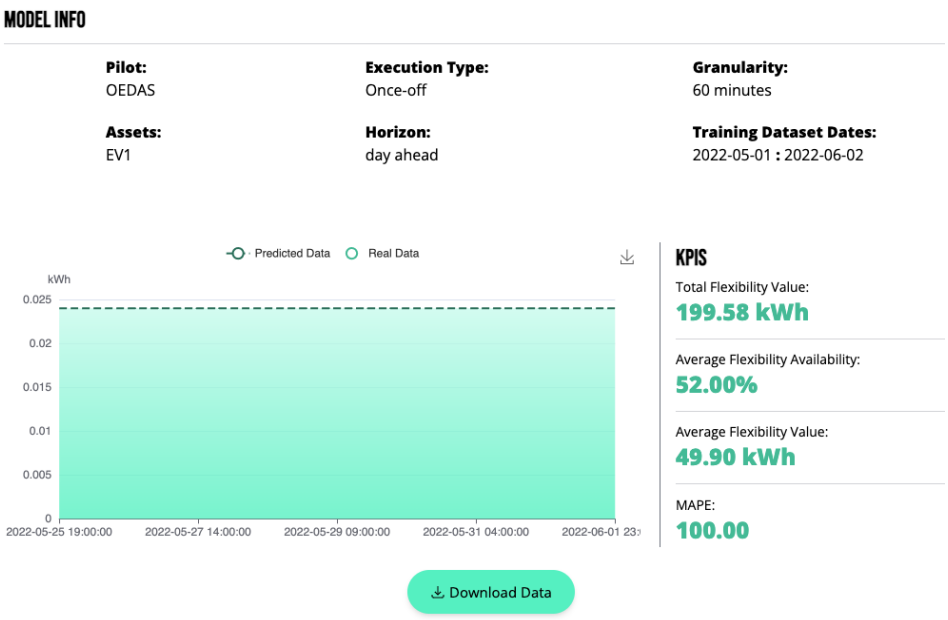


Figure 45: Model info" section of the UI

4.3.1.2 Data assessment

Table 12: Data Assessment

Data source needed	BD4OPEM ontology	Data quality assessment	Impact of the quality on the service
EV charging power	activaImport	Low	High
PV	production	Low	Medium

4.3.1.3 Service conclusions

The results are useful for DSOs and BRPs as an additional tool to be able to monitor which flexibility they should buy or not.

Nevertheless, the grid doesn't have enough storages available to allow a real flexibility.

Indeed, there are very few hours by week where flexibility is possible, this misleads the model and makes it very complicated to recognize any pattern.

Further improvement thanks to the feedbacks from the testing of the service can be an automatization of the service allowing the user to have the KPIs without running the model manually every day, also the possibility to zoom in the plot of the UI to better understand and interpret the forecast and training predictions.

4.3.2 JSI approach: Flexibility forecast

Service instance information

Service was run at: 2023-10-23 14:55:32.553331
Service was run with the following parameters (some parameters may have been overwritten based on pilot choice):

- pilot = OEDAS
- pilot strength = 282
- event day = 2022-01-20
- event duration = 120
- price ratio = 20
- population = 3500

4.3.2.1 Introduction

Being able to predict a customer's reaction to a price change is useful in a real-time power pricing setting where consumers are sensitive to changing rates. This study suggests estimation of aggregated load flexibility based on the historical price-response dynamics of consumers and demonstrates how one-way price signals can be utilized to control the aggregated electricity consumption.
The proposed approach requires aggregated historical consumption data along with the historical and current weather information to estimate "price-based" demand-side flexibility.

Service inputs

The following parameters control the service results:

- Planned event start, given as ISO 8601 time

- Event duration, given in minutes
- Price change, given as ratio between the price during the event and regular price during the event
- Population, the population participating in the event, given in percent of all population
- Aggregated consumption
- Weather data

Flexibility model

Model and building of the model

The model has been prepared during BD4OPEM project in cooperation with UiW (Use it Wisely) national project, led by Elektro Celje and supported by JSI. The UiW project has been supported by Agency for Energy of Slovenia which enabled a positive and negative critical peak network tariffs in a region of Elektro Celje network. During peak hours the network fee was 10 times higher as at ordinary hours. The Agency decree enabled 100 hours of positive critical peak tariff per year. Based on this the projects have organized 41 events of 2 hours flexibility events in 2021.
The model has been built on a dataset containing the 15 minute-resolution electricity consumption dataset from 791 households in Elektro Celje region. The dataset time span was from September 1, 2019 to December 31, 2021. The dataset was trimmed by removing the customers with missing load and finally 462 customers are used for the analysis. The dataset contains 41 events of 2 hour duration scheduled on different times and days in the year 2021. We have also used the weather data such as temperature, precipitation and radiation of the same region as users to increase the accuracy of our forecast model.

4.3.2.2 Data assessment

The dataset for this notebook service report has been provided by the distribution system operator OEDAS, Turkey. Below is a profile of a selected event day on 2022-01-20 in BD4OPEM OEDAS pilot AST6 transformer.

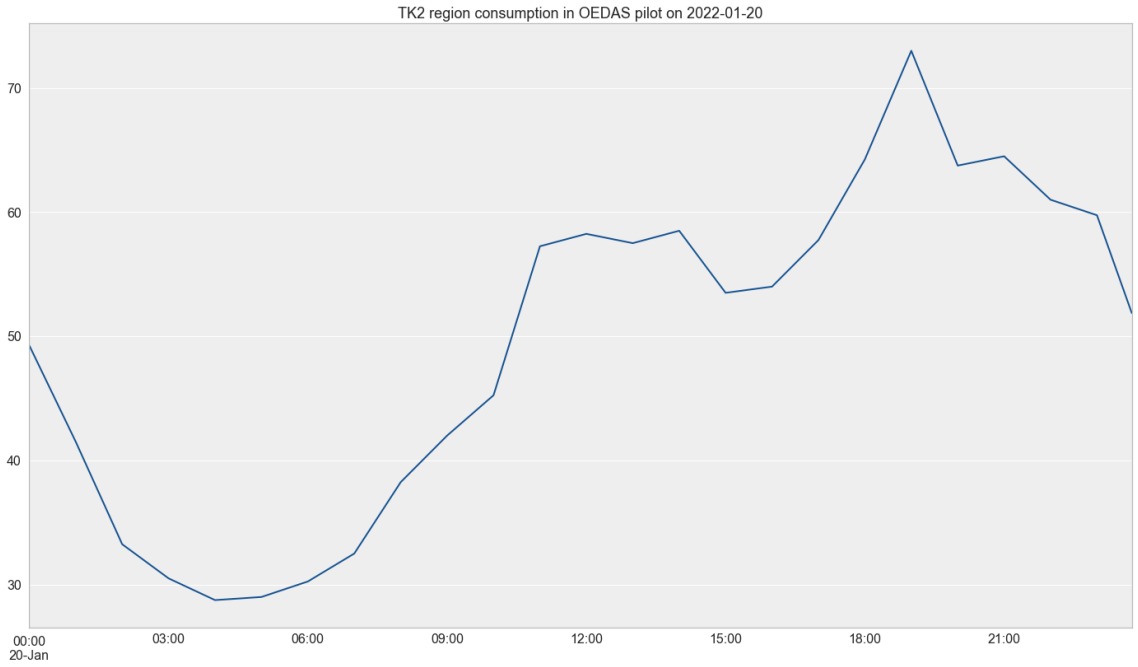


Figure 46: TK2 region consumption in OEDAS pilot on 2022-01-20

Modelling flexibility harvested

In order to model the harvested flexibility on the scheduled events, the event data is removed from the dataset. This dataset is further used for forecasting the consumption of users at the time of the events. The real consumption during the event time period is then subtracted from the predicted consumption to estimate the flexibility harvested from the event.

Forecast Engine

After modelling the flexibility harvested and acquiring the weather data, event data (such as day of week, season), the normalized flexibility during the events can be calculated. These features can be further used to predict the aggregated price based demand response flexibility that can be achieved by changing the price or by increasing the target population.

Forecasted flexibility event

The Figure 47 below shows the comparison of the forecasted and actual values of aggregated demand response flexibility. It can be seen that the forecasted value could consistently follow the trend of the actual value, which reflects a good fitting performance between them.
The event itself is marked with the shaded area. In all six hours of the consumption are presented, two hours before the event, two hours after the event and 2 hours of the event itself. All in all, 15 minute values of flexibility are estimated. The event is modelled as the data is available in 15-minute intervals. If the data was available at 1 hour intervals the data values are filled in with extrapolation.

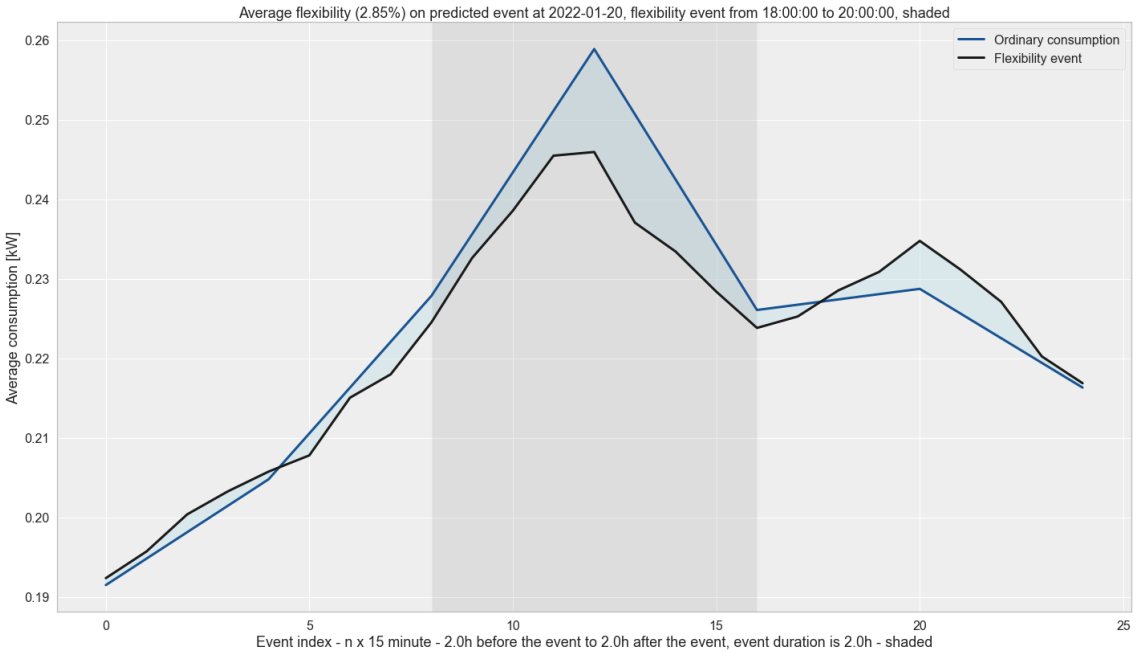


Figure 47: Average flexibility (2.85%) on predicted event at 2022-01-20, flexibility event from 18.00:00 to 20:00:00, shaded

Flexibility and event prices

The Figure 48 below shows the effect of the price change on the user's response on demand flexibility. It can be seen that the price scale has a significant effect on the user's demand flexibility. However, further increase in the price will not add much more to the flexibility harvested. Thus price change should be designed according to

the arctan function as after a certain point, consumers become numb to the further price change.

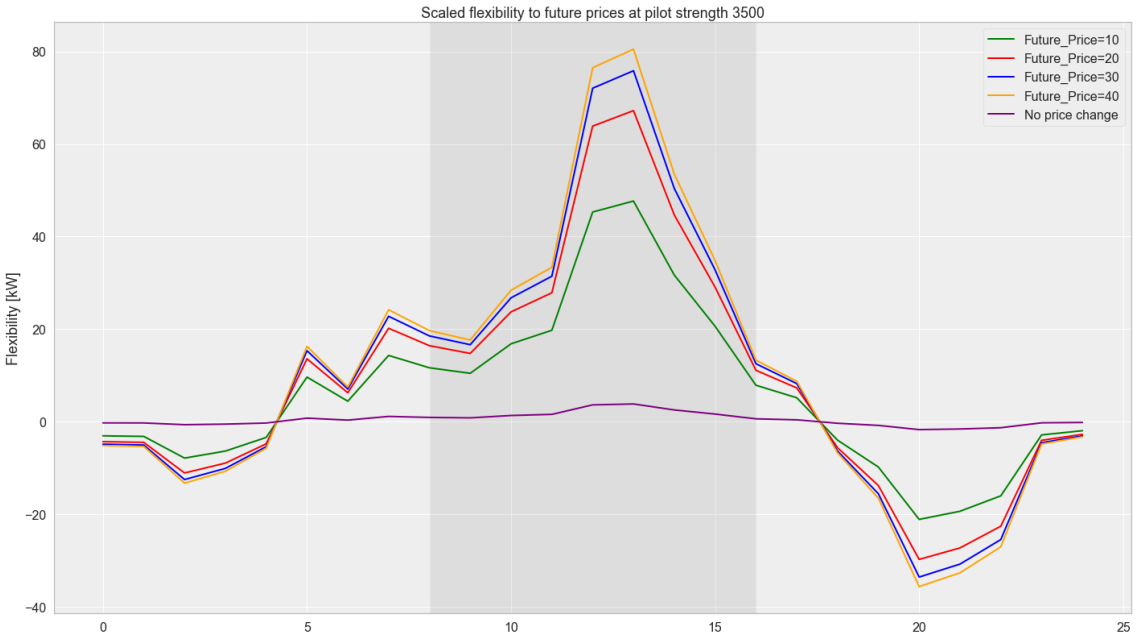


Figure 48: Scaled flexibility to future prices at pilot strength 3500

Flexibility according to pilot strength

The Figure 49 below shows the effect of the change in pilot strength on the harvested demand flexibility. It can be seen that the increase in the pilot strength has significant effect on the amount of flexibility harvested. However, this will also depend on the responsiveness of the pilot users. Thus, it needs to be studied further, at the moment it is just an estimation.

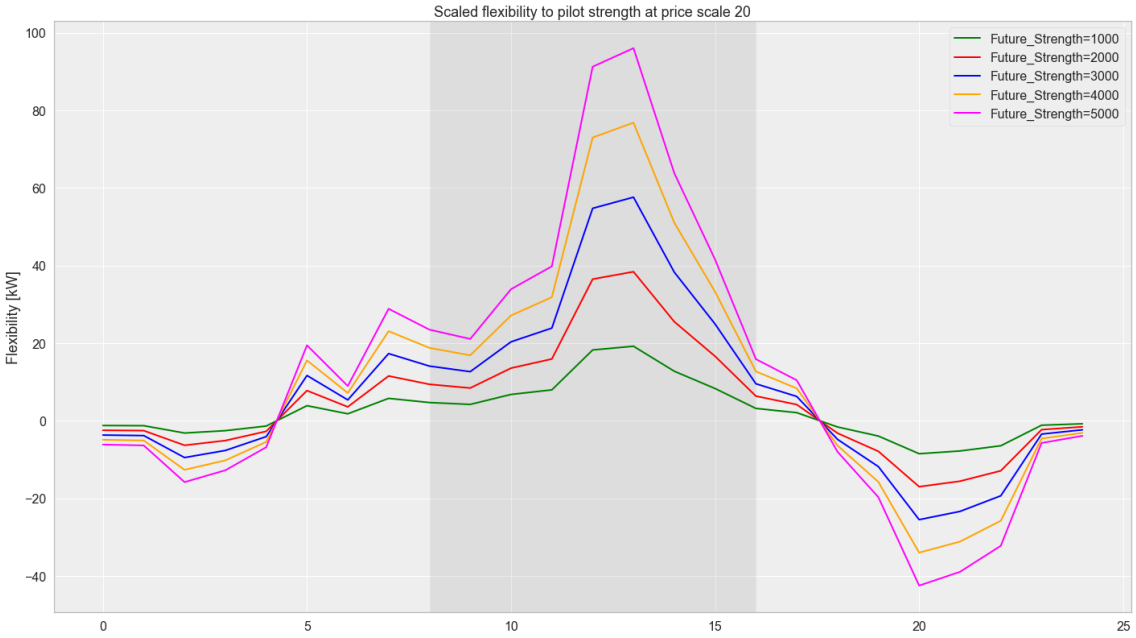


Figure 49: Scaled flexibility to pilot strength at price scale 20

4.3.2.3 Service conclusions

Total flexibility provided under 120 minutes time frame is 71.9 kWh at population 3500 and price scale 20.
Average flexibility availability under 120 minutes time frame is 3.07%.

4.3.3 JSI approach: Flexibility forecast (test 2)

In the section the day selected for estimating the flexibility is presented, as can be seen in the Figure 50 below. The modelling of the flexibility is briefly explained. The region consumption for the target day and region, Thursday, 18th of November 2021, in OEDAS network shows the daily profile in the network. The daily profile is based on SGAT transformer station 1 hour data. The daily profile shows to extent atypical consumptions, atypical in a sense it is not like a household consumption but more a mix of a household and business consumption due to high peak of usage in the morning hours. Please note the flexibility numbers provided are not properly scaled. The service needs pilot population numbers to be scaled properly.

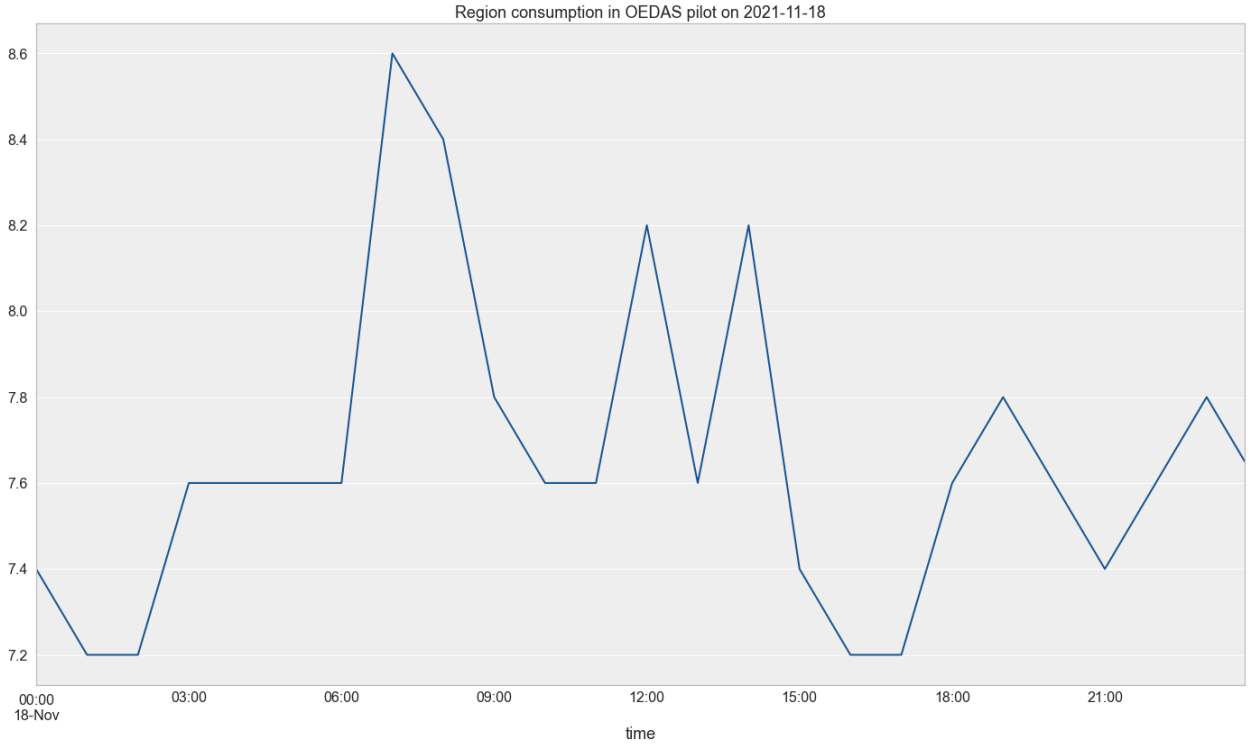


Figure 50: Region consumption in OEDAS pilot on 2021-11-18

Forecasted flexibility event

The flexibility event of two hours has been estimated in the Figure 51 below. The event itself is marked with the shaded area. In all six hours of the consumption are presented, two hours before the event, two hours after the event and 2 hours of the event itself. All in all, 24 hours 15 minute interval values of flexibility are estimated. The event is modelled as the data is available in 15-minute intervals. If the data was available at 1 hour intervals the data values are filled in with extrapolation.

In Figure 51 can be seen that the estimates before the event exhibit large flexibility and such results are quite unlikely. The difference in consumption pattern to the model origin can be a cause for such deviation.

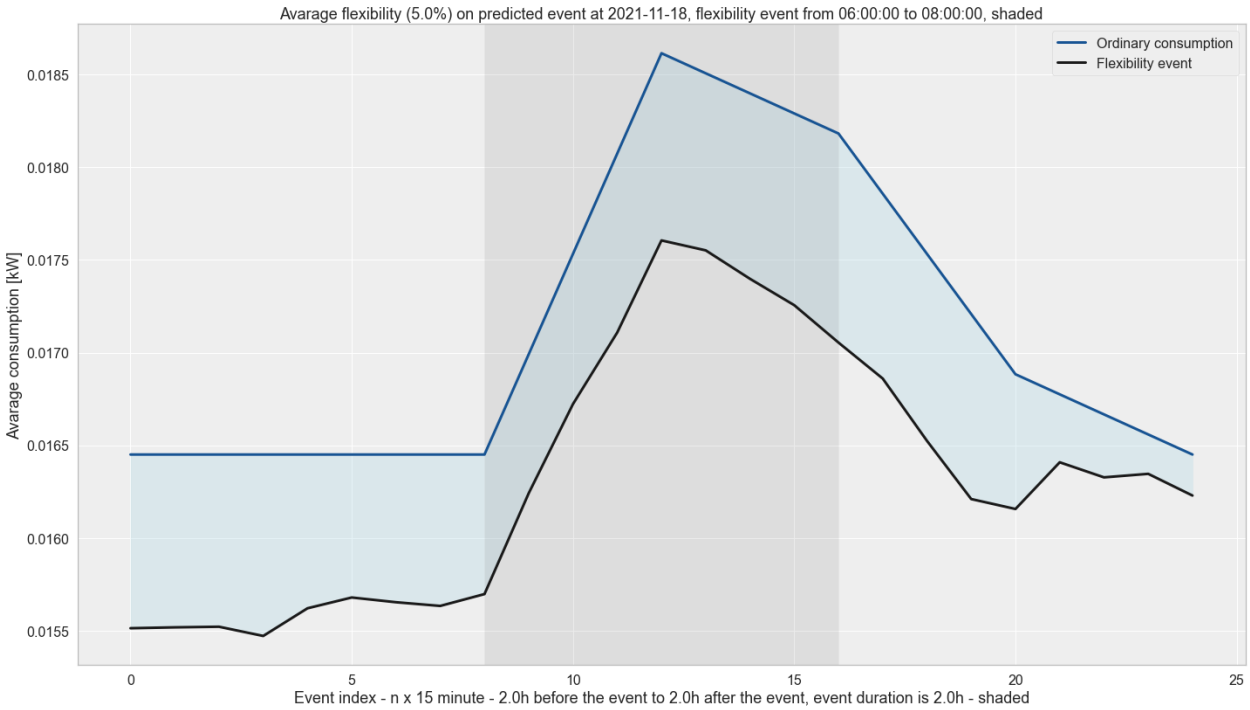


Figure 51: Average flexibility (5.0%) on predicted event st 2021-11-18, flexibility event from 06:00:00 to 08:00:00,shaded

The Figure 52 below shows the effect of the price change on the user's response on demand flexibility. It can be seen that the price scale has a significant effect on the user's demand flexibility. However, further increase in the price will not add much more to the flexibility harvested. Thus price change should be designed according to the arctan function as after a certain point, consumers become numb to the further price change.

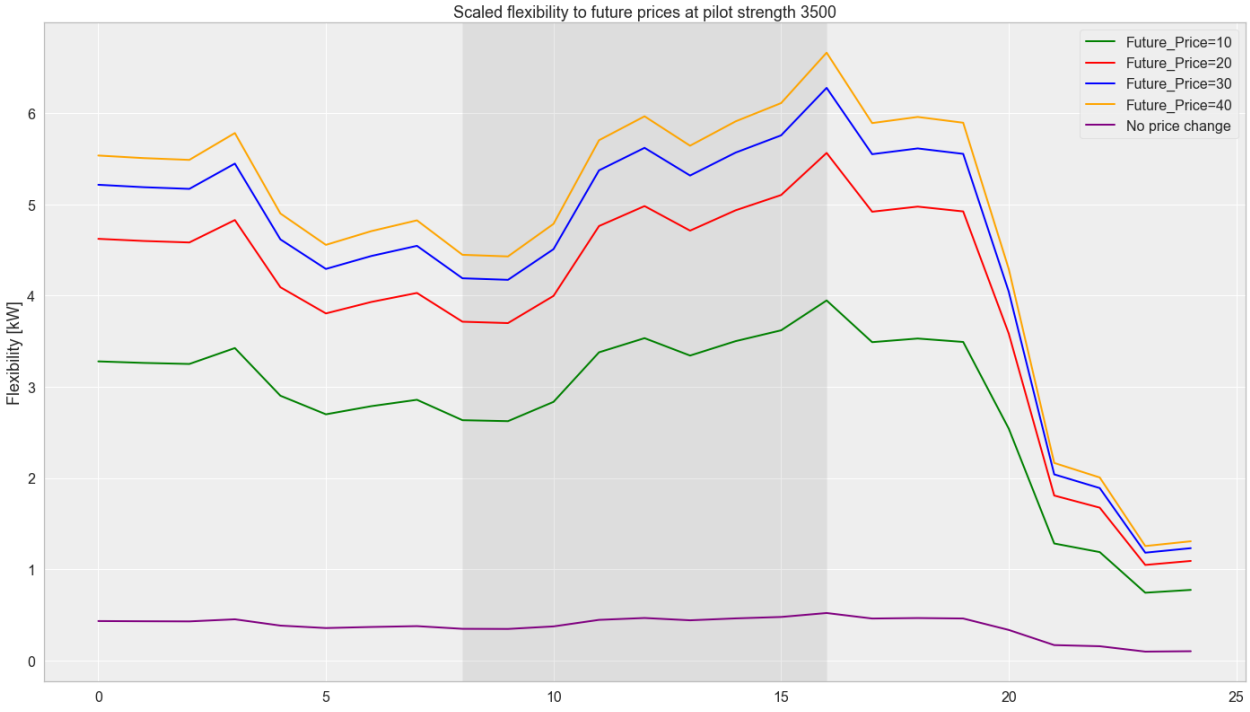


Figure 52: Scaled flexibility to future prices at pilot strength 3500

Figure 53 below shows the effect of the change in pilot strength on the harvested demand flexibility. It can be seen that the increase in the pilot strength has a significant effect on the amount of flexibility harvested. However, this will also depend on the responsiveness of the pilot users. Thus, it needs to be studied further, at the moment it is just an estimation.

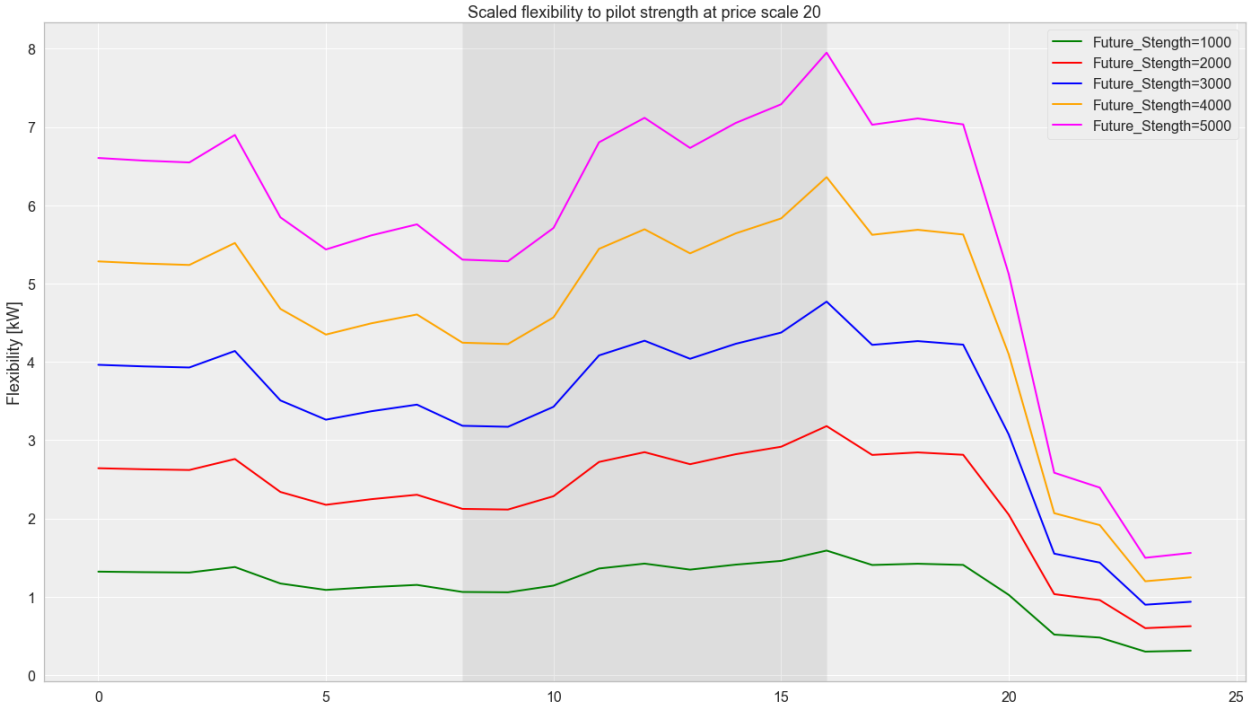


Figure 53: Scaled flexibility to pilot strength at price scale 20

Service KPIs

The section on service KPIs reports two major KPIs:

- Total flexibility in a given time frame: with selected event day, the total flexibility provided under 120 minutes time frame is 1.15 kWh at population 3500 and price scale 20.
- Average flexibility availability in a given time frame: with the selected event day, the average flexibility availability under 120 minute time frame is 5.35%.

4.4 S5.2 – Flexibility aggregated services for BRPs results

4.4.1.1 Introduction of the service

Name: Flexibility Aggregated Services for BRPs
Category: Flexibility and Demand Response
Task: T4.3
Location on the grid: LV

Flexibility aggregated services for BRPs are predictive tools to assist the operational decisions of the BRPs. The "Day-Ahead Portfolio Optimization" use case aims at minimizing electricity purchase costs on the day-ahead market by activating flexibility requests at a cheaper price to supply the BRP's portfolio. The second use case, "Self-Balancing portfolio" forecasts TSO's and BRP's schedule deviations, predicting periods for which it is advised to activate flexibility, avoiding deviations against the system.

Table 13: Use cases for the S5.2 service

Use case	Description
UC1	**As a:** Balance Responsible Party (BRP) **I want to:** Predict the profile of the total costs related to electricity purchase on the day-ahead market and know how much flexibility I need to activate. **So that I can**: Minimise the total electricity related costs of my portfolio by activating flexibility. **Acceptance criteria:** When I run the forecasting service for my portfolio, I know how much flexibility I should buy for the next day to reduce the costs on the day-ahead market.
UC2	**As a:** Balance Responsible Party **I want to:** Predict the deviations from the declared energy schedule of the Transmission System Operator and of my portfolio. **So that I can**: Be prepared to activate flexibility when deviations against the system are predicted. **Acceptance criteria:** When I predict the deviations of BRP's and TSO0s portfolio I want to know when to activate flexibility to avoid deviations against the system.

4.4.1.2 Use Case 1: Day Ahead Portfolio Optimization

The Day Ahead Portfolio Optimization predicts the total costs and energy provision for the next day, as well as showing records of historical predictions. Figure 54 provides an example of the UI, showing the choice of the target date, the required input parameters as well as the calendar interactivity and access to historical forecasts. The service can be easily executed multiple times with different input parameters, allowing the user to analyse the sensitivity to the flexibility price and max cost inputs.

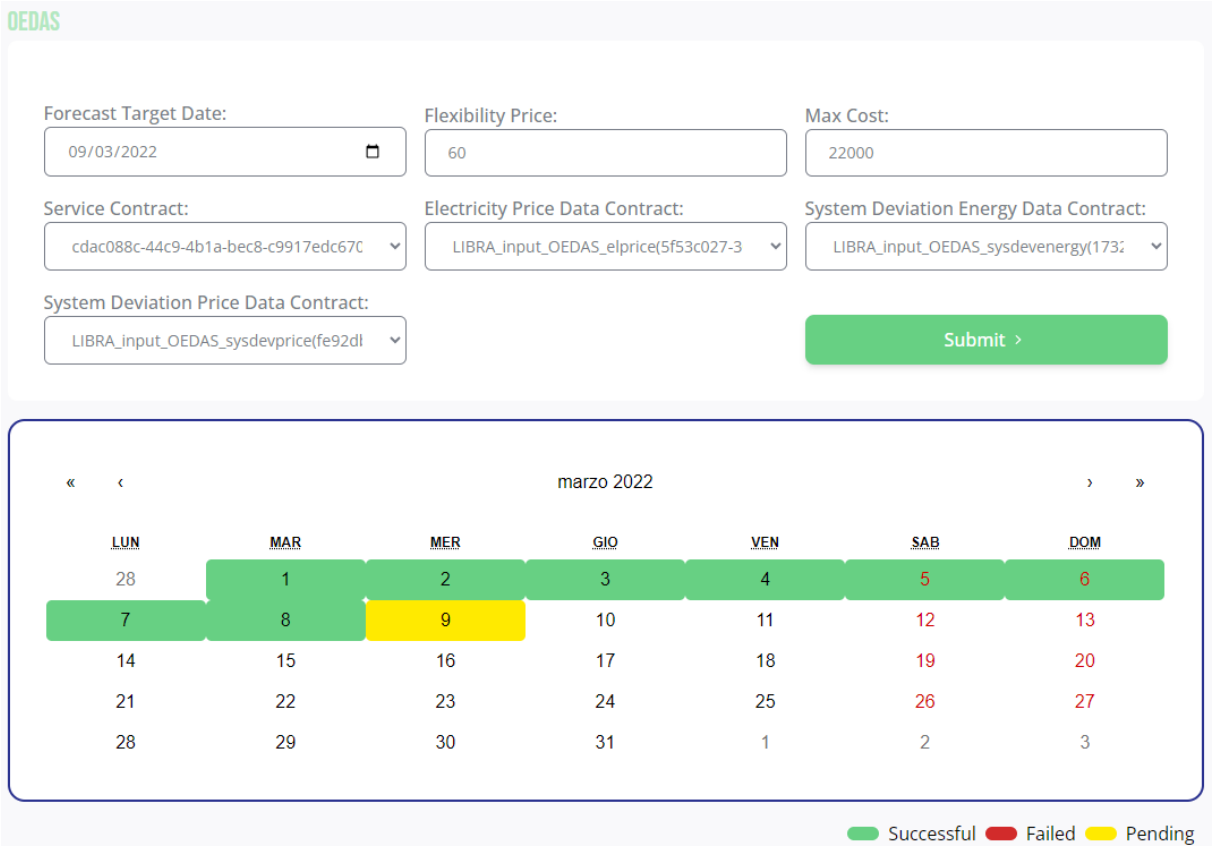


Figure 54: User interface, input parameters, historical and target date choice

For successful execution, the Balance Responsible Party BRP needs to provide the two inputs "Flexibility price" and "Max cost". "Flexibility price" expressed in €/MWh represents the price at which flexibility can be activated for the next day, chosen by the BRP according the contracts with the aggregator or the internal flexibility activation costs. The second parameter, "Max Cost", expressed in €, represents the maximum hourly cost that the BRP is willing to pay on the day-ahead market (DAM) before activating flexibility. If, for a given hour, the total cost of electricity purchase on the DAM is forecasted to be above the threshold, then, the flexibility request is made. On the DAM electricity is bought only until the "Max cost" is reached, then, it is purchased via flexibility request.

Figure 55 shows the results of the execution of the service for the day 09/03/2022, selecting a Flexibility Price of 60 €/MWh and an hourly Max cost of 22000 €. The plot "Predicted DAM vs flexibility costs" indicates how electricity is purchased, according to the chosen input values. It is obtained by multiplying the results of the DAM electricity price predictions with the BRP's portfolio demand prediction. For the displayed day, the "Max cost" effectively is able to identify the peaks of the total costs. The line in blue, "Total costs DAM", represents the costs of electricity purchase on the DAM, limited by the "Max cost". The line in green "Total cost flex" displays the total costs to supply the BRP's portfolio, adding to the costs on the DAM the costs of the flexibility request, purchased at the previously input "flexibility price".

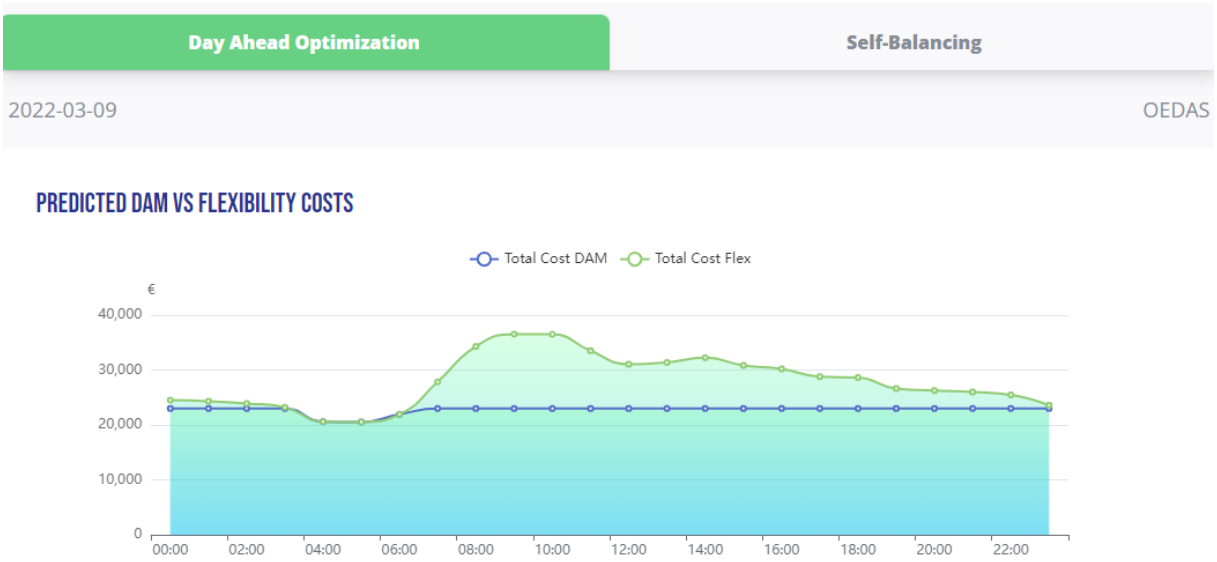


Figure 55: Costs of electricity on the DAM and with flexibility purchase

Having evaluated how much daily costs should be allocated to the purchase of flexibility, the algorithm computes the equivalent amount in energy, as shown by the plot "Predicted demand vs Flexibility request", displayed in Figure 56. The blue line "Predicted demand" represents the predicted consumption of the BRP's portfolio, before the implementation of the strategy, whereas the green line "Flexibility request" shows the amount of energy recommended to be purchased via flexibility activation, instead of being acquired on the DAM. It can be seen how it is only activated when the operational costs are forecasted to exceed the threshold defined by "Max cost".

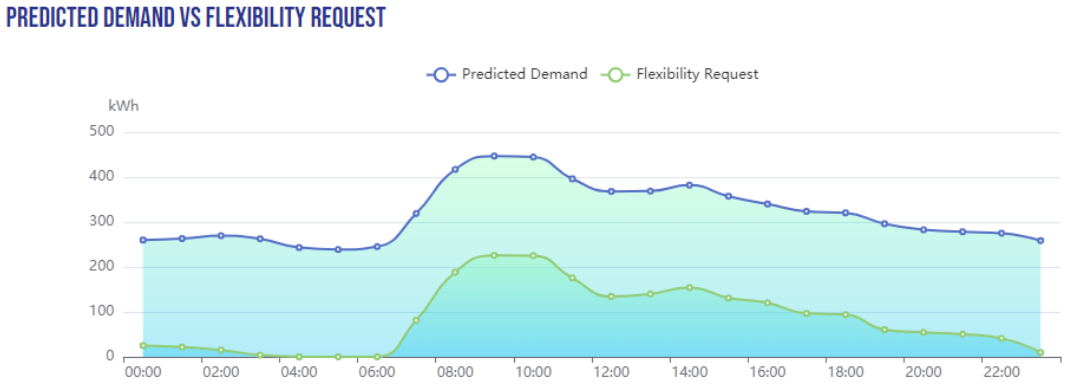


Figure 56: BRP's portfolio energy demand and suggested flexibility request

Finally, the KPIs are computed to show how the service performs for a given day. Show in Figure 57, are summarized the sums of the hourly profiles calculated, namely the total amount of flexibility requested and its cost, the total costs of DAM electricity purchase and the estimated savings by following the suggested strategy. Overall it can be noticed that the proposed strategy is beneficial for the BRP, successfully identifying cost reduction opportunities.

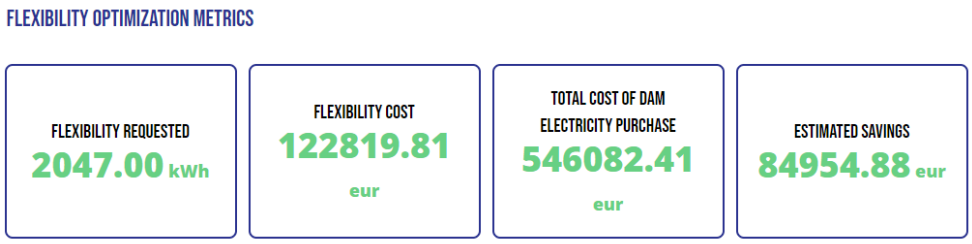


Figure 57: Day ahead portfolio optimization KPIs

4.4.1.3 Use Case 2: Self-balancing Portfolio Optimization

Although energy schedules are made as accurately as possible, the final delivery of electricity is seldom congruent to what initially declared. This is true for both the program of the Transmission System Operator (TSO) and the BRP's portfolio. The Self-balancing Portfolio Optimization aims at improving the BRP's assets management by studying the sign of the deviations from the declared energy schedules of both his portfolio and of the TSO, trying to avoid imbalance penalties that occur when the declared schedule is not respected, incrementing the system instability.

The results of two forecasting algorithms are combined to suggest action signals to the BRP on the day ahead of electricity delivery. The first is to predict the TSO deviations and the second the BRP portfolio deviations. Figure 58 shows the results of the imbalances predictions, with binary values being shown. The value of 1 means that there is an excess of electricity, for the TSO represents an excess of production whereas for the BRP an excess of demand. The value of 0, on the other hand, represents a negative deviation. Lack of electricity production from the TSO side and lack of consumption from the BRP.

Figure 58: TSO and BRP deviations forecast

The directions of the deviations, then, are compared to generate action signals in the hourly periods when the deviations bring to a further imbalance of the overall electricity system. The plot shown in Figure 59 displays the periods of suggested flexibility activation, indicated by the value of "1". When the value is "0", then no flexibility activation is required. Furthermore, the KPI shown below the plot summarizes the daily predicted deviations, indicating the percentage of deviations against the system.

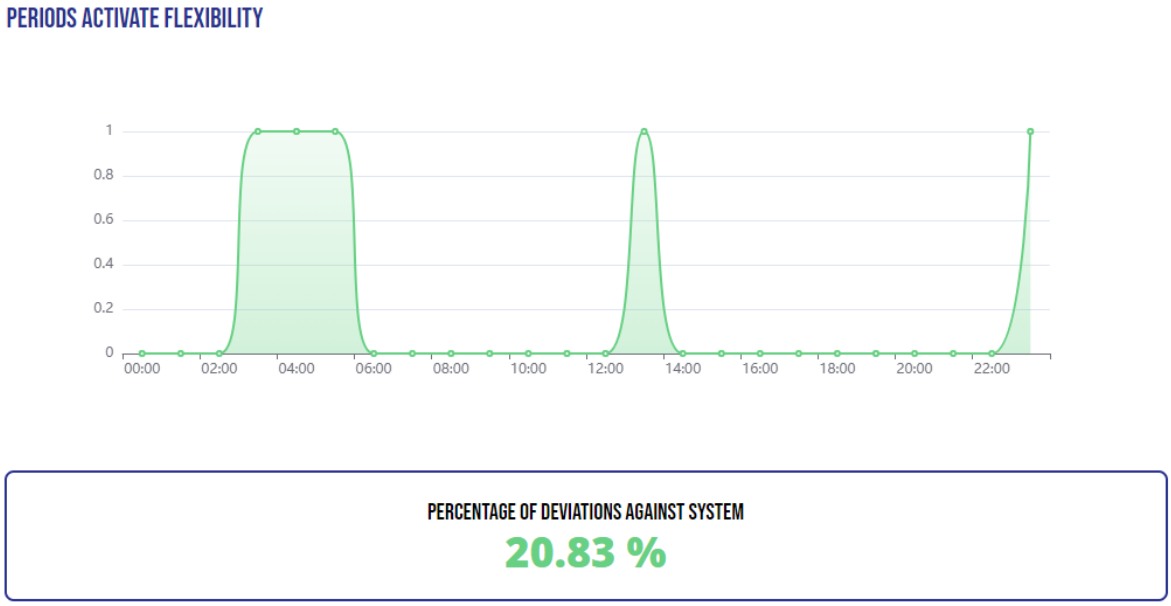


Figure 59: Suggested flexibility activations to restore electric system balance and daily percentage of deviations against the system

4.4.1.4 Data assessment

Table 14: Data Assessment

Data source needed	BD4OPEM ontology	Data quality assessment	Impact of the quality on the service
BRP demand	System_Deviation_Energy	Good quality	High
SPOT electricity prices	System_Deviation_Price	Good quality	High
Electricity market features	System_Deviation_Energy	Good quality	High
BRP imbalances	System_Deviation_Energy	Good quality	High
TSO imbalances	System_Deviation_Energy	Good quality	High

4.4.1.5 Service conclusions

The service comprised of the Day Ahead Portfolio Optimization and Self-balancing Portfolio Optimization use cases offers valuable tools for BRPs. The Day Ahead Portfolio Optimization service allows them to make informed decisions by predicting total costs and energy provision for the next day. By inputting flexibility prices and maximum cost thresholds, the BRP can strategically manage electricity purchases on the DAM through flexibility requests, optimizing cost savings. The visualization of

results, such as the breakdown of DAM costs versus flexibility costs and suggested flexibility requests, empowers the BRP to make efficient choices. On the other hand, the Self-balancing Portfolio Optimization service addresses the challenges of balancing electricity delivery schedules. By identifying excesses and shortfalls in electricity supply and demand, the service generates action signals for the BRP to avoid imbalance penalties while enhancing system stability.

Future work includes the improvement and personalization of the inputs for the Day Ahead Portfolio Optimization, such as the possibility of adding a 24h profiles instead of constant daily values. In addition, the flexibility provisions can be further investigated, including a study specifying the flexible resources required to supply the energy requests.

Additionally, the following feedback was raised during the testing:

- UI improvement with automatization of inputs (they are reset after every execution)
- Further sign of flexibility activation (upward or downward)
- Since the service operates with Turkish data consider the option of adding results conversion in Turkish lira

4.5 S5.3 – Flexibility aggregated services for DSOs results

4.5.1 UPC approach: Flexibility-based AC OPF

4.5.1.1 Introduction of the service

Name: Flexibility Aggregated services for DSOs
Category: Flexibility and Demand Response
Task: T4.3
Location on the grid: MV/LV network

DSOs are one of the main stakeholders to purchase flexibility services instead of changing the network topology or curtailing power for congestion management. This service calculates the flexibility request for the DSO for a correct operation of the network and sends that request to the aggregator, the entity providing the flexibility. This section considers two different approaches for mitigating and managing distribution network operation. UPC approach presents a methodology for mitigating distribution network congestion based on a flexibility-based AC-OPF approach, while JSI approach presents a methodology for congestion management based on neural networks and LSTM.

Under the network operation timeframe, the DSO faces two main problems, which are congestion management based on over currents, and voltage/reactive power control based on under and over voltages. The first one consists in avoiding the thermal overload of system components by reducing peak loads where a failure due to overloading may occur. The latter, voltage/reactive power control, is based on using load flexibility by increasing or decreasing loads and generation sources to avoid exceeding the voltage limits, typically, when PV systems generate significant amounts of electricity.

This tool aims to provide DSOs with the possibility to calculate the required flexibility to be activated in a specific time period and location. The objective is to provide information to the DSO to manage the efficiently the expected congestion. Additionally, this service aims to provide a tool for DSOs to calculate flexibility within the grid and generate insights for future management of the grid. With the output of this service, it is expecting to reduce DSO investments in grid reinforcements by profiting from the available flexibility.

Table 15: Use cases for the S5.3 service

Use case	Description
UC1	As a DSO analyst, I want to generate a congestion management plan for the next day
UC2	As a DSO analyst, I want to evaluate the grid I managed before and after my dispatch of flexibility.

4.5.1.2 Use Case 1

After the service is executed for a specific day, we can observe several interesting values for the flexibility of the flexible sources as shown in Figure 60. The service offers the possibility to observe values related to the flexibility sources. In this case, we can see that the flexibility sources capacity needed to clear congestions is 0.0%. Also, we can observe the usage of the flexibility sources, in terms of times instances (for OEDAS is an hourly frequency). For most of the sources is only 1, confirming that there are not many instances in the day where the grid is stressed. However, we observe that the congestion clearing is 100%, so for that specific case, the sources installed in the grid are enough to cover and avoid congestions, as seen in Figure 61.

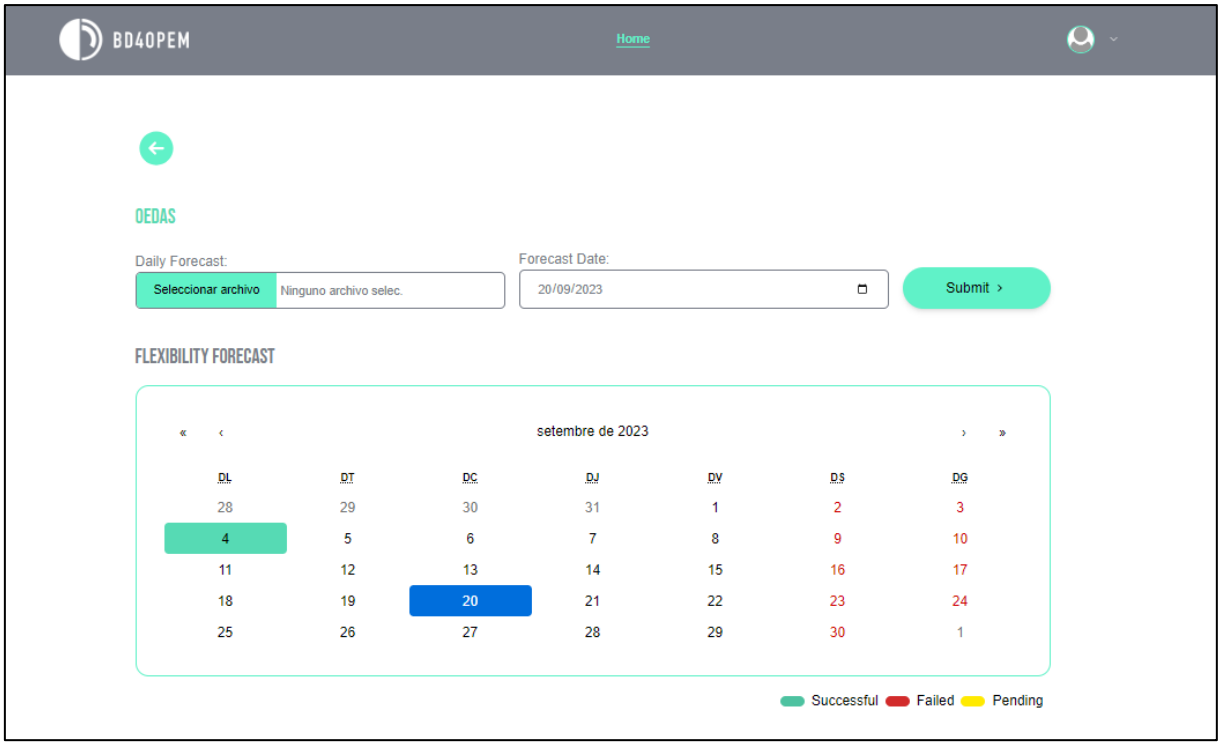


Figure 60: Service UI Execution Home

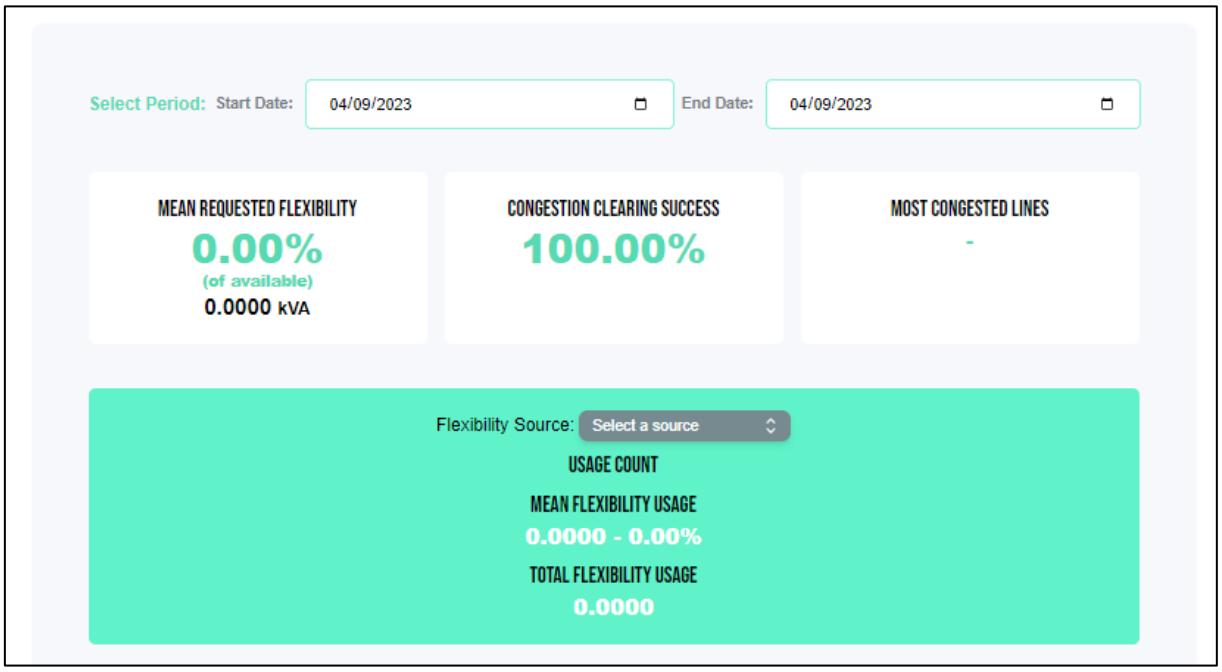


Figure 61: Period flexibility statistics

When selecting the specific day, we are able to retrieve more information about the needed flexibility. From the requested flexibility field, we can observe that no flexibility was required for this forecasted day. Also, we can observe the most loaded lines and hour with higher load. Additionally, we can observe the statistics for each of the flexibility sources used.

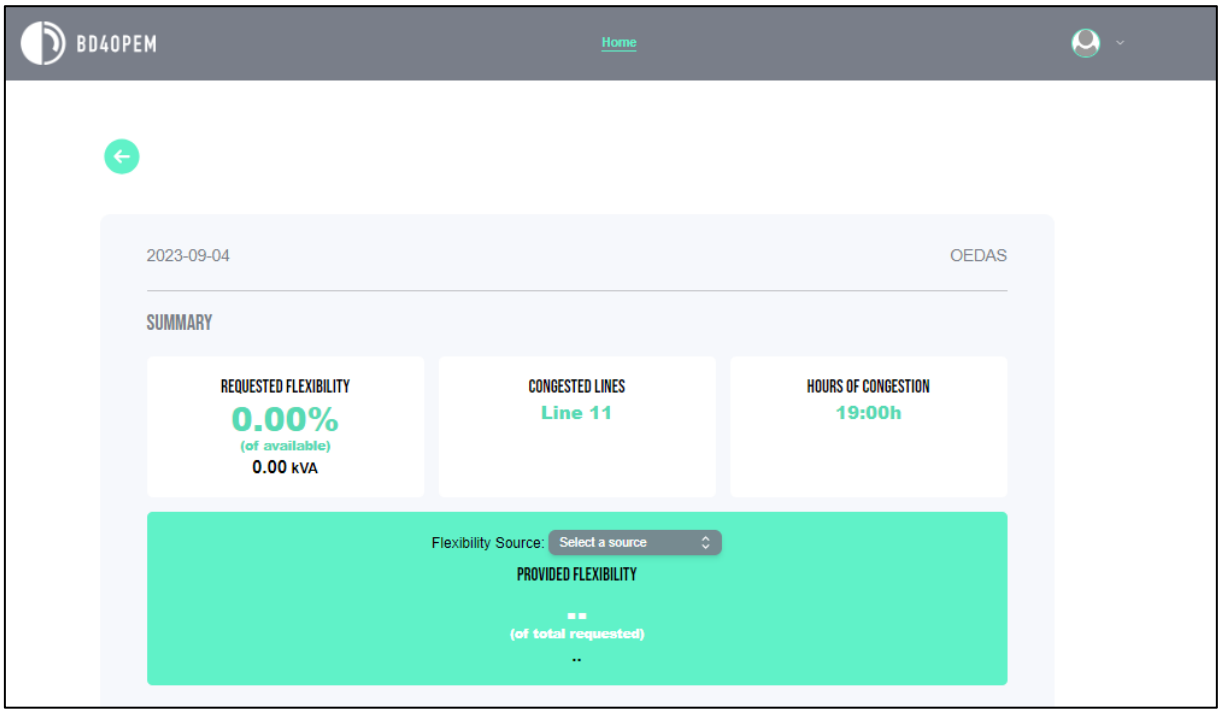


Figure 62: Forecast Day results

4.5.1.3 Use Case 2

One important feature that this service offers, is the possibility to see the grid before and after the application of the Flexibility Request (FR) calculated by the algorithm. This is important as the analyst is able to see actually the reduced loading of the lines and improvement of voltages, if any. In Figure 63, we are able to see the snapshots

of the grid before and after of the FR, for any desired hour. The images can be downloaded for any posterior purpose desired by the analyst.

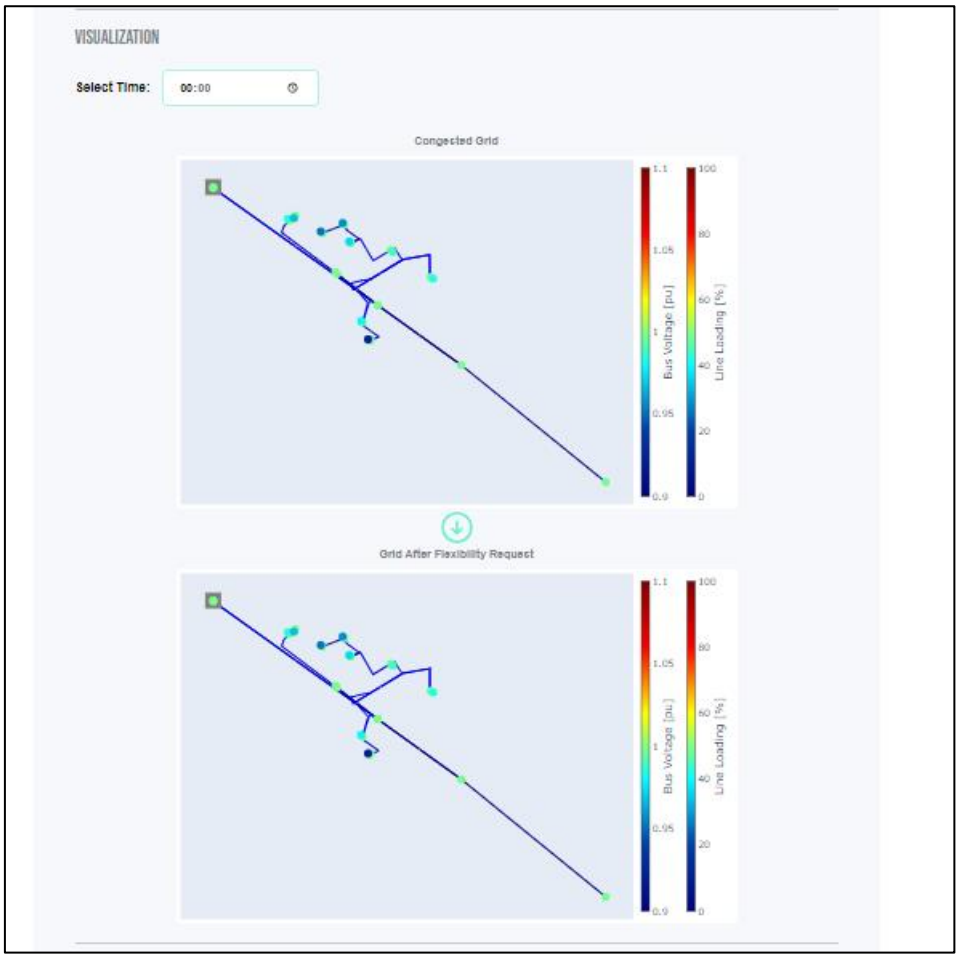


Figure 63: Flexibility Request

4.5.1.4Data assessment

The data required to establish the service mainly comprehends topology and grid parameters of the grid, and forecast calculations. The specific data files for this service can be observed in Table 16.

Table 16: Data Assessment

Data source needed	BD4OPEM ontology	Data quality assessment	Impact of the quality on the service
Grid Topology	Feature collection	Full information of topology	Some connection points missing

4.5.1.5 Service conclusions

For this pilot, the availability of data was limited, hence, some of the functionalities of the service cannot be fully appreciated. The functionality of this service is subjected to the regulations and configuration of flexibility markets where the DSOs is. The service's objective is to present the user information regarding flexibility procurement, however, there are many details regarding this type of procurement. However, the service's current output is very interesting to have a first look to

flexibility needs within the grid. For future iterations, the service could benefit from more details regarding the flexibility sources in the grid as input. For the development, the service can add more explanation on the flexibility request, aligned with current strategies of the DSO.

Additionally, feedback raised during the testing of the service is as follows:

- The red values for weekends in the calendar in the UI home calendar can be misleading.
- The values of the flexibility sources should be given in KW and not KVA.
- In Figure 62 Flexibility Request the indices should relate to the actual name of the buses, as then it is difficult to recognize to which bus the flexibility sources are connected.

4.5.2 JSI approach: Flexibility services for DSOs based on neural networks

4.5.2.1 Introduction of the service

Name: Flexibility services for DSOs based on neural networks
Category: Flexibility and Demand Response
Task: T4.3
Location on the grid: MV/LV network

Flexibility services for DSOs provide necessary services for the DSOs to schedule flexibility events in a region of their network. The services provide a prediction of consumption in the target region and propose an event schedule at the time of the peak. The service requires historic data of the region's consumption and weather forecast for the region. The service has been used with the following weather parameters: temperature, radiation and precipitation. At least temperature should be available.

The prediction of the consumption depends on the available weather forecast. More days of the forecast are available, longer can be the consumption prediction. For example, in Elektro Celje Case, if there are seven days of weather prediction data available the consumption can be predicted for a week in advance. Since the consumption is based on smart-metering and the metering is considered to be D-1, the effective prediction is less than a week long. The number of days is further reduced since the D-1 data is usually not good enough for prediction. Large portions of the network data is available as D-2 data. In summary, an effective prediction is only 5 days long.

The service results are presented in the HTML report in the services tab. The report has a name and table of content (ToC). In this case the service report head for OEDAS service results is presented. The ToC shows a section with reports on the service parameters so the service user can check the parameters used by the script. The next sections are Predictions and Event planning, which results are explained below.

Predictions

The predictions are based on SGAT transformer station smart metering data for the year 2021. The complete profile is shown Figure 64. Though the profile was very carefully selected it can be seen that it has some periods missing data or prolonged inactivity of some of its smart meters.

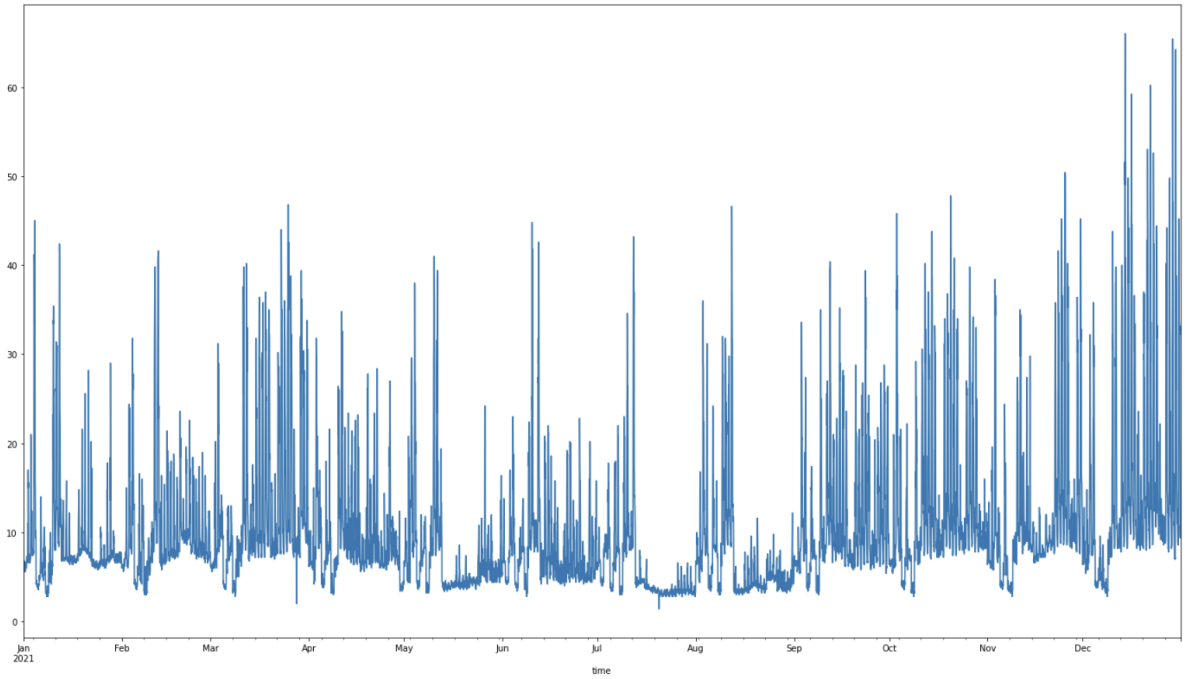


Figure 64: SGAT Transformers load profile

The predictions section reports on the importance of the features and errors in fitting the predictions to the train and test set. The results could be used to understand how good the algorithm is for predictions based on the provided data and which features are considered most important.

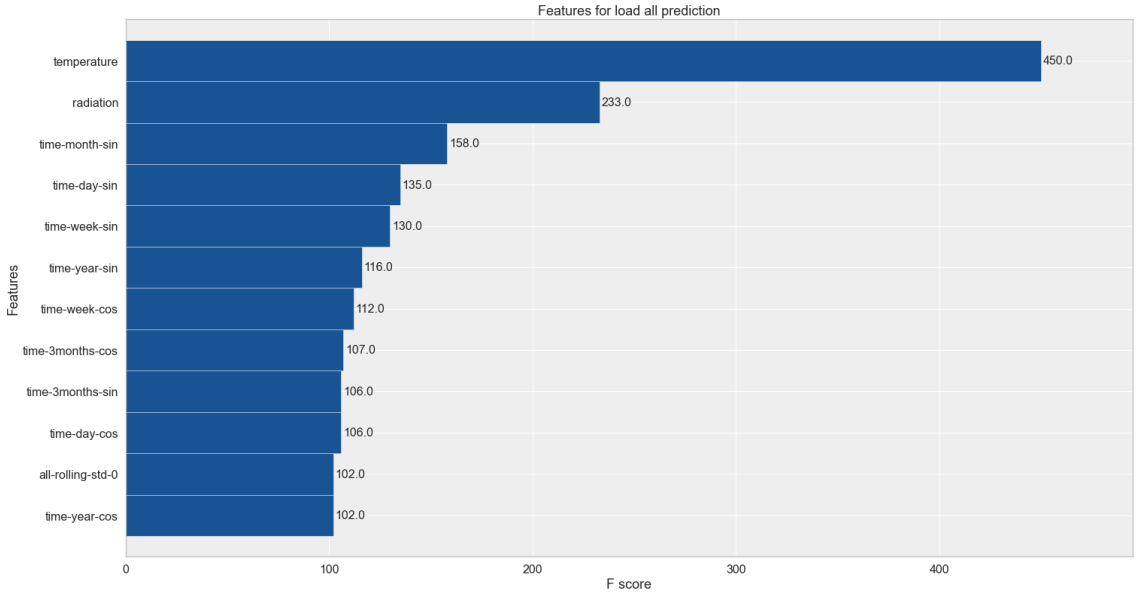


Figure 65: Features for load all prediction

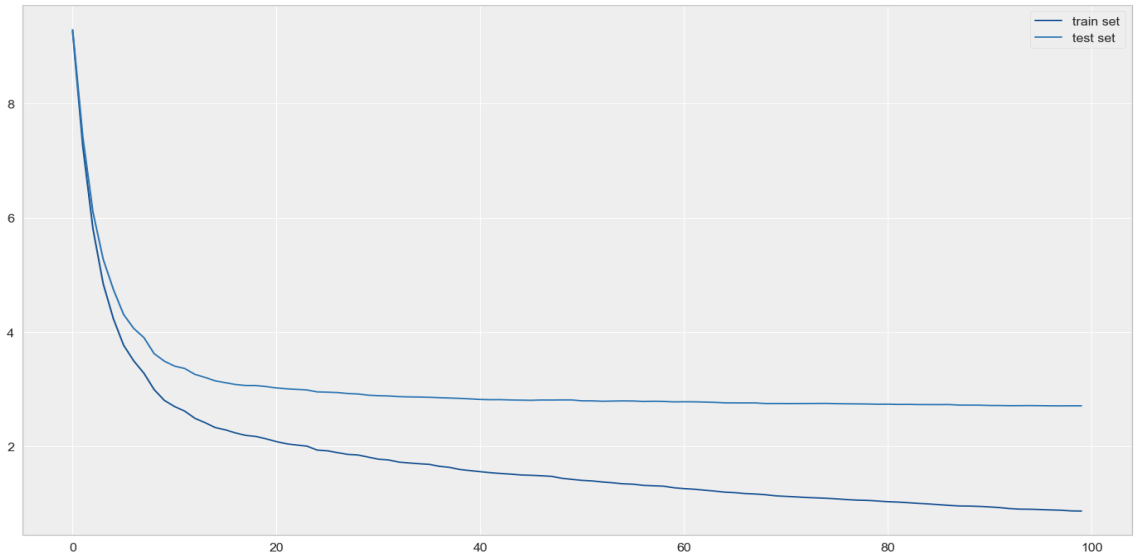


Figure 66: Train test graph

From the features we can see that the most important is the temperature which is followed by radiation. The fitting of the test and train set shows that the predictions won't be great, the data is not optimal for the algorithm selected by the developer.

In Figure 67 are given the predictions for the selected week. We see the amplitudes of the predicted consumptions, in red, are well off the consumption realization, in blue. The peak times seem to be mostly matched.

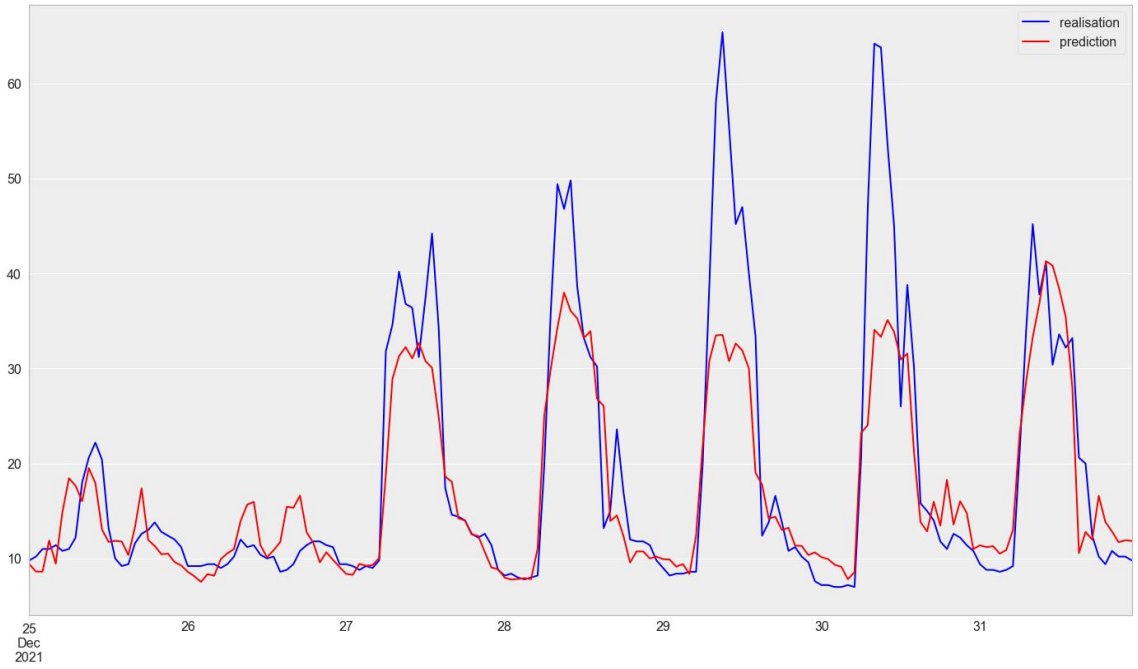


Figure 67: Predicted/ Real consumption

The accuracy of the results are given in the next table. The most important parameter for the service is the Peak hour difference. Based on this parameter the event intervals for the flexibility events are chosen. Even here we see for this week some of the predictions are quite off the realization.

date	peak error [%]	min error [%]	corr	ptp [%]	std [%]	mean [%]	error [kW]	MAE	MSE	RMSE	Peak hour difference
2021-12-25	19.21	-28.03	0.553594	16.19	6.37	1.55	0.0	2.675201	10.677666	3.267670	0 days 01:00:00
2021-12-26	-16.29	-36.39	0.350807	-167.35	-154.30	-11.50	0.0	2.037231	7.835917	2.799271	0 days 09:00:00
2021-12-27	31.96	-7.16	0.952317	31.00	25.78	13.28	0.0	3.407637	28.735189	5.360521	0 days 02:00:00
2021-12-28	27.59	-1.62	0.923619	28.08	20.67	9.47	0.0	4.022202	36.588866	6.048873	0 days 01:00:00
2021-12-29	48.72	-40.06	0.953610	56.46	50.02	21.55	0.0	6.974241	127.085512	11.273221	0 days 00:00:00
2021-12-30	46.92	-30.33	0.910855	52.30	49.59	17.22	0.0	7.185403	129.469452	11.378464	0 days 02:00:00
2021-12-31	26.32	-22.19	0.912187	15.86	8.27	-2.60	0.0	3.938218	25.430571	5.042873	0 days 02:00:00

Figure 68 Weekly Prediction data set

An example event day presented below is Tuesday, 28th of December. In the table above we can see the peak prediction is one hour off but the proposed interval fits the realization consumption well. The suggestion of the event for the DSO seems to be correct.

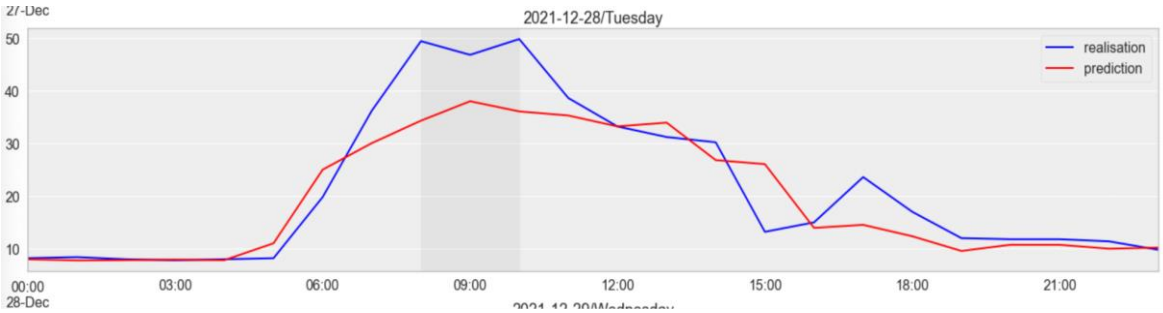


Figure 69: 28th of December's consumption and prediction

4.6 S7.1 – P2P trading results

4.6.1.1 Introduction of the service

Name: P2P energy trading

Category: Smart house, buildings and industries
Task: T5.4

Location on the grid: LV

Citizen Energy Communities (CECs) provide prosumers, consumers and small-scale community producers with the ability to locally trade their energy among its members. The P2P Trading service enables these transactions in a trusted and automated fashion, through the use of smart contracts on the blockchain. The aim of this is to provide trusted trading between these end user CEC members and importantly also facilitate the trusted billing reconciliation between the CEC Administrators (that set up the CEC on behalf of its members) and the DSOs.

Table 17: Use cases for the S7.1 service

Use case	Description

UC1	As a CEC Administrator I want to set up a CEC so to provide trusted trading in an automatic fashion on behalf of its members.
UC2	As a CEC Administrator I want to be able to contract a smartmeter data set for P2P trading over a marketplace from the DSO concerned and benefit from trusted billing reconciliation

4.6.1.2 Use Case 1

In the Turkish P2P Trading pilot, a retailer acted as a CEC Administrator to setup and initialize the service for 3 smart meters.

The contracted service making use of an automatic fair trading cooperative algorithm for its 3 members is shown in Figure 70.

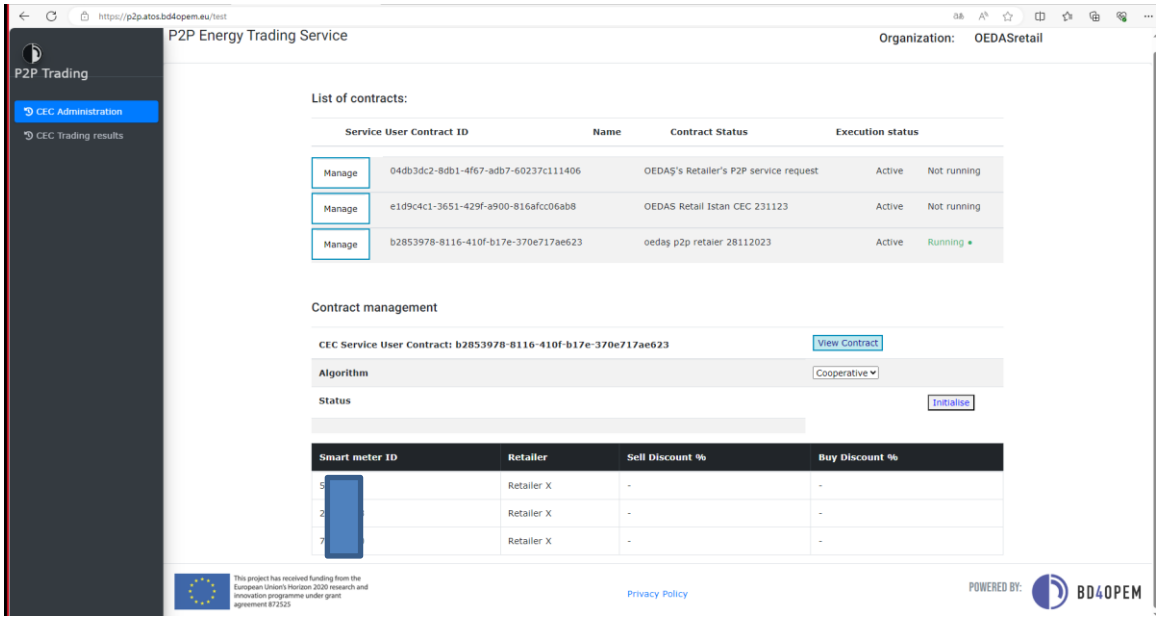


Figure 70: CEC Administrator setup & initialize view of P2P Trading Service

4.6.1.3 Use Case 2

In the Turkish P2P Trading pilot, a blockchain peer node was set-up by the Service Provider (SP) Atos and another for the Data Provider (DP).

The retailer (OEDASretail) contracted the data source from the OEDAS Data offer on the marketplace and activated the service on the Atos peer node, through its frontend dApp service. The trading results are obtained by OEDASretail over the Atos peer node. OEDAS also has a peer node installed as the other trusted party in the blockchain network, in order to get access to the same trading results as OEDASretail. The trading results are downloaded as a csv file as shown in Figure 71 and checked in Figure 72 that the members´ smart meter data is traded correctly and used for billing reconciliation between the retailer and the DSO.

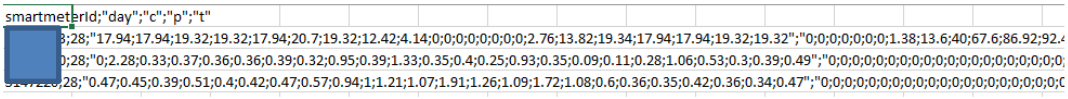


Figure 71: P2P Trading downloaded CSV

	A	B	I	J	K	L	M	N	O	P	Q	R	S	T	U
1	smartmeterId	day	CONS.7	CONS.8	CONS.9	CONS.10	CONS.11	CONS.12	CONS.13	CONS.14	CONS.15	CONS.16	CONS.17	CONS.18	CONS.19
2	2	28	19.32	12.42	4.14	0	0	0	0	0	0	0	0	2.76	13.82
3	7	28	0.39	0.32	0.95	0.39	1.33	0.35	0.4	0.25	0.93	0.35	0.09	0.11	0.28
4		28	0.47	0.57	0.94	1	1.21	1.07	1.91	1.26	1.09	1.72	1.08	0.6	0.36
5															
6			PROD.7	PROD.8	PROD.9	PROD.10	PROD.11	PROD.12	PROD.13	PROD.14	PROD.15	PROD.16	PROD.17	PROD.18	PROD.19
7	2	28	0	1.38	13.6	40	67.6	86.92	92.46	93.84	86.94	74.52	49.68	15.18	0
8	7	28	0	0	0	0	0	0	0	0	0	0	0	0	0
9		28	0	0	0	0	0	0	0	0	0	0	0	0	0
10															
11			TRADE.7	TRADE.8	TRADE.9	TRADE.10	TRADE.11	TRADE.12	TRADE.13	TRADE.14	TRADE.15	TRADE.16	TRADE.17	TRADE.18	TRADE.19
12	2	28	0	0	1.89	1.39	2.54	1.42	2.31	1.51	2.02	2.07	1.17	0.71	0
13	7	28	0	0	-0.95	-0.39	-1.33	-0.35	-0.4	-0.25	-0.93	-0.35	-0.09	-0.11	0
14		28	0	0	-0.94	-1	-1.21	-1.07	-1.91	-1.26	-1.09	-1.72	-1.08	-0.6	0

Figure 72: P2P Trading spreadsheet to check the cooperative algorithm.

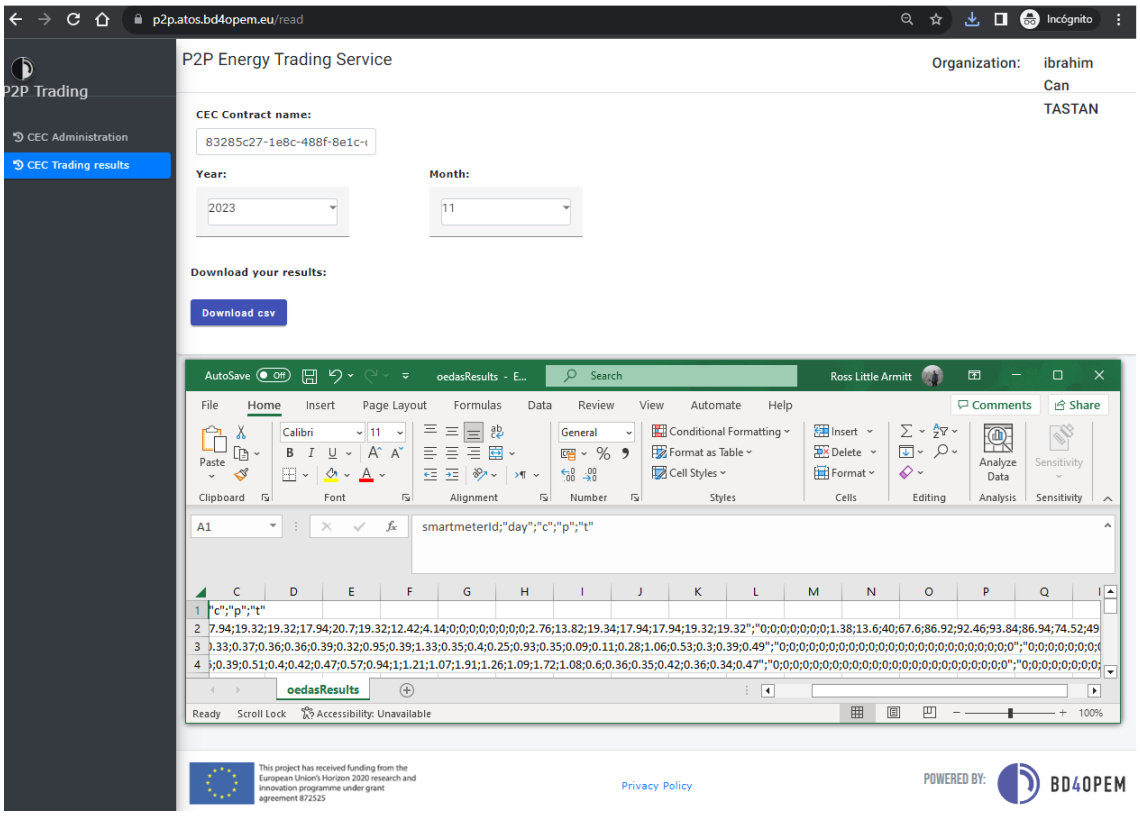


Figure 73: CEC Trading results from DSO view

4.6.1.4Data assessment

Table 18: Data assessment for S7.1

Data source needed	BD4OPEM ontology	Data quality assessment	Impact of the quality on the service
Smart meter	activeEnergyExport, activeEnergyImport	Good quality	High

4.6.1.5 Service conclusions

The P2P trading energy service utilizes blockchain technology to empower not only established retailers, but also newcomers in the energy market to create Citizen Energy Community (CEC). The solution is versatile and open to alternative models, such as retailers serving as Service Providers to new entrants, acting as

representatives for CECs etc. Additionally, the blockchain provides advantages in sharing trading data among different retailers, where CEC Members may be affiliated with other retail entities. It's worth noting that the latter scenario was not tested during the pilot phase, which focused solely on the initial prototype and a basic cooperative trading algorithm. As a DSO view in the future this service will be helpful to manage trading gap in distribution level.

4.7 S8.1 – Asset and investment planning results

4.7.1.1 Introduction of the service

Name: Asset and Investment Planning
Category: Planning
Task: T4.5 Asset and Investment Planning
Location on the grid: MV and LV grid

This service aims to develop optimal investment strategies that contribute to the long-term planning using traditional assets combined with flexible assets to drive into an optimal decision-making. The objective is to minimize the capital expenditure and operational expenditure costs for DSOs.

Table 19: Use cases for Service 8.1

Use case	Description
UC1	As a grid analyst, I want to evaluate the impact of integrating new loads into the MV Network by specifying the incremental growth percentage of a transformer.
UC2	As a grid planner, I want to determine the best techno-economic reinforcement strategy that mitigates congestions in lines and transformers.

4.7.1.2 Use Case 1: Impact study of demand growth

In this use case, the DSOs assess the impact of integrating new loads into the grid by specifying the transformer's incremental growth percentage. Figure 54 provides an example of a stress test using real data from the OEDAS Network. Firstly, DSO needs to select a transformer expansion loading percentage, in this case the secondary substation with ID: AST2 is increase by 400%. Then a type of power flow analysis must be selected, in this case time series power flow, from 07/02/2022 00:00 to 11/02/2022 23:00. This means that each hour a power flow is going to be calculated. Figure 70 shows the results of the power flow in a table format considering the worst-case hour from the selected date time range.

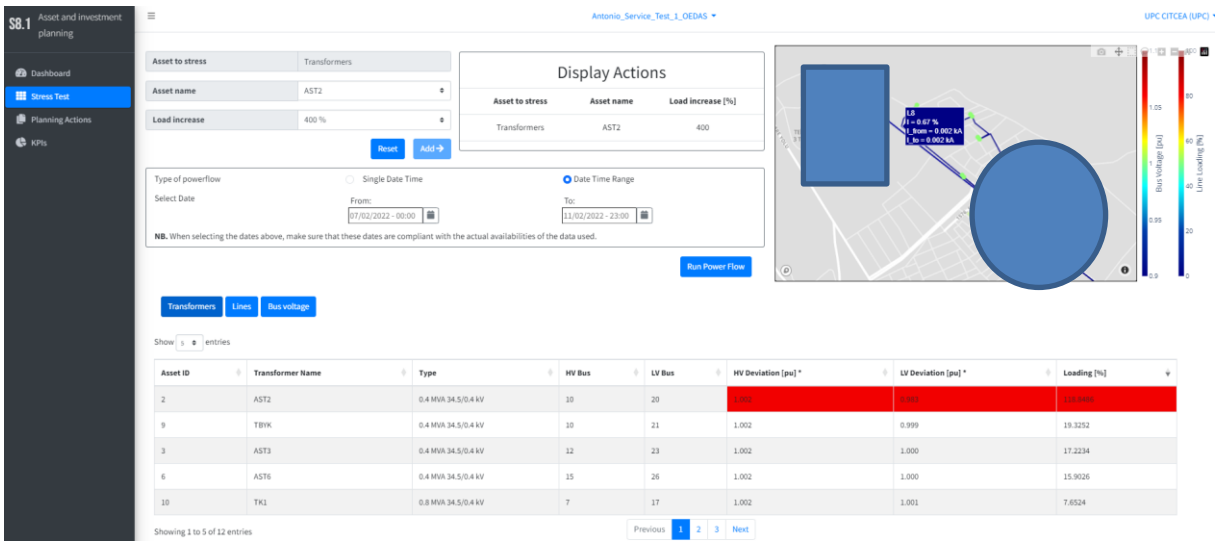


Figure 74: Stress test scenario

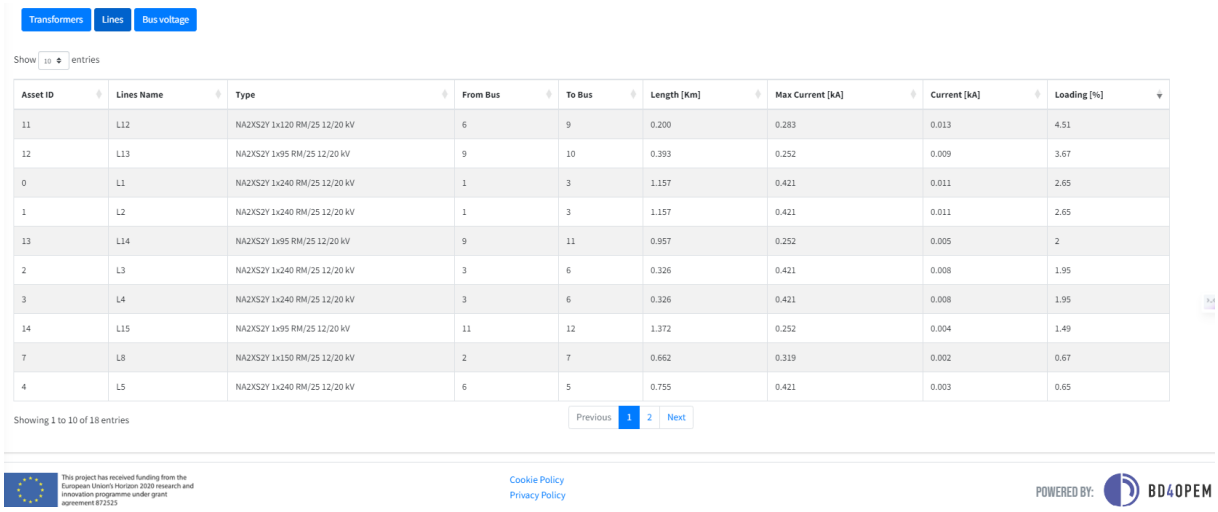


Figure 75: Power flow results of assets

Figure 75 presents a colour GIS map showing the power flow results. The lines and transformers exceeding the 100% loading limit are in red colour, for example the AST2 transformer. On the other hand, the assets in blue colour means that asset loading are below 50%. The nodes are also colour depending in the voltage deviation. This colour style provides an immediate overview of the power flow simulation results to the grid analyst.

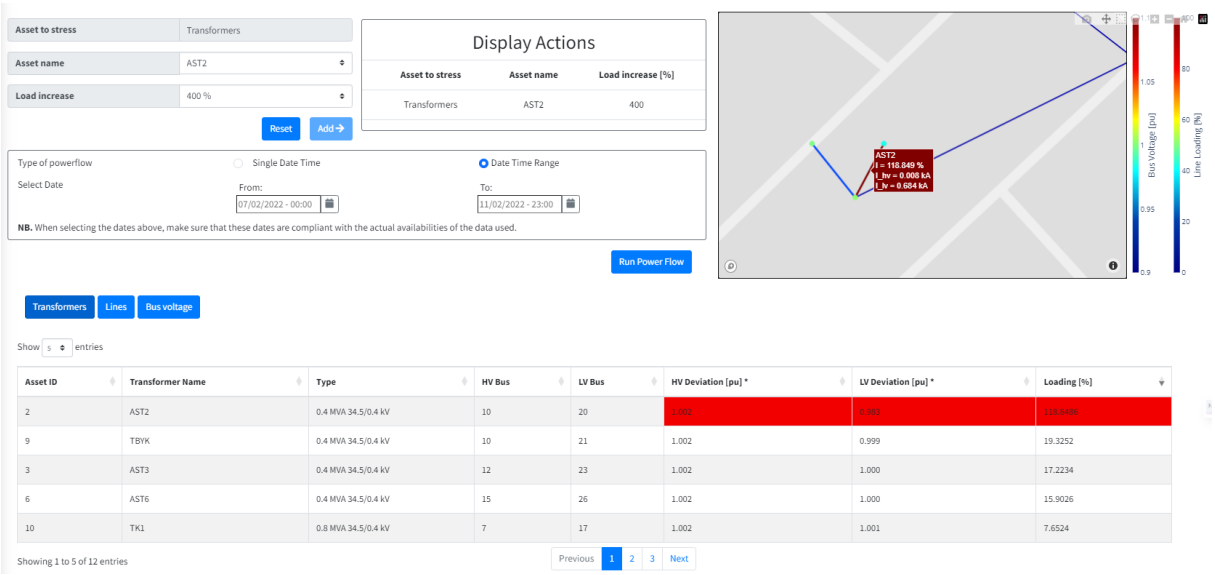


Figure 76: Transformer congestion in red colour

4.7.1.3 Use Case 2: Best techno-economic planning solution

In this use case, we assume that the DSO has already identified the asset congestions in the distribution network. The planning service execute four planning strategies — two passive and two flexible planning alternatives, and in the asset list results box prints the most cost-effective and technically suitable solution, see Figure 76. This tool aims to assist DSO grid planner to evaluate the impact of reinforcement decisions. In this instance, installing a transformer in parallel at AST2 with equivalent capacity and power emerges as the best techno-economic solution. The table results indicate that asset loading levels are now reduced by 50%. This enhancement ensures greater reliability and improved quality of the energy service.

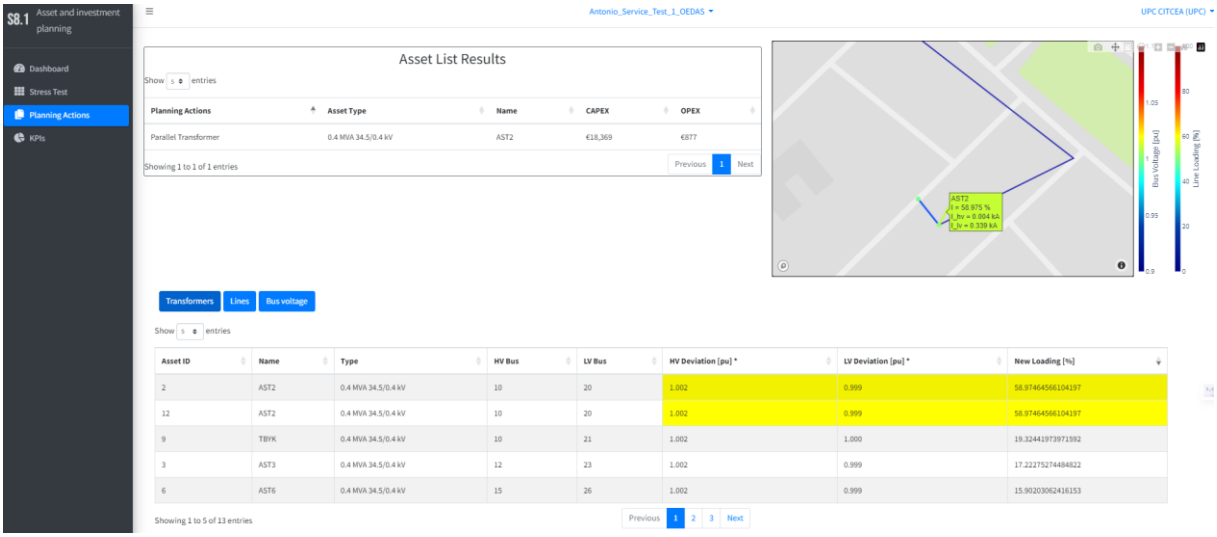


Figure 77: Execution of planning actions

Figure 78 and Figure 79 display the KPI results for the reinforcement solutions. Users can view the total percentage of decongestions for each asset and observe voltage deviations for each node in per unit terms. Additionally, the total cost of the asset reinforcement solutions is provided. The results for these KPIs can be downloaded in a .csv format.

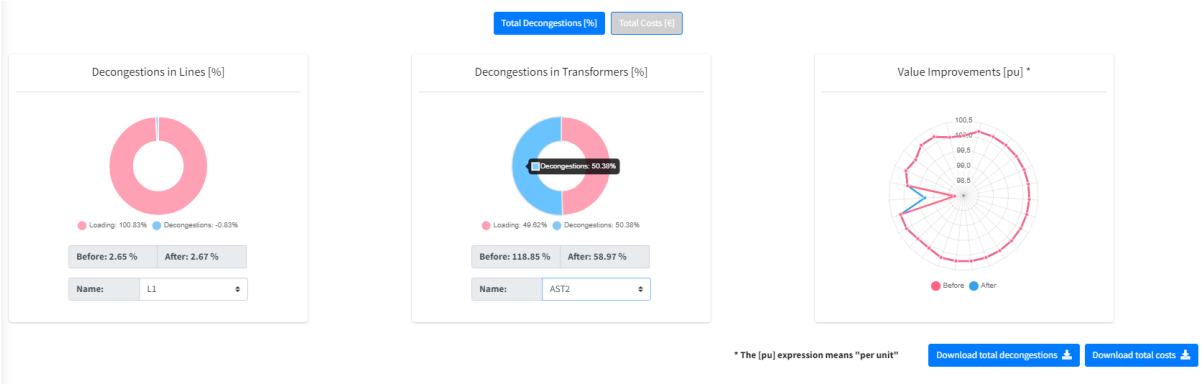


Figure 78: Asset decongestions results

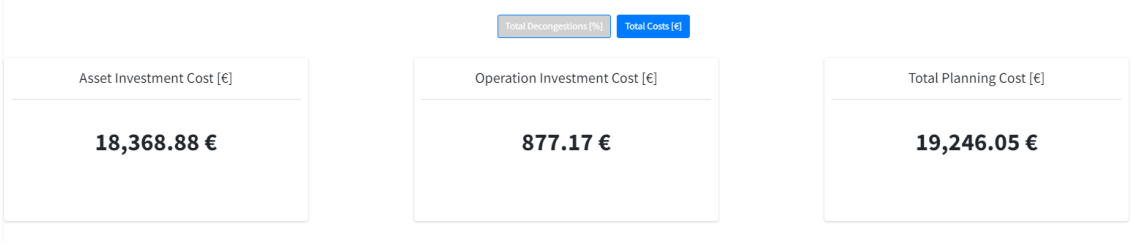


Figure 79: CAPEX and OPEX of planning solutions

4.7.1.4 Data assessment

Table 20: Data assessment

Data source needed	BD4OPEM ontology	Data quality assessment	Impact of the quality on the service
Grid Topology	Service_parameters	Good quality	High
Historical measurements	Smart_Meter	Missing values and null values detected. A preprocessing and segmentation of the data was needed.	High
Asset Costs	Service_parameters	Good quality	High

4.7.1.5 Service conclusions

The use of this service resulted interesting for the DSOs, especially in the simulation of the stress scenarios for future demand growth of the consumers. The time series power flow simulation permits to consider the peak values of a selected range of date-times. Also, the DSO can interact with the platform to provide more precise information regarding the expansion of the network based on new contract requests

and vegetative projections. The quality of the historical data is important, and also a pre-processing module is recommended in this tool to ensure the harmonization of the data, and the good performance of this service.

Feedback comments from DSOs are the following:

- GIS map: Change the transformer icon to a square with the name displayed in the map. Display the name of the node in the GIS map.
- User interface: Date-time modification manually.
- Algorithm: Integration of EV charging stations in the Stress Test Scenario with real profiles. Integration of new feeder routes and substations to test the impact on the grid.
- Network: Integrate Distributed Generation. Integrate two or more fields to test the planning service.

4.8 S8.2 – Asset estimation optimization for microgrids results

4.8.1.1 Introduction of the service

Name: Asset estimation optimization for microgrids
Category: Planning
Task: T4.5
Location on the grid: LV grid

This service is oriented towards highly reliable and redundant local energy systems or microgrids, such as hospitals or manufacturing plants, whereas the operational limits, the remaining capacity and the chance on critical failure of different assets are of major importance for a fail-safe operation of the grid.

The service should allow the pilot grid operators to explore new operational strategies and business cases. For example, semi-traction UPS-systems could be used for external (e.g. R1) or internal (e.g. voltage regulation) grid services. However, the safety prerequisites of the grid should never be violated, whereas an accurate state of health estimation is of major importance.

Table 21: Use cases for the S4.1 service

Use case	Description
UC1	As a grid operator or asset operator, you wish to check the current state of health of your assets as well as the historical degradation profile of these assets.
UC2	The grid investment planner has the ability to check the remaining useful life of the different assets within his grid.
UC3	Microgrid operators you want to acquire knowledge on the different operational regimes

	of your assets and the impact it has on the degradation.

4.8.1.2 Use Case 1

Given the provided data of an asset, the service offers grid operators or asset operators valuable feedback on the current state-of-health (SoH) of the asset under investigation. This by designated indexes such as (i) the capacity degradation (for the provided period), (ii) the percentage of expected lifetime reached and (iii) the expected remaining useful lifetime by conducting a similar behaviour/regime of the asset. This can be for both, a PV system (not a part of the Turkish pilot) or for a battery energy storage system (BESS Figure 80). The analyst (i.e. grid operator or asset operator) gets an overview of the measured degradation, based on the provided data, as well as a forecasting. Furthermore, this is displayed as a function of the typical lifetime of such assets. For instance, a PV system with be reviewed based on the warranty time, while a battery energy storage system will be reflected towards the end-of-life capacity which is typically at a SoH of 80%.

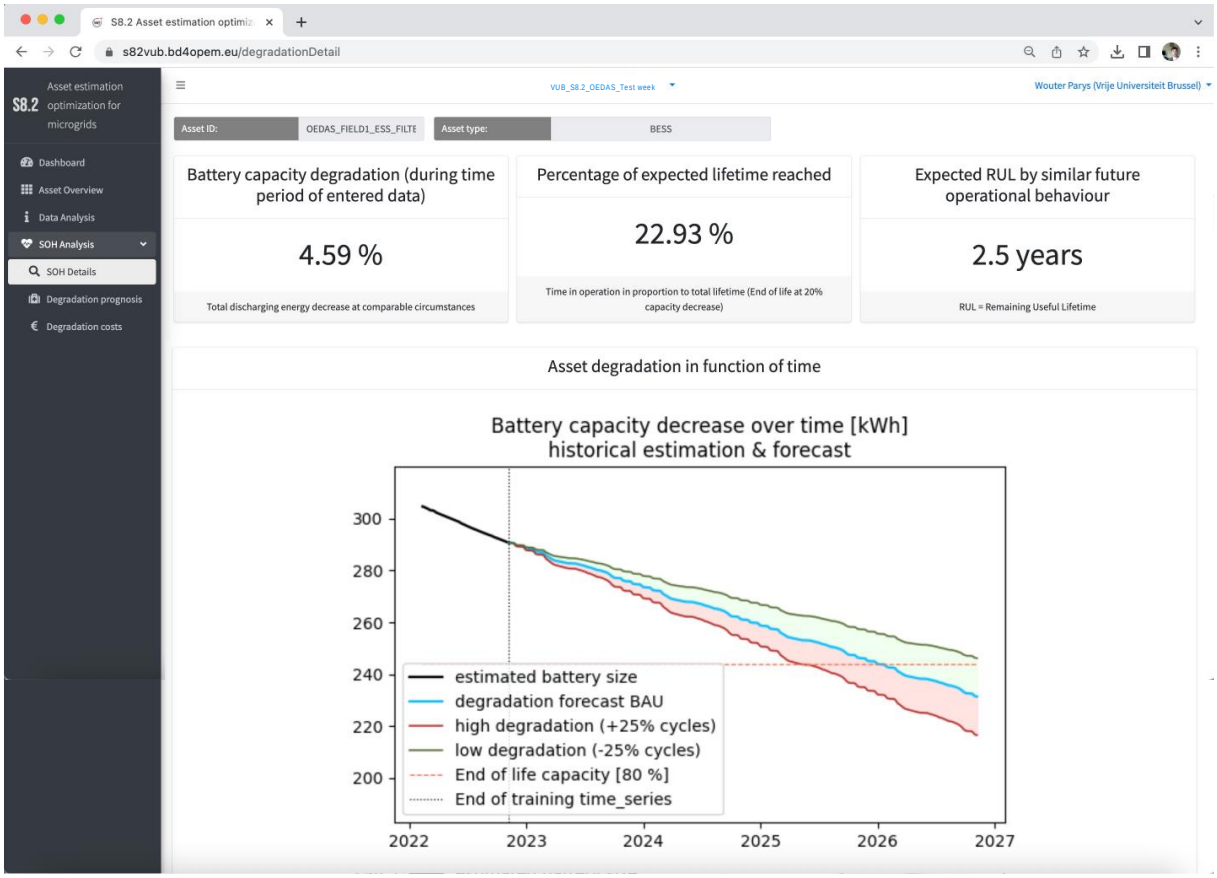


Figure 80: Data analysis from a battery energy storage system

4.8.1.3 Use Case 2

In order to help the grid planner with thoughtful choices towards future investments, the graphs (Figure 81 and Figure 82) display the expected remaining useful lifetime. This by displaying the intersection between the forecasted capacity (i.e. maximal production or battery capacity for respectively the PV system and the BESS) and a 20% decrease compared to the maximum value.

Next to the graphs, the grid planner can also retrieve this information on the top of the UI, where the values are written as well. This is in case the PV system and/or battery maintain their current degradation. In other words, if the business-as-usual (BaU) applies.

4.8.1.4 Use Case 3

Finally, operators of distribution networks (or assets owner) whom includes a battery energy storage system may wish to know which impact the operational regime of their BESS might have on the degradation. To acquire this knowledge, the tool allows the operator to visualize the different regimes via a dropdown menu on the UI, Figure 78. This high-level degradation analysis differentiates in between parameters like: cycles/year, depth of discharge and power rating. Figure 80 shows the last step where an operator can even go in more detail to see how a specific operational profile affects the battery degradation.

4.8.1.5 Data assessment

Table 5 shows the data needs for the service S8.2 in the Turkish pilot and adopts the impact of potential bad data quality.

Table 22: Data assessment for the S8.2 service

Data source needed	BD4OPEM ontology	Data quality assessment	Impact of the quality on the service
Battery data: State of Charge	Storage data: State of Charge	Sufficient	Decreasing the amount of missing data would imply longer contiguous series of data which will increase accuracy
Battery data: Power	Energy meter data: Charged or discharged power [kW] or Energy [kWh]	Sufficient	Decreasing the amount of missing data would imply longer contiguous series of data which will increase accuracy

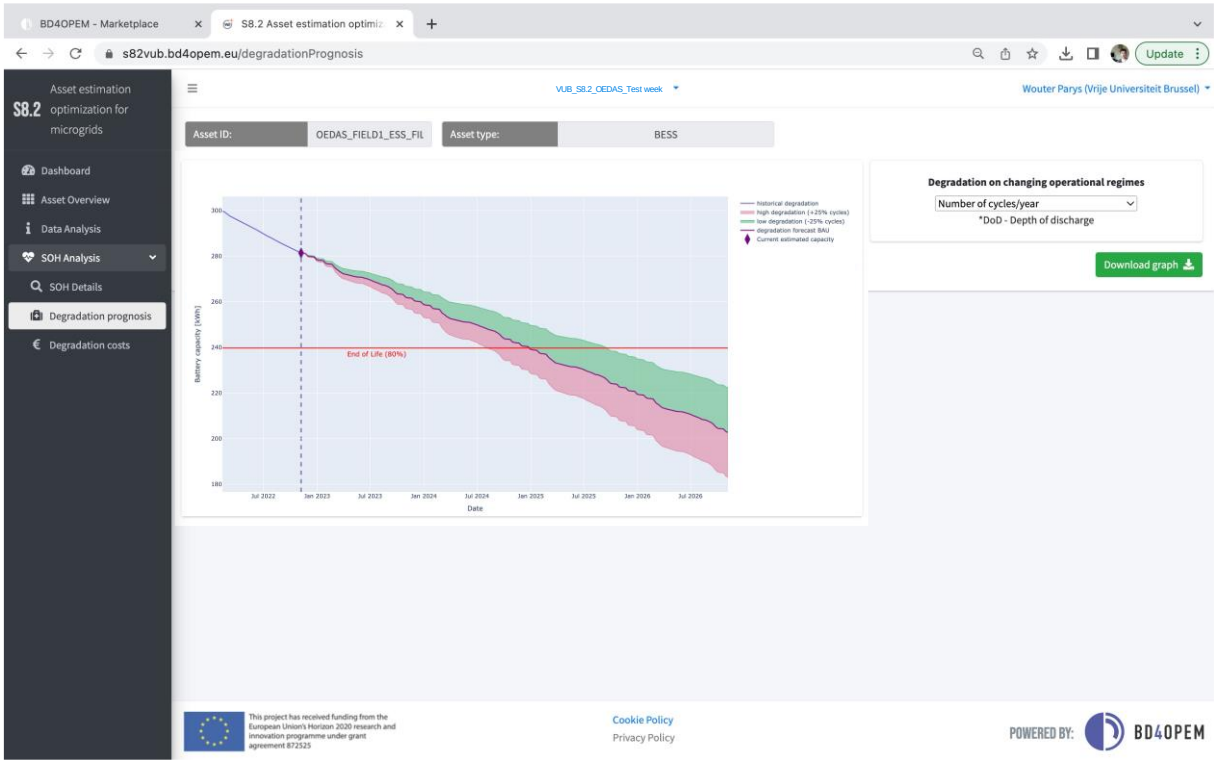


Figure 81: Degradation prognosis for different regimes

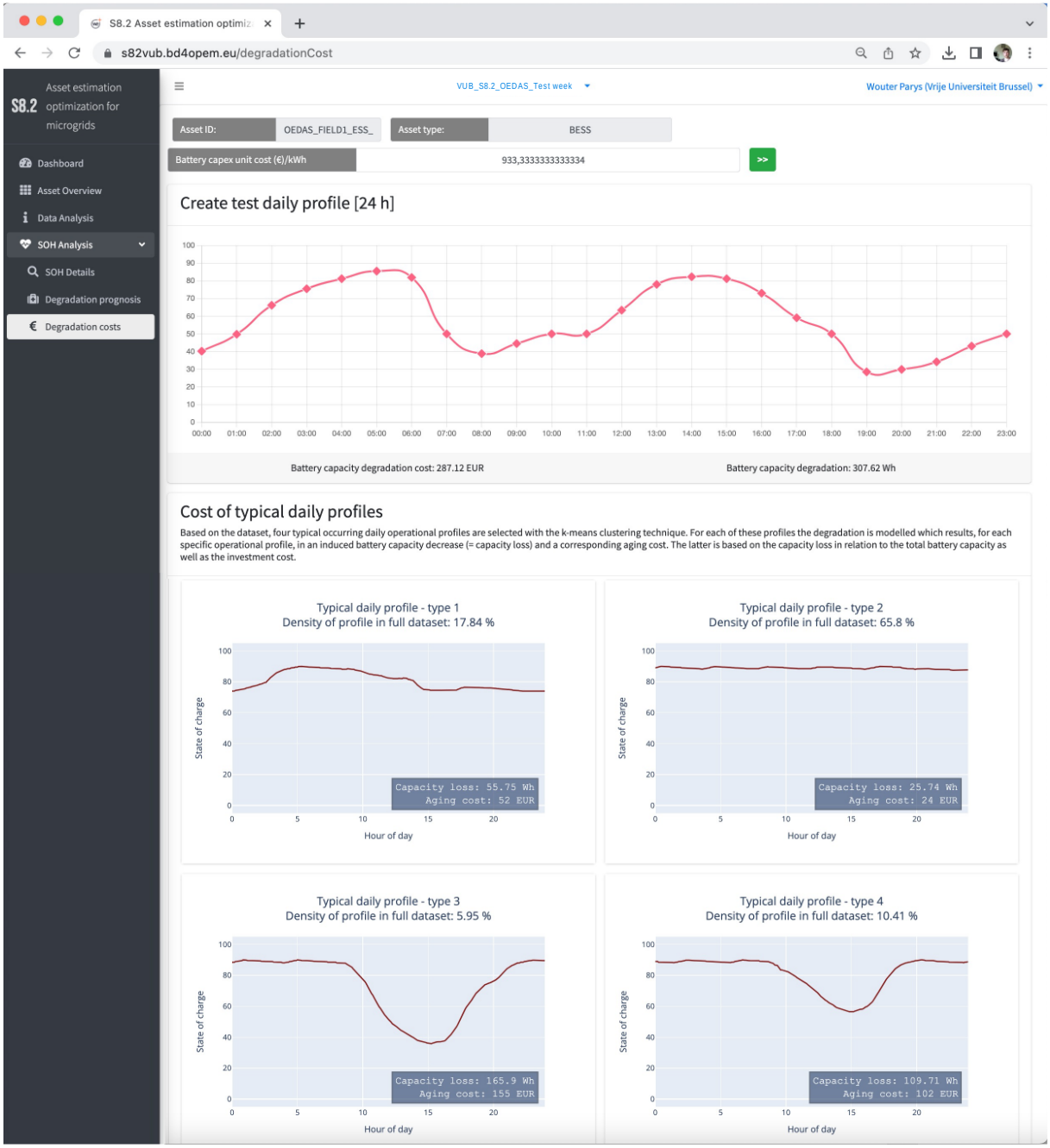


Figure 82: daily profile analysis

Pilot Deployment

The service will be tested on two different battery systems independently that are part of field 1.

Description of pilot set-up

The set-up of the service in this pilot is adapted to the specific use case:

- Time series data is available for two different battery systems:
  - Battery ESS1:
    - 336 kWh – 375 kVA
    - Data available from 2022-02-11 until 2022-11-06
  - Battery ESS2:
    - 32 kWh – 45 kW
    - Data available from 2022-10-04 until 2023-06-12

- No solar systems or other assets are part of de pilot demonstration site or no data is available

Specific adaptations for pilot set-up
No adaptations are needed, however the time series data is limited in time which has a negative effect on the accuracy of the algorithm. No problems are expected.

Results for Turkish pilot
Figure 82 shows the assets of the Turkish pilot that are modelled in this service. Because of some inconsistent data for battery ESS1, an additional cleaning process is performed which is annotated with '_FILTER' as a suffix, which results in three assets in the overview.

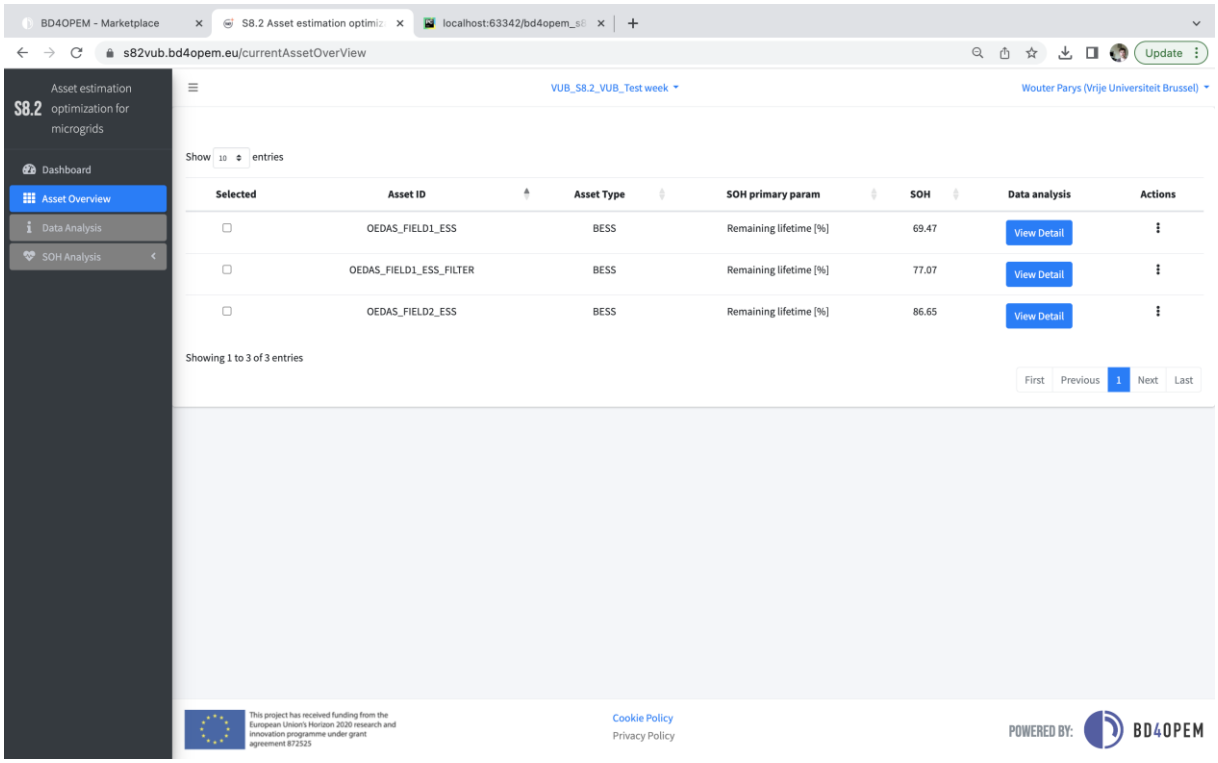


Figure 83: Overview of Turkish pilot assets

Figure 84 and Figure 85 show the service results for BESS1. Figure 84 shows a summary of the battery behaviour based on the historical data. Figure 85 shows the results of the degradation model built on this historical data and shows the future projection.

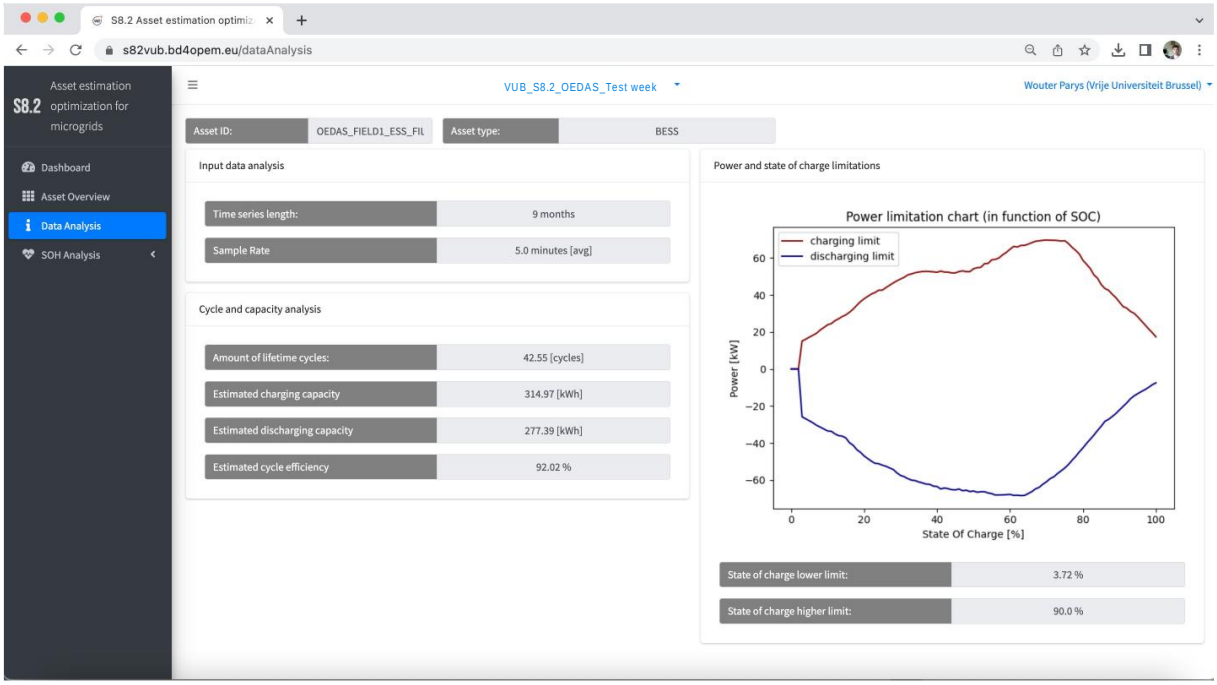


Figure 84: Battery data analysis

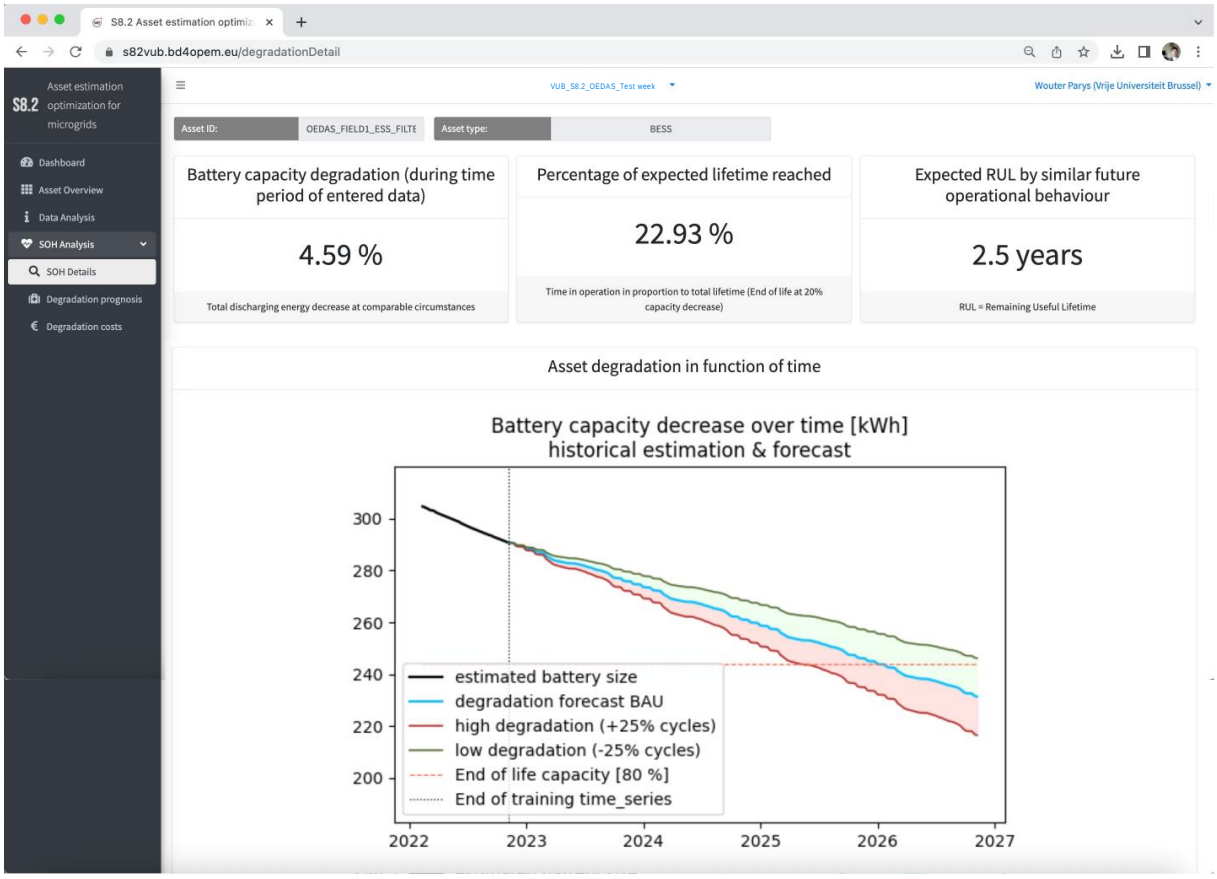


Figure 85: Battery degradation modelling

Those figures show the results in the UI of the trained degradation model based on the historical (cleaned) data of BESS1. Because the short time window of available data, the accuracy of the model is low which means the results as shown should be used carefully. However, we see a rather fast degradation for BESS1 which is could

be considered as something that should be checked on the field. If the results of the service check out, using the battery less aggressively could resolve the fast degradation. When the new data is then again fed in the algorithm, even more accurate and useful results will be generated.

4.8.1.6 Service conclusions

During the service testing, the service user had a positive feeling on the usage and applicability of the service. As a distribution system operator with multiple assets located on different places, the tool allows the system operator to keep track of the status of the different assets. Other feedback related to the UI can be summarized as follows:

- The tool will provide valuable insights in the performance of the BESS systems connected to the network.

From the features we can see that the most important is the temperature which is followed by radiation. The fitting of the test and train set shows that the predictions won't be great, the data is not optimal for the algorithm selected by the developer.

In Figure 86 are given the predictions for the selected week. We see the amplitudes of the predicted consumptions, in red, are well off the consumption realization, in blue. The peak times seem to be mostly matched.

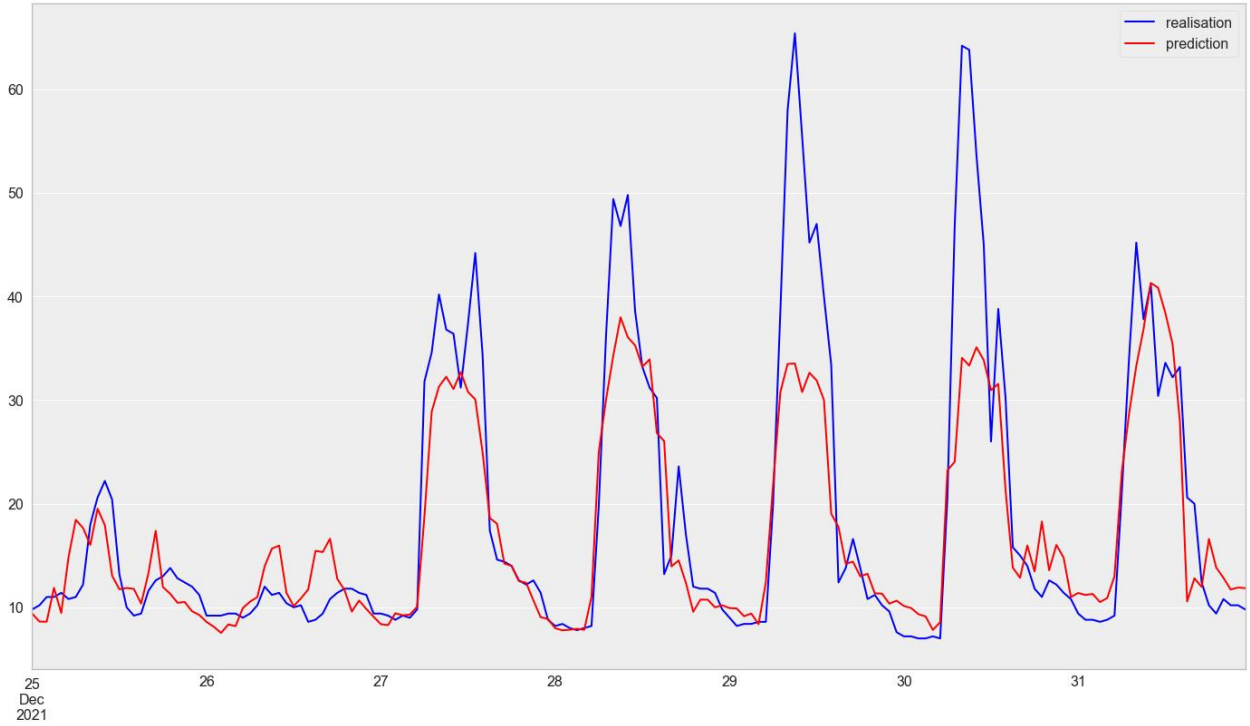


Figure 86: Prediction – Realisation

The accuracy of the results are given in the next table. The most important parameter for the service is the Peak hour difference. Based on this parameter the event intervals for the flexibility events are chosen. Even here we see for this week some of the predictions are quite off the realization.

date	peak error [%]	min error [%]	corr	ptp [%]	std [%]	mean [%]	error [kW]	MAE	MSE	RMSE	Peak hour difference
2021-12-25	19.21	-28.03	0.553594	16.19	6.37	1.55	0.0	2.675201	10.677666	3.267670	0 days 01:00:00
2021-12-26	-16.29	-36.39	0.350807	-167.35	-154.30	-11.50	0.0	2.037231	7.835917	2.799271	0 days 09:00:00
2021-12-27	31.96	-7.16	0.952317	31.00	25.78	13.28	0.0	3.407637	28.735189	5.360521	0 days 02:00:00
2021-12-28	27.59	-1.62	0.923619	28.08	20.67	9.47	0.0	4.022202	36.588866	6.048873	0 days 01:00:00
2021-12-29	48.72	-40.06	0.953610	56.46	50.02	21.55	0.0	6.974241	127.085512	11.273221	0 days 00:00:00
2021-12-30	46.92	-30.33	0.910855	52.30	49.59	17.22	0.0	7.185403	129.469452	11.378464	0 days 02:00:00
2021-12-31	26.32	-22.19	0.912187	15.86	8.27	-2.60	0.0	3.938218	25.430571	5.042873	0 days 02:00:00

Figure 87: Result parameter

An example event day presented below is Tuesday, 28th of December. In the table above we can see the peak prediction is one hour off but the proposed interval fits the realization consumption well. The suggestion of the event for the DSO seems to be correct.

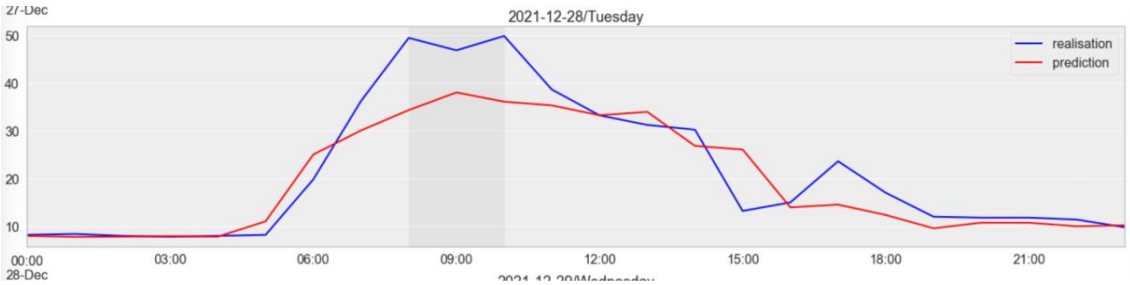


Figure 88: Sample estimate

5 Project KPIs to be monitored in this deliverable

5.1 KPI 2.1: Data coming from renewable technologies

KPI Name:	Data coming from renewable technologies
KPI ID	2.1
Global objective	Technological choice and provision of tools contributing to the Digital Marketplace for Energy
Owner	OEDAS – Ibrahim Tastan
Definition	Considering the uptake of renewable energy, it is important to have available data from different renewable technologies to shape adequate services. This KPI consist in the number of data sources available from different technologies. As some of the identical RE Sources are connected to the transmission level and services and pilot areas are tackling distribution level, The scope of KPI is therefore extended to renewable technologies and new technologies; like Energy Storage Systems, Heat Pumps, EV Chargers and V2G Chargers.
Involved partners	The involved partners are demonstration sites
Calculation process and Formula	$\left[\frac{\sum Renewable\ Energy\ Tech.Assets + \sum New\ Tech.assets}{No\ of\ Services\ in\ Pilot} + \frac{No\ of\ RE\ source\ types\ and\ new\ Tech\ types}{Services\ Using\ "RE\ Tech.\ and\ New\ Tech.\ Assets"\ datas}\right]$
Unit	Ratio
Target (Adapted)	Data available from 1 renewable energy asset (wind, PV Hydro, Geothermal) and 3 new technologies (ESS, V2G Charger, Heat Pumps, DC Chargers, etc.) Calculation result $\left[\frac{A}{B} + \frac{C}{D}\right] > 1$ should more than 1, A: $No\ of\ Renewable\ Energy\ Tech.\ Assets + No\ of\ New\ Tech.\ assets$ B: $No\ of$ Services in pilot C: $No\ of\ RE\ source\ types\ and$ New $Tech\ types$ D: $Services\ Using$ "RE Tech. and New Tech. Assets" $datas$ in pilot
Results at the end of the project	OEDAŞ has 27 PV's in Field 2 and 1 PV, 1 DC Charger, 1 V2G Charger and 2 Energy Storage Systems in Field 1. So Parameter A is 27+1+1+1+2=33 and parameter C is 4 (different assets). A: $No\ of\ Renewable\ Energy\ Tech.$ assets +No of $New\ Tech.\ assets$ 33

KPI Name:	Data coming from renewable technologies

B: No of Services in pilot 12

Predictive maintenance applied to smart meters
Multiple asset maintenance schedule prediction in critical grids
Grid elements congestions detection
Power quality issues and voltage disturbances analysis
Aggregated flexibility forecast
Flexibility forecast based on price signals
Flexibility aggregated services for BRPs
Flexibility services for DSOs: Flexibility-based AC OPF
Flexibility services for DSOs based on neural networks
P2P trading
Asset and investment planning
Asset estimation optimization for microgrids

C: *No of RE* Tech *types and new Tech types* 4

Figure 89: V2G and DC Chargers

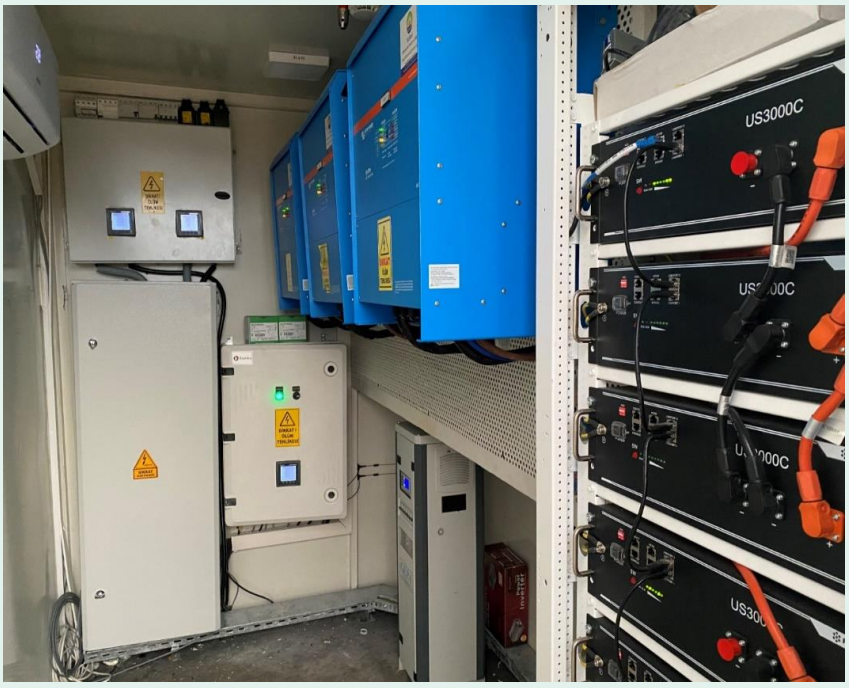


Figure 90: Energy Storage System 2: 45kW 32kWh

KPI Name:	Data coming from renewable technologies

Figure 91: Field 1PV Area

D: *Services Using* "RE Tech. and New Tech. Assets" *data* in pilot 9

Result:

$$\left[\frac{33}{12}+\frac{4}{9}\right] = 3{,}19 > 1$$ Succeeded.

6 Lessons learned & Conclusions

6.1 Lessons learned – Pilot's perspective

From the Osmangazi Elektrik Dağıtım A.Ş (OEDAŞ) pilot's perspective; during the timeline of project, it offered OEDAŞ experience about various services with various approaches with high tempo data needs, grids real world unavailability's or missing data or unfinished integration processes with also step by step solved regulation barriers teaches us proactive project managing perspective.

Generally OEDAŞ was working on near future's problems with future services and expecting futuristic regulations on processing BİG Data technics with new privacy technics and on Green Energy transition with coming problems and having flexibility solutions also with its future local trading operations.

6.2 Lessons learned – Service developer's perspective

From the service developers' perspective, the Osmangazi Elektrik Dağıtım A.Ş (OEDAŞ) pilot within the BD4OPEM project has offered valuable insights and challenges. As the second-largest Distribution System Operator (DSO) in Turkey, OEDAŞ faces distinctive conditions, particularly with its high penetration of photovoltaic (PV) installations. The inclusion of the MV Feeder Pilot area with 12 substations and 1 LV Transformer area offers a practical setting for the development and testing of various services.

The OEDAŞ pilot focused on addressing grid challenges in the specified demonstration sites, offering a real-world environment for testing and refining services that can adapt to the unique characteristics of the Turkish electricity distribution landscape.

In particular, one of the pilot's objective was to provide real-time data to enable the deployment of high value services. This was an important challenge both in terms of data collection and data integration. Overall the deployment of the concerned services was complex but this demonstration brought a lot of insight into this kind of work for future service developers.

6.3 General conclusions

The OEDAŞ pilot within the BD4OPEM project exemplifies a proactive approach to addressing the challenges associated with high PV penetration and the growing demand for electric vehicles. The strategic selection of specific services, such as predictive maintenance, grid disturbance simulations, flexibility forecasting, and peer-to-peer trading, aligns with the diverse needs of a modern electricity distribution network.

The collaboration between developers, including JSI, VUB, UPC, and ATOS, demonstrates a concerted effort to bring diverse expertise to the table. This collaborative approach was crucial for the successful implementation and validation of the services outlined.

As OEDAŞ continues to navigate the complexities of the evolving energy landscape, the insights gained from this pilot will play an important role in refining the BD4OPEM platform. The legal compliance with data protection regulations, the use of middleware solutions, and the inclusion of various data sources contributed to a successful deployment of smart grid technologies.

Looking ahead, the lessons learned from the OEDAŞ pilot will serve as a valuable resource for other DSOs and service developers dealing with similar challenges in the

energy ecosystem. The commitment to innovation and collaboration underscores the project's broader contribution to the advancement of smart grid technology.

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8 Annex A: Storylines

8.1 S1.3 – Predictive maintenance

8.1.1 JSI approach: Predictive maintenance

Introduction

The predictive maintenance service is provided for a class of equipment in a distribution network. The service will detect situations when the equipment observed could potentially fail due to failure.

The solution utilizes classification of the equipment into maintenance classes. Roughly the classes are divided into one that has high probability of failure and the other with lower probability. The equipment is classified according to the features that are available for a particular class of the system. For example, networking and energy grid equipment like smart meters, are often accompanied by ITC systems collecting and monitoring the state of the equipment. A number of logs and error logs are available, internal registers state, together with some sensor information like temperature, etc. All this information can be utilized together with time as features that make classification possible. On the other hand, to train the models that could be used for classification, targets are needed as well. The targets tell which equipment has failed, when and at what conditions. The features of failed equipment are needed as well. As a general requirement, more information is available on failed equipment, better will be the classification model for the equipment still in use.

The solution can be then extended with features prediction in the next period and maintenance cycle. The classification is performed again on predicted features and the equipment classified in a class with a high probability of failure is then flagged in the service report and returned to the service user.

Data contract

First, we need a data contract for the service. On the "Search" page of the Marketplace, we search for "predictive maintenance" data. It should be the only result.

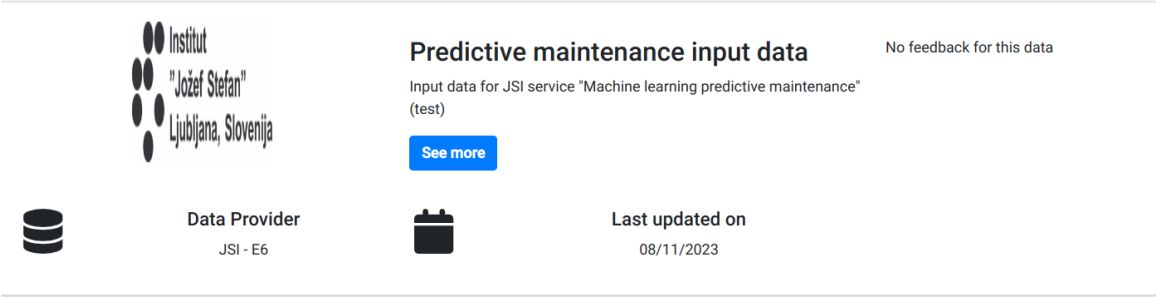


Figure 92: S1.3 input data in MP

Click on "See more", then "Contract data" at the very bottom. Give the contract whichever name, for example "S1.3 data". For the data period, select today's date as "From", and whichever date in the future as "To". Finally, press "Submit".

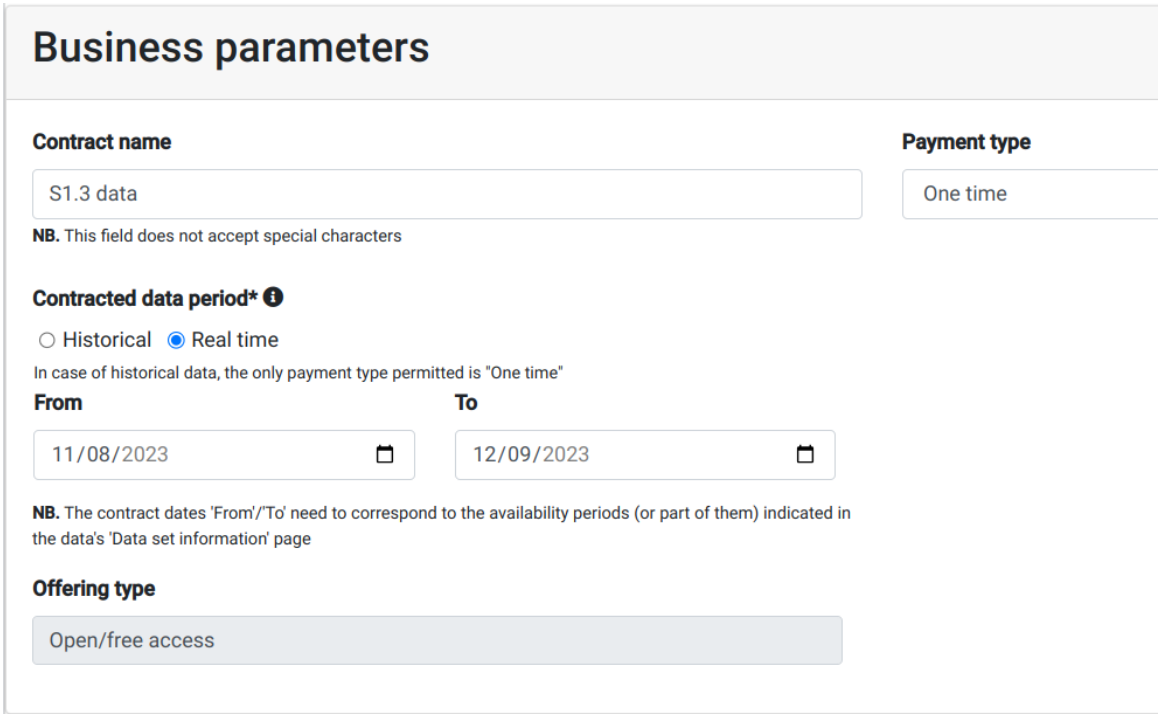


Figure 93: S1.3 Data parameters

Service Provisioning receives the data contract right after the "Submit" button is pressed. You should be able to see your data contract request in the "My Data" page, with the role "Data User". The contract status should be COMPLETE.

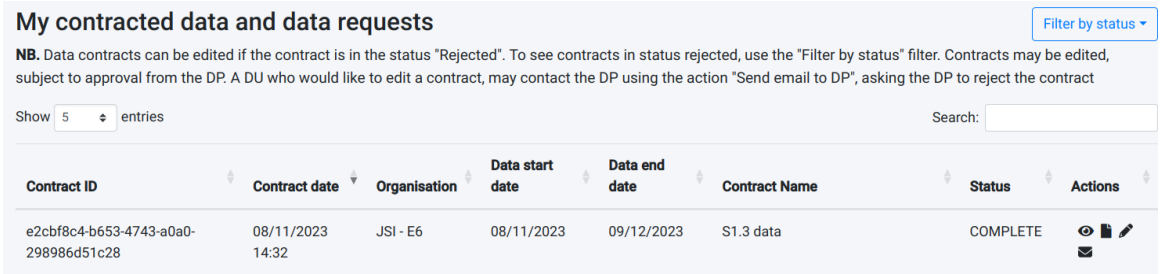


Figure 94: Contracted data

However, to be able to use the data contract, it needs to be approved and activated by the Data Provider (in this case, JSI). Approving and activating the data contract will advance the contract status from COMPLETE to APPROVED, and then to ACTIVE. Once contract status is ACTIVE, it can be selected when contracting a service, as we will see shortly.

Service contract

Contracting a service follows similar steps as contracting data. Service S1.3 can be found on the Marketplace under the name "Machine learning predictive maintenance". Under "Advanced search", we can also select "JSI - E6" organization to filter the results.

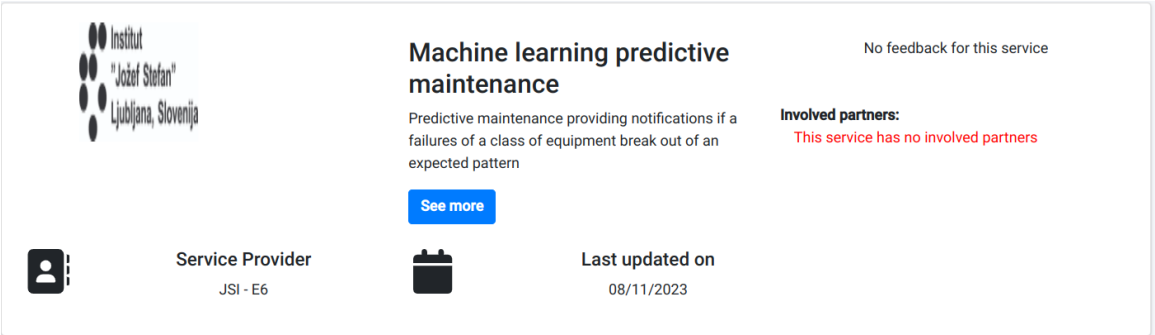


Figure 95: Service contract

Click on "See more", and then "Request new service" at the top of the page. We first fill in the business parameters, same as for the data contract. Contract name can be whatever, for example "S1.3 test contract [today's date] - OEDAS". Leave "Payment type" as is, and select the contract period.

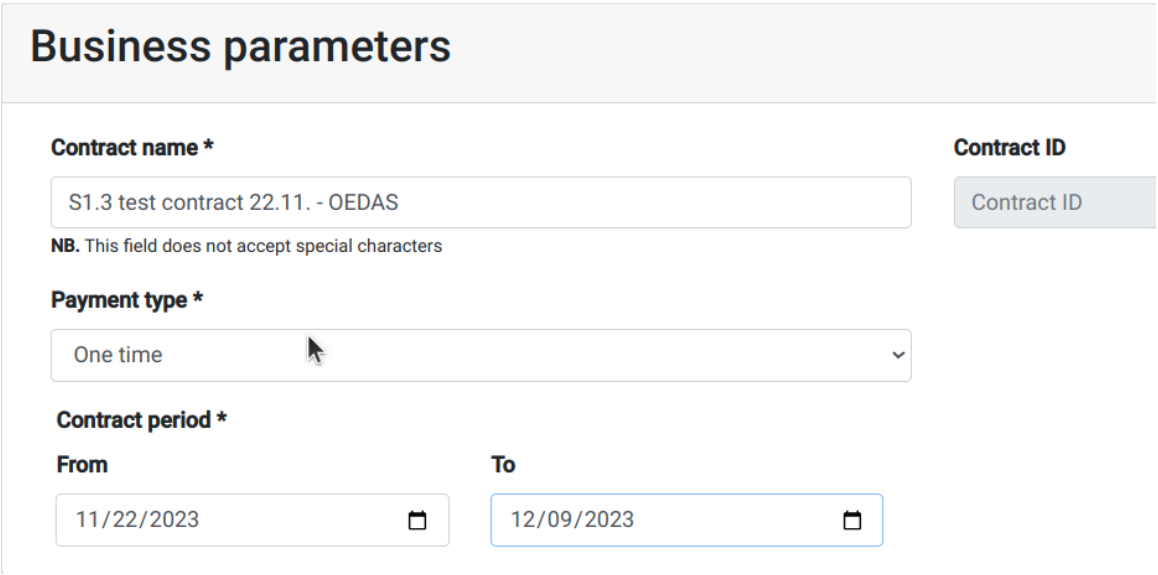


Figure 96: Business parameters of service

Next, we select the technical parameters. Select one value for each technical parameter. A description of each parameter can be seen in the image.

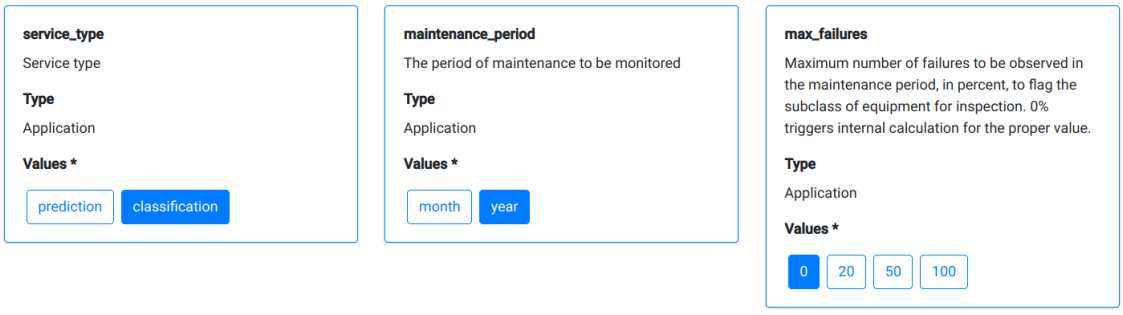


Figure 97: Technical parameters of service

We then select the corresponding data contract. Find the "S1.3 data" (or whatever name you put) data contract, check it, and click "Confirm". The data contract will not be present unless it was activated by the Data Provider. Be sure to also select "Yes" for "Enable immediate execution", otherwise the service will not actually be run in the ASM module.

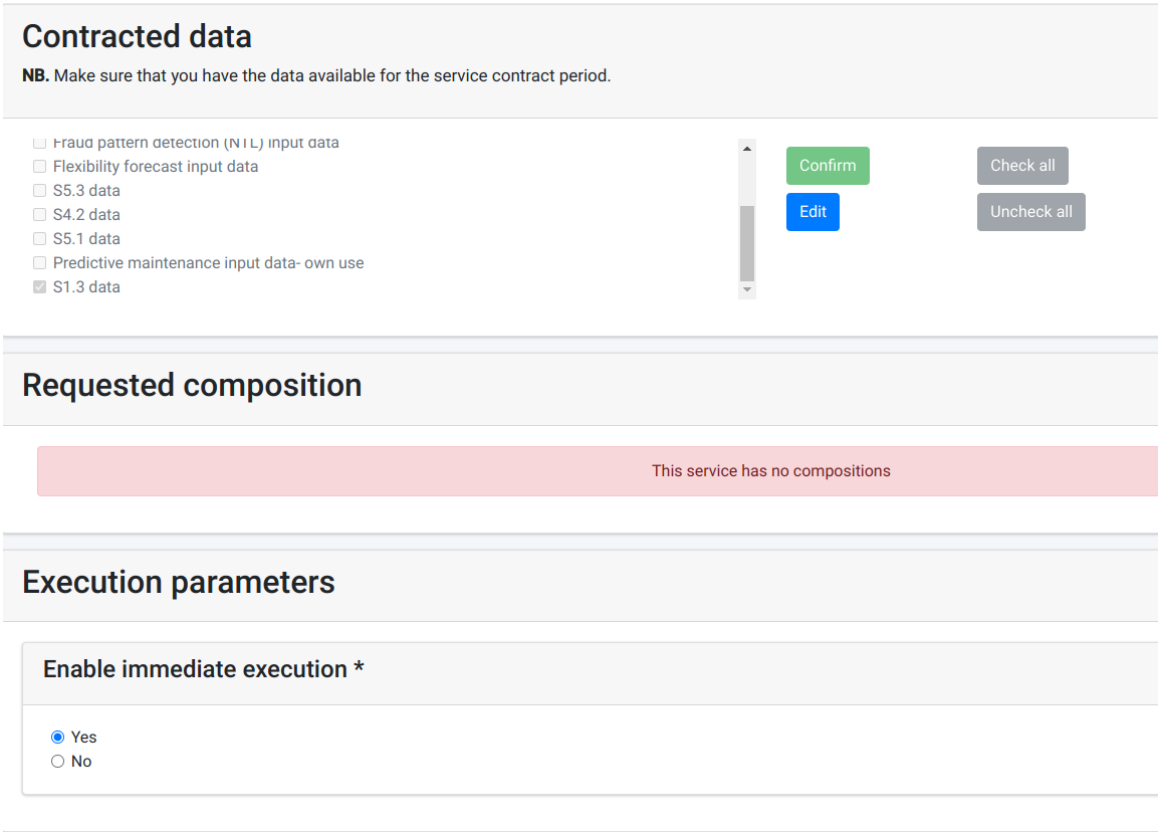


Figure 98: Selecting Contracted Data

Finally, click on the "Request service" button at the bottom. Similarly as for the data contract, Service Provisioning receives the contract right after the button is pressed. You should be able to see your service contract request in the "Service requests" table, found on the "My Services" page, with the role set to "Service User". The contract, provisioning and execution status should be as in the below image.

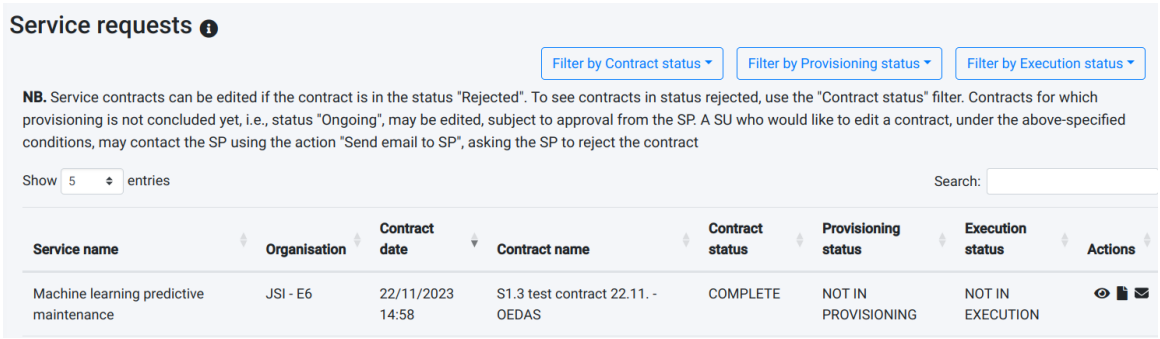


Figure 99: Service user screen

Running the service

Similarly, to be able to use the service contract, it needs to be approved and activated by the Service Provider (in this case, JSI). Immediately after the contract is activated, an instance of the S1.3 service will be started in the ASM module. This will happen because the service is set to be auto instantiated *if* immediate execution was set to "Yes".

As soon as the contract is activated, i.e. the service starts executing in ASM, the Marketplace will provide us with a link to our front-end, where we can see the logs and results of the service. This link is accessible via the "Go to service" button, present in the corresponding entry in the "Service requests" table.

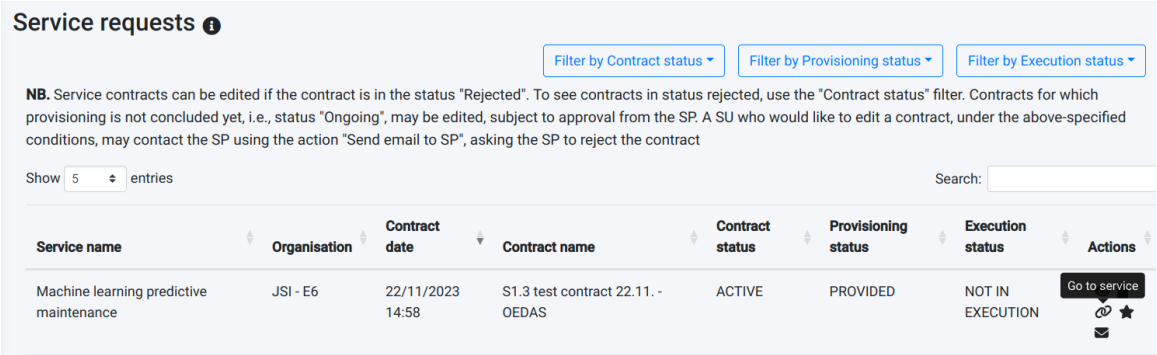


Figure 100: Service request

Clicking on the "Go to service" button takes us to our front-end.

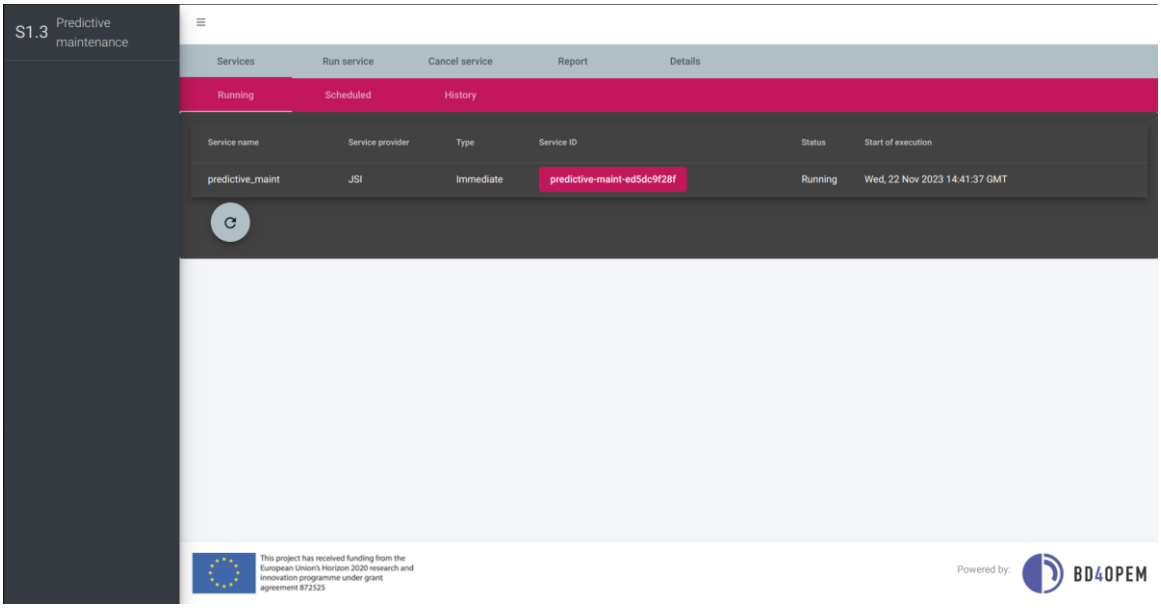


Figure 101: Service 1.3 interface

If the service is still executing, it should be present in the "Running" tab. Clicking on the ID in the "Running" tab will take you to the "Details" page and stream any logs of the service.

If the service has finished, we should be able to find it in the tab "History". You can click on the refresh button to see whether it has. By clicking on the service ID in the "History" tab, the report i.e. result of the service will be fetched and you will be automatically moved to the "Report" tab.

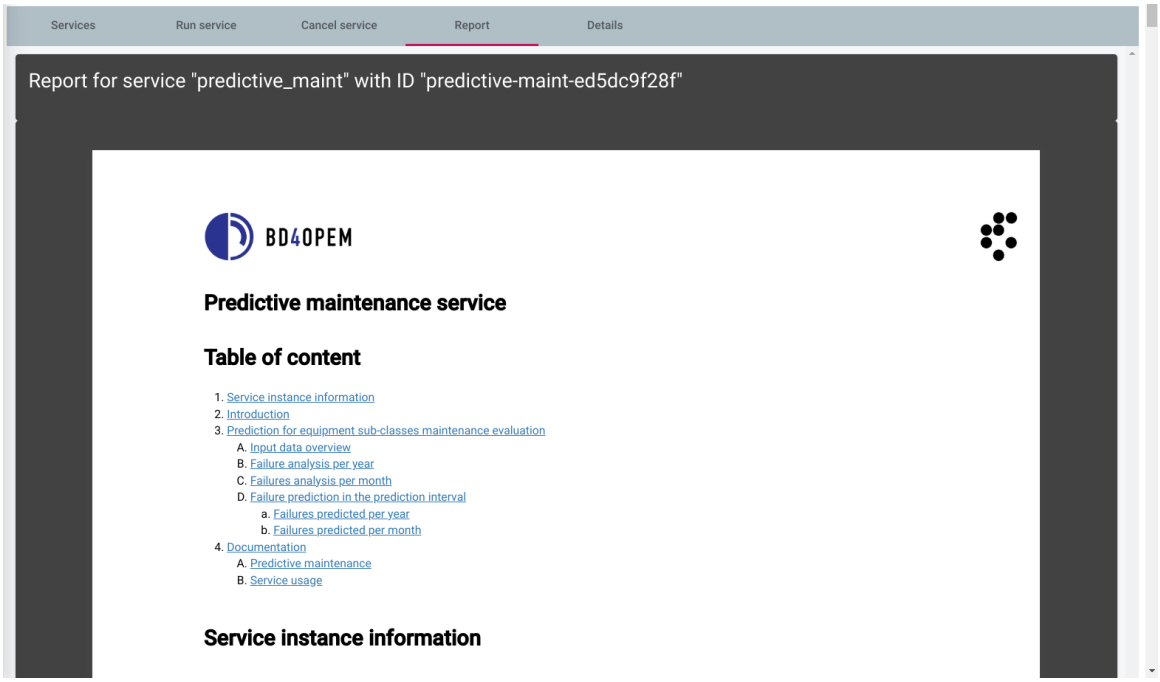


Figure 102: Service 1.3 Report

Additionally, by clicking on the tab "Details", you will be able to see the technical parameter values you selected, as well as any stdout and stderr logs of the service.

8.1.2 VUB approach: Multiple asset maintenance scheduler

Service	**S1.3 Predictive maintenance in electrical power systems**
Algorithm provider	**VUB**
Solution provider	**WEP**
Release date	14/09/2023

Service 1.3: Predictive maintenance in electrical power systems

[IMPORTANT !] Data should be contracted prior to the service contracting, this in order to contract the service with the required data, see pt. 3.

1. Users must go to the Marketplace main page (https://marketplace.bd4opem.eu/) and using the search bar, look for the service *"Multiple asset maintenance scheduler".*

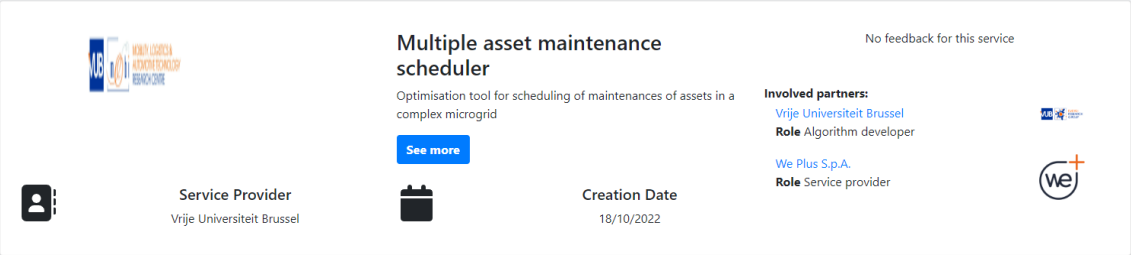


Figure 103: Multiple asset maintenance scheduler

2. Select the desired service (‘**See more**’) and follow the instructions.
   NOTE: the contract period is the period during which the service will be accessible.

3. Contract the service, following the default and/or required contract parameters. Select the data as needed by checking the box of the data:

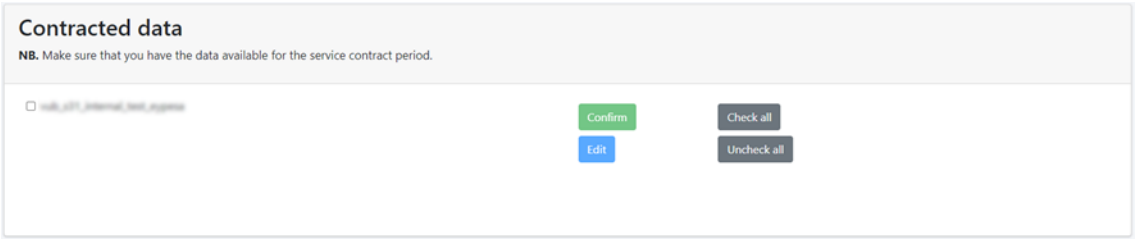


Figure 104: Contracted data

Once the service has been approved by the ‘**Service Provider**’ on the marketplace users can proceed to the next steps:

4. Execution of the service through the marketplace, make sure users are logged in as ‘**Service User’**, see top right corner. Click on ‘🚀’ to access the service:

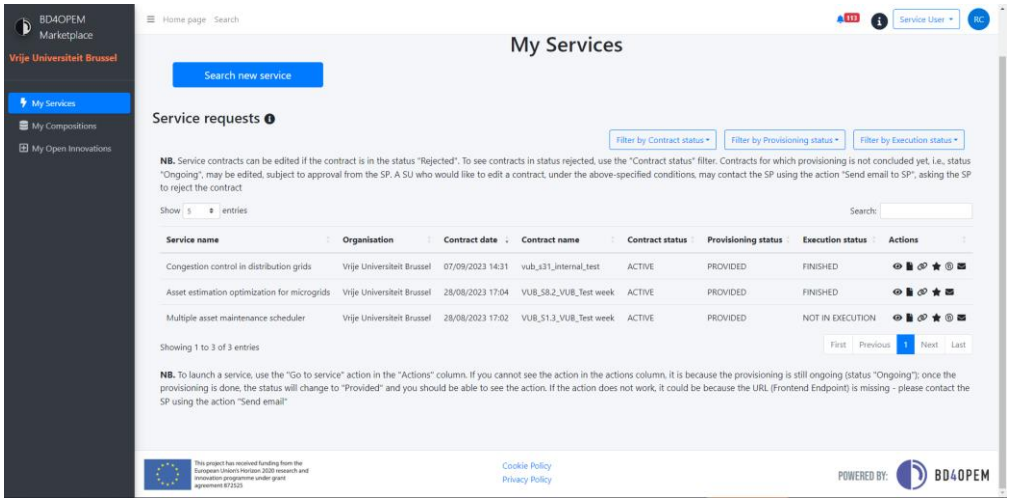


Figure 105: Service requests

Or after being logged in on the Marketplace, user can directly run the service by navigating to: https://s13vub.bd4opem.eu/.

5. **Usability Testing:** After executing the service, user can follow the indicated steps to test various aspects.

a. Initial screen displays the '***Dashboard***' including information such as the contract duration and latest update.

NOTE: your contract ID appears at the top.

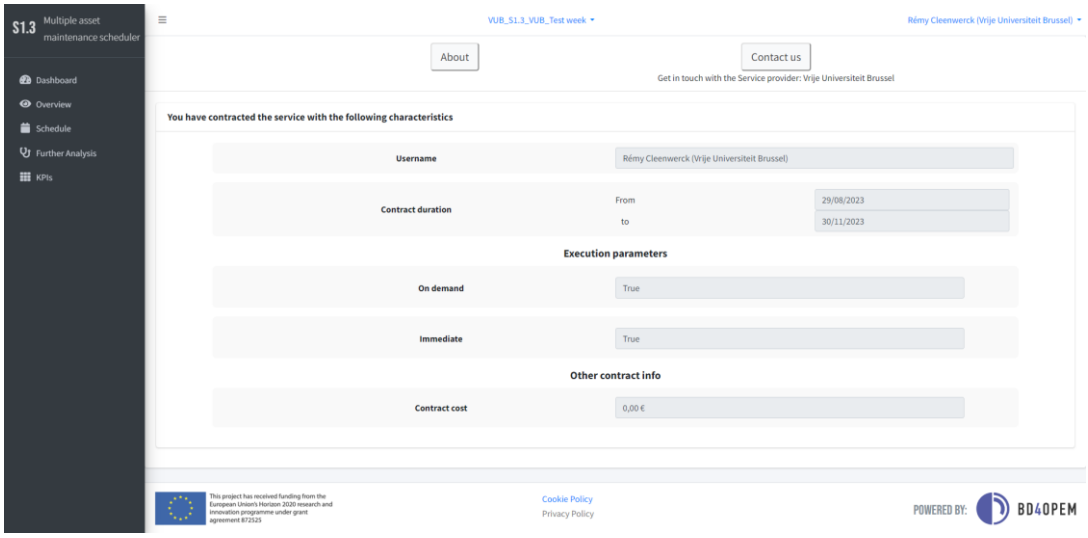


Figure 106: Multiple asset maintenance scheduler

b. As this is a service by request – the '***Overview***' tab will display the assets selected for the service once the algorithm developers have processed the data:

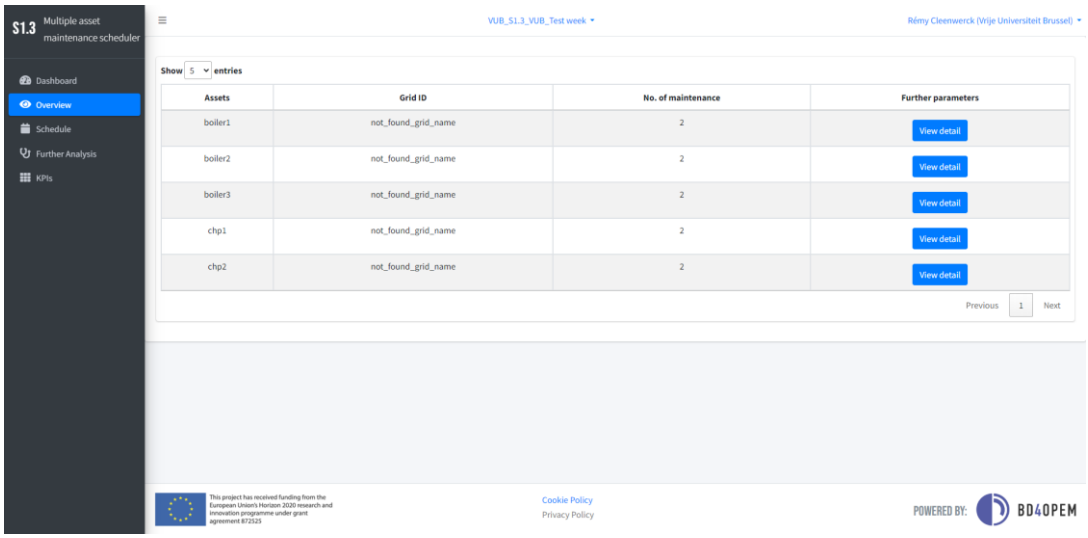


Figure 107: Multiple asset maintenance scheduler / Overview

Here an overview of the simulated assets is given with the numbers of maintenance that are required for each asset.

Accessing the '***View detail***' button opens a pop-up screens where details provided by the service user are shown for each asset such as (i) the maintenance duration, (ii) periodicity of the maintenance etc. This is demonstrated in the figure below:

Figure 108: Multiple asset maintenance scheduler / Overview / View detail

c. Within the '***Schedule***' tab, a representation of the scheduled maintenances per – selected – asset(s) is provided for a given timeline. Hovering through this overview also provides the type of maintenance, e.g. "Full maintenance" and the optimal period to execute this maintenance.

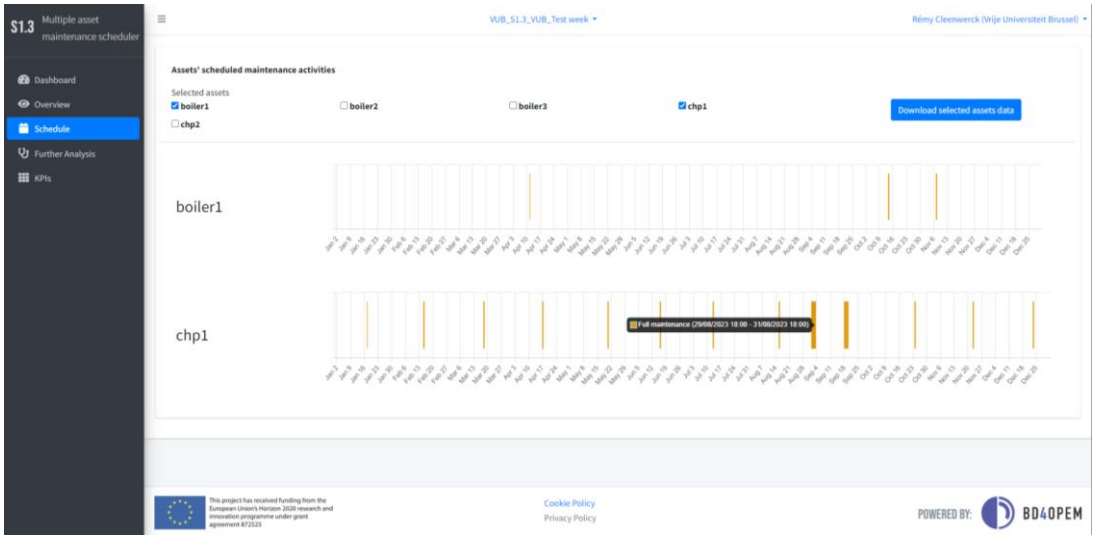
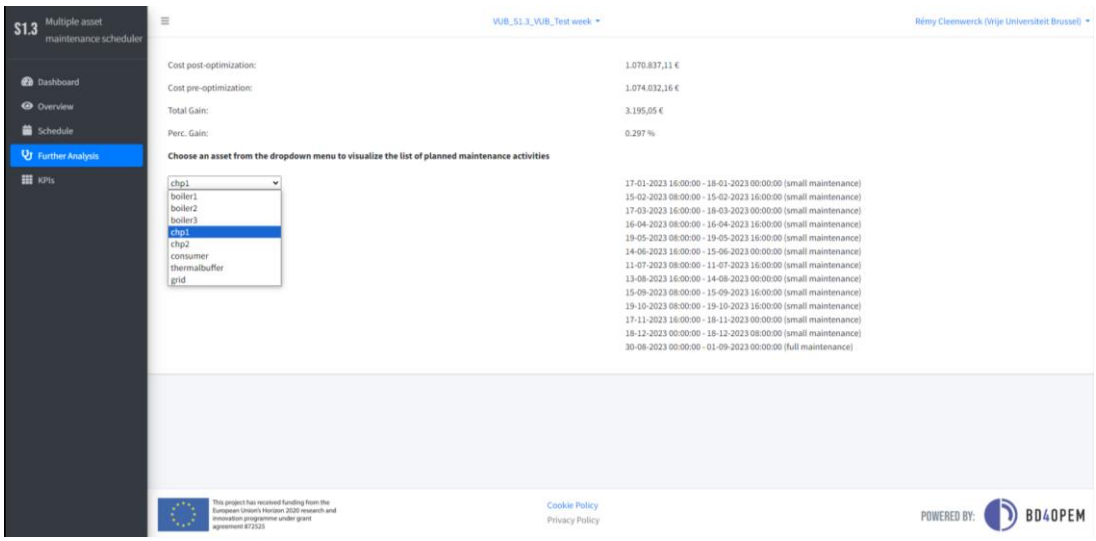


Figure 109: Multiple asset maintenance scheduler / Schedule

The scheduled maintenance activities can also be downloaded for the selected assets.

d. In the '***Further Analysis***' tab, you can select an asset from the dropdown menu which summarizes the planned maintenance activities for that asset. But also provides an overview of the cost reduction by optimizing the timeslots at which the maintenances should take place.

   This by considering the users preferences and the asset's needs.



f

Figure 110: Multiple asset maintenance scheduler / Further Analysis

e. Finally, the *'**KPIs**'* tab provides information about the constraints, i.e. if the planned maintenance are respected in the optimization scheduler or not.

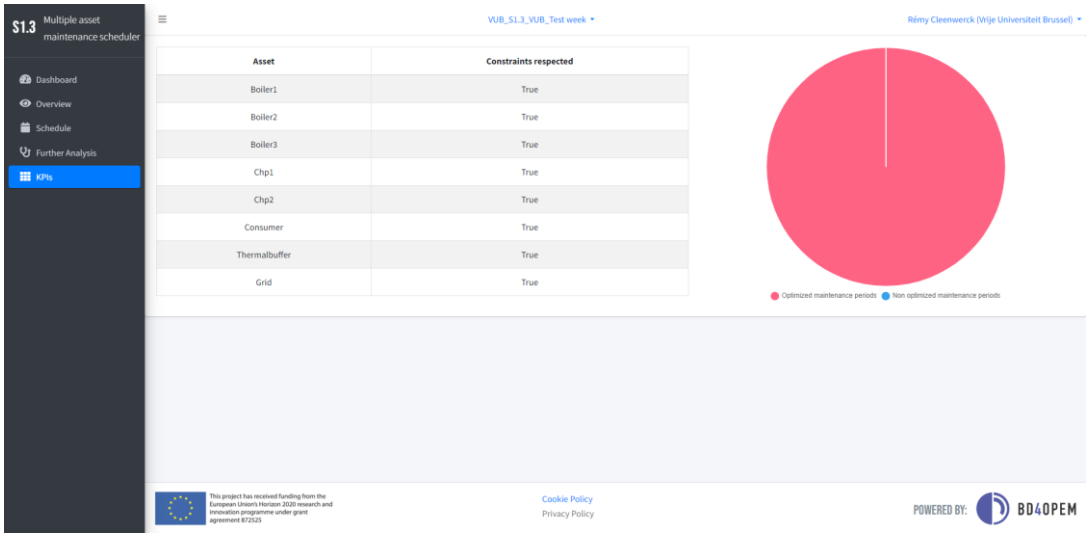


Figure 111: Multiple asset maintenance scheduler / KPIs

8.2 S3.1 – Grid disturbance simulations

8.2.1 UPC approach: Congestions forecast for day ahead

Service	**S3.1 Grid Disturbance Simulation – Congestions Forecast day-ahead**
Algorithm provider	**UPC** – Alejandro Hernández

Service 3.1

1. Contract the service with the demanded parameters.

2. User will get your contracts on top. Select the desired to investigate

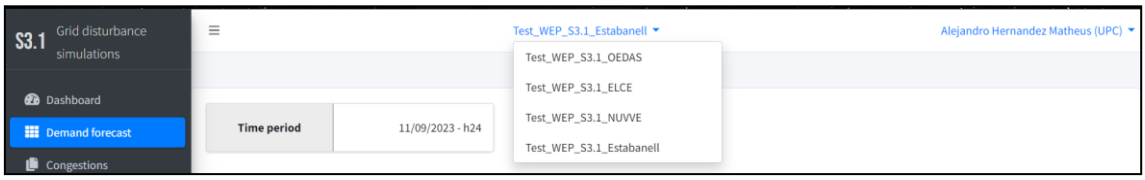


Figure 112: Demand forecast

3. Go to *Demand Forecast* tab and browse to several loads from the breakdown list and check the demand forecasted for a few loads and evaluate the response for each plot.
    a. Check first aggregated demand

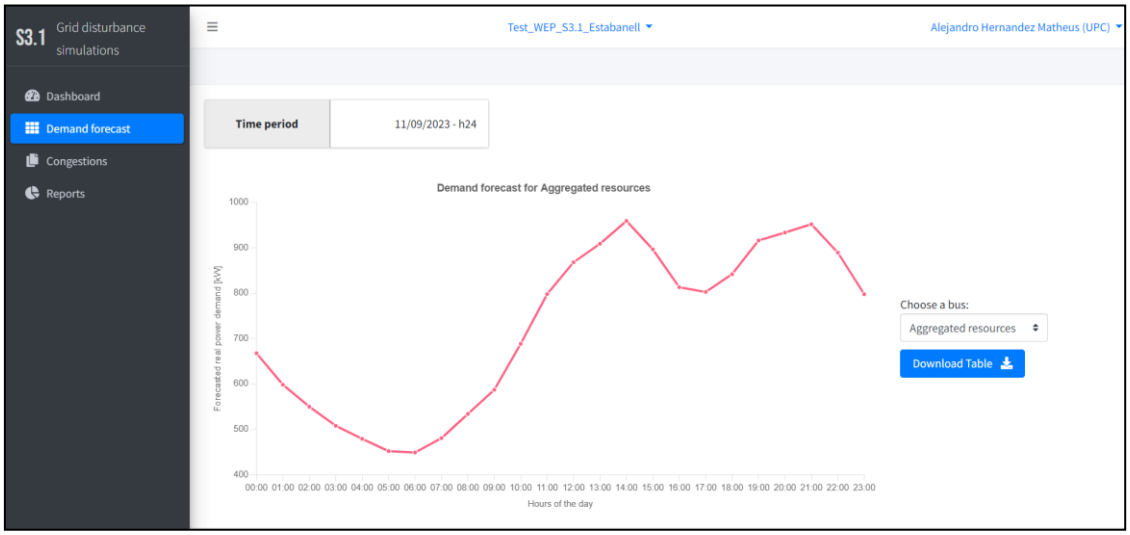


Figure 113: Demand forecast

    b. Scroll through the dropdown list and review the forecast of other loads.

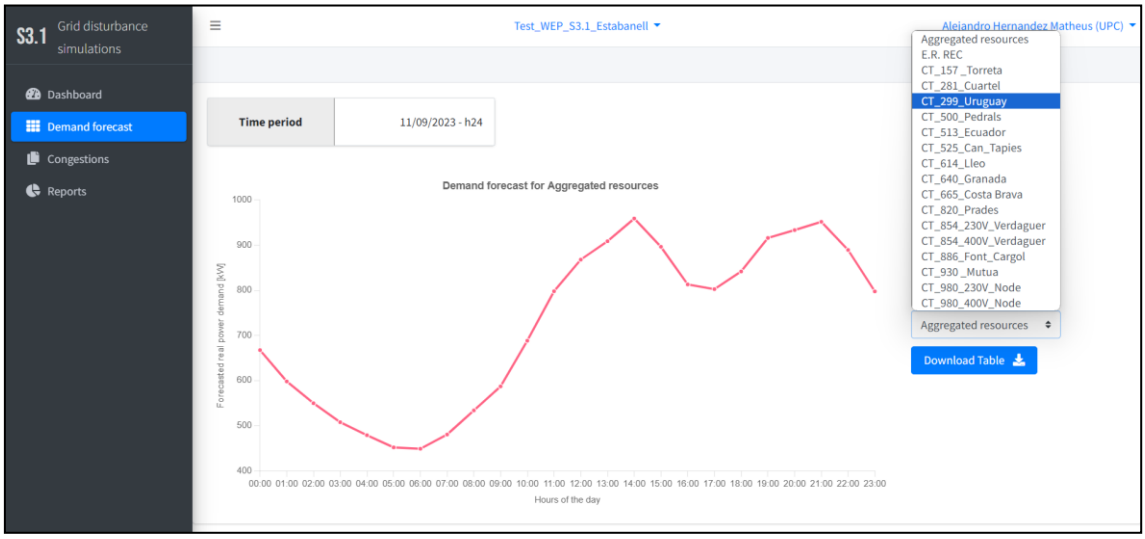


Figure 114: Demand forecast for Aggregated resources

Figure 115: Demand Forecast for CT_299_Uruguay

4. Move to *Congestions* and select different lines to analyse their congestions, if any. Select to show the forecasted behaviour for *Line* 1 and *Line 2*. Following, select the *download button* to get the results in excel format for further analysis.

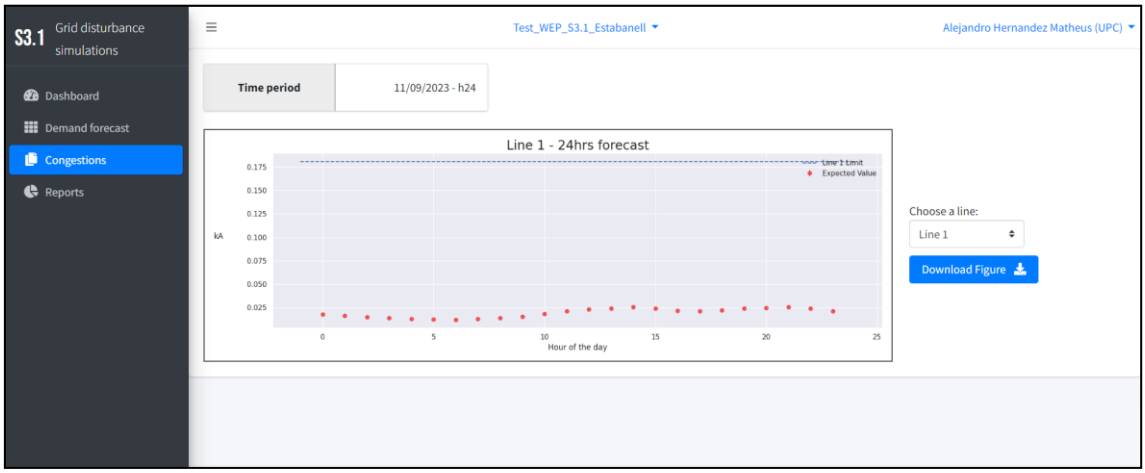


Figure 116: Congestion Line 1

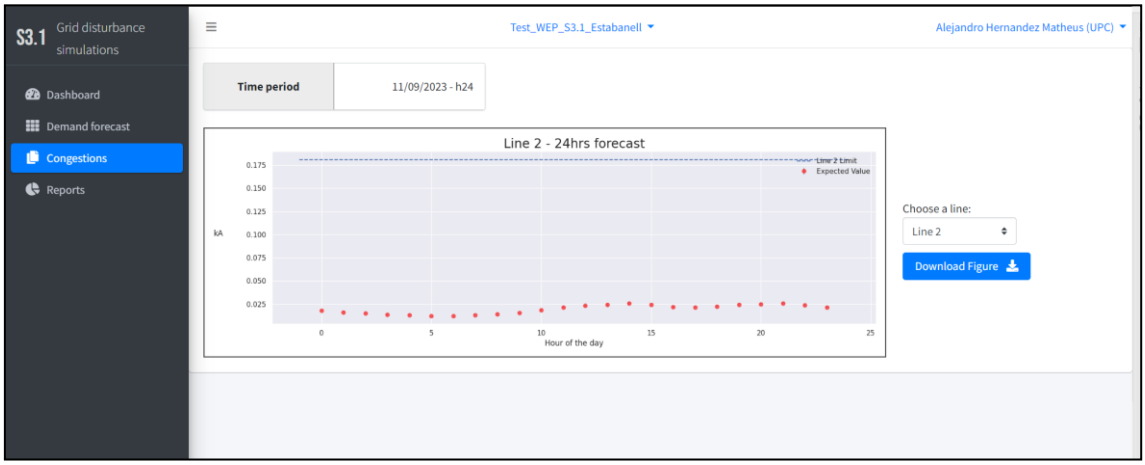


Figure 117: Congestion Line 2

5. Go to *Report* tab, scroll down to appreciate the probabilities of congestions for all the lines for the all times of the day. Finally, push the *download file* button to obtain the report in excel form.

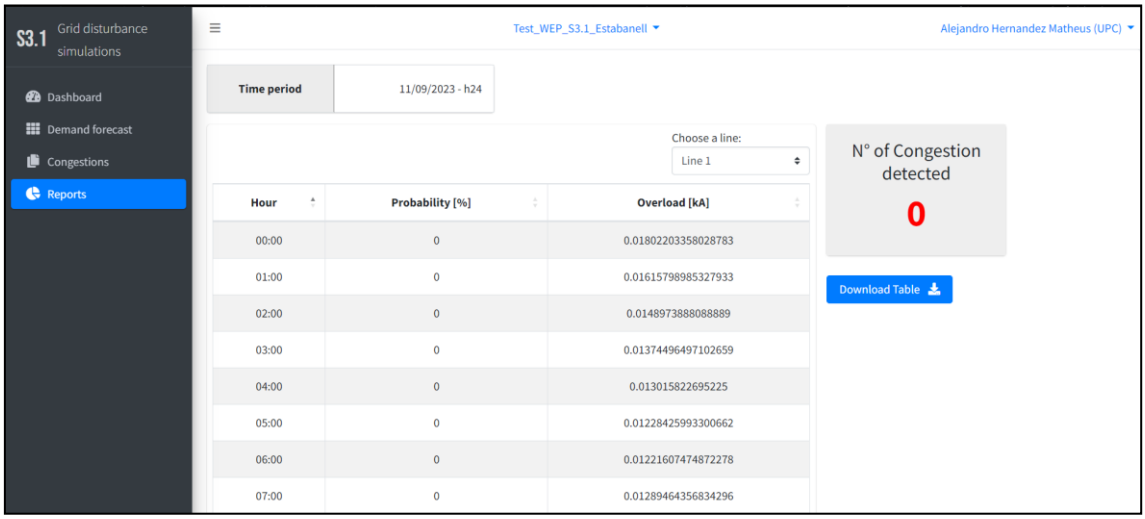


Figure 118: Reports Line 1

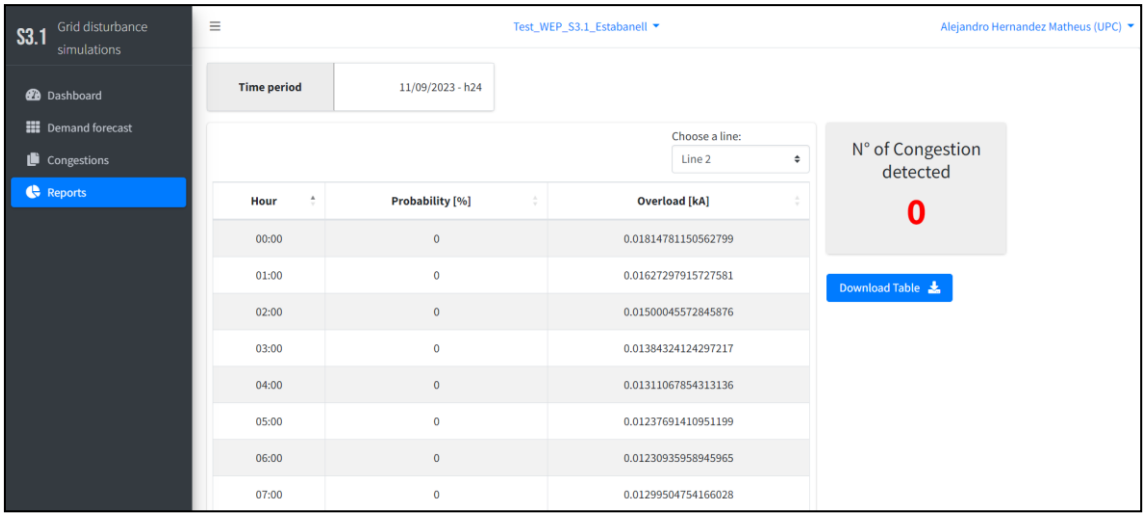


Figure 119: Reports Line2

8.2.2 JSI approach: PQ-related disturbances

Service 3.1: Grid Disturbance Simulation: PQ-related disturbances

1. Go to the Marketplace main page and go to the search bar and look for the service "*Grid disturbance simulations: PQ-related disturbances".*

   Select the desired service
   Contract the service, following the default and/or required contract parameters. Upload the data as needed.

Execution of the service through the marketplace or by login to the marketplace and running http://s31jsi.bd4opem.eu/

Usability Testing:

After executing the service, follow the indicated steps to test various aspects

a. Initial screen shows the available contracts for this service. You can select the appropriate one.

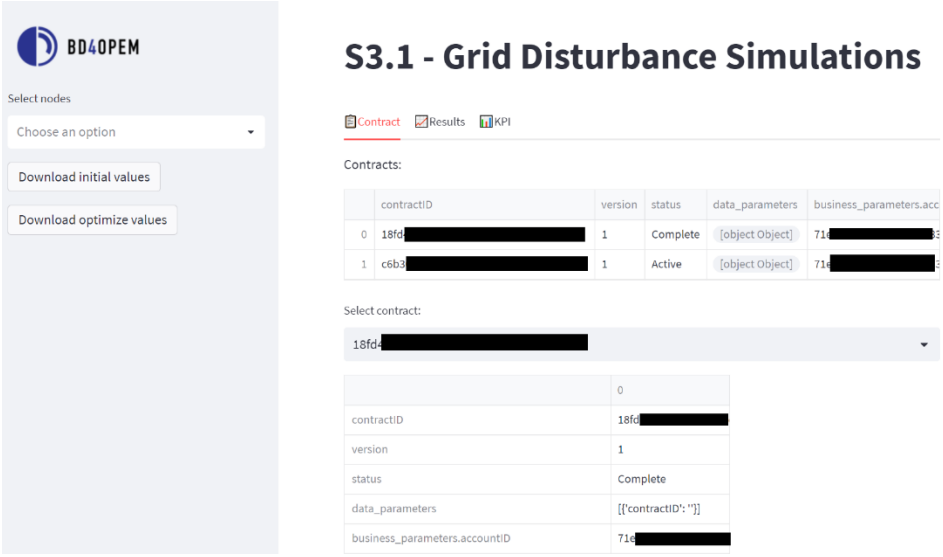


Figure 120: Grid Disturbance Simulations

b. Go to the *Results* tab where you will see the topology of the grid that was simulated. On the left sidebar, you can select the nodes in which you are interested. After choosing the nodes of interest, the graphs will be shown below the topology figure with initial and optimal values for selected nodes. Due to transparency, only 5 nodes can be chosen; otherwise, the graphs are overcrowded.

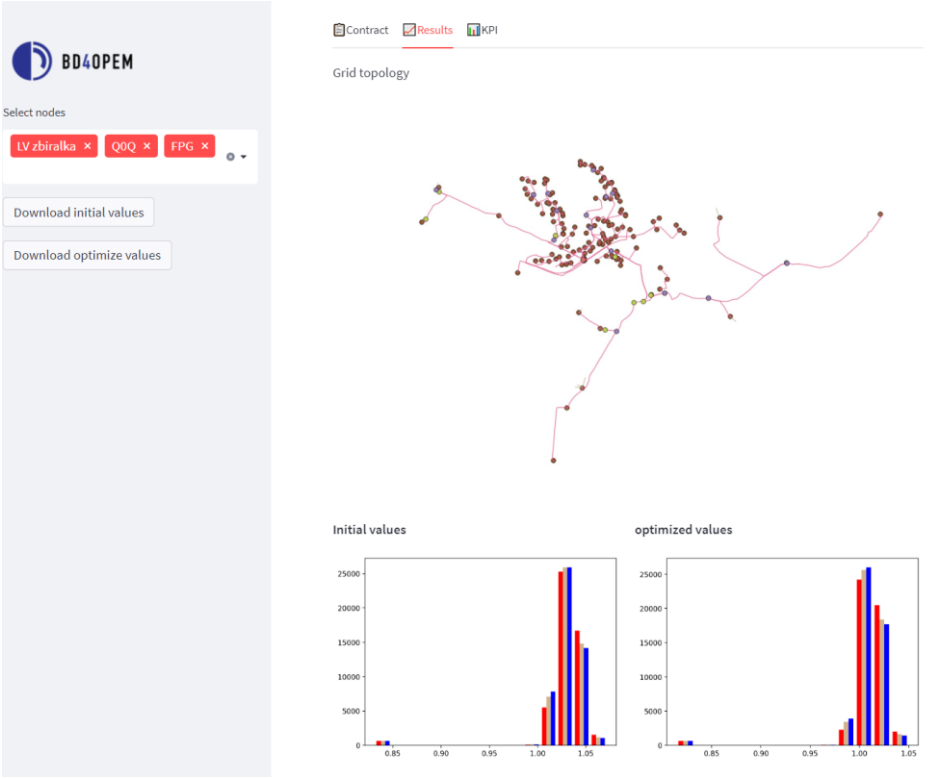


Figure 121: Grid topology

c. Move to *the KPI tab to see each node's KPI*. KPI<1 means there was some improvement obtained with the measures taken. Since these

are manual simulations, all possible measures are defined before simulation and only the optimal is shown.

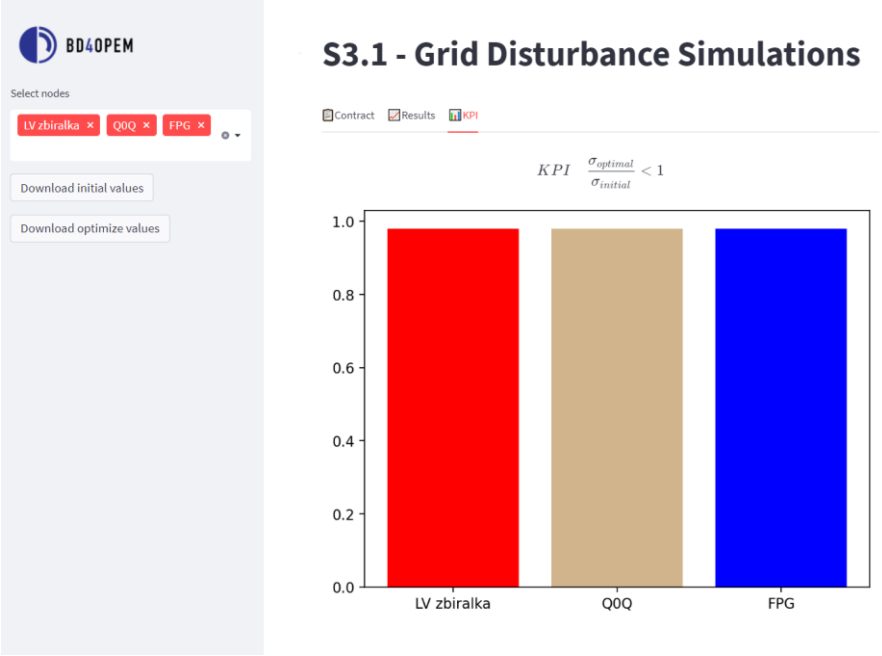


Figure 122: KPI

d. On the left side, you have two buttons to download all the numerical data of the initial state of the grid and for optimal value in CSV format.

2. Fill out the questionnaire following the results and experience perceived after the previous steps.

8.3 S5.1 – Flexibility Forecast

8.3.1 UPC approach: Flexibility forecast

Service 5.1: Flexibility Forecast

1. Go to the Marketplace main page and go to the search bar and look for the service "*Flexibility Forecast".*
2. Select the service desired.
3. Contract the service, following the default and/or required contract parameters. Upload the data as required.
4. Execution of the service. On the initial menu: create new execution.
5. Click on "Add Forecast Model".

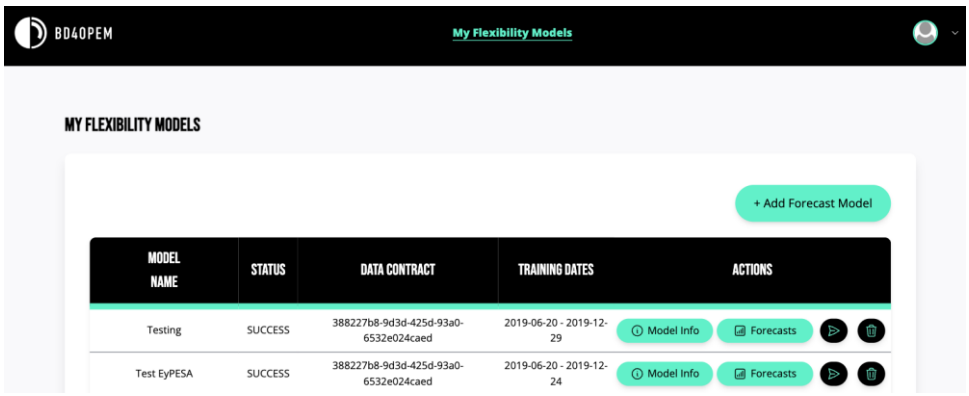


Figure 123: My Flexibility Models

Fill the following information to initiate the forecast.

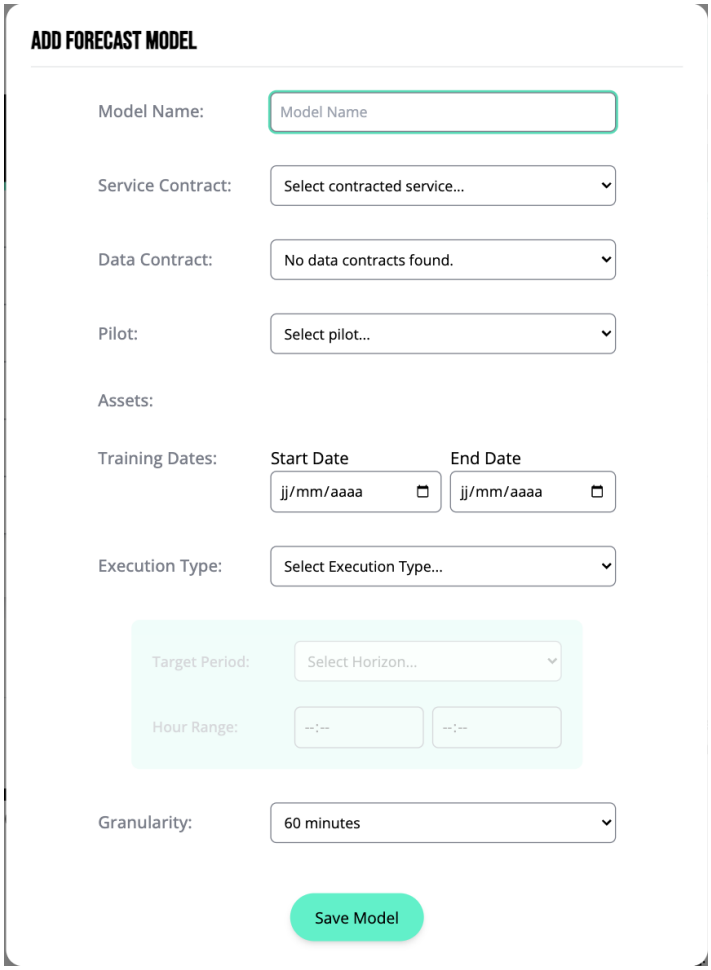


Figure 124: Add Forecast Model

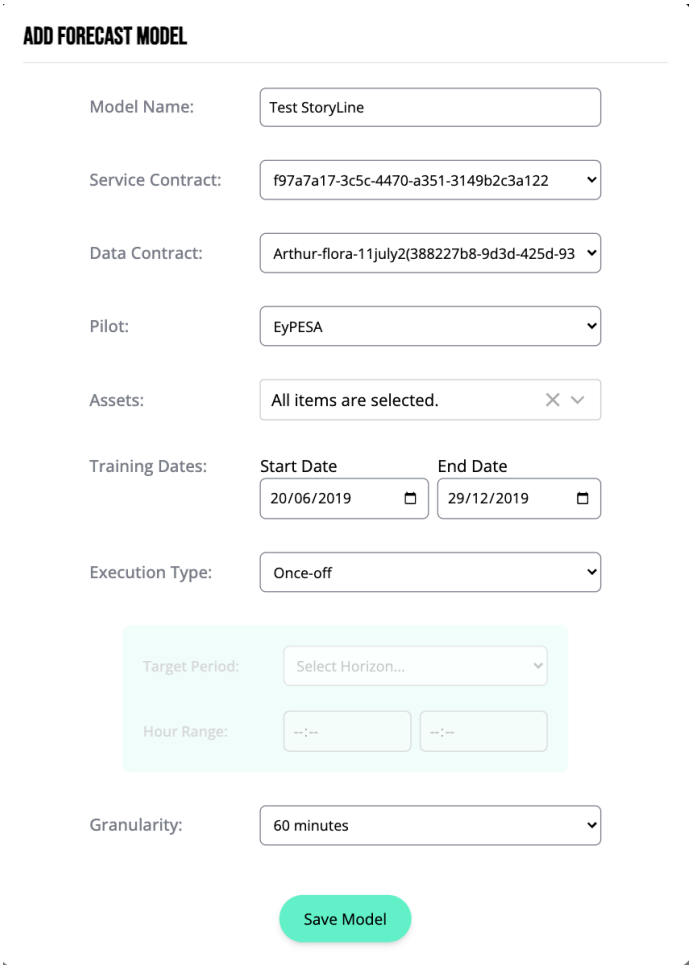


Figure 125: Added forecasting model

6. Save it and the model appear in your forecast models.

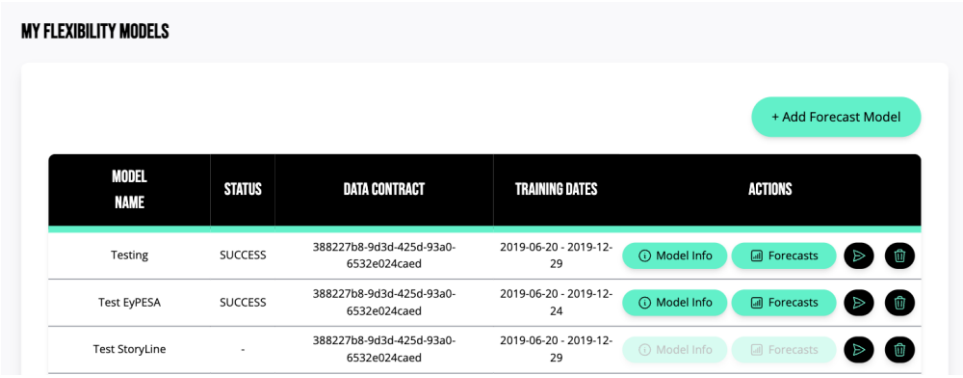


Figure 126: Model image

To make it run, click on the right arrow button. Changing its status to "pending":

Figure 127: Model info and forecasts pending

and then to success, enabling the tabs ”model info” and ”forecasts” :

Figure 128: Flexibility Model info and forecasts

Usability Testing: On the initial menu: check previous executions.

a. Click on the “Model Info” tab, scroll down to discover the following:

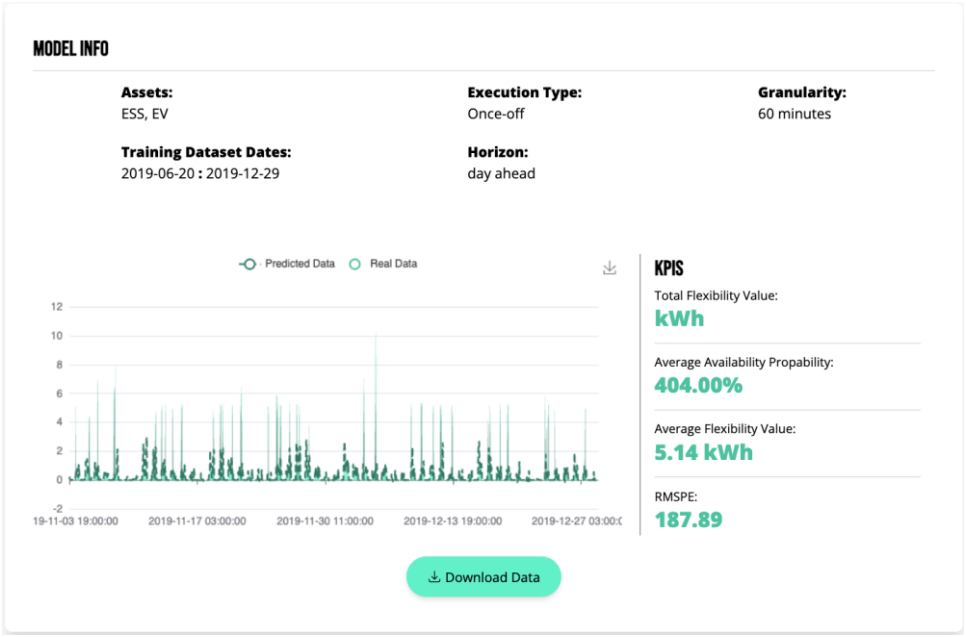


Figure 129: Model Info

It will deliver the information on the selection and the training results (real flexibility estimated and the forecasted) with the corresponding KPIs.

b. Select the forecast tab

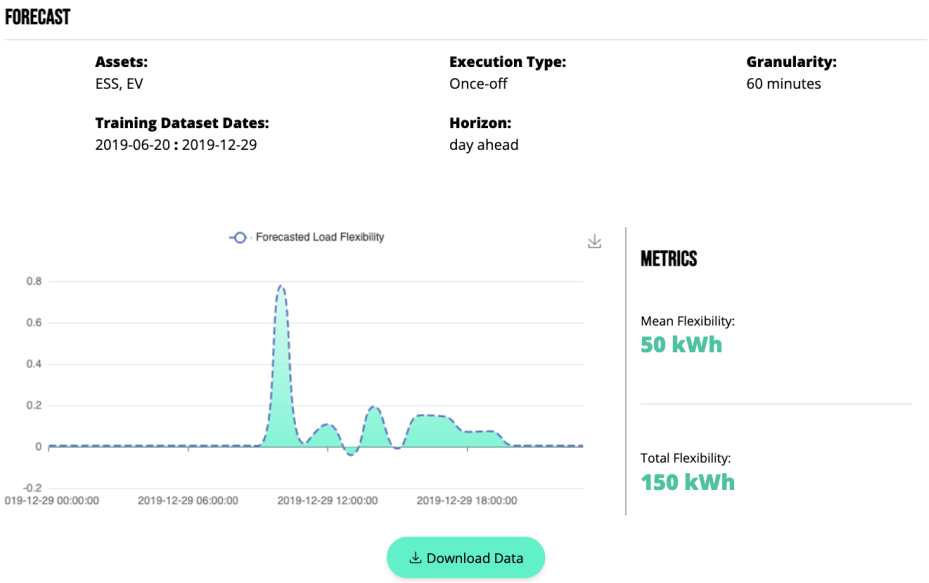


Figure 130: Forecast

It will deliver the information on a graph with the results of the forecast for the next day. Also, the metrics of flexibility are presented: total and mean flexibility values.
Click on "Download Data" to be able to export a CSV file with the forecasting results and on to download the chart.

8.3.2 JSI approach: Flexibility forecast

Introduction

Being able to predict a customer's reaction to a price change is useful in a real-time power pricing setting where consumers are sensitive to changing rates. This study suggests estimation of aggregated load flexibility based on the historical price-response dynamics of consumers and demonstrates how one-way price signals can be utilized to control the aggregated electricity consumption.

The proposed approach requires aggregated historical consumption data along with the historical and current weather information to estimate "price-based" demand-side flexibility.

In the next sections the steps needed to contract the service and request execution are presented. On the end the service results obtainable through the report are briefly presented. Before dwelling into the service contracting, provisioning and execution a brief introduction to the flexibility model is given in the next section.

About the flexibility model

The model has been prepared during BD4OPEM project in cooperation with UiW (Use it Wisely) national project, led by Elektro Celje and supported by JSI. The UiW project has been supported by the Agency for Energy of Slovenia which enabled positive and negative critical peak network tariffs in a region of Elektro Celje network. During peak hours the network fee was 10 times higher as at ordinary hours. The Agency decree enabled 100 hours of positive critical peak tariff per year. Based on this the projects have organized 41 2 hours flexibility events in 2021.

The model has been built on a dataset containing the 15 minute-resolution electricity consumption dataset from 791 households in Elektro Celje region. The dataset time span was from September 1, 2019 to December 31, 2021. The dataset was trimmed by removing the customers with missing load and finally 462 customers were used for the analysis. The dataset contains 41 events of 2 hour duration scheduled on different times and days in the year 2021. We have also used the weather data such as temperature, precipitation and radiation of the same region as users to increase the accuracy of our forecast model.

Data contract

First, we need a data contract for the service. On the "Search" page of the Marketplace, we search for "flexibility forecast" data. There will be a few results, but we select "Flexibility forecast input data".

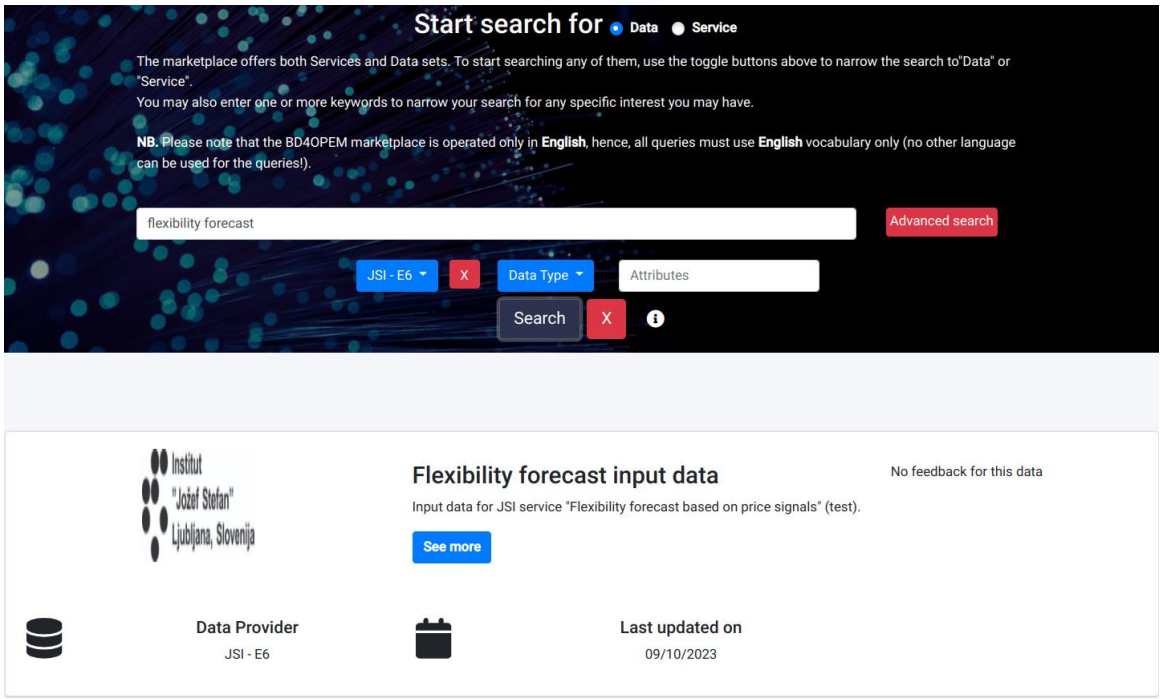


Figure 131: Data in Marketplace

To make a data contract, click on "See more", then "Contract data" at the very bottom. Give the contract whichever name, for example "S5.1 input data" For the data period, select today's date as "From", and whichever date in the future as "To". Finally, press "Submit".

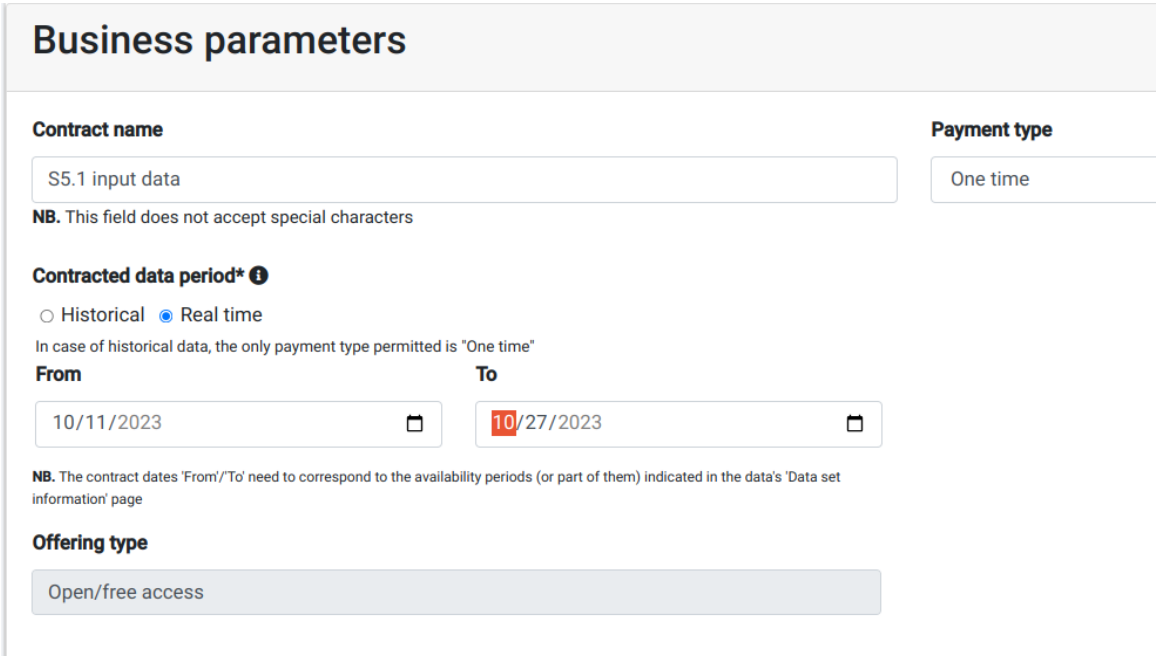


Figure 132: Data input screen

Service Provisioning receives the data contract right after the "Submit" button is pressed. You should be able to see your data contract request in the "My Data" page, with the role "Data User". The contract status should be COMPLETE.

Figure 133: Contracted data

However, to be able to use the data contract, it needs to be approved and activated by the Data Provider (in this case, JSI). Approving and activating the data contract will advance the contract status from COMPLETE to APPROVED, and then to ACTIVE. Once contract status is ACTIVE, it can be selected when contracting a service, as we will see shortly.

Service contract

Contracting a service follows similar steps as contracting data. Service S5.1 can be found on the Marketplace under the name "Flexibility forecast based on price signals". Under "Advanced search", we can also select "JSI - E6" organization to filter the results.

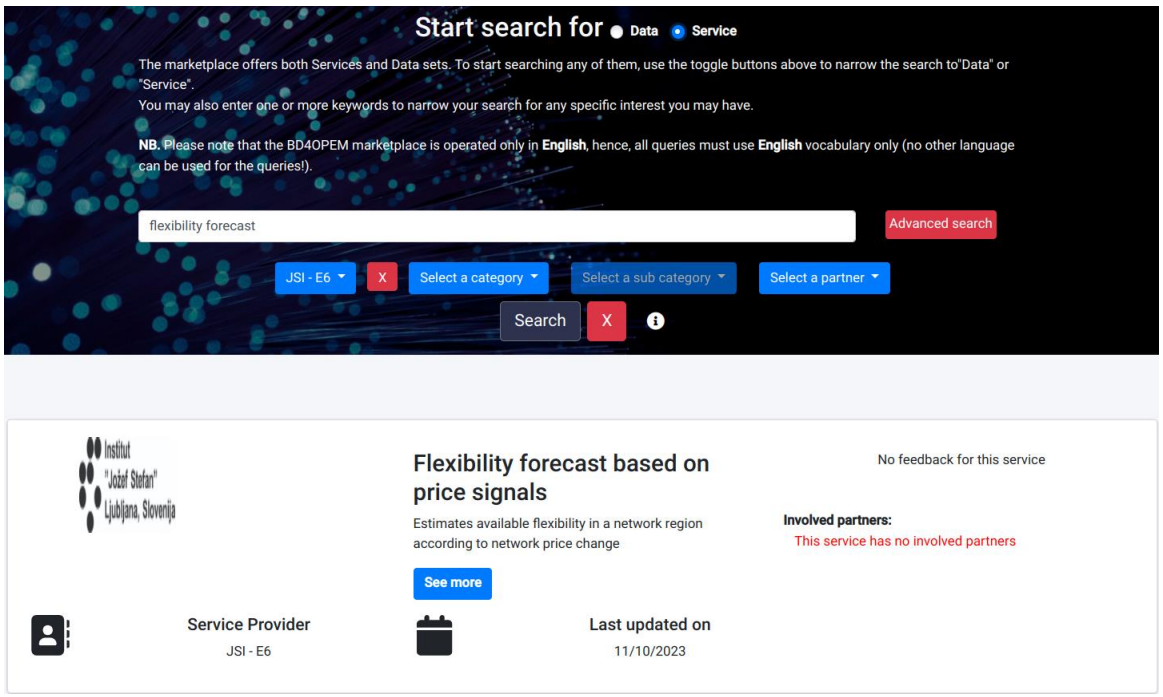


Figure 134: Service in Market Place

Click on "See more", and then "Request new service" at the top of the page. We first fill in the business parameters, same as for the data contract. Contract name can be whatever, for example "S5.1 test contract [today's date]". Leave "Payment type" as is, and select the contract period.

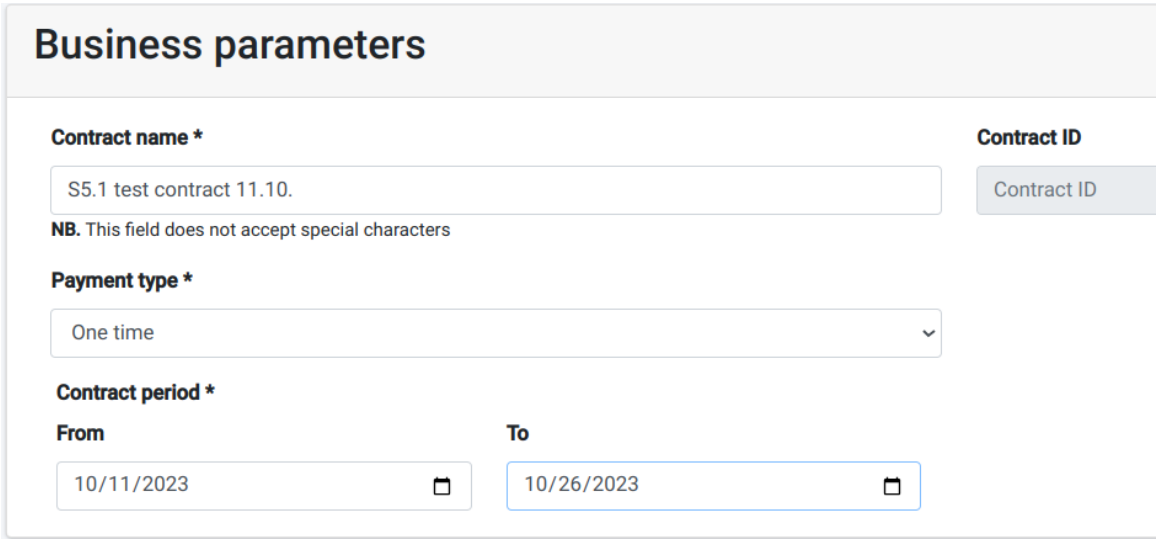


Figure 135: Service contract

Next, we select the technical parameters. Select one value for each technical parameter. A description of each parameter can be seen in the image. The most important one to select is the pilot - this essentially determines whose data will be used during execution. The parameter "pilot_strength" should be the approximate number of smart meters in the planned event.

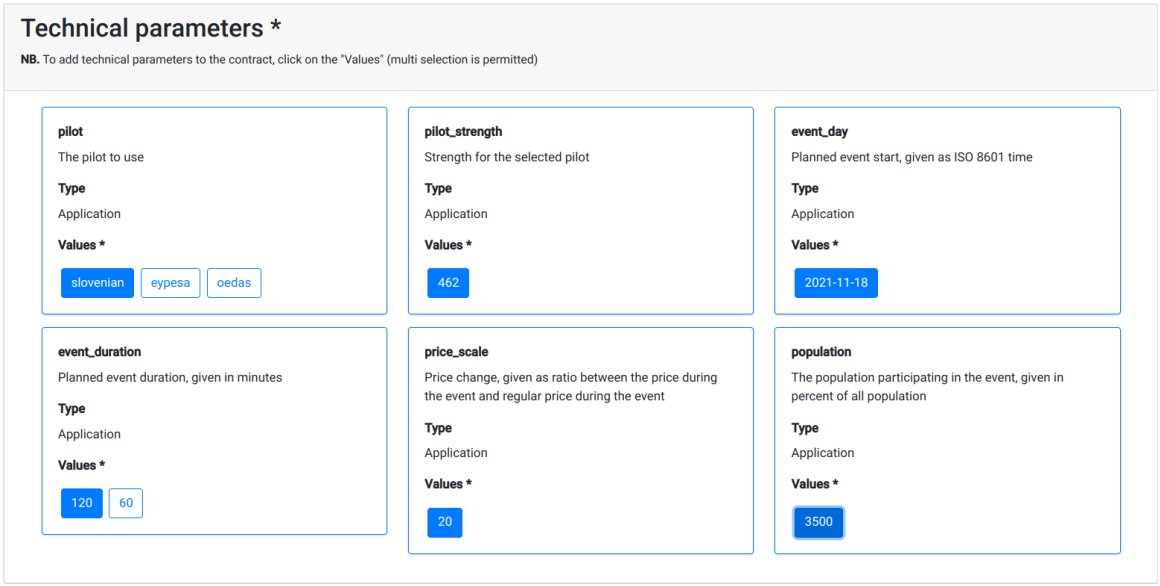


Figure 136: Service Data Parameters

We then select the data contract. Find the "S5.1 input data" (or whatever name you put) data contract, check it, and click "Confirm". The data contract will not be present unless it was activated by the Data Provider. Be sure to also select "Yes" for "Enable immediate execution", otherwise the service will not actually be run in the ASM module.

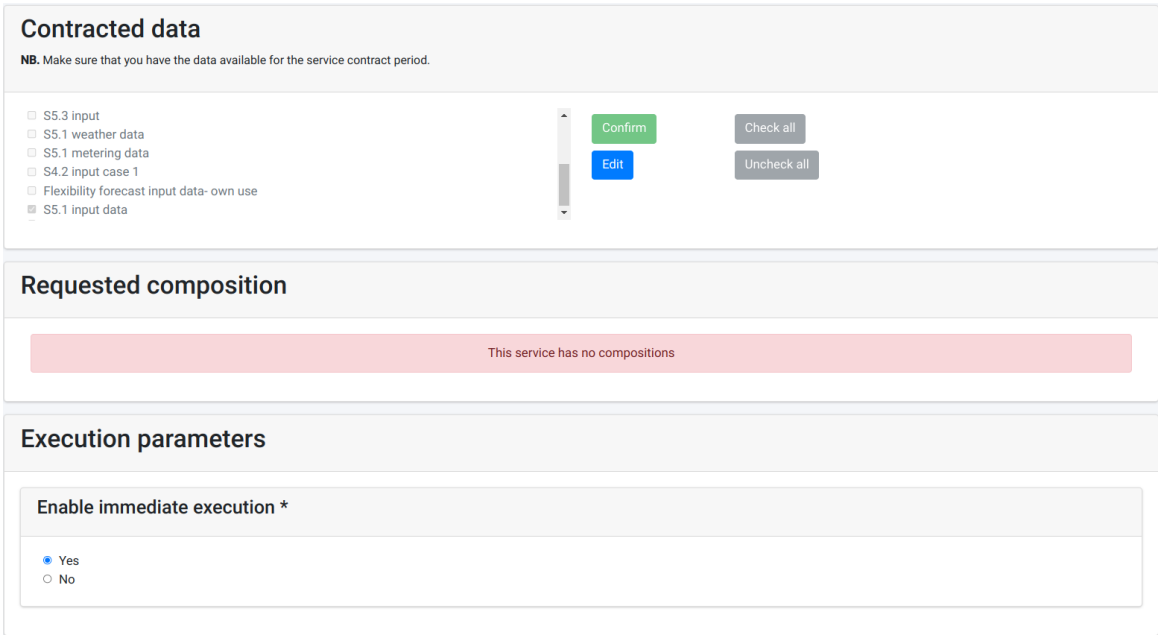


Figure 137: Selecting contracted data

Finally, click on the "Request service" button at the bottom. Similarly as for the data contract, Service Provisioning receives the contract right after the button is pressed. You should be able to see your service contract request in the "Service requests" table, found on the "My Services" page, with the role set to "Service User". The contract, provisioning and execution status should be as in the below image.

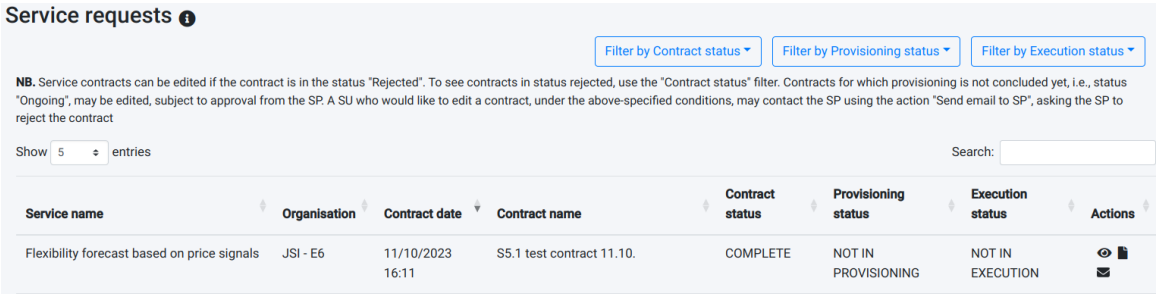


Figure 138: Service request

Running the service

Similarly, to be able to use the service contract, it needs to be approved and activated by the Service Provider (in this case, JSI). Immediately after the contract is activated, an instance of the S5.3 service will be started in the ASM module. This will happen because the service is set to be auto instantiated *if* immediate execution was set to "Yes".

As soon as the contract is activated, i.e. the service starts executing in ASM, the Marketplace will provide us with a link to our front-end, where we can see the logs and results of the service. This link is accessible via the "Go to service" button, present in the corresponding entry in the "Service requests" table.

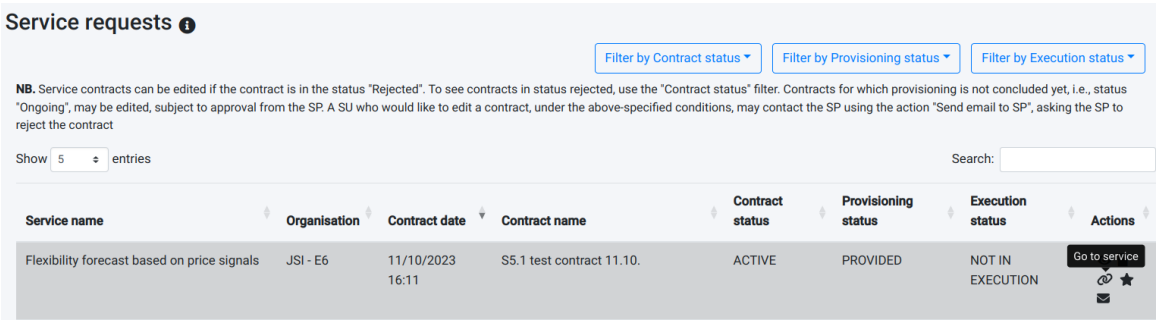


Figure 139: Service link from Market place

Clicking on the "Go to service" button takes us to our front-end.

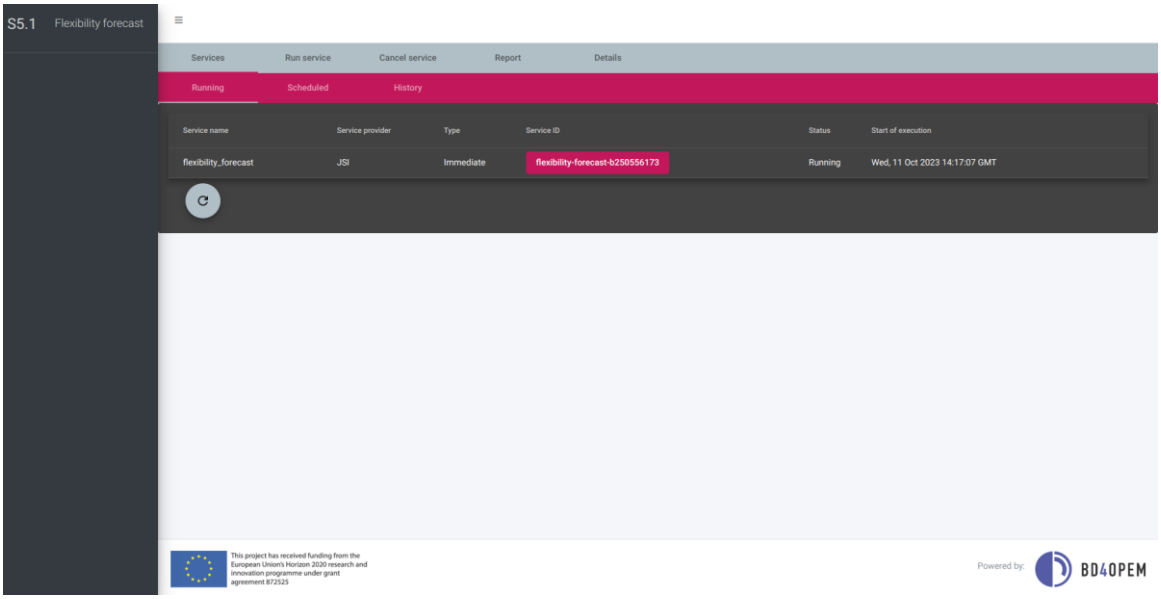


Figure 140: Service test screen

If the service is still executing, it should be present in the "Running" tab. Clicking on the ID in the "Running" tab will take you to the "Details" page and stream any logs of the service.

If the service has finished, we should be able to find it in the tab "History". You can click on the refresh button to see whether it has. By clicking on the service ID in the "History" tab, the report i.e. result of the service will be fetched and you will be automatically moved to the "Report" tab.

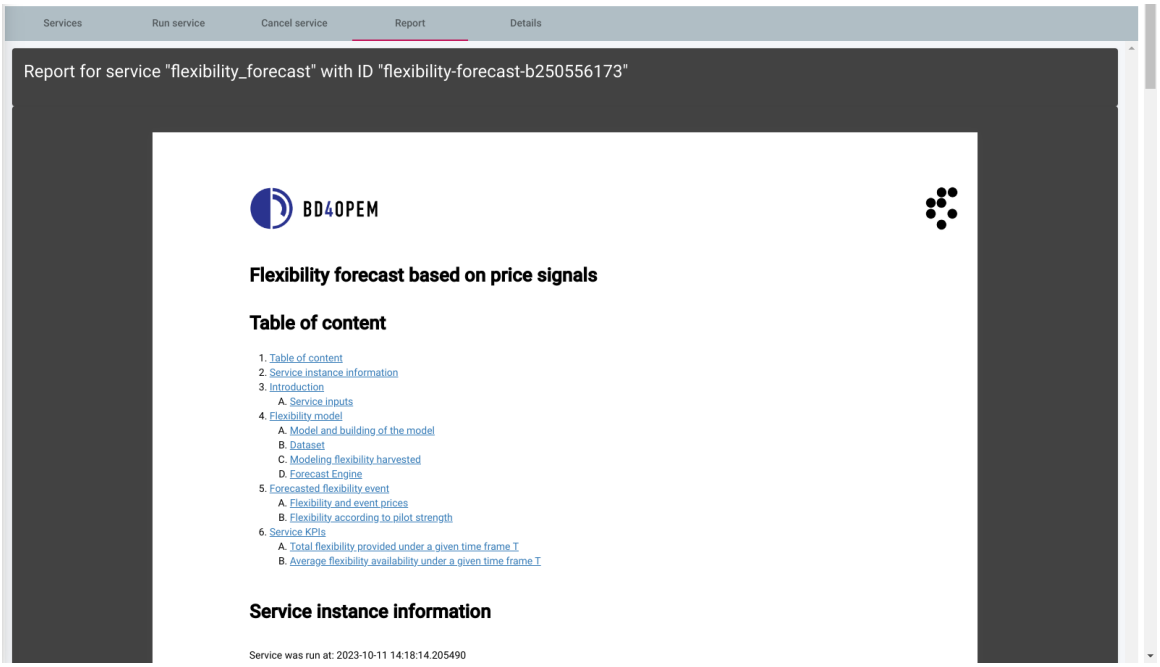


Figure 141: Report of the service

Additionally, by clicking on the tab "Details", you will be able to see the technical parameter values you selected, as well as any stdout and stderr logs of the service.

8.4 S5.2 – Flexibility aggregated services for BRPs

1. Go to the Marketplace main page and go to the search bar and look for the service "*Flexibility Services for BRPs".*

Select the service desired.
Contract the service, following the default and/or required contract parameters. Upload the data as required.

Execution of the service

Usability Testing:

After executing the service, check the following steps to explore and verify the different features

Check the first sub-service: "Day-ahead optimization" and explore the two tabs: "Forecast" and "Optimization"

In the "Forecast" tab, using the "Start Date", "End Date" and "Frequency it is possible to select the date range for the plot of the historical values. Using the "Select what to display" button it is possible to choose the forecasted variable to be displayed, between "Day-ahead marginal price", "BRP demand" or "Total costs". The first displays day-ahead forecasts of the chosen variable, whereas the second one allows to evaluate the performance of the model, comparing past predictions against real data. In the last section of the tab, KPIs of the historical performance are presented, according to the chosen error metric "MAPE" or "R2".

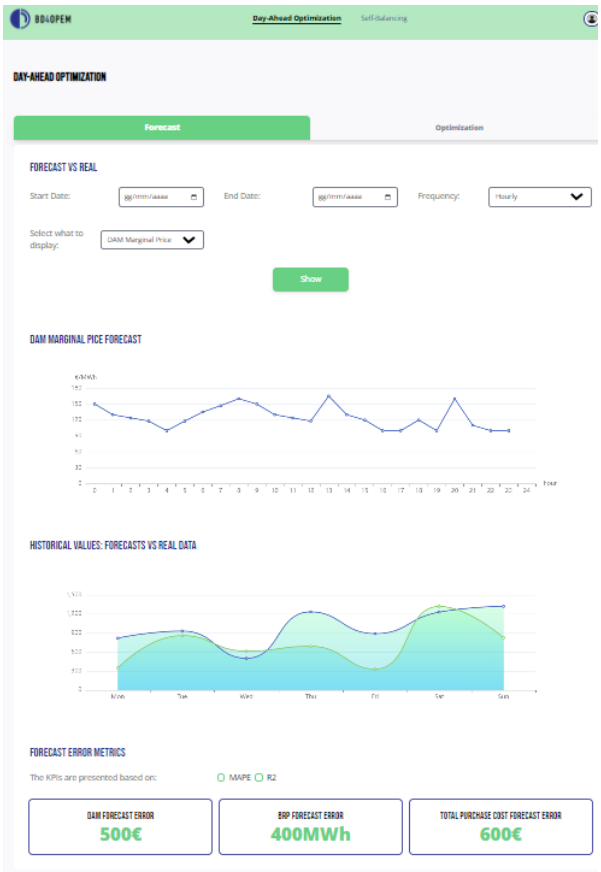


Figure 142: Day-Ahead Optimization

In the "Optimization" tab, the results displayed in the "Forecast" tab are used to evaluate the day-ahead balancing optimization of the BRP. Insert the "Max cost" and

"Flexibility price" inputs and verify that the outputs change accordingly. The KPIs below summarize the results of this sub-service.

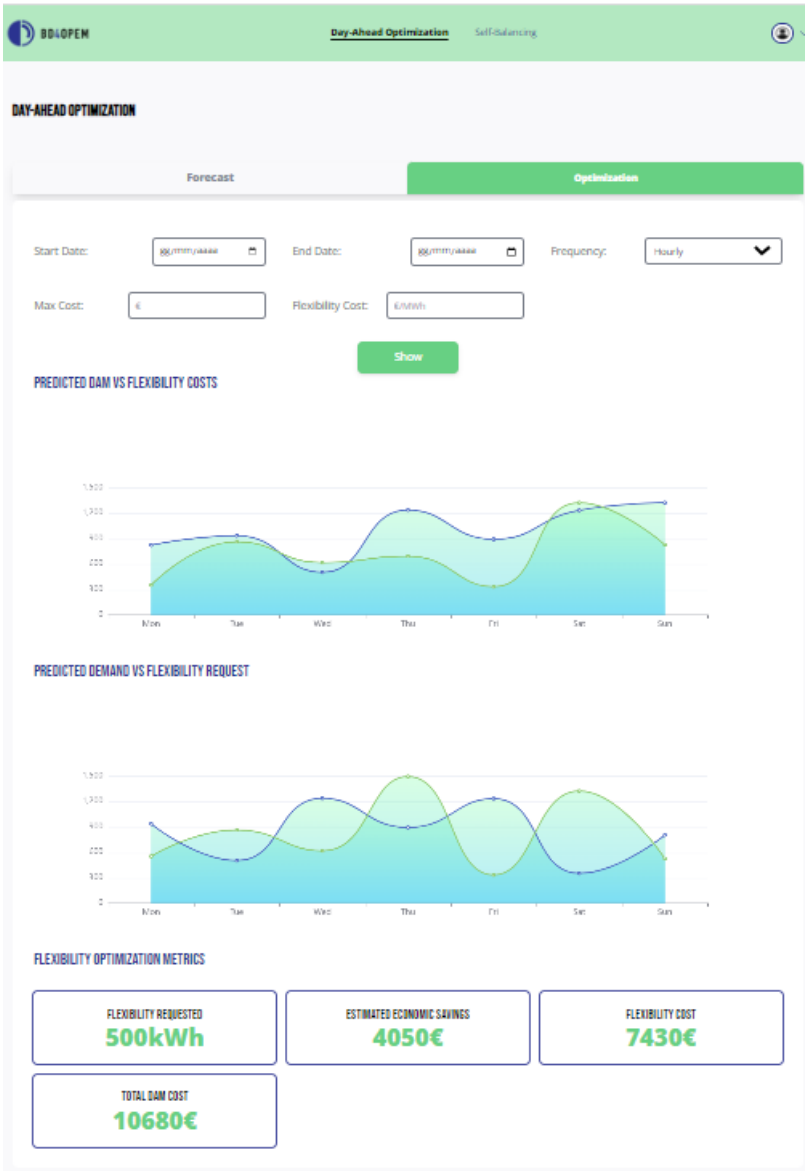


Figure 143: Results summaries

2. Navigate to the "Self-balancing" page, where the results of the self-balancing optimization are displayed. The plots show respectively the predicted deviations against the system for the day-ahead, and the relative periods to activate fleixibility. Summarizing the results, a KPI showing a percentage of the imbalances against the system is shown.

Figure 144: Display of system imbalances as a percentage

8.5 S5.3 – Flexibility aggregated services for DSOs

8.5.1 UPC approach: Flexibility-based AC OPF

Service	**S5.3 Flexibility agg. services for DSOs**
Algorithm provider	**UPC** – Alejandro Hernández

Service 5.3

Contract the service with the demanded parameters.
Select the pilot/grid.

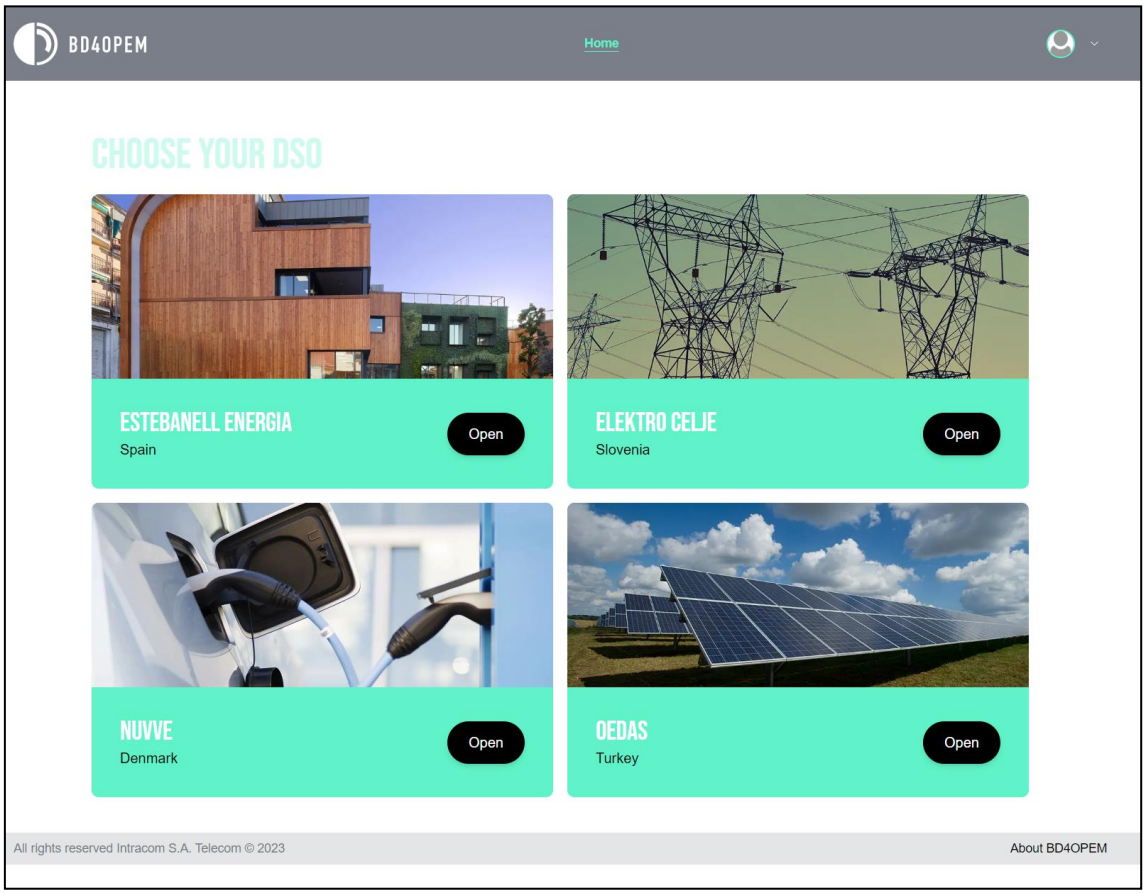


Figure 145: Choose your DSO

1. Upload the *daily forecast.* The daily forecast file corresponds to the excel file with the forecast for all loads for the next day. Select the date accordingly to such forecast. Then select *Submit*.

   The forecast files are the following with their forecasted date:

   - Estabanell*: Estabanell_forecast-1.xlsx (21-07-2023)*
   - CELJE: *ELCE_forecast-1.xlsx (07-07-2023)*
   - NUVVE: *NUVVE2_b_forecast-1.xlsx*
   - OEDAS: *OEDAS_forecast-1.xlsx (13-07-2023)*

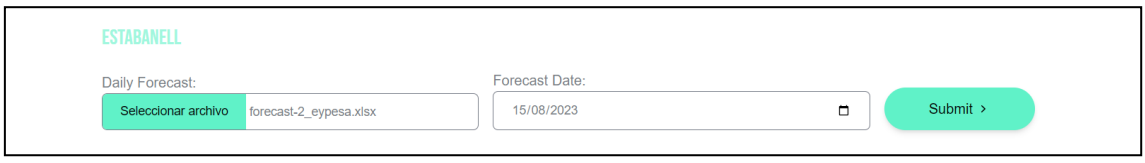


Figure 146: Estabanell

The service will start the execution for that specific day. Wait until the service is completed, hence, *Successful*.

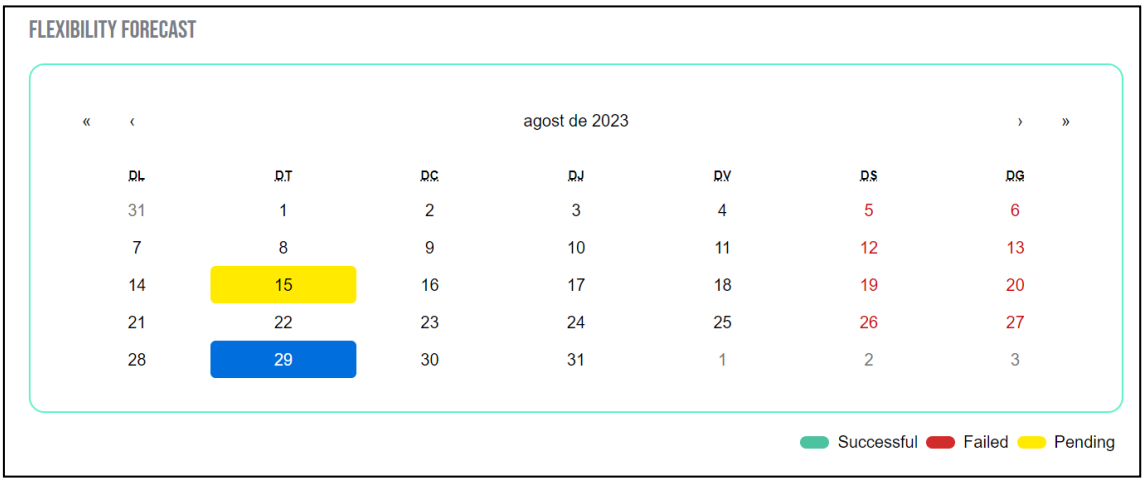


Figure 147: Flexibility Forecast / Successful screening

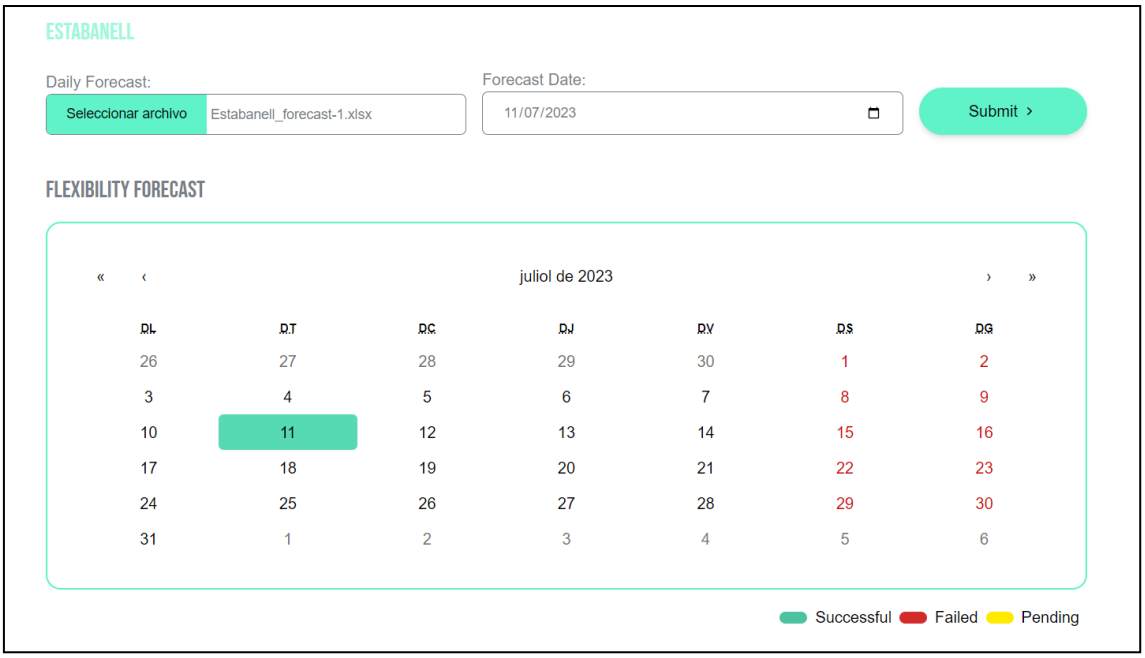


Figure 148: Daily forecast

Technical Testing: After executing the service, explore the performance factors of the period selected.

2. Select period. If you only have given data for one day, just select that day. (Like the example in this Storyline)

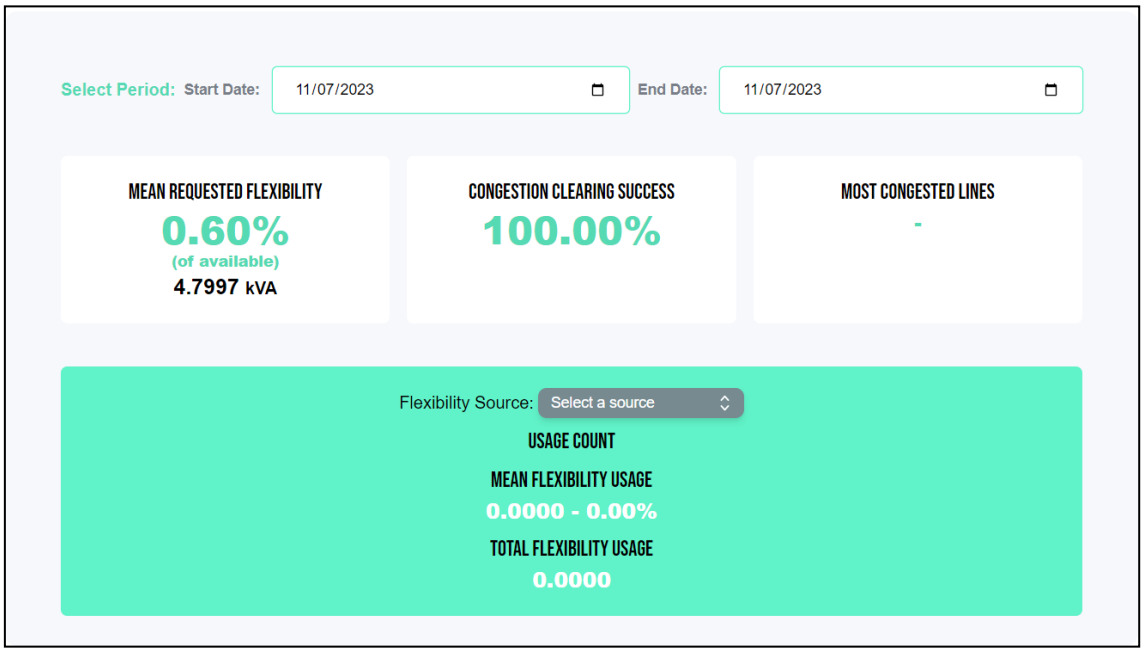


Figure 149: Flexibility forecast/ Selected period

Evaluate the results provided in this tab by verifying the summary values of Requested Flexibility and Congested Lines.
Scroll down and check the flexibility source ID dropdown list. Explore sources ID1 y ID2 and check their values.

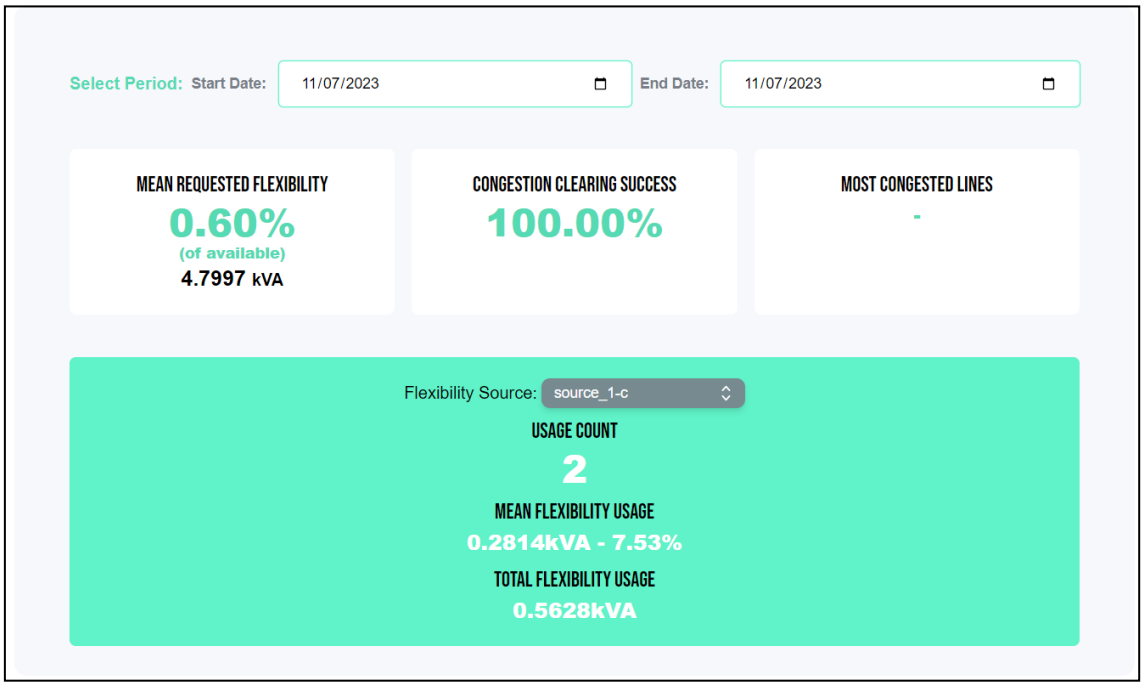


Figure 150: Control screen

3. Repeat the previous two steps for different available dates.

Click on the date on the calendar to get the visualizations of the results of that day.

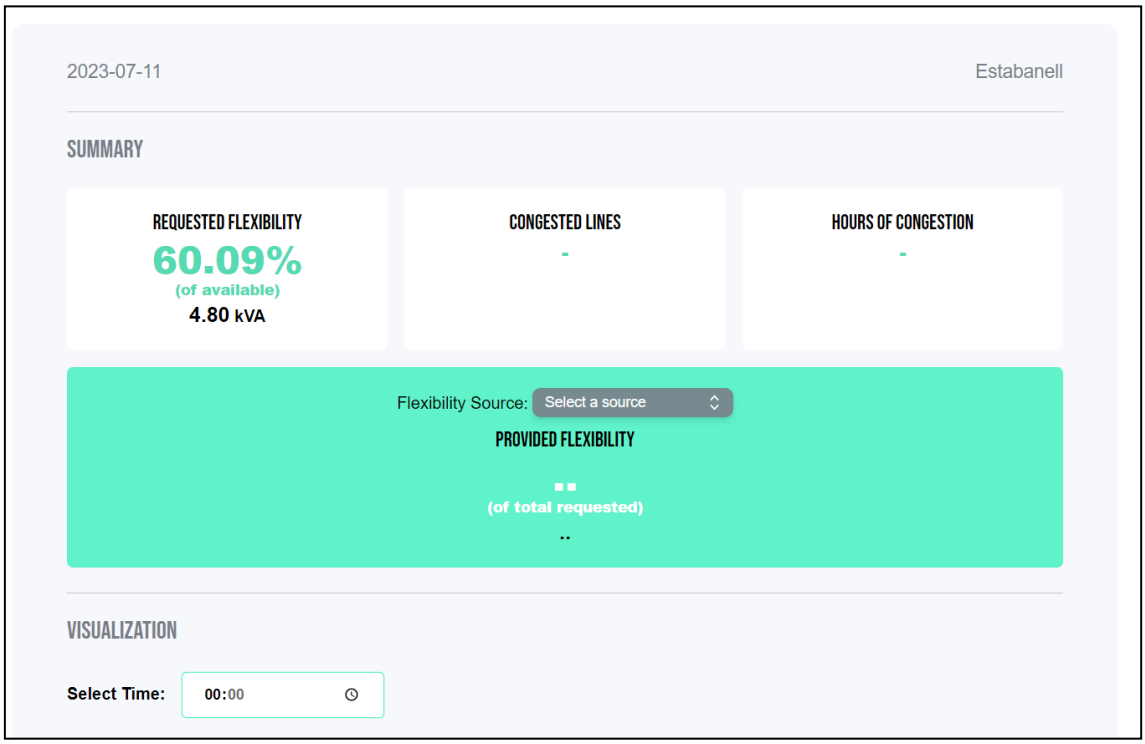


Figure 151: Summary

Change different times of the day. The figures depict the grid before and after the execution of the service. This corresponds to the use of the service to calculate the appropriate amount of flexibility to overcome the forecasted congestions in the grid.

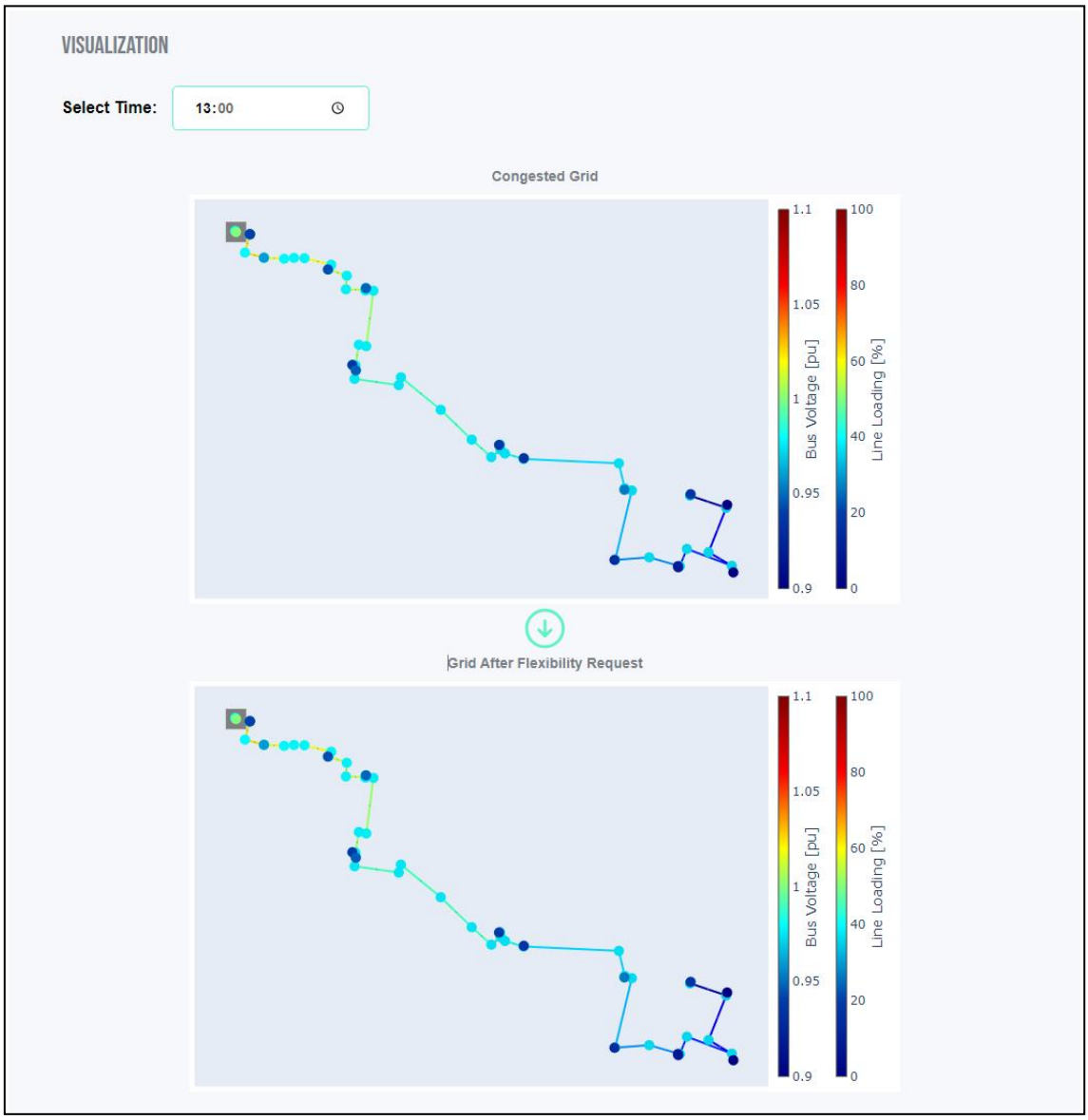


Figure 152: Visualization

a. Download figures for the most congested time of the day.
b. Following up the last step, make sure you can observe the image correctly after downloaded locally or in any other form.

4. Scroll down once again and position yourself in the preview of data.

c. In this section you are you going to select different buses IDs and explore their behaviour
d. Download the data in excel form.
e. Open data downloaded file and explore further results to make sure everything works.

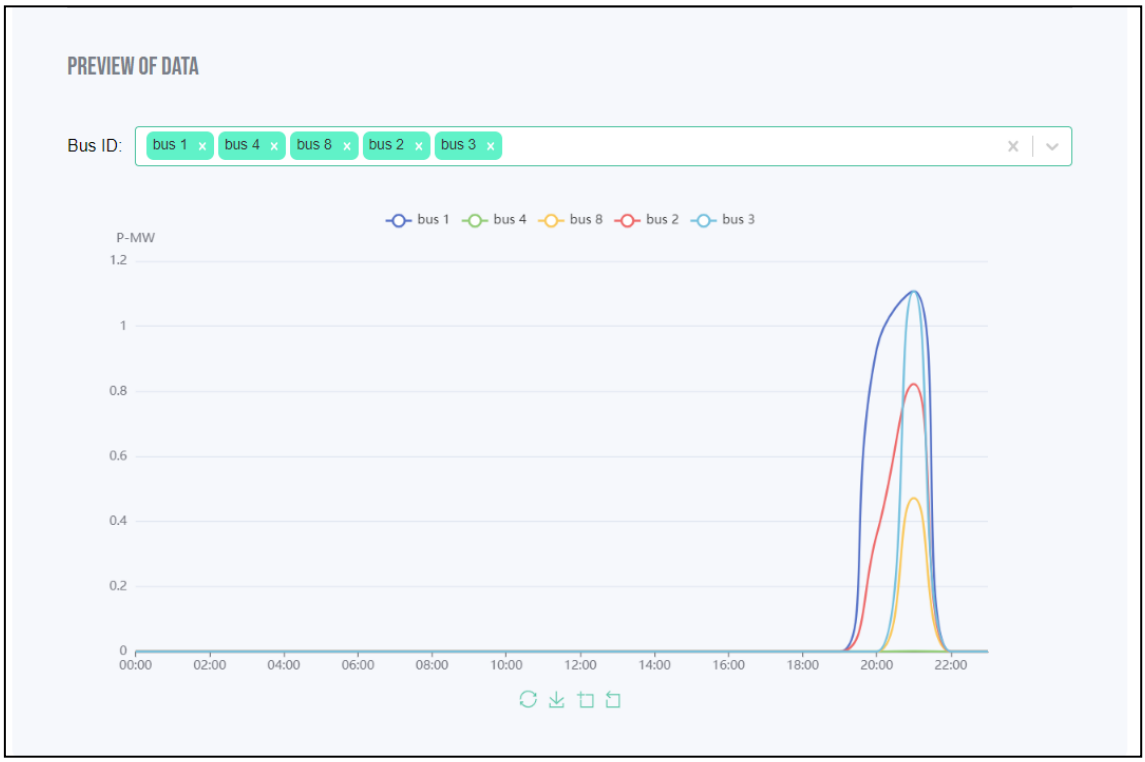


Figure 153: Preview of data

8.5.2 JSI approach: Flexibility services for DSOs based on neural networks

Flexibility services for DSOs provide necessary services for the DSOs to schedule flexibility events in a region of their network. The services provide a prediction of consumption in the target region and propose an event schedule at the time of the peak.

The service requires historic data of the region's consumption and weather forecast for the region. The service has been used with the following weather parameters: temperature, radiation and precipitation. At least temperature should be available.

The prediction of the consumption depends on the available weather forecast. More days of the forecast are available, longer can be the consumption prediction. For example, in Elektro Celje Case, if there are seven days of weather prediction data available the consumption can be predicted for a week in advance. Since the consumption is based on smart-metering and the metering is considered to be D-1, the effective prediction is less than a week long. The number of days is further reduced since the D-1 data is usually not good enough for prediction. Large portions of the network data is available as D-2 data. In summary, an effective prediction is only 5 days long.

The predictions in this story line are shown on historic data so the service can be more easily evaluated. Working on the edge and predicting into the future requires a flowing stream of data.

In the next sections the steps needed to contract the service and request execution are presented. On the end the service results obtainable through the report are briefly presented.

Data contract : First, we need a data contract for the service. On the "Search" page of the Marketplace, we search for "Flexibility services for DSOs" data, as seen in the below screenshot.

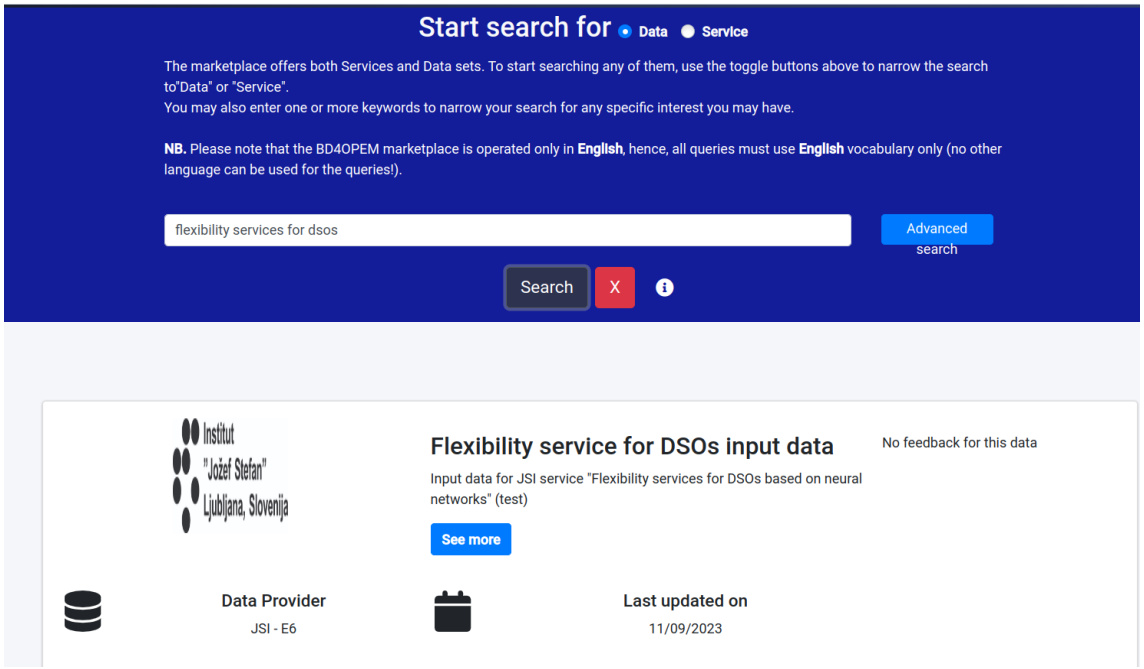


Figure 154: DATA contract

To contract this data, click on "See more", then "Contract data" at the very bottom. Give the contract whichever name, for example "S5.3 input". For the data period, select today's date as "From", and whichever date in the future as "To". Finally, press "Submit".

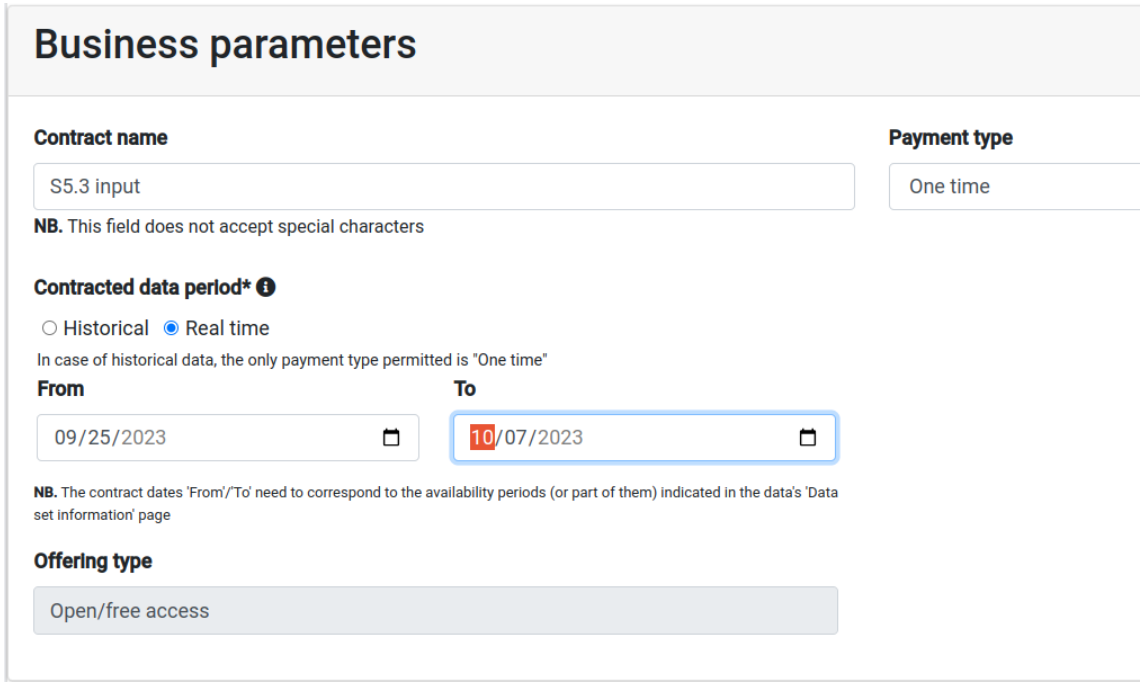


Figure 155: Business parameters

Service Provisioning receives the data contract right after the "Submit" button is pressed. The Service Provisioning details are shown in the text box below.

The following image shows the corresponding log entry in the SP module, indicating the data contract was received.

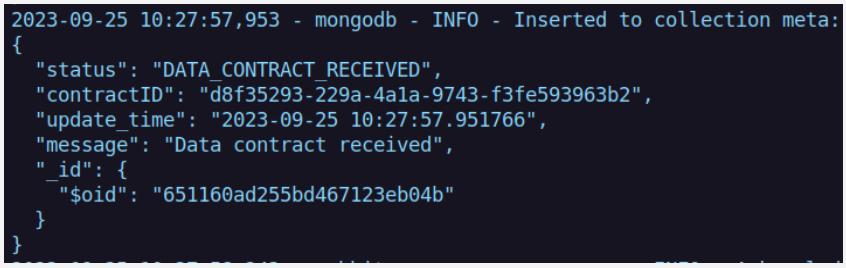


Figure 156: log entry in the SP Module

You should be able to see your data contract request in the "My Data" page, with the role "Data User". The contract status should be COMPLETE.

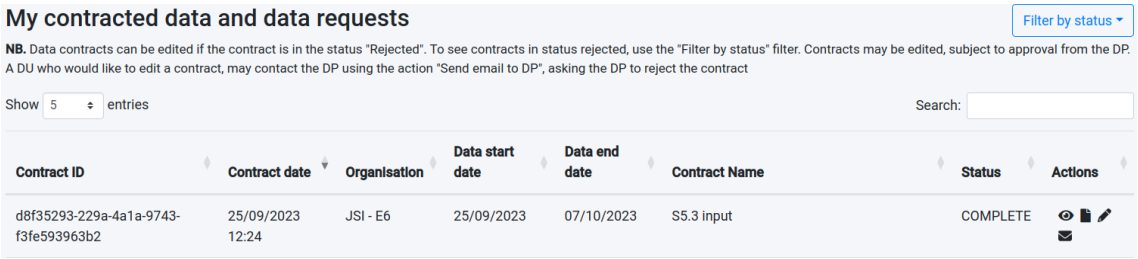


Figure 157: My contracted data and data requests

However, to be able to use the data contract, it needs to be approved and activated by the Data Provider (in this case, JSI). Approving and activating the data contract will advance the contract status from COMPLETE to APPROVED, and then to ACTIVE. Once contract status is ACTIVE, it can be selected when contracting a service, as we will see shortly.

Service contract

Contracting a service follows similar steps as contracting data. We first search for service S5.3, flexibility services for DSOs. Under "Advanced search", we can also select "JSI - E6" organization to filter the results.

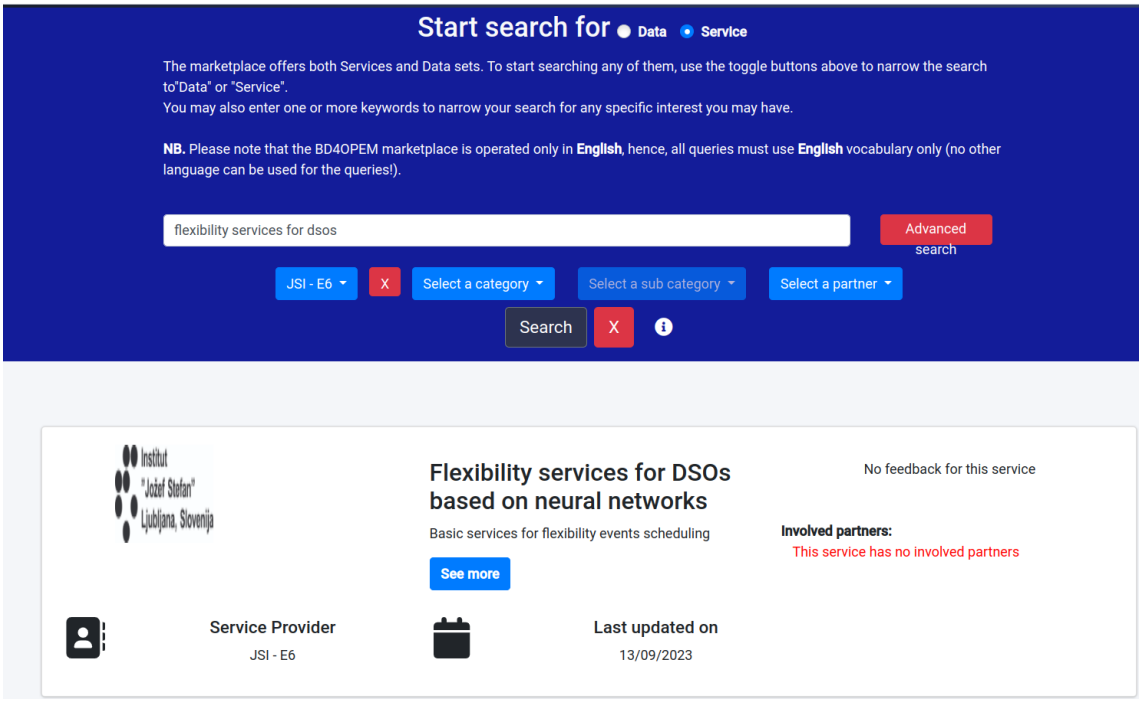


Figure 158: Flexibility services for DSOs based on neural networks

Click on "See more", and then "Request new service" at the top of the page. We first fill in the business parameters, same as for the data contract. Contract name can be whatever, for example "S5.3 test contract [today's date]". Leave "Payment type" as is, and select the contract period.

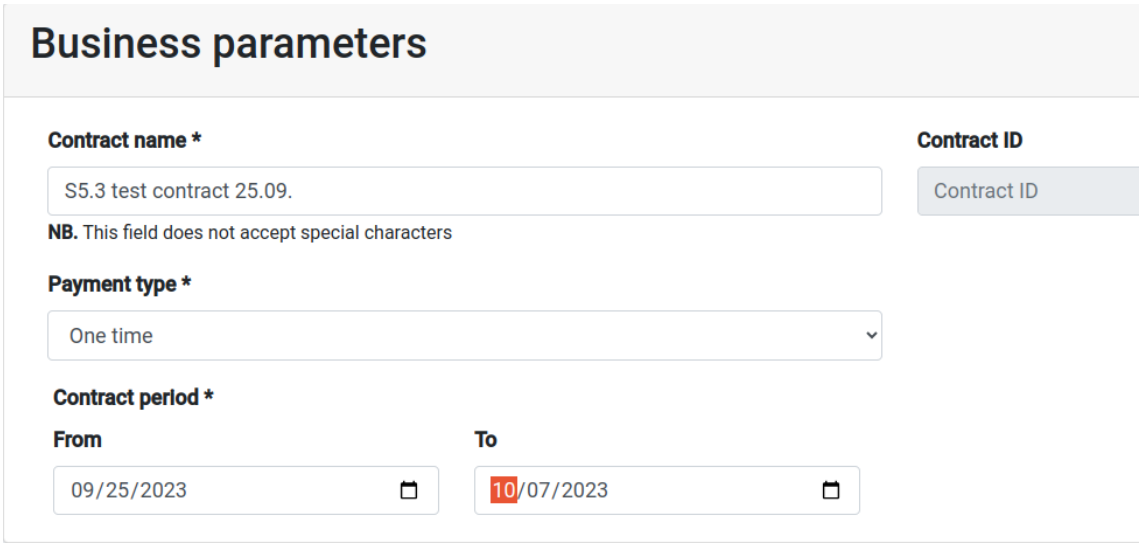


Figure 159: Business parameters

Next, we select the technical parameters. Select one value for each technical parameter. A description of each parameter can be seen in the image. The most important one to select is the pilot - this essentially determines whose data will be used during execution.

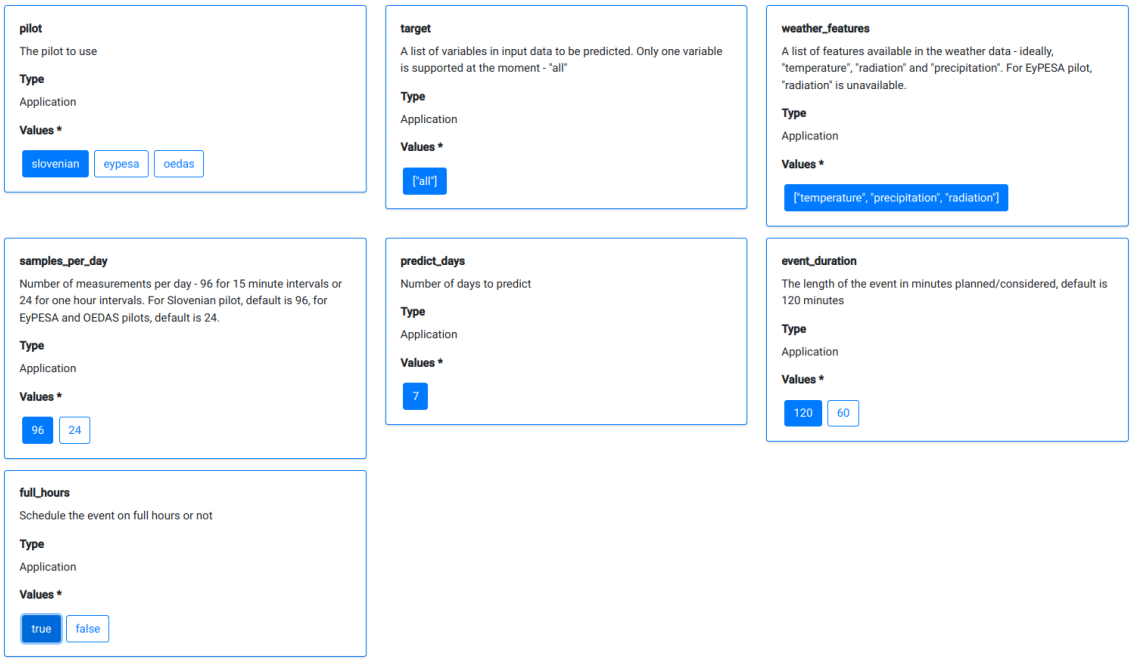


Figure 160: Parameter selection

We then select the data contract. Find the "S5.3 input" (or whatever name you put) data contract, check it, and click "Confirm". The data contract will not be present unless it was activated by the Data Provider. Be sure to also select "Yes" for "Enable immediate execution", otherwise the service will not actually be run in the ASM module.

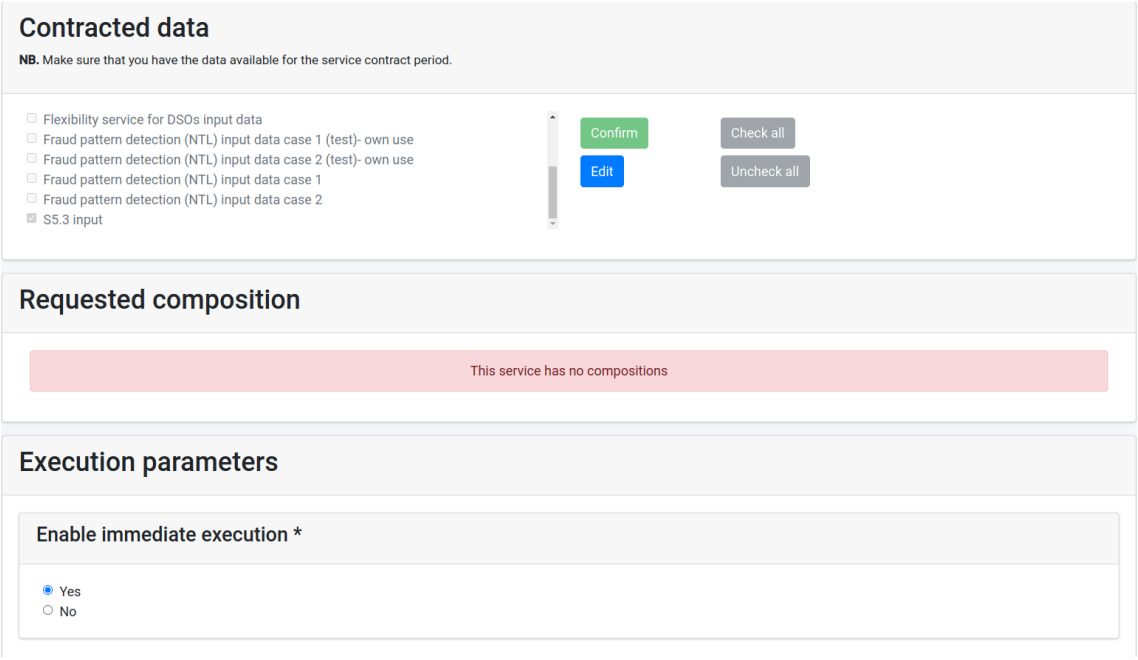


Figure 161: Stages

Finally, click on the "Request service" button at the bottom. Similarly as for the data contract, Service Provisioning receives the contract right after the button is pressed.

We can see the corresponding log entries in the SP module, indicating that the service contract was received, and in short, that everything is okay.


```
2023-09-25 10:32:14,442 - mongodb - INFO - Inserted to collection meta:
{
  "status": "SERVICE_CONTRACT_RECEIVED",
  "contractID": "ca85f245-f6da-45f7-8887-e0a8a40d853c",
  "update_time": "2023-09-25 10:32:14.440261",
  "message": "Service contract received",
  "_id": {
    "$oid": "651161ae255bd467123eb04d"
  }
}
2023-09-25 10:32:14,670 - mongodb - INFO - Inserted to collection meta:
{
  "status": "CONTRACT_AVAILABLE",
  "contractID": "ca85f245-f6da-45f7-8887-e0a8a40d853c",
  "update_time": "2023-09-25 10:32:14.668001",
  "message": "Service and data contracts available",
  "_id": {
    "$oid": "651161ae255bd467123eb04e"
  }
}
```


Figure 162: SP Module

You should be able to see your service contract request in the "Service requests" table, found on the "My Services" page, with the role set to "Service User". The contract, provisioning and execution status should be as in the below image.

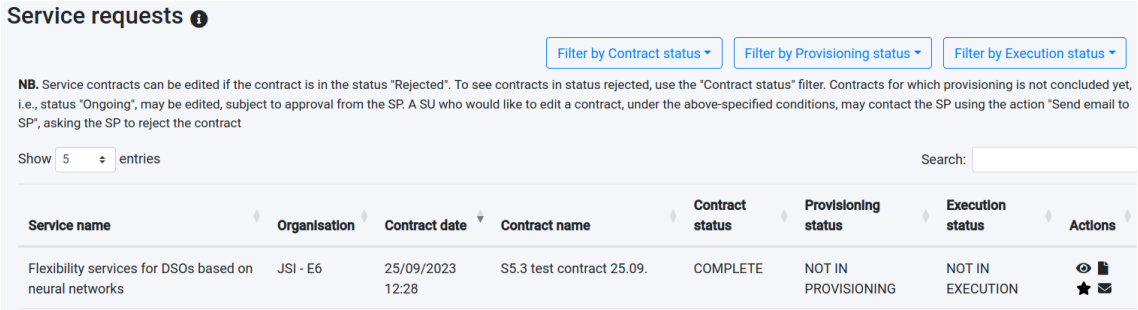


Figure 163: Service Requests

Running the service

Similarly, to be able to use the service contract, it needs to be approved and activated by the Service Provider (in this case, JSI). Immediately after the contract is activated, an instance of the S5.3 service will be started in the ASM module. This will happen because the service is set to be auto instantiated if immediate execution was set to "Yes".

The following image shows a screenshot of running so-called pods (think of them as microservices) in the ASM module in our Kubernetes cluster. We can see that one of them is called "fs-dsos-<random strings>" - this pod is executing an instance of S5.3 i.e. flexibility forecast for DSOs service.

```
NAME↑                                          PF READY RESTARTS STATUS
enqueue-64c8bb84fb-pl5hz                       ● 1/1          0 Running
fs-dsos-cdabd1a8f6-vj5dp                       ● 1/1          0 Running
job-launcher-9cbb8f5c8-2pd9r                   ● 1/1          0 Running
job-watcher-7986bffd5c-fxbc8                   ● 1/1          0 Running
rabbitmq-controller-f86r9                      ● 1/1          0 Running
scheduler-b6fc576d5-zft7l                      ● 1/1          0 Running
service-front-end-7646d746f6-74zks             ● 1/1          0 Running
service-management-database-848495868c-8vnt8   ● 1/1          0 Running
service-manager-59c78d78f7-czvvj               ● 1/1          0 Running
```

Figure 164: Elasticity estimation screenshot for DSO's service

As soon as the contract is activated, i.e. the service starts executing in ASM, the Marketplace will provide us with a link to our front-end, where we can see the logs and results of the service. This link is accessible via the "Go to service" button, present in the corresponding entry in the "Service requests" table.

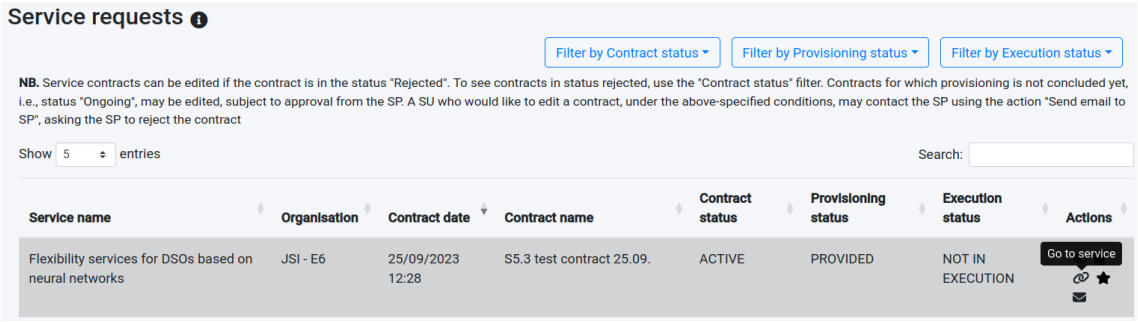


Figure 165: Service requests status screen

Clicking on the "Go to service" button takes us to our front-end.

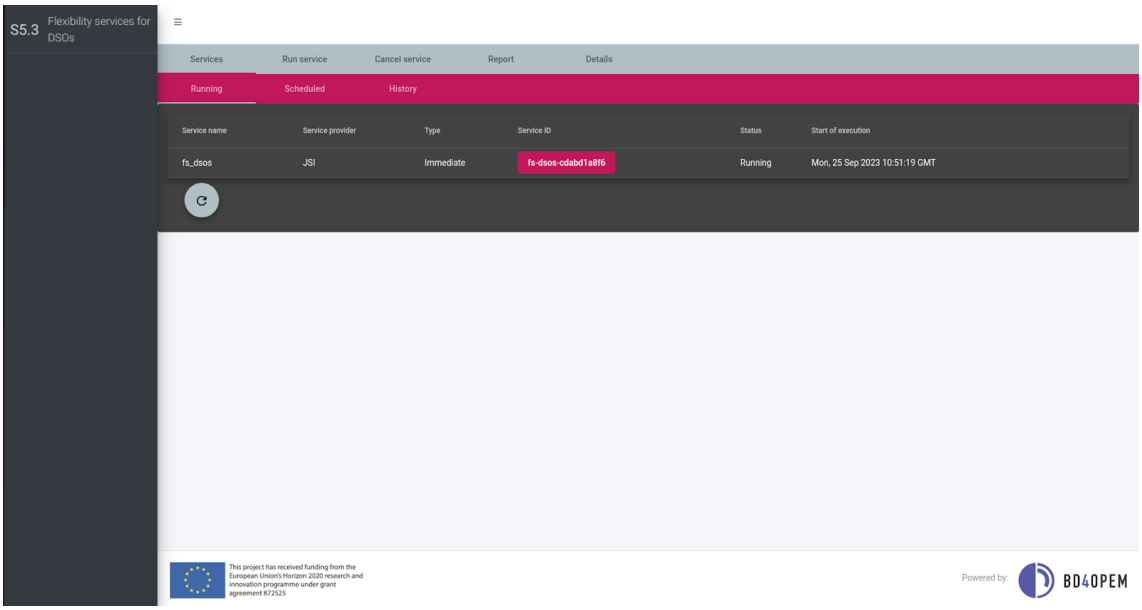
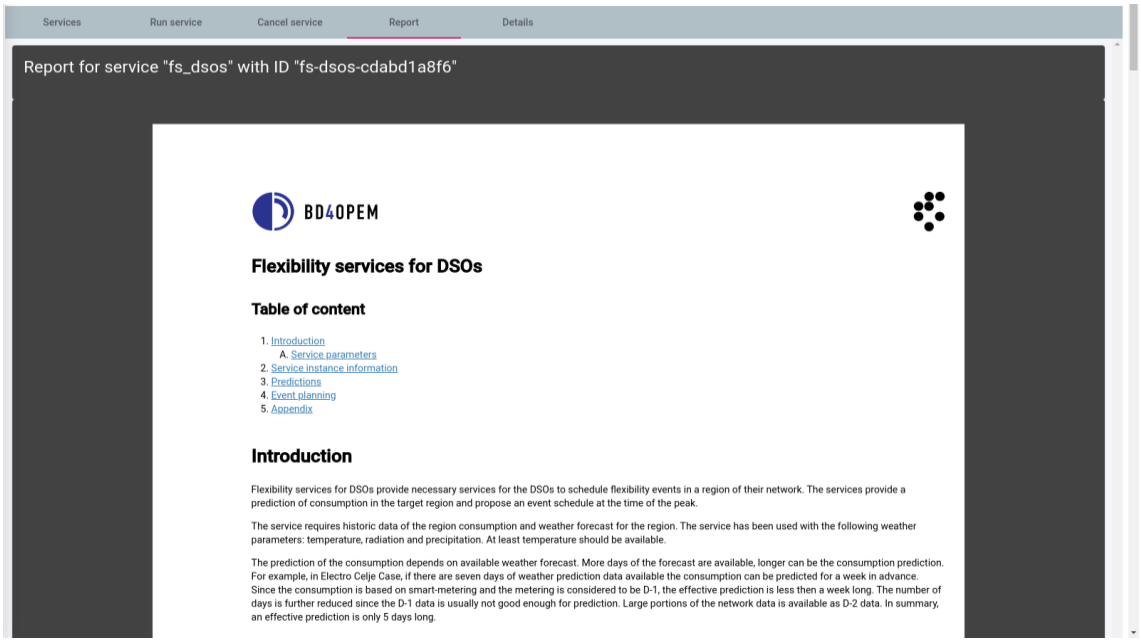


Figure 166: Details page

If the service is still executing, it should be present in the "Running" tab. Clicking on the ID in the "Running" tab will take you to the "Details" page and stream any logs of the service.

If the service has finished, we should be able to find it in the tab "History". You can click on the refresh button to see whether it has. By clicking on the service ID in the "History" tab, the report i.e result of the service will be fetched and you will be automatically moved to the "Report" tab.



f

Figure 167: Report screen

Additionally, by clicking on the tab "Details", you will be able to see the technical parameter values you selected, as well as any stdout and stderr logs of the service.

8.6 S7.1 – P2P trading

Service	**S7.1 P2P Energy Trading**
Algorithm provider	**ATOS**
Solution provider	**ATOS**
Release date	10/07/2023

Contracting Service:

1. Go to the Marketplace main page and go to the search bar and look for the services provided by *"ATOS" and* select P2P Trading.

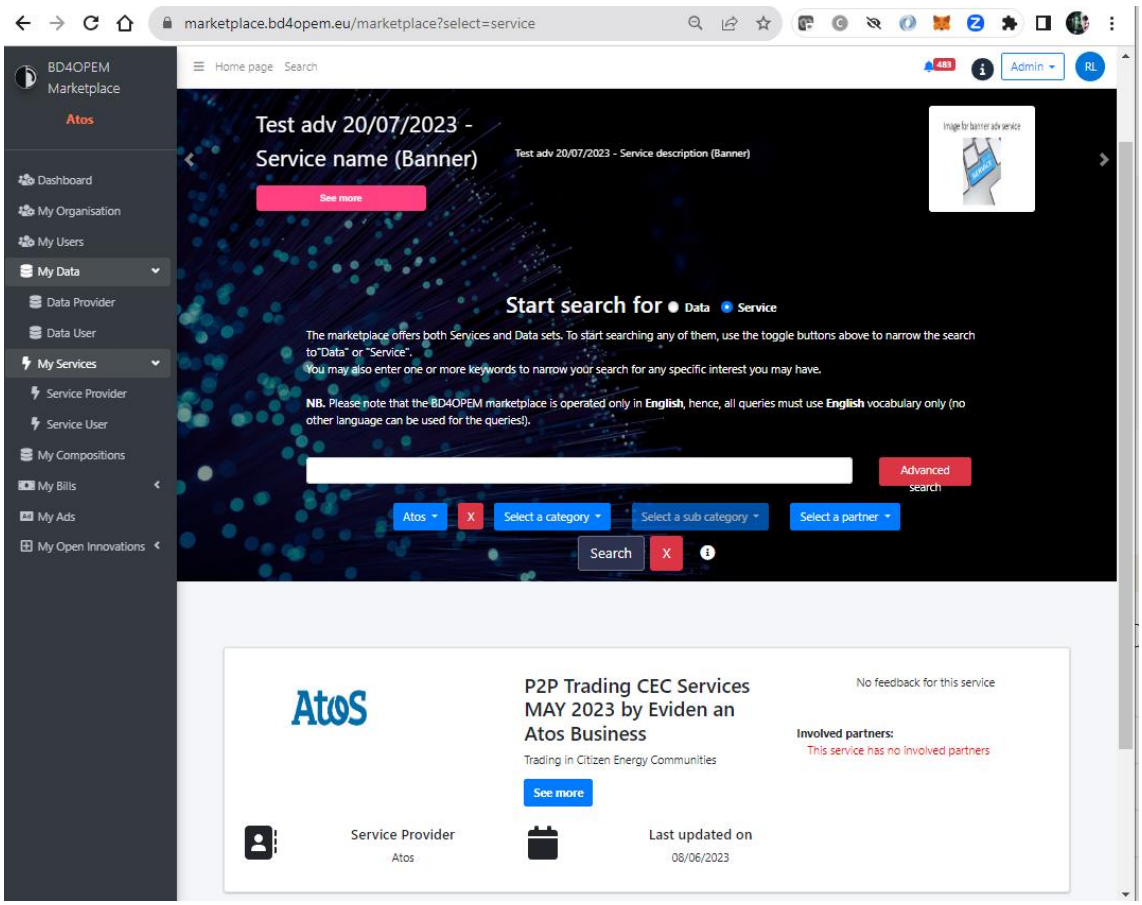


Figure 168: Service title in MP

2. Contract the smart meter data required by the service, and then contract the service, following the default and/or required contract parameters.

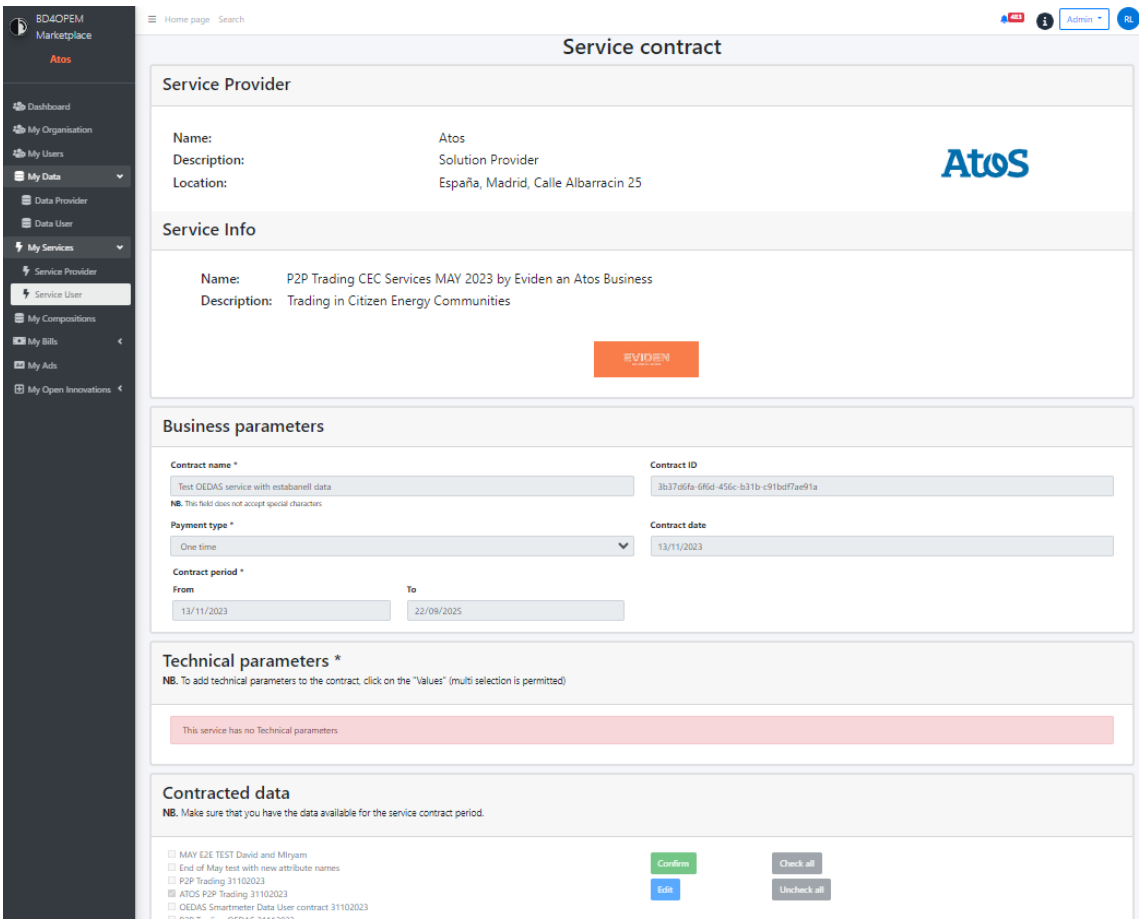


Figure 169: Service contract screen in MP

Usability Testing:

1. Login to P2P Trading https://p2p.atos.bd4opem.eu/ from the service link and this automatically will re-direct to the marketplace login.

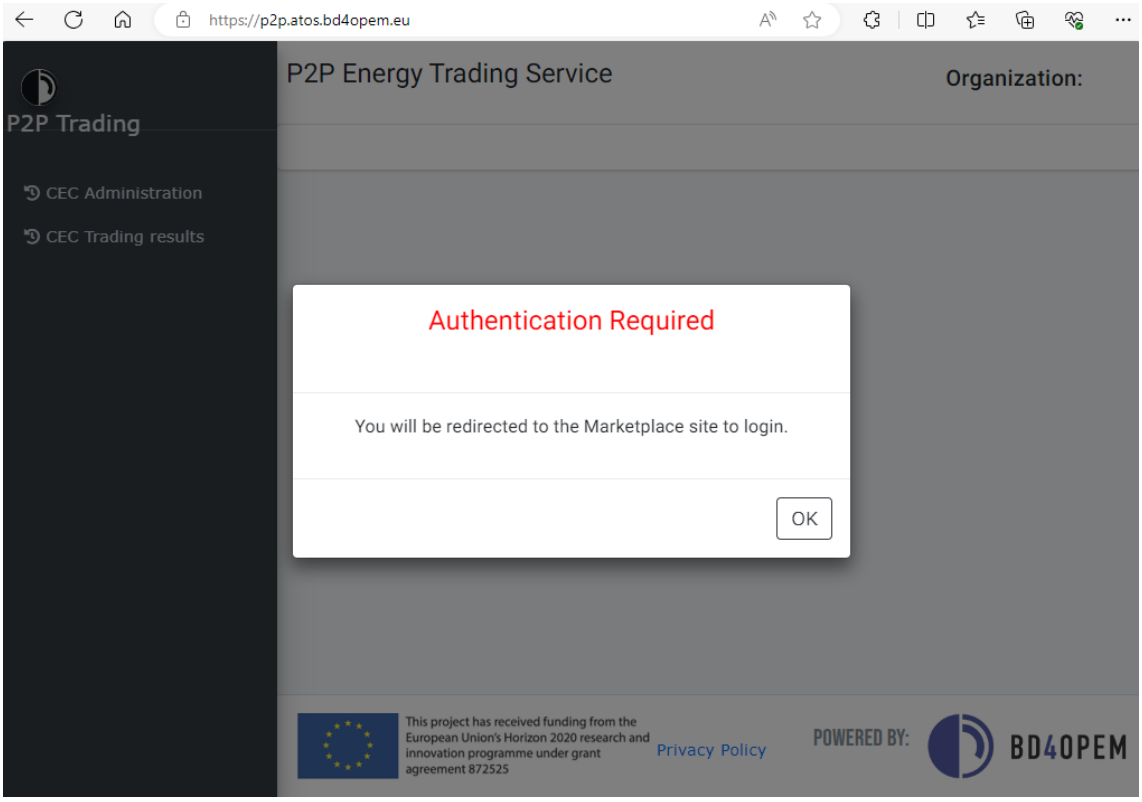


Figure 170: Service screen

2. Upon successful login, the user is then redirected back to the P2P trading service, to view the Service User contracts for their organization.

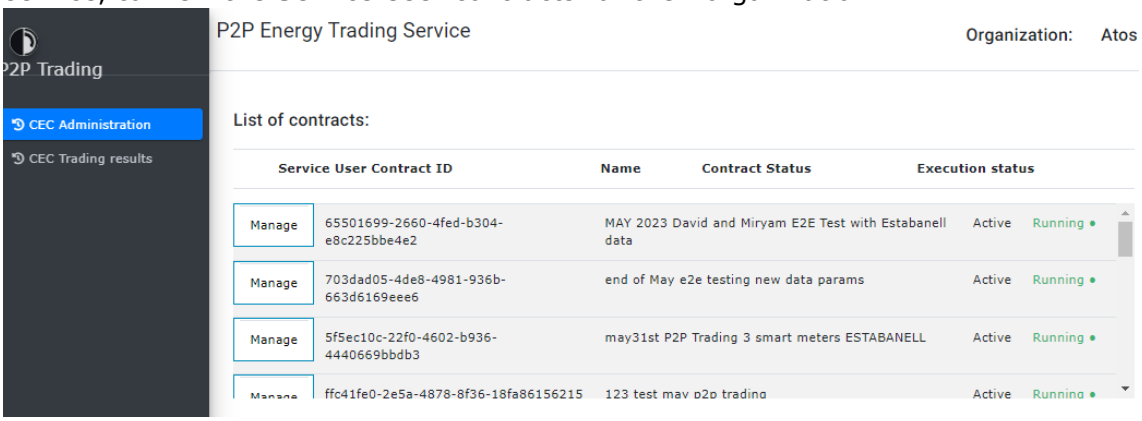
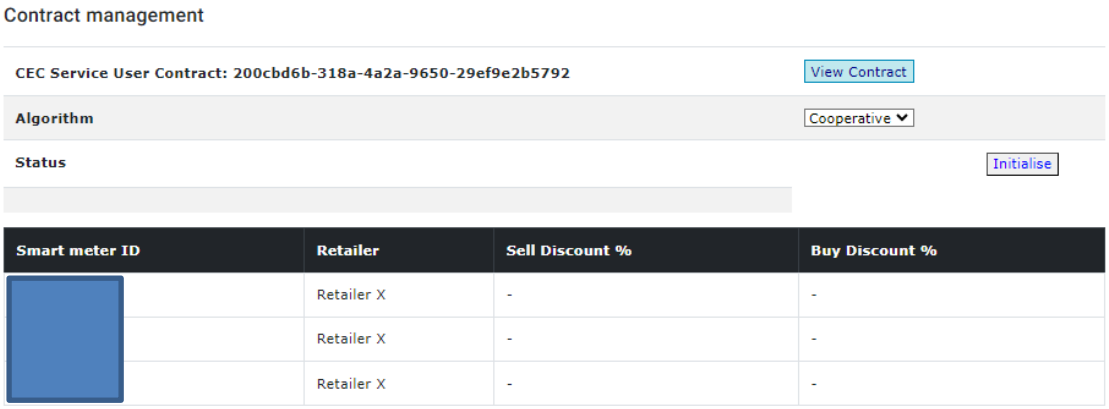


Figure 171: Service User Contracts

3. Select the contract of interest and initialize it for the cooperative trading algorithm.



Contract management

CEC Service User Contract: 200cbd6b-318a-4a2a-9650-29ef9e2b5792 — View Contract

Algorithm — Cooperative

Status — Initialise

Smart meter ID	Retailer	Sell Discount %	Buy Discount %
[redacted]	Retailer X	-	-
	Retailer X	-	-
	Retailer X	-	-

Figure 172: Meter ID's in Service user contract

4. Wait at least 24 hours to select the Trading results tab to download the csv.

	A	B	C	D	E	F	G	H	I	J	K	L
1	smartmeterId	day	Cons.1	Cons.2	Cons.3	Cons.4	Cons.5	Cons.6	Cons.7	Cons.8	Cons.9	Cons.10
2	ES0113500000001180SE	13	10.163	12.979	10.084	11.48	12.784	14.823	14.892	14.798	17.835	15.973
3	ES0113500000001180SE	14	0.071	0.072	0.072	0.072	0.072	0.072	0.072	0.073	0.077	0
4	ES0113500000001180SE	15	8.094	8.073	7.973	7.887	9.605	9.742	7.799	12.29	11.494	14.395
5	ES0113500000001611BQ	13	0.072	0.072	0.072	0.073	0.072	0.074	0.072	0.073	0.072	0
6	ES0113500000001611BQ	14	5.171	5.112	8.364	10.738	11.563	9.397	10.729	13.806	13.544	15.869
7	ES0113500000001611BQ	15	0.069	0.072	0.072	0.071	0.072	0.072	0.072	0.077	0.087	0.001
8	ES0113000053634017CS	13	16.112	10.902	13.488	14.865	9.927	16.67	11.29	11.94	19.435	14.678
9	ES0113000053634017CS	14	8.12	7.985	7.979	8.645	11.149	7.788	7.801	9.32	16.026	18.147
10	ES0113000053634017CS	15	5.255	5.293	5.082	5.117	9.679	11.26	10.634	10.142	12.846	10.467

Figure 173: CSV Output of Trading Results

5. Check the trading cooperative trading algorithm has performed equal sharing of production and consumption figures, over one of the 24hour periods.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	smartmeterId	day	Cons.1	Cons.2	Cons.3	Cons.4	Cons.5	Cons.6	Cons.7	Cons.8	Cons.9	Cons.10	Cons.11	Cons.12
2	ES0113500000001180SE	13	10.163	12.979	10.084	11.48	12.784	14.823	14.892	14.798	17.835	15.973	19.356	21.523
3	ES0113500000001611BQ	13	0.072	0.072	0.072	0.073	0.072	0.074	0.072	0.073	0.072	0	0	0
4	ES0113000053634017CS	13	16.112	10.902	13.488	14.865	9.927	16.67	11.29	11.94	19.435	14.678	11.375	10.947
5														
6			Prod.1	Prod.2	Prod.3	Prod.4	Prod.5	Prod.6	Prod.7	Prod.8	Prod.9	Prod.10	Prod.11	Prod.12
7	ES0113500000001180SE	13	0	0	0	0	0	0	0	0	0	0	0	0
8	ES0113500000001611BQ	13	0	0	0	0	0	0	0	0	0.009	1.345	4.79	10.363
9	ES0113000053634017CS	13	0	0	0	0	0	0	0	0	0	0	0	0
10														
11			Trade.1	Trade.2	Trade.3	Trade.4	Trade.5	Trade.6	Trade.7	Trade.8	Trade.9	Trade.10	Trade.11	Trade.12
12	ES0113500000001180SE	13	0	0	0	0	0	0	0	0	0	-0.6725	-2.395	-5.1815
13	ES0113500000001611BQ	13	0	0	0	0	0	0	0	0	0	1.345	4.79	10.363
14	ES0113000053634017CS	13	0	0	0	0	0	0	0	0	0	-0.6725	-2.395	-5.1815

Figure 174: csv file

8.7 S8.1 – Asset and investment planning

Service	**S8.1 Asset and Investment Planning**
Algorithm provider	**UPC**
Solution provider	**WEP**
Last update	11/09/2023

Contracting Service:

Go to the Marketplace main page and go to the search bar and look the service "*Investment Planning".*
Select the service.
Contract the service, following the default and/or required contract parameters. Contract the required data.
Execution of the service through the marketplace or by login to the marketplace and running https://s81upc.bd4opem.eu/

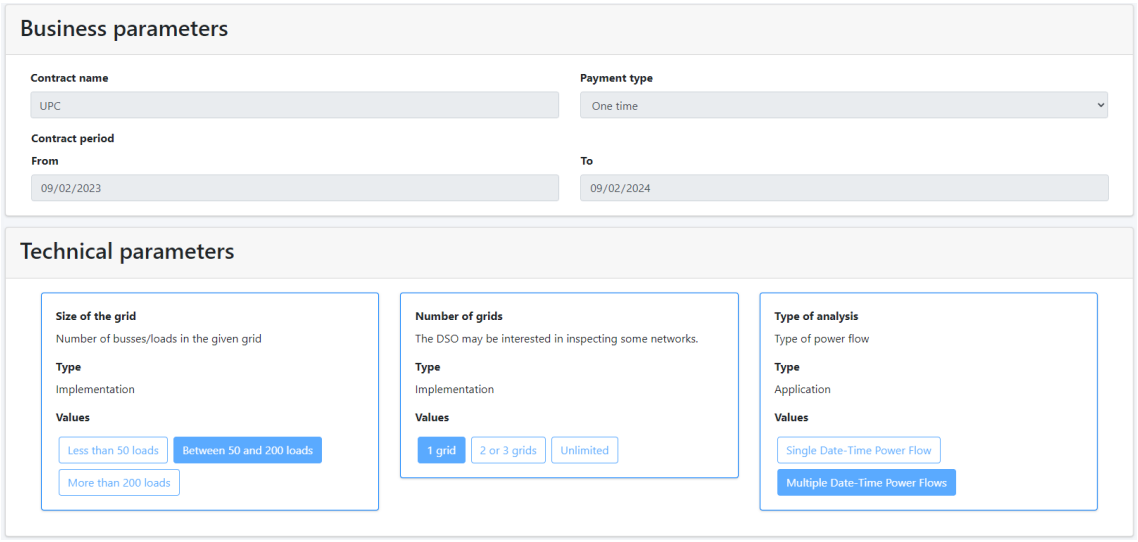


Figure 175 : Example of the contract parameters for Service 8.1

Usability Testing:

1. Go to Dashboard tab to check the contract parameters. The About button provides a short and long description of the service. There's also a Contact us button.

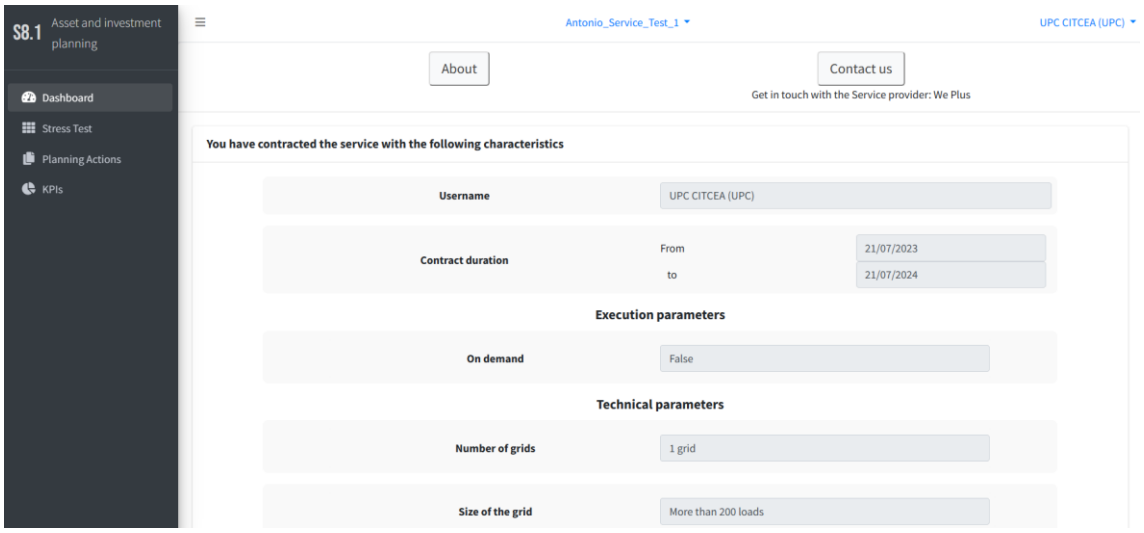


Figure 176 : Example of the User interface Contracted parameters

1. Go to the Stress Test TAB to start creating an expansion scenario.

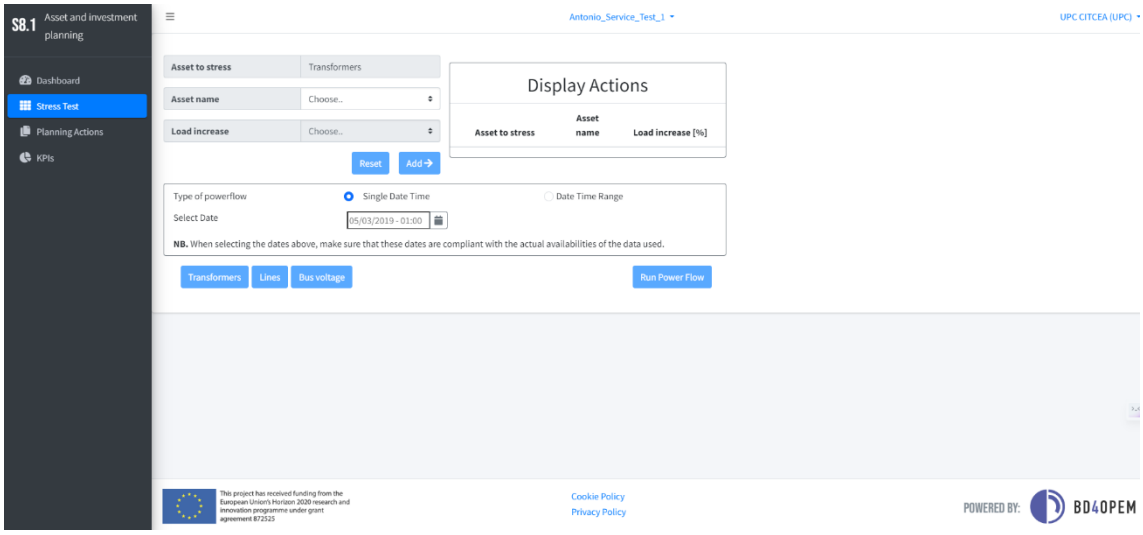


Figure 177 : Stress Test UI visualization

2. Stress the distribution Network by incrementing the loading % of the selected transformers. In this example case follow the configuration showed in the Display Planning Acting box of Fig.170.
3. Select the Power Flow analysis Type "Date Time Range"
4. Select date-time range for example. When selecting the dates, make sure that these dates are compliant with the actual availabilities of the data used.
5. Click on the "Run Power Flow" push button

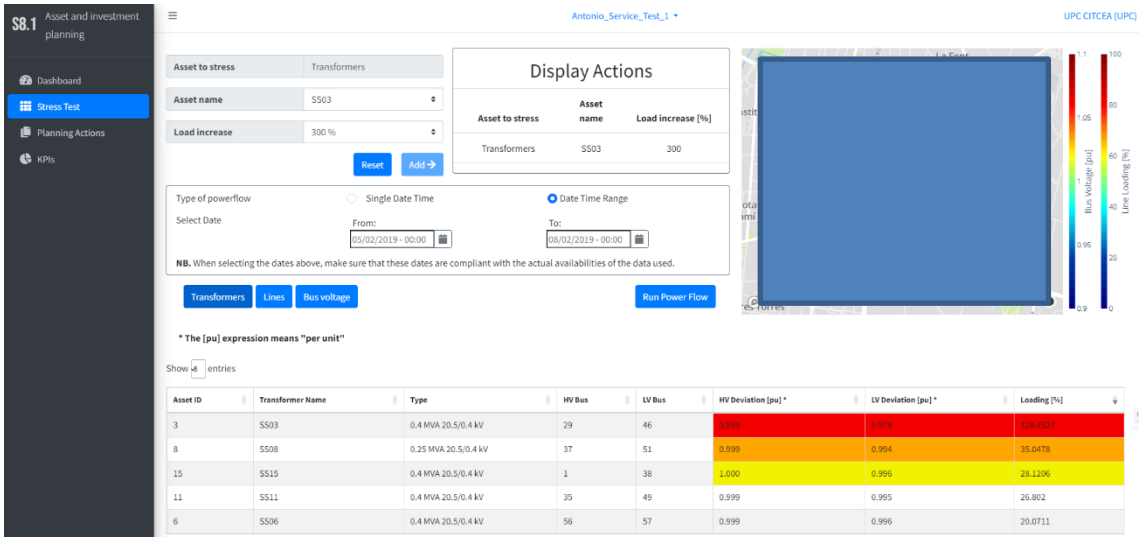


Figure 178 : Example of the results in the Stress Test

6. Go to the "Planning Actions" Tab, by clicking in the left side bar.
7. A new table of results with 3 different subtabs should be displayed, as showed in Fig.171. Verify also that the table results correspond with the GIS maps results displayed on the right side.

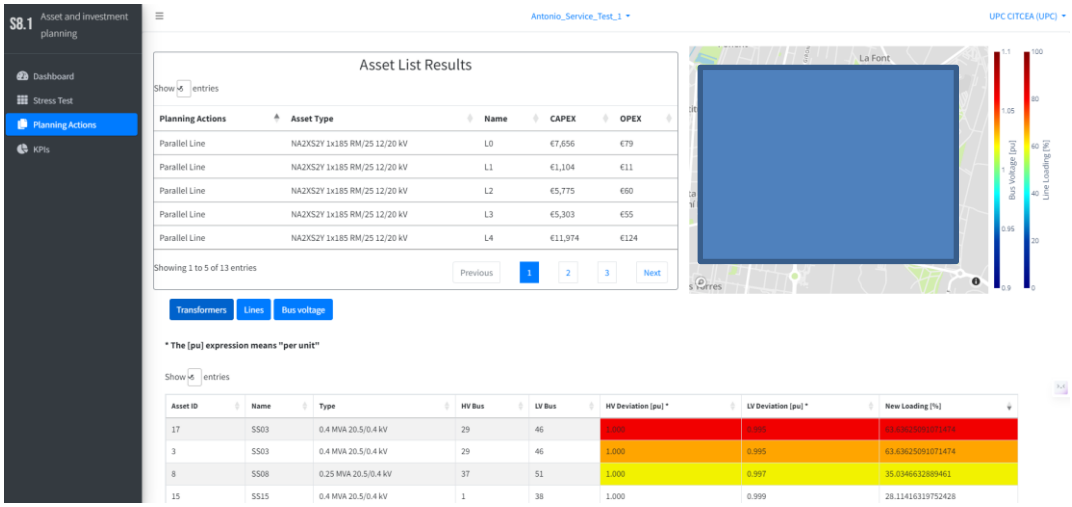


Figure 179 : Example of the results in the Planning Actions

8. Finally click the KPIs TAB located on the left side bar. You can download the KPIs in a .xlsx format by clicking in the buttons below.

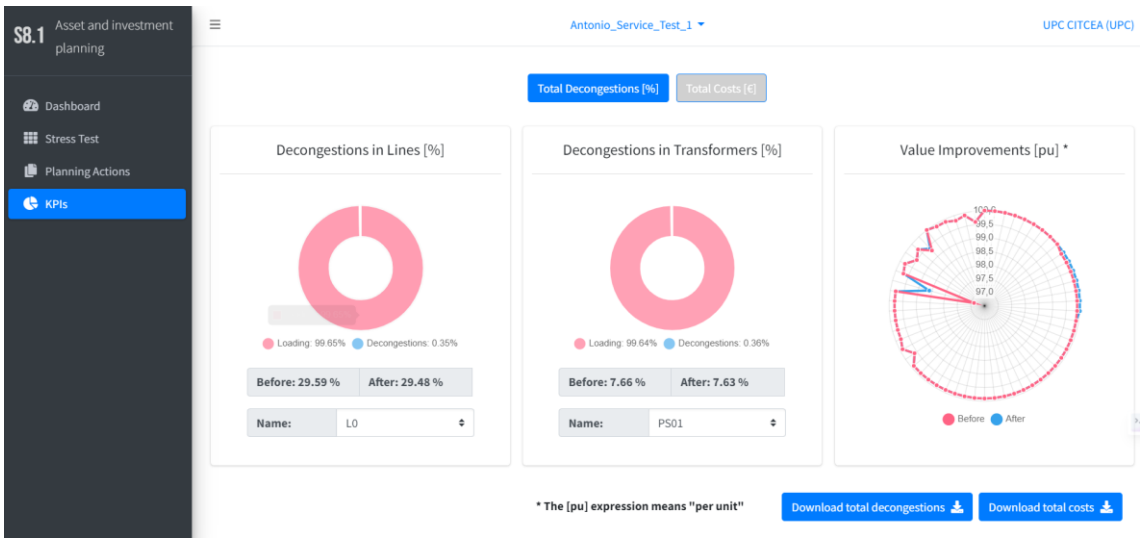


Figure 180: Example of the results in the KPIs, Total Decongestion TAB

Click on the total cost ($) TAB to see the following:

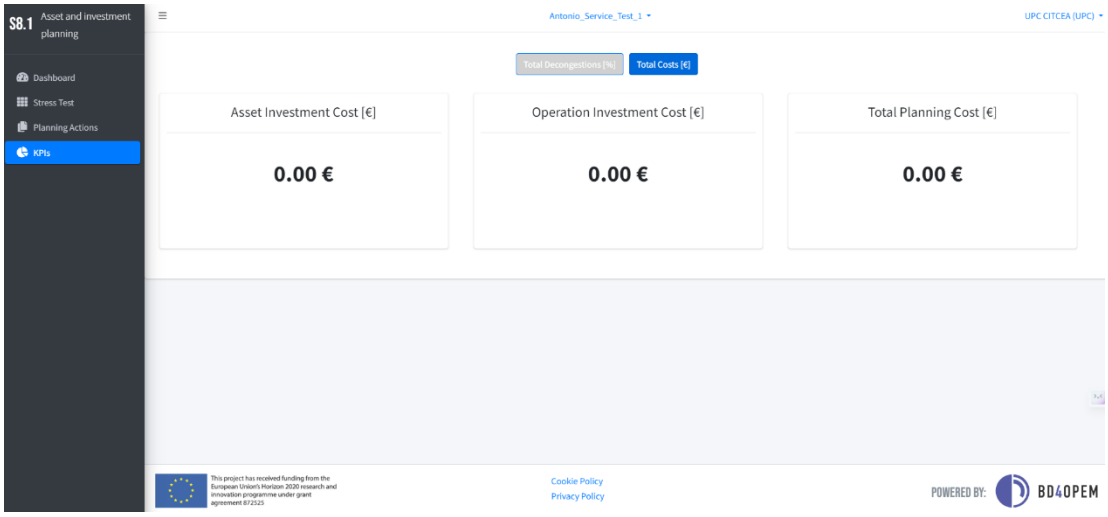


Figure 181: Example of the results in the KPIs, Total Cost TAB

8.8 S8.2 – Asset estimation optimization for microgrids

Service	**S8.2 Asset estimation optimization for microgrids**
Algorithm provider	**VUB**
Solution provider	**WEP**
Release date	06/04/2023

Service 8.2 Asset estimation optimization for microgrids

[IMPORTANT !] Data should be contracted prior to the service contracting, this in order to contract the service with the required data,

Go to the Marketplace main page (https://marketplace.bd4opem.eu/) and using the search bar, look for the service *"Asset estimation optimization for microgrids".*

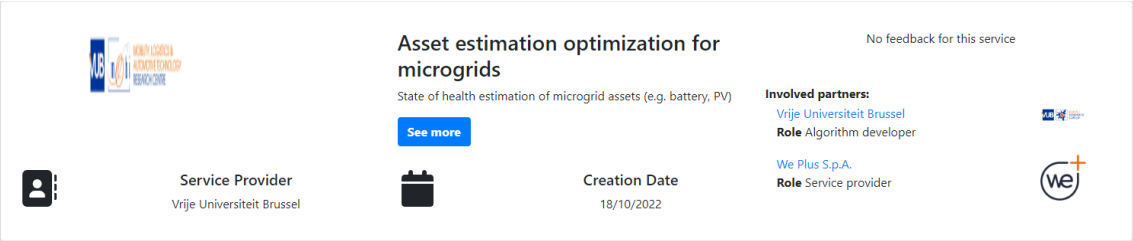


Figure 182: Asset estimation optimization for microgrids

Select the desired service ('**See more**') and follow the instructions.
NOTE: the contract period is the period during which the service will be accessible.

Contract the service, following the default and/or required contract parameters. Select the data as needed by checking the box of the data:

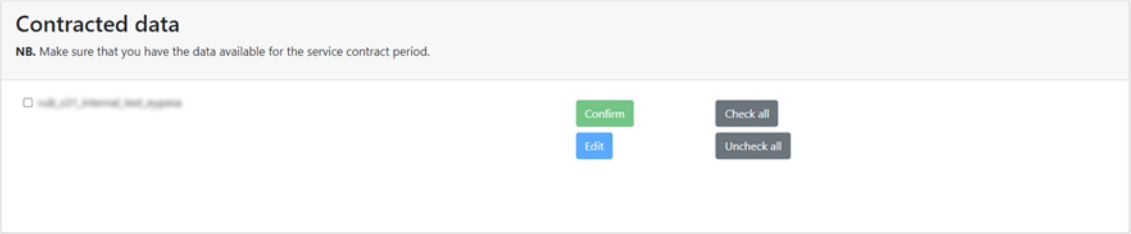


Figure 183: Service Provider

Once the service has been approved by the '**Service Provider**' on the marketplace you can proceed to the next steps:

Execution of the service through the marketplace, make sure you are logged in as '**Service User'**, see top right corner. Click on '🔗' to access the service:

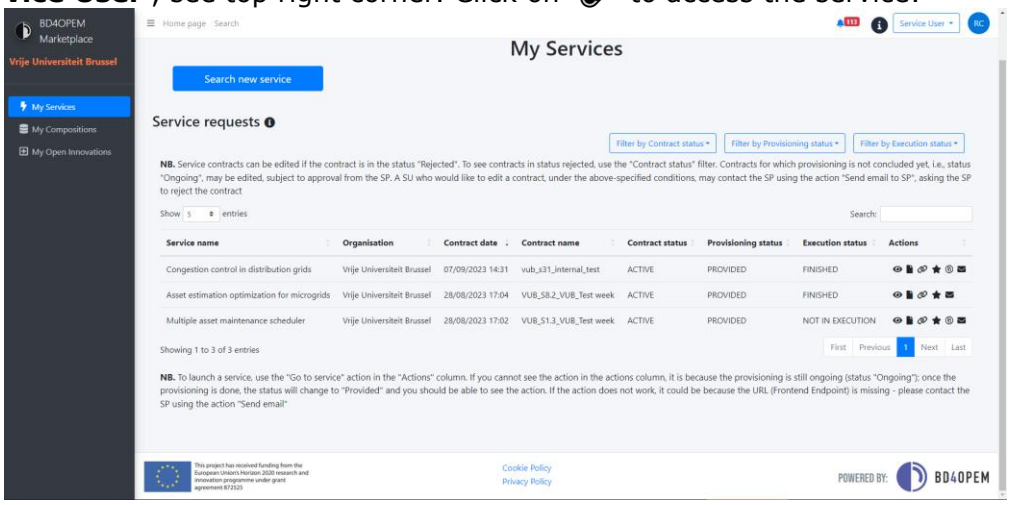


Figure 184: Service User

Or after being logged in on the marketplace, you can directly run the service by navigating to: https://s82vub.bd4opem.eu/.

Usability Testing: After executing the service, follow the indicated steps to test various aspects.

Initial screen displays the '***Dashboard***' including information such as the contract duration and latest update.

NOTE: your contract ID appears at the top.

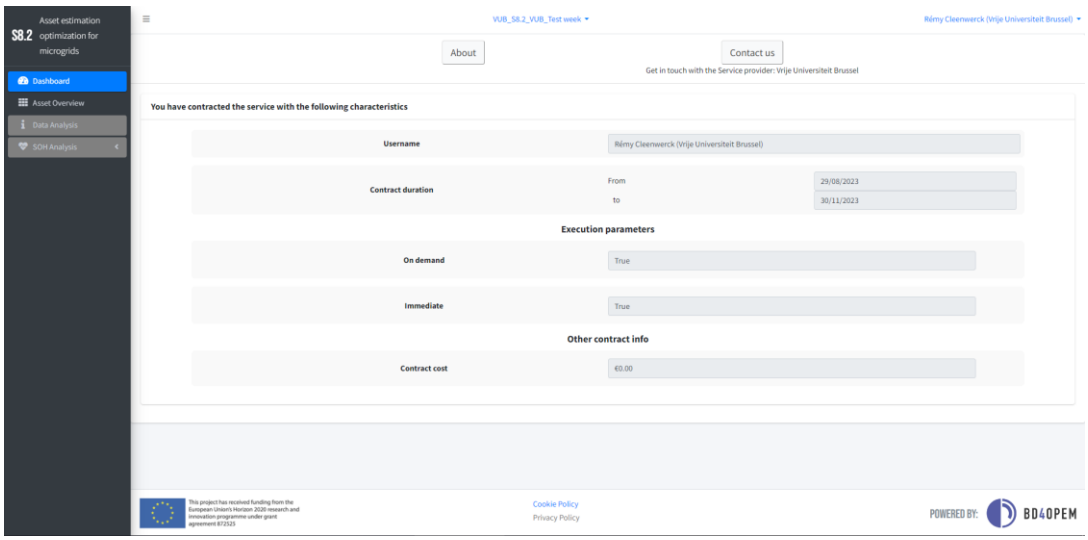


Figure 185: Service test screen

Go to the '***Asset Overview***' tab where all your assets will be listed. On the left side, you can select the asset in which you are interested.

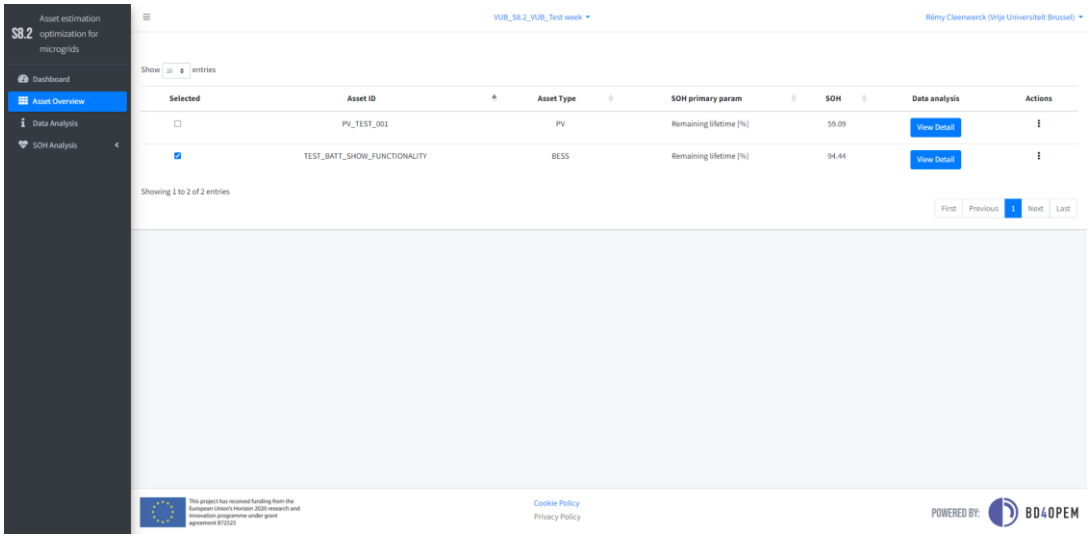


Figure 186: Asset Overview

After choosing the asset of interest (e.g. 'TEST_BATT_SHOW_FUNCTIONALITY'), access the "***View Detail***" button. As user, you will be redirected to the '***Data Analysis***' tab.

By selecting an asset, the tab in the left pane will also be accessible to navigate to directly. Here results are showed for the selected asset (in this example a battery energy storage system) :

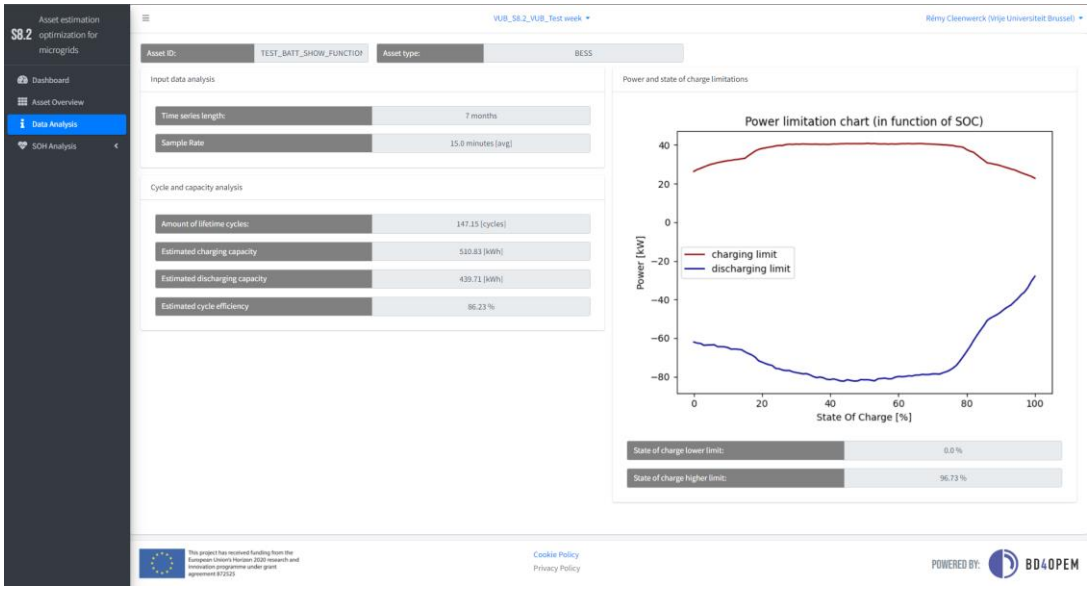


Figure 187: Data Analysis

The provided information is restricted to an analysis of the provided data. In order to inspect the results from the optimization algorithm, go to the '***SOH Analysis***'.

Within the '***SOH Analysis***' tab, a detailed overview of the current battery capacity degradation, the expected lifetime that is reached and the expected remaining useful lifetime (RUL) by pursuing a similar operation, are displayed. Additionally, a graph displays the battery degradation over time:

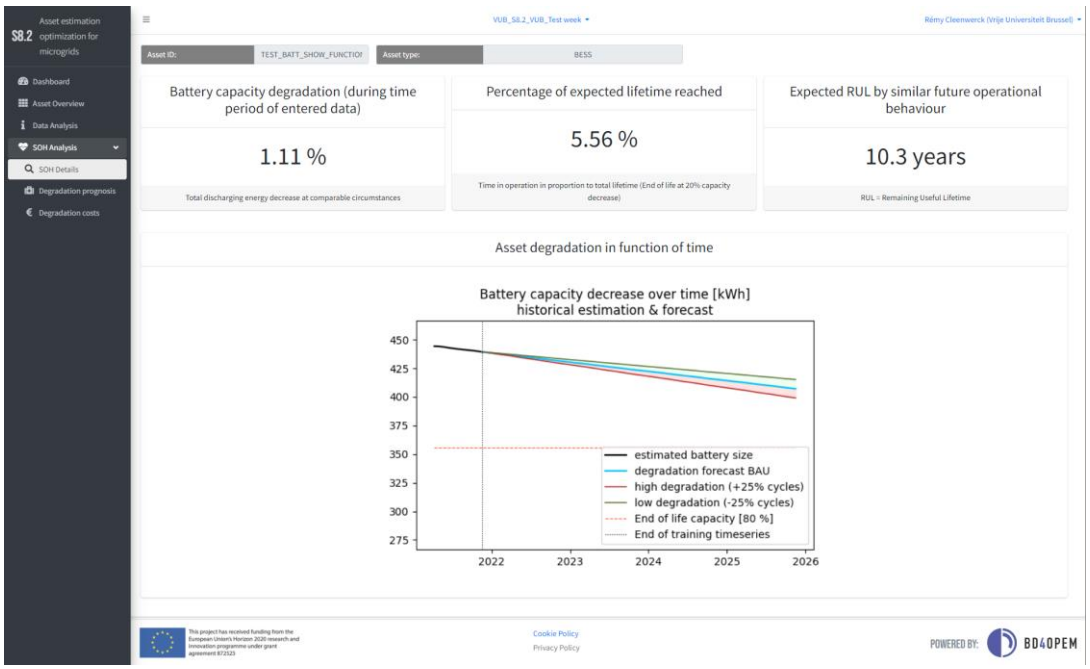


Figure 188: SOH Analysis

Following tab, ***'Degradation prognosis'***, gives an interactive graphical representation of the battery capacity degradation over time.

This for multiple operation regimes, i.e.:

1. Number of cycles/year:

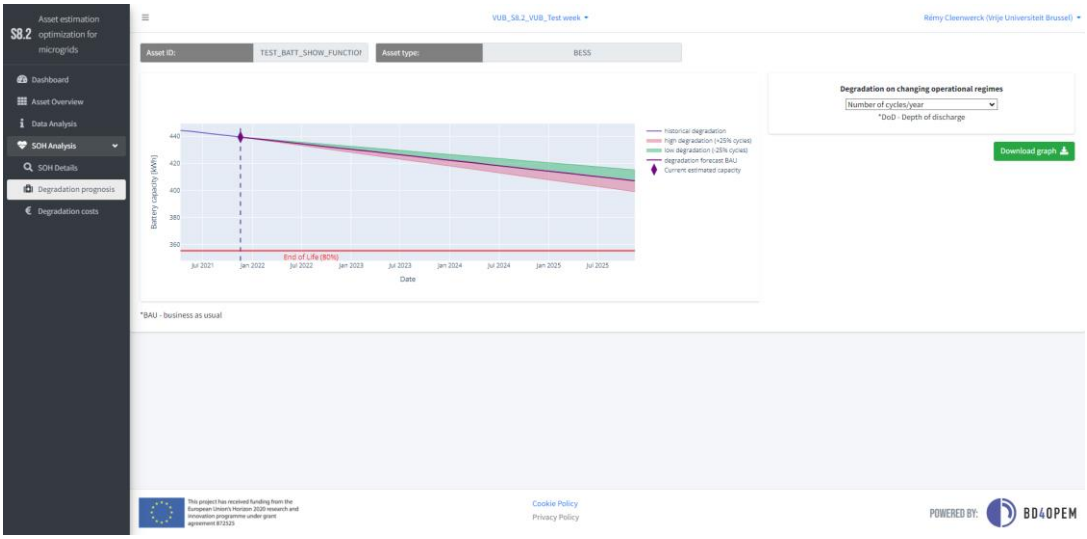


Figure 189: Degradation prognosis'

Change in average dept-of-discharge (DoD):

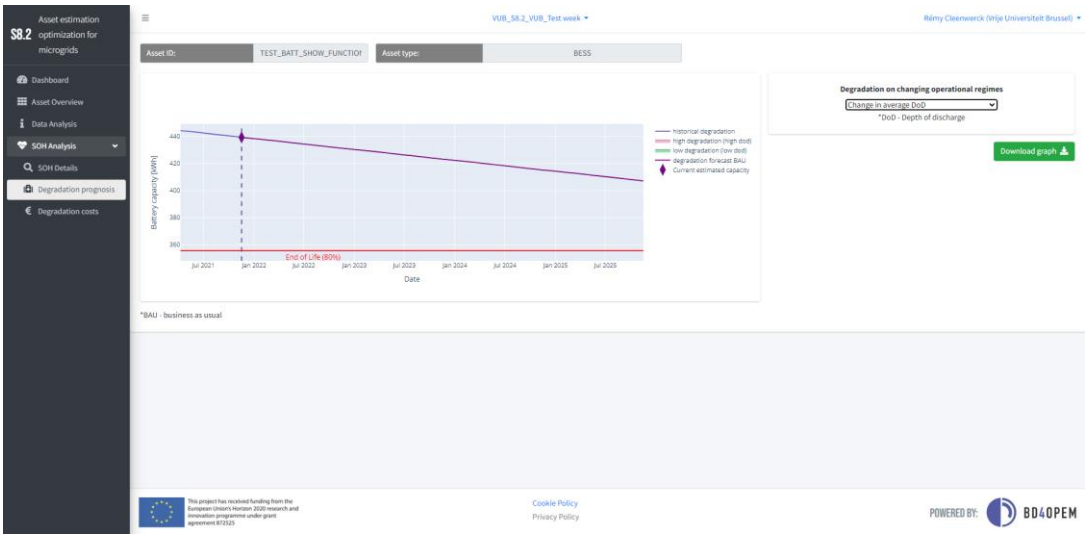


Figure 190: Change in average dept-of-discharge

Average (dis)charging current:

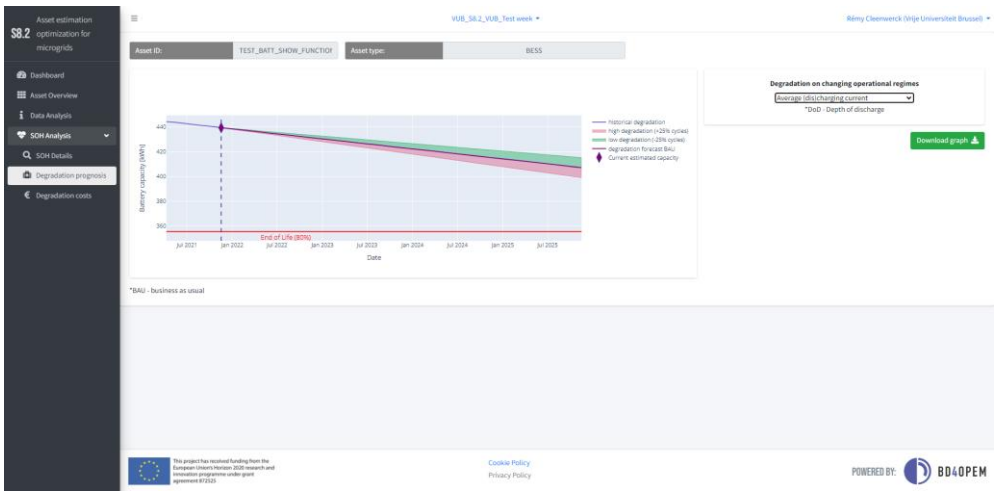


Figure 191: Average (dis)charging current

An option to download the graphs is available.

To finalize, '***Degradation costs***' tab let you interpret the costs of typical daily profiles on your battery degradation. In a first instance, four pre-defined typical profiles are displayed for a given Battery CAPEX unit cost in [€/kWh].

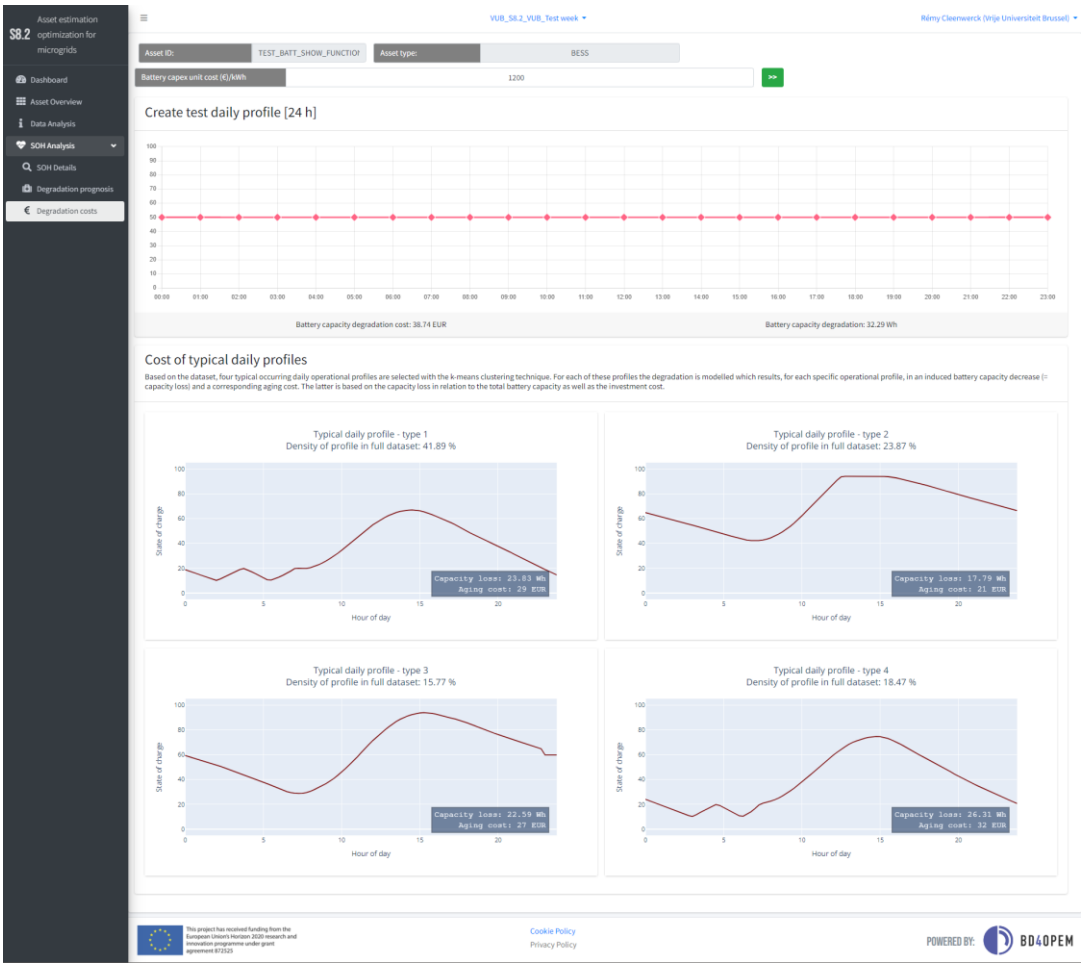


Figure 192: Degradation costs

Service user have also the possibility to create their own daily profile for another Battery CAPEX unit cost. Therefore, use the slides on the "Create test daily profile [24h]" and change the value of the cost. To run the simulation, click on the green icon:

Figure 193: Test Daily Profile

9 Annex B: Service testing & Service KPIs

9.1 S1.3 – Predictive maintenance

9.1.1 JSI approach: Predictive maintenance

Service	**S1.3 - Predictive Maintenance**
Algorithm provider	**JSI** – Dušan Gabrijelčič
Solution provider	**JSI**
	Good performance ●
	Non-critical error ●
	Error detected ●
Release date	21/11/2023

Service testing summary

Functional and KPIs testing

Table 23: Testing Summary Table

Pilot	Functional Test ID	Functional Test	Check	Test responsible	Comments
Türkiye	OEDAS_1.3_JSI_FT.1	Create data contract	●	OEDAS	
	OEDAS_1.3_JSI_FT.2	Activate data contract	●	JSI	
	OEDAS_1.3_JSI_FT.3	Create service contract	●	OEDAS	
	OEDAS_1.3_JSI_FT.4	Activate service contract	●	JSI	
	OEDAS_1.3_JSI_FT.5	Service execution and results	●	OEDAS	

Usability testing

UI Critical errors
/

UI Non-critical errors

/

UI Recommendations
/

9.1.1.1 Service Functional and KPIs Testing Actions

Pilot: OEDAS

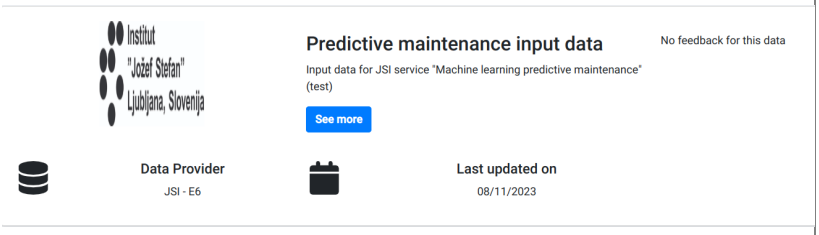
Functional Test Description	Test Actions	Check
1. Create data contract	Search for the data set "Predictive maintenance input data" on Marketplace. Click on "See more" and "Contract data". 	●
	Enter business parameters and click "Submit"	●

Table 24: OEDAS_1.3_JSI_FT.1 Functional Test Task 1

Functional Test Description	Test Actions	Check
2. Activate data contract	Approve the data contract from functional task 1 - data contract structure and parameters are okay	●
	Activate the data contract - data contract can now be used in service contracts	●

Table 25: OEDAS_1.3_JSI_FT.2 Functional Test Task 2

Functional Test Description	Test Actions	Check
3. Create service contract	Search for the "Machine learning predictive maintenance" service on the Marketplace. Click on "See more" and then "Request new service".	●

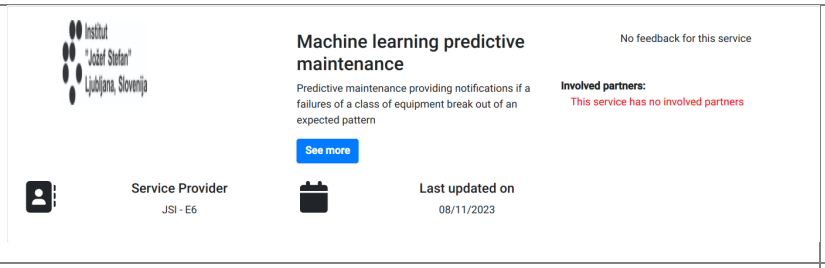
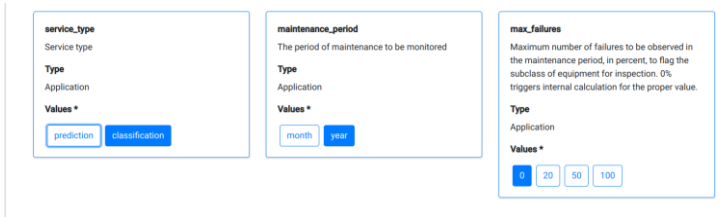
		
	Enter business parameters	●
	Select the corresponding service parameters: 	●
	Select data contract created in functional task 1 and activated in functional task 2	●
	Click on "Yes" for "Enable immediate execution"	●
	Click on "Request service" to send the service contract	●

Table 26: OEDAS_1.3_JSI_FT.3 Functional Test Task 3

Functional Test Description	Test Actions	Check
4. Activate service contract	Approve the service contract from functional task 3 - contract structure, business and technical parameters are okay, data contract selected and immediate execution enabled	●
	Activate the service contract - this will make an instance of the service	●
	ASM invoked	●
	Data accessed through the data lake	● *Comment: Data has been uploaded in service Docker image*
	Read technical parameters and run the correct service (predictive maintenance by **classification**)	

Table 27: OEDAS_1.3_JSI_FT.4 Functional Test Task 4

Functional Test Description	Test Actions	Check

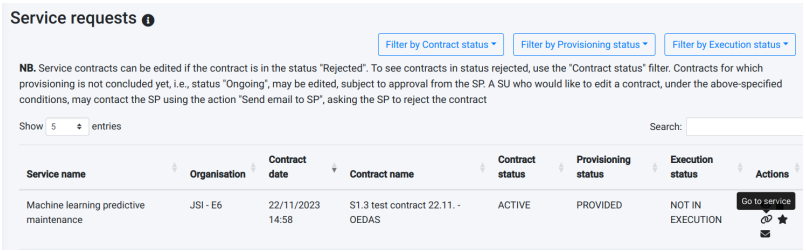
5. Service execution and results	Upon activation of service contract, click on "Go to service" button for the corresponding service contract, found in the "Service requests" table on "My Services" page for "Service User": 	●
	UI accessed after clicking "Go to service button"	●
	Notebook executed - service no longer in "Services" -> "Running" tab	●
	Click on service ID in "Services" -> "History" tab to fetch report	●

Table 28: OEDAS_1.3_JSI_FT.5 Functional Test Task 5

1. Usability testing

UI Critical errors

Errors that affect the tangible/numeric results: graphs display, login error, etc.

Critical errors	Screen shots and description	Reporter
/		

UI Non-critical errors

Errors that do not affect the tangible/numeric results: font sizes, colors of graphs, limits of the axis, etc.

Non-critical errors	Screen shots
/	

UI Recommendations

Provide recommendations for improving the front-end UI

Recommendations	Screen shots
/	

9.1.2 VUB approach: Multiple asset maintenance scheduler

Service	**S1.3 Predictive maintenance in electrical power systems**
Algorithm provider	**VUB** – Wouter Parys
Solution provider	**WEP**
	Good performance ●
	Non-critical error ●
	Error detected ●
Release date	14/09/2023

Service testing summary

Functional and KPIs testing (Responsible: Algorithm dev)

Table 29: Testing Summary Table

Pilot	Functional Test ID	Functional Test	Check	Test responsible	Comments
BELGIUM	1.3_VUB_FT.1	Overview tab	●	VUB	
	1.3_VUB_FT.2	Scheduler display	●	VUB	
	1.3_VUB_FT.3	Further analysis	●	VUB	
	1.3_VUB_KPI	KPIs	●	VUB	
	1.3_VUB_EXEC	Execution time	●	WEP	
Türkiye	1.3_VUB_FT.1	Overview tab	●	VUB	Service demo not given with OEDAS data, instead used VUB data.
	1.3_VUB_FT.2	Scheduler display	●	VUB	
	1.3_VUB_FT.3	Further analysis	●	VUB	
	1.3_VUB_KPI	KPIs	●	VUB	
	1.3_VUB_EXEC	Execution time	●	WEP	

Usability testing

UI Critical errors
Once going from dashboard to another tab, it wasn't possible to return to the dashboard tab: Error fixed
Sometimes the screen freezes when trying to analyse results in the 'Further Analysis' tab.

UI Non-critical errors

Overview tab does not show elements directly, needs to be refreshed sometimes.

UI Recommendations
The graph for the scheduler could distinct the types of maintenances by the size of the bar, this is most of the times the case.

9.1.2.1 Service Functional and KPIs Testing Actions

Table 30: 1.3_ VUB_FT.1 Overview tab

Functional Test Description	Test Actions	Pilot	Check
1. Overview tab	Make sure that the .json files are read correctly and display each individual asset, the grid ID and number of maintenances.	VUB	●
		OEDAS	●
	Check if '*View Detail*' displays the correct information and if no information is not provided.	VUB	●
		OEDAS	●

Table 31: 1.3_VUB_FT.2 Scheduler display

Functional Test Description	Test Actions	Pilot	Check
2. Schedule	Verify that all the assets are displayed and that the maintenances are shown on the plot.	VUB	●
		OEDAS	●
	Check if '*Download selected asset data*' downloads the data.	VUB	●
		OEDAS	●
	Analyse if the downloaded data corresponds with the visualization on the UI.	VUB	●
		OEDAS	●

Table 32: 1.3_VUB_FT.3 Further analysis

Functional Test Description	Test Actions	Pilot	Check
3. Further analysis	Verify if the dropdown menu works, i.e. if selecting another asset displays other results	VUB	●
		OEDAS	●

Functional Test Description	Test Actions	Pilot	Check
	Check if all the displayed results are identical to the visualization on the '*Scheduler display*' tab.	VUB	•
		OEDAS	•

Table 33: 1.3_VUB_KPI Functional Test KPIs

Functional Test Description	Test Actions	Pilot	Check
4. KPIs	KPI: are the constraints respected	VUB	•
		OEDAS	•

Table 34 1.3_VUB_EXEC Functional Test Execution

Functional Test Description	Test Actions	Execution time local/front-end	Check
5. Execution time	Display the results	1 s/ 10 s	•

1. Usability testing

UI Critical errors

Errors that affect the tangible/numeric results: graphs display, login error, etc.

Critical errors	Screen shots and description	Reporter
While navigating from one tab to the other, in this case to the 'Further Analysis' tab, the screen freezes and nothing can be done. Needs to refresh the page.		Rémy Cleenwerck

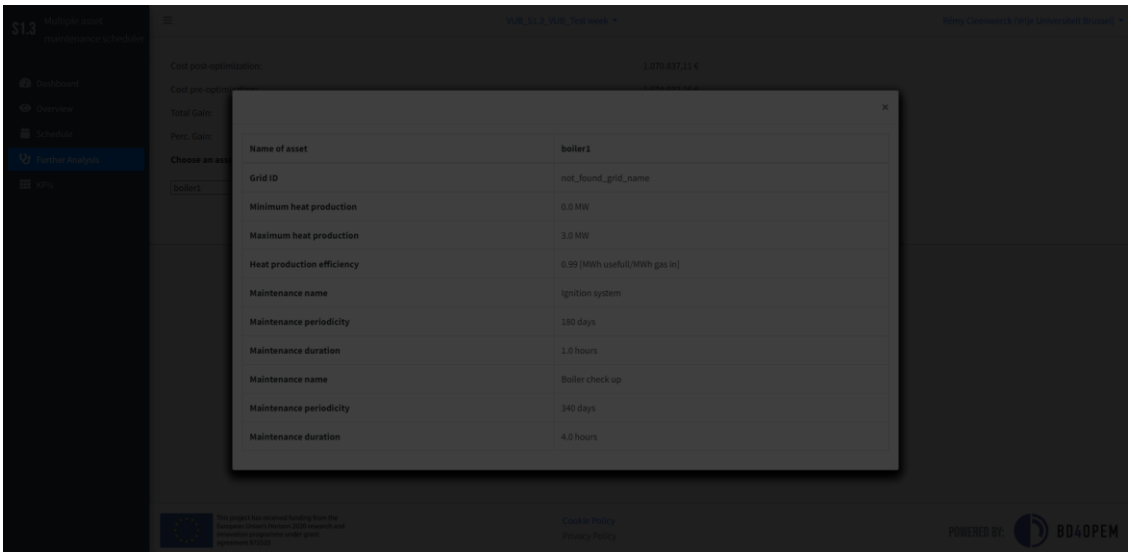


Figure 194: UI Critical errors

UI Non-critical errors

Errors that do not affect the tangible/numeric results: font sizes, colours of graphs, limits of the axis, etc.

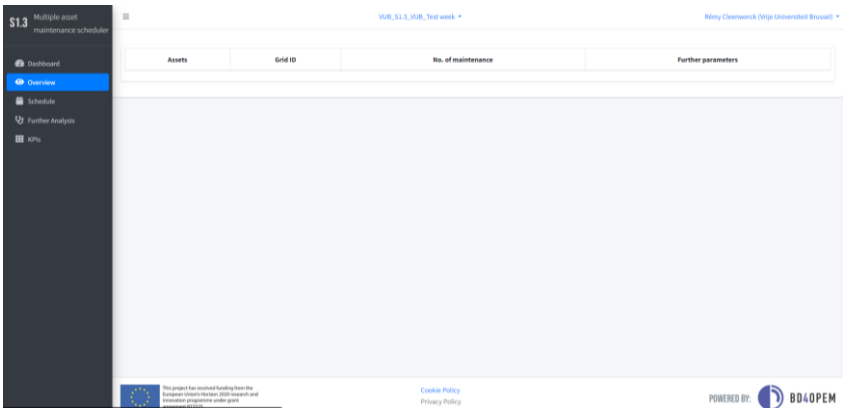
Non-critical errors	Screen shots
Occurred a few times that going to the 'Overview' page did not show anything, only a blank page is given. However, after refreshing the page this is solved.	

Figure 195: UI Non-critical errors

UI Recommendations

Provide recommendations for improving the front-end UI

Recommendations	Screen shots
1. The optimized scheduler shows no difference between a small and a full maintenance. Bars are ticker as a function of the time elapsed between the start and the stop (or the timeframe in which they can be executed. A recommendation would be to change the style or colour for these kind of maintenances:	

Figure 196: UI Recommendations

9.2 S3.1 – Grid disturbance simulations

9.2.1 UPC approach: Congestions forecast for day ahead

Service	**S3.1 Grid Disturbance Simulation**
Algorithm provider	**UPC** – Alejandro Hernandez
Solution provider	**WEP**
	Good performance ●
	Non-critical error ●
	Error detected ●
Release date	15/08/2023

Service testing summary

Functional and KPIs testing (Responsible: Alejandro Hernandez)

Table 35: Testing Summary Table

Pilot	Functional Test ID	Functional Test	Check	Test responsible	Comments
TURKEY	**TURKEY_S3.1_UPC_FT.1**	Data Ingestion	●		Brief description of the error detected
	TURKEY _S3.1_UPC_FT.2	Review Load forecasts	●		
	TURKEY _S3.1_UPC_FT.3	Evaluate Lines behaviour	●		
	TURKEY _S3.1_UPC_FT.4	Analyse Report Tab	●		
	TURKEY _S3.1_UPC_KPI.5	KPIs	●		
	TURKEY _SP.3.1_UPC_EX.1	Execution times	●		

Usability testing

Table 36: Usability testing

UI Non-critical errors
N/A
N/A

UI Recommendations
N/A

9.2.1.1 Service Functional and KPIs Testing Actions

Pilot: TURKIYE

Table 37: TURKEY_S3.1_UPC_FT.1 Functional Test Task 1

Functional Test Description	Test Actions	Check
6. Data Ingestion	Make sure the data from the pilot is correctly ingested for the service.	●
	Verify there are no NaN values	●

Table 38: TURKEY _S3.1_UPC_FT.2 Functional Test Task 2

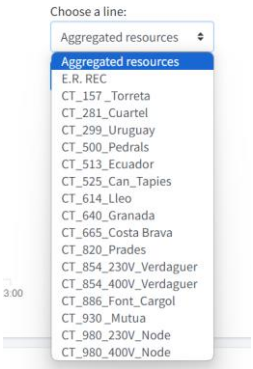
Functional Test Description	Test Actions	Check
7. Review Loads forecast	Check Aggregated Loads forecast plot	●
	Check dropdown list working Working  Comment: The caption should be "Choose a bus" or "Choose Load".	●
	Verify Load1 button from dropdown list to plot	●
	Verify Load2 button from dropdown list to plot	●
	Verify download file button	●

Table 39: TURKEY _S3.1_UPC_FT.3 Functional Test Task 3

Functional Test Description	Test Actions	Check
8. Evaluate Lines behaviour	Check *Lines* tab button to be sent to new window	●
	Select *Line1* from dropdown	●
	Select *Line2* from dropdown	●
	Verify download file button	●

Table 40: TURKEY _S3.1_UPC_FT.4 Functional Test Task 4

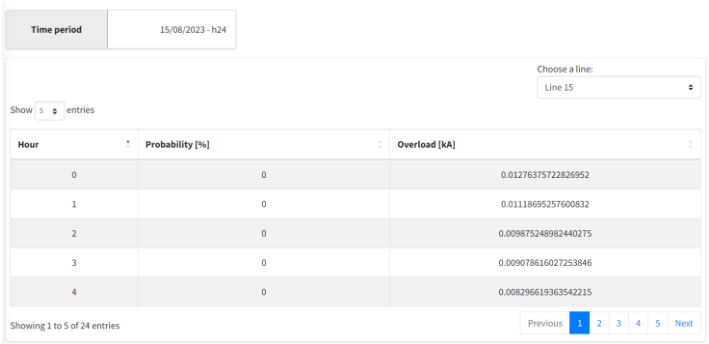
Functional Test Description	Test Actions	Check
9. Analyse Report Tab	Check *Report* tab button to be sent to new window	●
	Verify the results for all lines for all hours  Comment: I think the table should show the 24 hrs for default, instead of needing to select the number of entries. Additionally, the hour column should be in hour format: e.g 00:00, 01:00, …. Also, the labels of the columns [Hour, Probability and Overload] should be centred.	●
	Download report in excel form	●

Table 41: TURKEY_S3.1_UPC_KPI.5Functional Test Task 5

Functional Test Description	Test Actions	Check
10. KPI	KPI benchmark/range comparison number of congestions found	●

Table 42: PILOT_SP.3.1_UPC_EX.1 Functional Test Task 6

Functional Test Description	Test Actions	Execution time local/front-end	Check
11. Execution time	Executing algorithm for Use Case 1	10 s/ 60 s	●
	Training algorithm for algorithm	60 s/ 70s	●

2. Usability testing

UI Non-critical errors

Errors that do not affect the tangible/numeric results: font sizes, colours of graphs, limits of the axis, etc.

Table 43: UI Non-critical errors

Non-critical errors	Screen shots
Font size	Font sizes in the whole UI is good.
Limit axis	N/A

UI Recommendations

Provide recommendations for improving the front-end UI

Table 44: UI Recommendations

Recommendations	Screen shots
Recommendation 1	The recommendations have been made in section 1.

9.2.2 JSI approach: PQ-related disturbances

Service	**S3.1 Grid Disturbance Simulation**
Algorithm provider	**JSI**– Andrej Čampa
Solution provider	**JSI**
	Good performance ●
	Non-critical error ●
	Error detected ●
Release date	17/04/2023

Service testing summary

Functional and KPIs testing (Responsible: Algorithm dev)

Table 45: Service testing summary

Pilot	Functional Test ID	Functional Test	Check	Test responsible	Comments

TURKIYE	TURKEY_3.1_JSI_FT.1	Data ingestion	●	JSI	
	TURKEY _3.1_JSI_FT.2	LV/MV modelling	●	JSI	
	TURKEY_3.1_JSI_FT.3	Analyse results through UI	●	JSI	
	TURKEY _3.1_JSI_FT.4	Results export	●	JSI	
	TURKEY _3.1_JSI_KPI.1	KPIs	●	JSI	

Usability testing

Table 46: UI Critical errors

UI Critical errors
Log-in error /
Graph display /

Table 47: UI Non-critical errors

UI Non-critical errors
Font size /
Limit axis /

Table 48: Recommendations

UI Recommendations
/

9.2.2.1 Service Functional and KPIs Testing Actions

Table 49: 3.1_JSI_FT.1 Data ingestion

Functional Test Description	Test Actions	Pilot	Check
12. Data ingestion	Make sure the data from the pilot is correctly ingested for the service.	ELCE	●
		OEDAS	●
	Check if the Results tab shows initial values	ELCE	●
		OEDAS	●

Table 50: 3.1_JSI_FT.2 LV/MV modelling

Functional Test Description	Test Actions	Pilot	Check
13. LV/MV modelling		ELCE	●

	Check if 'Selected nodes' shows the list of all simulated nodes.	OEDAS	●
	Select nodes and observe the initial values and optimize values graphs if they change.	ELCE	●
		OEDAS	●
	Histograms of the optimized values should be closer to the nominal value (1) compared to the initial values.	ELCE	●
		OEDAS	●

Table 51: 3.1_JSI_FT.3 Analyse results through UI

Functional Test Description	Test Actions	Pilot	Check
14. Analyse results through UI	Check if plots are generated by selecting the nodes	ELCE	●
		OEDAS	●
	Check if grid topology is the same as described in GIS	ELCE	●
		OEDAS	●
	Check if all contracts are listed	ELCE	●
		OEDAS	●
	Check if selecting the contract shows the results of the right contract	ELCE	●
		OEDAS	●

Table 52: 3.1_JSI_FT.4 Results export

Functional Test Description	Test Actions	Pilot	Check
15. Results export	Verify '*Download initial values*' button function. [Downloads the .csv file of the initial state.]	ELCE	●
		OEDAS	●
	Verify 'Download optimized values' button function. [Downloads the .csv file of optimized state and report file pdf]	ELCE	●
		OEDAS	●

Table 53: 3.1_JSI_KPI.1 KPIs

Functional Test Description	Test Actions	Pilot	Check
16. KPIs	KPI for selected nodes is shown. It should be lower <1 for worst-case nodes.	ELCE	●
		OEDAS	●

3. Usability testing

UI Critical errors

Errors that affect the tangible/numeric results: graphs display, login error, etc.

Table 54: UI Critical errors

Critical errors	Screen shots and description	Reporter
Type of error (login….)	/	

UI Non-critical errors

Errors that do not affect the tangible/numeric results: font sizes, colors of graphs, limits of the axis, etc.

Table 55: UI Non-critical errors

Non-critical errors	Screen shots
Font size	/
Limit axis	/

UI Recommendations

Provide recommendations for improving the front-end UI

Table 56: UI Recommendations

Recommendations	Screen shots
Recommendation	/

9.3 S5.1 – Flexibility Forecast

9.3.1 UPC approach: Flexibility forecast

Service	**S5.1 FLEXIBILITY FORECAST**
Algorithm provider	**UPC** – Rafaela Ribeiro / Arthur Pasquet
Solution provider	**ICOM**
	Good performance ●
	Non-critical error ●
	Error detected ●
Release date	20/10/2023

Service testing summary

Functional and KPIs testing (Responsible: Algorithm dev)

Table 57: Testing Summary table

Pilot	Functional Test ID	Functional Test	Check	Test responsible	Comments
Spain	SPAIN_5.1_UPC_FT.1	History	●		
	SPAIN_5.1_UPC_FT.2	Data Selection	●		
	SPAIN_5.1_UPC_FT.3	Training model results	●		
	SPAIN_5.1_UPC_FT.4	Forecast results	●		
	SPAIN_5.1_UPC_KPI.1	KPIs	●		
	SPAIN_5.1_UPC_EXEC	Execution times pilot	●		
Slovenia	SLOVENIA_5.1_UPC_FT.1	History	●		
	SLOVENIA_5.1_UPC_FT.2	Data Selection	●		
	SLOVENIA_5.1_UPC_FT.3	Training model results	●		The model fails to be trained
	SLOVENIA_5.1_UPC_FT.4	Forecast results	●		The model doesn't forecast
	SLOVENIA_5.1_UPC_KPI.1	KPIs	●		No KPIs
	SLOVENIA_5.1_UPC_EXEC	Execution times pilot	●		No execution
Turkey	TURKEY_5.1_UPC_FT.1	History	●		
	TURKEY_5.1_UPC_FT.2	Data Selection	●		
	TURKEY_5.1_UPC_FT.3	Training model results	●		The model fails to be trained
	TURKEY_5.1_UPC_FT.4	Forecast results	●		The model doesn't forecast
	TURKEY_5.1_UPC_KPI.1	KPIs	●		No KPIs
	TURKEY_5.1_UPC_EXEC	Execution times pilot	●		No execution

Usability testing

Table 58: UI Non-critical errors

UI Non-critical errors
Font size
Limit axis

Table 59: UI Recommendations

UI Recommendations
Include selection of "Positive Flexibility" or "Negative Flexibility"

9.3.1.1 Service Functional and KPIs Testing Actions

Pilot: Turkey

Table 60: TURKEY_5.1_UPC_FT.1 History.

Functional Test Description	Test Actions	Check
1. History	List of previous runs can be observed	●
	"Model Info" and "Forecast" buttons return corresponding information	●
	Within "Model Info" functions as verified in Table 14.	●
	Within "Forecast" functions as verified in Table 15.	●

Table 61: TURKEY_5.1_UPC_FT.2 Data selection.

Functional Test Description	Test Actions	Check
2. Data selection	Selection on either "ESS1" and/or "ESS2" and/or "PV" and/or "EV1" and/or "EV2" from drop list	●
	Selection of either "Positive Flexibility" or "Negative Flexibility"	●
	Date selection is more than 1 year and it exists on dataset	●
	Data selected is correctly loaded: non-zero and more than 25% non-available.	●
	If time resolution is lower than present in the data, the time resolution of the data is used.	●
	The last 7 days of data exist.	●

	The user can consult previous runs.	●

Table 62: TURKEY_5.1_UPC_FT.3 Training model results.

Functional Test Description	Test Actions	Check
3. Training model results	Summary of Data Selection correctly presented	●
	Table presents model results and real data comparison with correct units and title	●
	Plot presents the model results and real data comparison with correct units and title	●
	Selection of training line or input values on plot	●
	Interaction with plot lines is available	●
	Data download button delivers the file	●

Table 63: TURKEY_5.1_UPC_FT.4 Forecast results.

Functional Test Description	Test Actions	Check
4. Forecast results	Summary of Data Selection correctly presented	●
	Table presents the forecasted flexibility values for all times of the day with correct units and title	●
	Plot presents the forecasted flexibility values for all times of the day with correct units and title	●
	Interaction with plot line is available	●
	Metrics shown should be bigger or equal to zero	●

Table 64: TURKEY_5.1_UPC_KPI.1 Forecast results.

Functional Test Description	Test Actions	Check
5. KPI	Use case 1 - Total flexibility value: 122600/>0	●
	Use case 1 - Average flexibility value: 12.5/>0	●
	Use case 1 - Average flexibility availability: 100%/[0-100%]	●
	Use case 1 - Mean Absolute Percentage Error: 0/[0-100%]	●
	Use case 2 - Total flexibility value: benchmark/range comparison	

Table 65: TURKEY_5.1_UPC_EXEC.X Functional Test Task 4

Functional Test Description	Test Actions	Execution time local/front-end	Check
6. Execution time	Training + Executing algorithm for Use Case 1	9 min/ 60 s	●

1. Usability testing

UI Non-critical errors

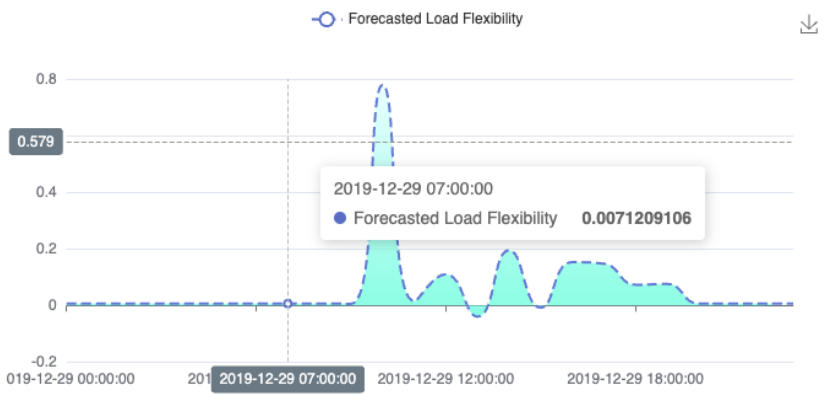
Errors that do not affect the tangible/numeric results: font sizes, colours of graphs, limits of the axis, etc.

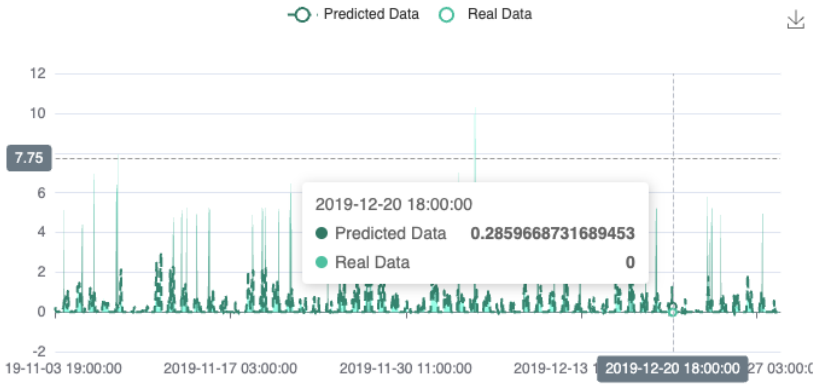
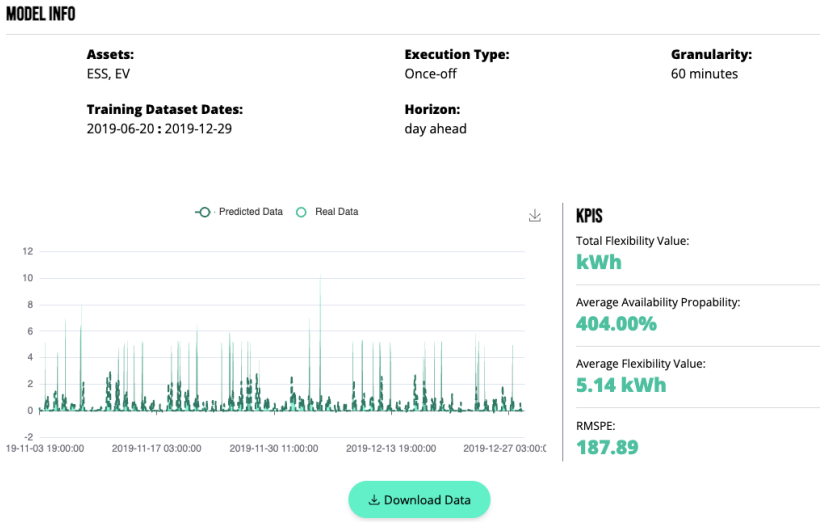
Table 66: UI Non-critical errors

Non-critical errors	Screen shots
Font size	Nothing to declare.
Limit axis	Nothing to declare.

UI Recommendations

Provide recommendations for improving the front-end UI

Recommendations	Screen shots
Recommendation 1	For forecast  Add the unit on the Y axis

Recommendation 2	For model training the same 
Recommendation 3	In model and forecast, put the name of the pilot 

Pilot: Turkey

Use case 1: single asset

Assets: ESS1, positive flexibility

Dates: 2022/01/10 to 2022/05/24; 15 minutes time resolution

Use case 2: aggregation

Assets: EV1 + EV2, positive flexibility

Dates: 2022/05/01 to 2022/06/16; 15 minutes resolution

9.3.2 JSI approach: Flexibility forecast

Service	**S5.1 - Flexibility Forecast Based On Price Signals**
Algorithm provider	**JSI** – Dušan Gabrijelčič
Solution provider	**JSI**
	Good performance ●
	Non-critical error ●
	Error detected ●
Release date	21/11/2023

Service testing summary

Functional and KPIs testing (Responsible: Algorithm dev)

Table 67: Testing summary table

Pilot	Functional Test ID	Functional Test	Check	Test responsible[11]	Comments
Slovenia	ELCE_5.1_JSI_FT.1	Create data contract	●	ELCE	
	ELCE_5.1_JSI_FT.2	Activate data contract	●	JSI	
	ELCE_5.1_JSI_FT.3	Create service contract	●	ELCE	
	ELCE_5.1_JSI_FT.4	Activate service contract	●	JSI	
	ELCE_5.1_JSI_FT.5	Service execution and results	●	ELCE	
Spain	EyPESA_5.1_JSI_FT.1	Create data contract	●	EyPESA	
	EyPESA_5.1_JSI_FT.2	Activate data contract	●	JSI	
	EyPESA_5.1_JSI_FT.3	Create service contract	●	EyPESA	
	EyPESA_5.1_JSI_FT.4	Activate service contract	●	JSI	
	EyPESA_5.1_JSI_FT.5	Service execution and results	●	EyPESA	
Turkey	OEDAS_5.1_JSI_FT.1	Create data contract	●	OEDAS	
	OEDAS_5.1_JSI_FT.2	Activate data contract	●	JSI	
	OEDAS_5.1_JSI_FT.3	Create service contract	●	OEDAS	

	OEDAS_5.1_JSI_FT.4	Activate service contract	•	JSI	
	OEDAS_5.1_JSI_FT.5	Service execution and results	•	OEDAS	

Usability testing

UI Critical errors
/

UI Non-critical errors
/

UI Recommendations
/

9.3.2.1 Service Functional and KPIs Testing Actions

Pilot: OEDAS

Table 68: OEDAS_5.1_JSI_FT.1 Functional Test Task 1

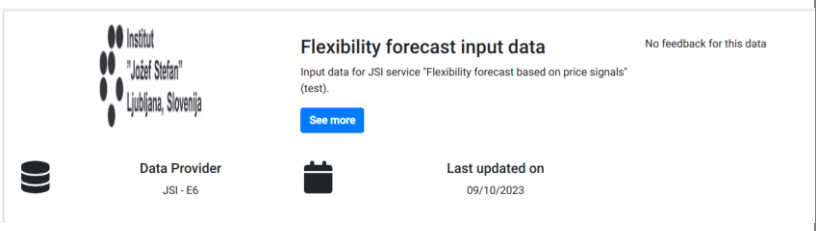
Functional Test Description	Test Actions	Check
1. Create data contract	Search for the data set "Flexibility forecast input data" on Marketplace. Click on "See more" and "Contract data". 	•
	Enter business parameters and click "Submit"	•

Table 69: OEDAS_5.1_JSI_FT.2 Functional Test Task 2

Functional Test Description	Test Actions	Check
2. Activate data contract	Approve the data contract from functional task 1 - data contract structure and parameters are okay	●
	Activate the data contract - data contract can now be used in service contracts	●

Table 70: OEDAS_5.1_JSI_FT.3 Functional Test Task 3

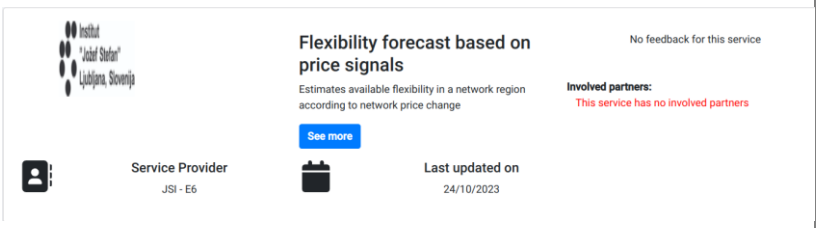
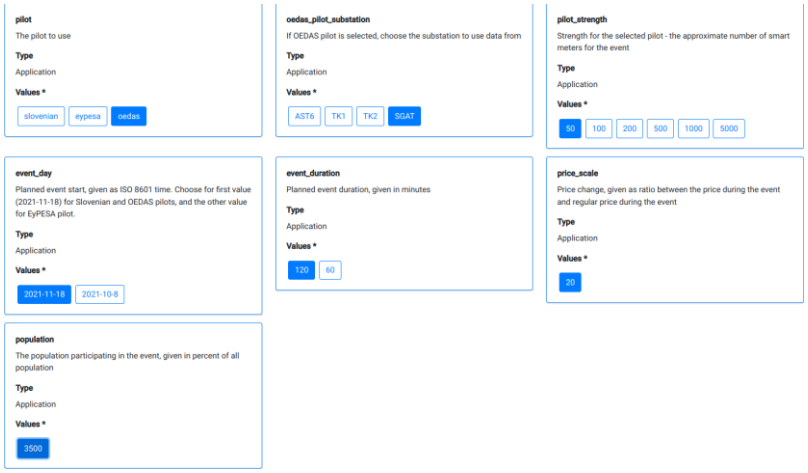
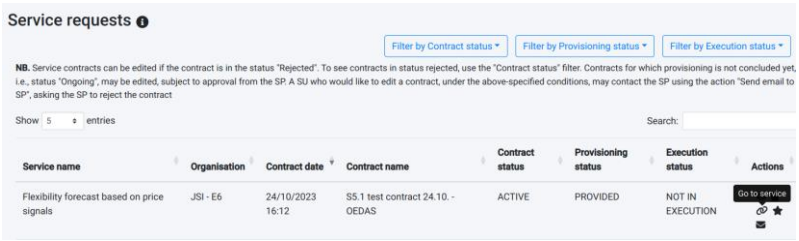
Functional Test Description	Test Actions	Check
3. Create service contract	Search for the "Flexibility forecast based on price signals" service on the Marketplace. Click on "See more" and then "Request new service". 	●
	Enter business parameters	●
	Select the corresponding service parameters: 	●
	Select data contract created in functional task 1 and activated in functional task 2	●
	Click on "Yes" for "Enable immediate execution"	●
	Click on "Request service" to send the service contract	●

Table 71: OEDAS_5.1_JSI_FT.4 Functional Test Task 4

Functional Test Description	Test Actions	Check

4. Activate service contract	Approve the service contract from functional task 3 - contract structure, business and technical parameters are okay, data contract selected and immediate execution enabled	●
	Activate the service contract - this will make an instance of the service	●
	ASM invoked	●
	Data accessed through the data lake	● *Comment: Data has been uploaded in service Docker image*
	Read technical parameters and run the service	

Table 72: OEDAS_5.1_JSI_FT.5 Functional Test Task 5

Functional Test Description	Test Actions	Check
5. Service execution and results	Upon activation of service contract, click on "Go to service" button for the corresponding service contract, found in the "Service requests" table on "My Services" page for "Service User": 	●
	UI accessed after clicking "Go to service button"	●
	Notebook executed - service no longer in "Services" -> "Running" tab	●
	Click on service ID in "Services" -> "History" tab to fetch report	●

1. Usability testing

UI Critical errors

Errors that affect the tangible/numeric results: graphs display, login error, etc.

Critical errors	Screen shots and description	Reporter
/		

UI Non-critical errors

Errors that do not affect the tangible/numeric results: font sizes, colors of graphs, limits of the axis, etc.

Non-critical errors	Screen shots
/	

UI Recommendations

Provide recommendations for improving the front-end UI

Recommendations	Screen shots
/	

Service KPIs

The section on service KPIs reports two major KPIs:

- Total flexibility in a given time frame: with selected event day, the total flexibility provided under 120 minutes time frame is 1.15 kWh at population 3500 and price scale 20.
- Average flexibility availability in a given time frame: with the selected event day, the average flexibility availability under 120 minute time frame is 5.35%.

9.4 S5.2 – Flexibility aggregated services for BRPs

Service	**S5.2 Flexibility Services for BRPs**
Algorithm provider	**UPC** – Adriano Caprara/ Sara Barja Martínez
Solution provider	**ICOM**
	Good performance ●
	Non-critical error ●
	Error detected ●
Release date	20/10/2023

Service testing summary

Functional and KPIs testing (Responsible: Algorithm dev)

Table 73: Functional and KPIs testing

Pilot	Functional Test ID	Functional Test	Check	Test responsible	Comments
PILOT 1	**SPAIN_S5.2_UPC_FT.1**	Functional Test Task 1	●		Brief description of the error detected
	SPAIN_S5.2_UPC_FT.2	Functional Test Task 2	●		
	SPAIN_S5.2_UPC_FT.3	Functional Test Task 3	●		
	SPAIN_S5.2_UPC_EXEC	Execution times pilot 1	●		
PILOT 2	**TURKEY_S5.2_UPC_FT.1**	Functional Test Task 1	●		
	TURKEY _S5.2_UPC_FT.2	Functional Test Task 2	●		
	TURKEY _S5.2_UPC_FT.3	Functional Test Task 3	●		
	TURKEY_S5.2_UPC_EXEC	Execution times pilot 2	●		

Table1. Testing Summary Table

Usability testing

Table 74: UI Non-critical errors

UI Non-critical errors
Font size
Limit axis

Table 75: UI Recommendations

UI Recommendations
Provide recommendations for improving the front-end UI

9.4.1 Service Functional and KPIs Testing Actions

Pilot: TURKEY

Table 76: TURKEY_5.2_UPC_FT.1 Functional Test Task 1

Functional Test Description	Test Actions	Check
1. Day-ahead optimization: "Forecast" tab	Explore different forecasting variables to be displayed, changing the input of "Select what to display". Verify that the shown plots represent the chosen variable	●
	Verify the date range selection; by changing "Start Date" and "End Date" values, the visualizations should change accordingly	●
	Verify frequency selection; by changing the value the granularity of the visualizations should also change	●
	Verify that KPIs are updated when changing date range	●
	Verify that KPIs are updated when changing KPI metric button	●

Table 77: TURKEY _5.2_UPC_FT.2 Functional Test Task 2

Functional Test Description	Test Actions	Check
2. Day-ahead optimization: "Optimization" tab	Try different values for the inputs "Max cost" and "Flexibility cost", the plotted profiles should change accordingly	●
	Verify that the values are plotted for the 24 hours of the day ahead	●
	Verify that the KPIs are correctly displayed	●

Table 78: TURKEY _5.2_UPC_FT.3 Functional Test Task 3

Functional Test Description	Test Actions	Check
3. Self-balancing	Verify that the values "Prediction of the imbalances" and "periods to activate flexibility" are plotted for the 24 hours of the day ahead	●
	Verify that the KPI "Percentage of BRP imbalances" is correctly displayed	●

Table 79: TURKEY _5.2_UPC_EXEC.1 Functional Test Task 4

Functional Test Description	Test Actions	Execution time local/front-end	Check
4. Execution time	Generation of "Day-ahead optimization: forecast" visualizations	<20 s	●
	Generation of "Day-ahead optimization: optimization" visualizations	<20 s	●
	Generation of "Self-balancing" visualizations	<20 s	●

4. Usability testing

UI Non-critical errors

Errors that do not affect the tangible/numeric results: font sizes, colours of graphs, limits of the axis, etc.

Table 80: UI Non-critical errors

Non-critical errors	Screen shots
Font size	
Limit axis	

UI Recommendations

Provide recommendations for improving the front-end UI

Table 81: UI Recommendations

Recommendations	Screen shots
Recommendation 1	
Recommendation 2	

9.5 S5.3 – Flexibility aggregated services for DSOs

9.5.1 UPC approach: Flexibility-based AC OPF

Service	**S5.3 Flexibility Agg Services for DSOs**
Algorithm provider	**UPC** – Alejandro Hernandez
Solution provider	**ICOM**
	Good performance ●
	Non-critical error ●
	Error detected ●
Release date	27/07/2023

Service testing summary

Functional and KPIs testing (Responsible: Algorithm dev)

Table 82: Testing Summary Table

Pilot	Functional Test ID	Functional Test	Check	Test responsible	Comments
TURKEY	TURKEY_X.X_PARTNER_FT.X	Functional Test Task 1	●	Alejandro Hernandez	
	TURKEY_X.X_PARTNER_FT.X	Functional Test Task 2	●	Alejandro Hernandez	
	TURKEY_X.X_PARTNER_FT.X	Functional Test Task 3	●	Alejandro Hernandez	
	TURKEY_X.X_PARTNER_KPI.X	KPIs Task *n*	●	Alejandro Hernandez	
	TURKEY_X.X_PARTNER_EXEC	Execution times pilot 1	●	Alejandro Hernandez	

Usability testing

Table 83: UI Non-critical errors

UI Non-critical errors
Font color
Axis label

Table 84: UI Recommendations

UI Recommendations
Recommendations such as more informative messages for the user to understand some features of the interface should be considered. Darker tone of some fonts.

9.5.1.1 Service Functional and KPIs Testing Actions

Pilot: OEDAS TURKEY

Table 85: TURKEY_S5.3_UPC_FT.1 Functional Test Task 1

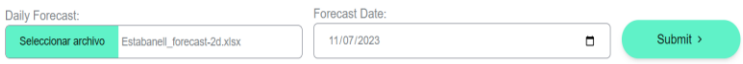
Functional Test Description	Test Actions	Check
1. Data Ingestion	Make sure the data from the pilot is correctly ingested for the service.  Suggestion: Change the font of the daily forecast and forecast to a darker font. Current is very subtle.	●
	Verify the data from the service S3.1 is correctly received	●
	Verify there are no NaN values	●

Table 86: TURKEY_S5.3_UPC_FT.2 Functional Test Task 2

Functional Test Description	Test Actions	Check
2. Review daily results	Check Summary values shown. All of the values should be coherent and appropriate.	●

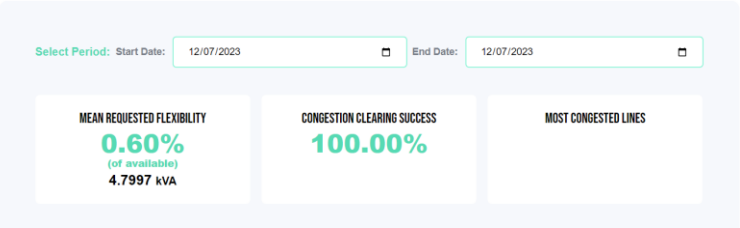
	 Comment: Most congested lines not appearing	
	Explore different selection of flexibility sources. Try two and make sure the values change. Comment: Mean flexibility usage is not appearing	●
	Check the values shown for different dates selection. Choose at least two available dates and make sure the values change.  Some values are missing display	●

Table 87: TURKEY_S5.3_UPC_FT.3 Functional Test Task 3

Functional Test Description	Test Actions	Check
3. Evaluate visualization	Select different times of the day, confirm the plots change	●
	Download figures for the most congested time of the day	●
	Confirm the images open correctly	●

Table 88: TURKEY_S5.3_UPC_FT.4Functional Test Task 4

Functional Test Description	Test Actions	Check

4. Preview of data	Select different buses IDs and explore their behaviour	●
	Download the data in excel form It can only be downloaded as a figure. Is it possible to change it also to Excel form?	●
	Confirm the downloaded dataset opens correctly	●

Table 89: TURKEY_S5.3_UPC_FT.4Functional Test Task 5

Functional Test Description	Test Actions	Check
5. Execute Use Case 1	Compare results given the set	●

Table 90: TURKEY_S5.3_UPC_KPI.5Functional Test Task 6

Functional Test Description	Test Actions	Check
6. KPI	KPI benchmark/range comparison Requested Flexibility in range of 20 to 50%	●
	KPI benchmark/range comparison congestion clearing in range of 80 to 100%	●

Table 91: TURKEY_S5.3_UPC_EX.6 Functional Test Task 7

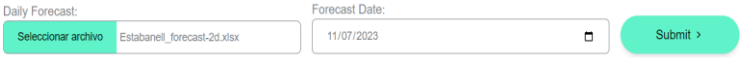
Functional Test Description	Test Actions	Execution time local/front-end	Check
7. Execution time	Executing algorithm for Use Case 1	10 s/ 60 s	●
	Training algorithm for algorithm	60 s/ 70s	●

5. Usability testing

UI Non-critical errors

Errors that do not affect the tangible/numeric results: font sizes, colours of graphs, limits of the axis, etc.

Table 92: UI Non-critical errors

Non-critical errors	Screen shots
Font color	
Limit axis	 This plot should have a label on the y-axis "P-MW"

UI Recommendations

Provide recommendations for improving the front-end UI

Table 93 UI Recommendations

Recommendations	Screen shots
Recommendation 1	 If possible, change FR for "Flexibility Request" for clarity.
Recommendation 2	More recommendations have been given through this document.

9.5.2 JSI approach: Flexibility services for DSOs based on neural networks

Service Testing

Service	**S5.3 - Flexibility Services For DSOs**
Algorithm provider	**JSI** – Dušan Gabrijelčič
Solution provider	**JSI**
	Good performance ●
	Non-critical error ●
	Error detected ●
Release date	22/11/2023

Service testing summary

Functional and KPIs testing (Responsible: Algorithm dev)

Pilot	Functional Test ID	Functional Test	Check	Test responsible[1]	Comments
Turkey	OEDAS_5.3_JSI_FT.1	Create data contract	●	OEDAS	
	OEDAS_5.3_JSI_FT.2	Activate data contract	●	JSI	
	OEDAS_5.3_JSI_FT.3	Create service contract	●	OEDAS	
	OEDAS_5.3_JSI_FT.4	Activate service contract	●	JSI	
	OEDAS_5.3_JSI_FT.5	Service execution and results	●	OEDAS	

Table 94: Service Testing summary

Usability testing

UI Critical errors
/

UI Non-critical errors
/

UI Recommendations
/

9.5.2.1 Service Functional and KPIs Testing Actions

Pilot: OEDAS

Table 95: OEDAS_5.3_JSI_FT.1 Functional Test Task 1

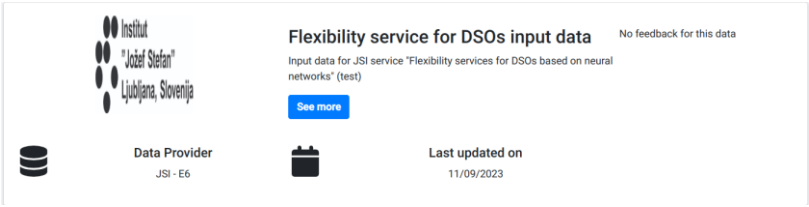
Functional Test Description	Test Actions	Check
1. Create data contract	Search for the data set "Flexibility service for DSOs input data" on Marketplace. Click on "See more" and "Contract data". 	●
	Enter business parameters and click "Submit"	●

Table 96: OEDAS_5.3_JSI_FT.2 Functional Test Task 2

Functional Test Description	Test Actions	Check
2. Activate data contract	Approve the data contract from functional task 1 - data contract structure and parameters are okay	●
	Activate the data contract - data contract can now be used in service contracts	●

Table 97: OEDAS_5.3_JSI_FT.2 Functional Test Task 3

Functional Test Description	Test Actions	Check
3. Create service contract	Search for the "Flexibility services for DSOs based on neural networks" service on the Marketplace. Click on "See more" and then "Request new service".	●

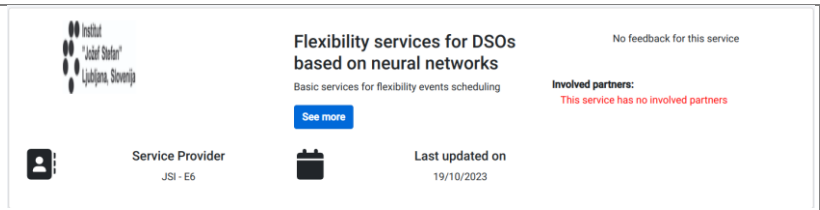
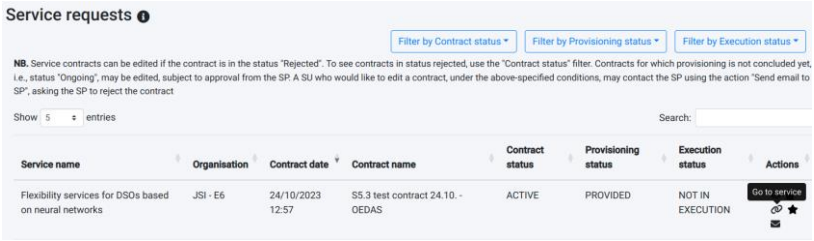
		
	Enter business parameters	●
	Select the corresponding service parameters: 	●
	Select data contract created in functional task 1 and activated in functional task 2	●
	Click on "Yes" for "Enable immediate execution"	●
	Click on "Request service" to send the service contract	●

Table 98: OEDAS_5.3_JSI_FT.2 Functional Test Task 4

Functional Test Description	Test Actions	Check
4. Activate service contract	Approve the service contract from functional task 3 - contract structure, business and technical parameters are okay, data contract selected and immediate execution enabled	●
	Activate the service contract - this will make an instance of the service	●
	ASM invoked	●
	Data accessed through the data lake	● *Comment: Data has been uploaded in service*

		Docker image
	Read technical parameters and run the service	

Table 99: OEDAS_5.3_JSI_FT.2 Functional Test Task 5

Functional Test Description	Test Actions	Check
5. Service execution and results	Upon activation of service contract, click on "Go to service" button for the corresponding service contract, found in the "Service requests" table on "My Services" page for "Service User": 	●
	UI accessed after clicking "Go to service button"	●
	Notebook executed - service no longer in "Services" -> "Running" tab	●
	Click on service ID in "Services" -> "History" tab to fetch report	●

1. Usability testing

UI Critical errors

Errors that affect the tangible/numeric results: graphs display, login error, etc.

Critical errors	Screen shots and description	Reporter
/		

UI Non-critical errors

Errors that do not affect the tangible/numeric results: font sizes, colors of graphs, limits of the axis, etc.

Non-critical errors	Screen shots

/	

UI Recommendations

Provide recommendations for improving the front-end UI

Recommendations	Screen shots
/	

9.6 S7.1 – P2P trading

Service	**S7.1 P2P Energy Trading**
Algorithm provider	**ATOS** – Ross Little
Solution provider	**ATOS**
	Good performance ●
	Non-critical error ●
	Error detected ●
Release date	09/06/2023

Service testing summary

9.6.1 Functional and KPIs testing

Table 100: Service7.1_ATOS_Testing Summary Table.

Pilot	Functional Test ID	Functional Test description	Check	Comments
TURKEY	TURKEY_7.1_ATOS_FT.1	Service User login and list P2P SU contracts	●	
	TURKEY_7.1_ATOS_FT.2	Select & initialise contract	●	
	TURKEY_7.1_ATOS_FT.3	Download trading results after a 24 hour period	●	
	TURKEY_7.1_ATOS_KPI.1	KPIs	●	
	TURKEY_7.1_ATOS_EXEC	Execution time	●	

9.6.2 Usability testing

Table 101: Service7.1_ATOS_Usability testing.

UI Critical errors

UI Non-critical errors

UI Recommendations

Service Functional and KPIs Testing Actions

Table 102: Service7.1_ATOS_FT.1 Service User login and list P2P SU contracts

Functional Test Description	Test Actions	Check
1. Service User login and list P2P SU contracts	SU performs successful federated login by clicking on P2P Trading url and then being redirected to the Marketplace login, and after successful login is automatically redirected back to the P2P Trading service.	●
	Upon being redirected back the SU is able to view all P2P Trading Service User contracts for their organization.	●

Table 103: Service7.1_ATOS_FT.2 Select & initialise contract

Functional Test Description	Test Actions	Check
2. Select & initialise contract	SU selects P2P Trading contract of interest and checks its parameters and associated Data User contract parameters.	●
	SU initialises the contract and confirms its state as active	●

Table 104: Service7.1_ATOS_FT.3 Download trading results after a 24-hour period

Functional Test Description	Test Actions	Check
3. Download trading results after a 24-hour period	SU selects contract to view trading results and downloads the csv	●
	Importing csv into excel and check that the trading figures are in accordance with the equality sharing cooperative trading algorithm specified in D5.4	●

Table 105: Service7.1_ATOS KPIs

Functional Test Description	Test Actions	Check
4. KPI	Number of CEC members (smart meters) in a P2P Trading Service (minimum 3)	●
	Number of CEC members trading energy during 24-hour period (minimum 1)	●

Table 106: Service7.1_ATOS Execution time

Functional Test Description	Test Actions	Execution time local/front-end	Check
5. Execution time	Executing algorithm	- s/ - s	●

9.7 S8.1 – Asset and investment planning

Service	**S8.1 Asset and Investment Planning**
Algorithm provider	**UPC** – Antonio E. Saldaña González
Solution provider	**WEP**
	Good performance ●
	Non-critical error ●
	Error detected ●
Release date	22/03/2023

Service testing summary

Functional and KPIs testing (Responsible: Algorithm dev)

Table 107: Testing Summary Table

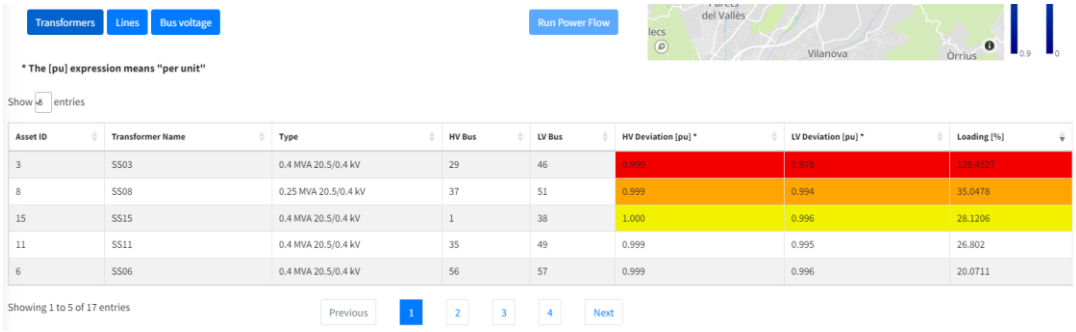
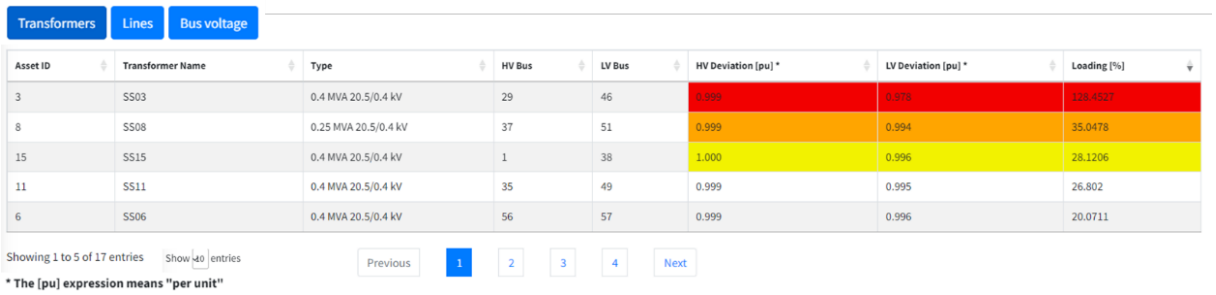
Pilot	Functional Test ID	Functional Test description	Check	Comments
Turkey	Turkey_8.1_UPC_FT.1	Stress test tab display options	●	
	Turkey_8.1_UPC_FT.2	Planning Action tab display options	●	
	Turkey_8.1_UPC_FT.3	KPIs results	●	Corrected: Total Costs are not correct in the UI (Zero value only).
	Turkey_8.1_UPC_FT.4	Download results	●	Corrected: I cannot open the excel file "KPI Results" (only download).
	Turkey_8.1_UPC_FT.5	Execution time	●	

USABILITY TESTING

Table 108: UI Non-critical errors

UI Non-critical errors
Font size: - Font size of the two tables (Asset List Results and Results of the Power Flow) in the Planning Actions TAB need to be the same. - Color of the row could be better if it showed in red only if the value is higher than 100%. Orange color between 99% and 61 % and below 60% in yellow color. (But this action is not critical) - The maximum decimals of the New Loading % column need to be 4 (Planning Actions TAB).
Limit axis: No comments

Table 109: UI Recommendations

UI Recommendations
Instead of having the PU legend in the top of the table in the middle of the push buttons:  I propose to move the legend (* The [pu] expression means "per unit" …) to the bottom of the table. Also put the push button (Transformer, Lines, Bus Voltage) closer to the table. Please see an example of the image below: 

9.7.1 Service Functional and KPIs Testing Actions

Pilot: Turkey

Table 110: TURKEY_8.1_UPC_FT.1 Stress test Tab display options

Functional Test Description	Test Actions	Check
8. Stress test Tab display options	Select the **"Name"** options from the "Stress Test" tab to display all the transformer names. Make sure that all the names are written correctly.	●
	Select the **"Expansion"** option from the "Stress Test" tab to display the loading percent. Make sure that values are displayed correctly (Ex. 5%, 10%, 15%).	●
	Make sure that after adding (by clicking the add botton) the expansion of the asset, the planning actions must be displayed in the table located in the right side of the UI. Make sure is **displayed correctly**.	●
	Select "**Single Date Time"** in the Type of power flow options. Make sure that you can select **only one single date and time** using the calendar option. Select a random Date-time (specify range of possible dates).	●
	Select "**Multiple Date Time"** in the Type of power flow options. Make sure that you can select two range of **date and times (from and to)** using the calendar option. Select a random range of date-times (specify range of possible dates).	●

Table 111: TURKEY_8.1_UPC_FT.2 Planning Actions Tab Display Options

Functional Test Description	Test Actions	Check
9. Planning Actions Tab Display Options	Click the "Planning Actions" Tab (from the main left column). Make sure that there is no error in the time series or single power flow simulation.	●
	After running the power flow simulation, the planning actions must be displayed in the table located in the bottom side of the UI. Make sure is **displayed correctly**.	●
	After running the power flow simulation, a GIS map with a colour bar must be displayed. Make sure the **GIS map** is displayed correctly (zoom in and out, view results of the asset and coordinates correspond to the pilot).	●

	After running the power flow simulation, the results of the planning power flows must be shown in table formats, divided in 3 tabs (Transformers, Lines and Bus voltages). Make sure that all the assets names, types and results are shown correctly.	●

Table 112: TURKEY_8.1_UPC_FT.3 KPIs results in the marketplace

Functional Test Description	Test Actions	Check
10. KPIs results in the marketplace	Click the **"KPIs"** Tab (from the main left column). Then, select the **"Total Decongestion"** tab option (selected by default), and 3 KPIs options should display in a pie graph format (Decongestion in Lines %, Decongestion in Transformers % and Value Improvements). Make sure that the graphs are displayed correctly by selecting different asset types.	●
	Select the **"Total Cost"** tab option. Three different Investment Cost (CAPEX, OPEX and TOTEX) as a fixed number should be displayed. Make sure that the values are displayed correctly and the currency is in Euros.	●

Table 113: TURKEY_8.1_UPC_FT.4 Download results

Functional Test Description	Test Actions	Check
11. Download results	Download results by clicking in the Save Results button (.xlsx and .csv).	●
	Make sure that the file corresponds to the KPIs displayed in the UI.	●

Table 114: TURKEY_8.1_UPC_FT.5 Execution time

Functional Test Description	Test Actions	Execution time local/front-end	Check
12. Execution time	Executing algorithm for Use Case 1 (Annex)	10 s/ 60 s	●

Usability testing

UI Non-critical errors

Errors that do not affect the tangible/numeric results: font sizes, colours of graphs, limits of the axis, etc.

Table 115: UI Non-critical errors

Non-critical errors	Screen shots
Font size	
Limit axis	

UI Recommendations

Provide recommendations for improving the front-end UI

Table 116: UI Recommendations

Recommendations	Screen shots
Recommendation 1	
Recommendation 2	

9.8 S8.2 – Asset estimation optimization for microgrids

Service	**S8.2 Asset estimation optimization for microgrids**
Algorithm provider	**VUB** – Wouter Parys
Solution provider	**WEP**
	Good performance ●
	Non-critical error ●
	Error detected ●
Release date	14/09/2023

Service testing summary

Functional and KPIs testing (Responsible: Algorithm dev)

Table 117: Testing Summary Table

Pilot	Functional Test ID	Functional Test	Check	Test responsible	Comments
SPAIN	8.2_VUB_FT.1	Data ingestion	●	VUB	*Data manually ingested*
	8.2_VUB_FT.2	Review asset overview	●	VUB	
	8.2_VUB_FT.3	Evaluate SOH analysis	●	VUB	
	8.2_VUB_FT.4	Evaluate degradation prognosis	●	VUB	
	8.2_VUB_FT.5	Evaluate degradation costs	●	VUB	
	8.2_VUB_KPI	KPIs	●	VUB	
	8.2_VUB_EXEC	Execution time	●	WEP	
TURKEY	8.2_VUB_FT.1	Data ingestion	●	VUB	*Data manually ingested*
	8.2_VUB_FT.2	Review asset overview	●	VUB	
	8.2_VUB_FT.3	Evaluate SOH analysis	●	VUB	
	8.2_VUB_FT.4	Evaluate degradation prognosis	●	VUB	
	8.2_VUB_FT.5	Evaluate degradation costs	●	VUB	
	8.2_VUB_KPI	KPIs	●	VUB	
	8.2_VUB_EXEC	Execution time	●	WEP	
BELGIUM	8.2_VUB_FT.1	Data ingestion	●	VUB	*Data manually ingested*
	8.2_VUB_FT.2	Review asset overview	●	VUB	
	8.2_VUB_FT.3	Evaluate SOH analysis	●	VUB	
	8.2_VUB_FT.4	Evaluate degradation prognosis	●	VUB	
	8.2_VUB_FT.5	Evaluate degradation costs	●	VUB	
	8.2_VUB_KPI	KPIs	●	VUB	
	8.2_VUB_EXEC	Execution time	●	WEP	

Usability testing

Table 118: UI Critical errors

UI Critical errors

Table 119: UI Non-critical errors

UI Non-critical errors

Table 120: UI Recommendations

UI Recommendations
Labels on the plots could be better, sometimes it is difficult to understand the graph.

9.8.1 Service Functional and KPIs Testing Actions

Table 121: 8.2_VUB_FT.1 Data ingestion

Functional Test Description	Test Actions	Pilot	Check
13. Data ingestion	Make sure the data from the pilot is correctly ingested for the service.	EYPESA	●
		OEDAS	●
		VUB	●
	Verify that that the meta data (information of the 'asset type', the 'SOH primary param.' and SOH) is correctly represented	EYPESA	●
		OEDAS	●
		VUB	●

Table 122: 8.2_VUB_FT.2 Review asset overview

Functional Test Description	Test Actions	Pilot	Check
14. Review asset overview	Check if *'View detail'* re-directs the page to the *'Data Analysis'* tab of the selected asset.	EYPESA	●
		OEDAS	●
		VUB	●
		EYPESA	●

	Verify that the specifications given in the *'Data Analysis'* tab correspond to the ones from the *'Asset Overview'*.	OEDAS	•
		VUB	•
	Check if the visualization changes if another asset is selected.	EYPESA	•
		OEDAS	•
		VUB	•

Table 123: 8.2_VUB_FT.3 Evaluate SOH analysis

Functional Test Description	Test Actions	Pilot	Check
15. Evaluate SOH analysis	Verify that all results generated by the simulations are visualized in the *'SOH details'* tab.	EYPESA	•
		OEDAS	•
		VUB	•
	Check that the results are plotted for both cases, as a function of the cycles and as a function of the years.	EYPESA	N/A
		OEDAS	N/A
		VUB	N/A
	Verify that the tab works for each asset (display, changes in values etc.).	EYPESA	N/A
		OEDAS	N/A
		VUB	N/A
	Verify that if the asset is a different type i.e. Battery versus PV system, that the titles change.	EYPESA	•
		OEDAS	•
		VUB	•

Table 124: 8.2_VUB_FT.4 Evaluate degradation prognosis

Functional Test Description	Test Actions	Pilot	Check
16. Evaluate degradation prognosis	Check that names and option changes as a function of the type of selected asset, i.e. should only be valid for a Battery	EYPESA	•
		OEDAS	•

		VUB	●
	Verify that the plots do adapt as a function of the selection (i) Number of cycles per year, (ii) Changes in average DoD or (iii) Average (dis)charging current.	EYPESA	●
		OEDAS	●
		VUB	●
	Check if '*Download data*' downloads the data in the correct format and if the latter is interpretable once downloaded.	EYPESA	●
		OEDAS	●
		VUB	●
	Check if the '*Download image*' downloads the same image as shown on the UI.	EYPESA	●
		OEDAS	●
		VUB	●

Table 125: 8.2_VUB_FT.5 Evaluate degradation costs

Functional Test Description	Test Actions	Pilot	Check
17. Evaluate degradation costs	Check if all the costs are represented for typical profiles (pre-loaded profiles).	EYPESA	●
		OEDAS	●
		VUB	●
	Verify that the '*Degradation costs*' tab changes as a function of the selected asset type.	EYPESA	●
		OEDAS	●
		VUB	●
	Evaluate if dragging the data points (top figure), changes the degradation costs	EYPESA	●
		OEDAS	●
		VUB	●

Table 126: 8.2_VUB_EXEC Functional Test Execution Time

Functional Test Description	Test Actions	Execution time local/front-end	Check
18. Execution time	Executing algorithm for Use Case 1	< 1min	●

	Training algorithm for different models	3min / 15min	●

Usability testing

UI Critical errors

Errors that affect the tangible/numeric results: graphs display, login error, etc.

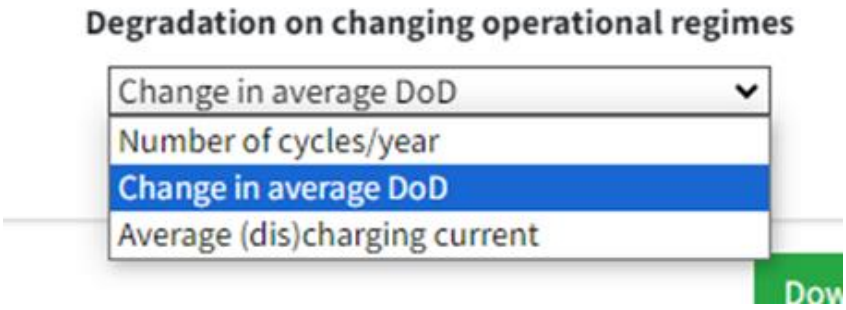
Table 127: UI Critical errors

Critical errors	Screen shots and description	Reporter
	N/A	

UI Non-critical errors

Errors that do not affect the tangible/numeric results: font sizes, colours of graphs, limits of the axis, etc.

Table 128: UI Non-critical errors

Non-critical errors	Screen shots
Results tend to appear the same for the different options (in the 'Degradation prognosis' tab): However, the test data might have been restricted to a short period.	

UI Recommendations

Provide recommendations for improving the front-end UI

Table 129: UI Recommendations

Recommendations	Screen shots
Provide better labels (x-axis and y-axis)	All plots

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