BD4OPEM

Big Data for OPen innovation Energy Marketplace

Deliverable 7.5.2
Pilot 5 – Danish pilot description and results

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Peer reviewed by:

Partner	Reviewer
VUB	Rémy Cleenwerck
ODT	Luc Richaud

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Abbreviations and Acronyms

Table 1 - Abbreviations and Acronyms

Acronym	Description
AI	Artificial Intelligence
BRP	Balancing Responsible Party
Dx	Deliverable x
DSO	Distribution System Operator
DTU	Danmarks Tekniske Universitet
EV	Electric Vehicle
EVSE	Electric Vehicle Supply Equipment
GDPR	General Data Protection Regulation
KPI	Key Performance Indicator
LV	Low Voltage
MV	Medium Voltage
PV	Photovoltaic
Tx	Task x
ToU	Time-of-Use
TSO	Transmission System Operator
UI	User Interface
V2G	Vehicle-to-Grid
WPx	Work Package x

1. Executive summary

This deliverable documents all the work performed within Task 7.5.2 (T7.5.2), related to the Danish demonstration site (Pilot 4.2). It follows the methodology of implementation described in Deliverable D7.1 "Large Scale pilots' methodology" [1].

The services implemented in this pilot are the following:

Table 2: Services implemented in Danish pilot

Service ID	Name of service (name of approach when relevant)	Service developer
S3.1	Grid disturbance simulations (Congestions forecast for day ahead)	UPC, WEP
S3.2	Impact study PV, EV & new loads	ODT
S5.1	Flexibility forecast (UPC approach)	UPC, ICOM
S5.4	EV to Grid	NUVVE
S8.1	Asset and investment planning	UPC, WEP

First, each service is presented succinctly and the use cases are reminded, based on 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 Danish demonstration site.

The main audience of this document is:

- WP7 partners themselves, to know the results of the project for the Danish 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 NUVVE.

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, T7.4, 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 Danish demonstration site

3.1 Global perimeter (update from D7.1)

Pilot company: Nuvve

DSO of the local grid: BEOF Bornholms Energi & Forsyning. Lately this Distribution System Operator (DSO) has changed ownership, now it is TRAFOR.

Description of assets:

- km of lines: N.A.
- Number of substations: 1, 10/0,4kV station Bellmansvej 54
- Asset pilot: Electric Vehicles (EVs) owned by national entity and plugged to Nuvve owned vehicle-to-grid (V2G) charging stations with a power rate of [redacted] kW. V2G technology allows not only to charge the EVs, but also gives the possibility to discharge the batteries to create flexibility.
- Total power of the pilot: around [redacted] peak charge or discharge with [redacted] units [redacted] kW.
- Total battery capacity of EVs depends on multiple factors. All cars have battery capacity of around [redacted] kWh. The driving patterns show a limited usage on certain units, while others have very irregular driving patterns.

Geographical overview: Rønne, Bornholm Island, Denmark.

Figure 1: Fleet location

For the Danish pilot site Nuvve has chosen the island of Bornholm, where a V2G infrastructure is already deployed. The island of Bornholm is located in the Baltic Sea, and its power system is connected with Swedish grid through a submarine cable of 60 MW. The 0.4 kV low voltage grid length is more than 1900 km and the number substations amount to 1039, while the 60 kV and the 10 kV grid are respectively 131 and 927 km long and 16 substations 60/10 kV are installed. The power system is characterized by a significant shares of renewable energy sources, continuously increasing.

This pilot development is used to test the provision of flexibility services to support the creation of DSO markets in the area, avoiding local congestions on the distribution grid. In the pilot [redacted] of Nuvve's bidirectional chargers [redacted]) were to be considered and used for the data analysis. [redacted] allocated for congestion management services for the LV grid where those are installed. This is achieved through the assessment of the available flexibility, its future forecast and optimization for its distribution. The forecasting algorithm designed can be compared with the pilot tools in development and, if possible, merged. The Danish pilot includes multiple charging stations operated by Nuvve, located on two different feeders of Bornholm island and subjected to different loading and customers' characteristics. Nuvve has offered a Electric Vehicle Supply Equipment (EVSE) infrastructure which is a relevant asset that can optimally provide flexibility to the local grid through V2G technology. V2G technology patented by Nuvve, allows charging and discharging vehicles with high-granular control. [redacted] the fleet has been aggregated to offer Frequency-Containment-Reserve for Normal Disturbance (FCR-N) to the Transmission System Operator (TSO), named Energinet, by using V2G chargers with second resolution control. The fleet is operated with two different models with slightly different battery capacities [redacted]

Connection point	Installed capacity	EVSEs
1	[redacted]	
2		
3		
4		
5		
6		
7		
8		
Total		

Figure 2: Nuvve demonstration site, assets and map

In parallel, Nuvve has provided data to assist other pilots requesting it. This pilot aims to test new services which are centred on bringing value to another type of actors. Through a collaboration between Nuvve and the local DSO Bornholms Energi & Forsyning (BEOF), the Danish pilot will assist in performing services for analysis and comparison of grid topologies. Here, customer loadings including EV penetration, driving and charging patterns, and temporal load flows will be investigated to estimate the flexiblility potential for the power system and its market. This can maximise the benefits of the system, the aggregator and the users. Grid services can be performed by controlling uni- and bi-directional charging stations. The remote charging control is handled by the Electric Vehicle Supply Equipment (EVSE) operator who activates the EV flexibility following signals measured directly on the grid and/or upon request. [redacted]

points. Further, the data for that specific radial network were also accessible, which enhanced the decision. Moreover, while the grid on the island is strong and does not experience congestion very often, the chosen reference radial network would expect a certain level of cable overloading. However, the congestion should be confirmed by further analysis.
In the case that no congestion would occur or that the effects are limited, the network congestion have been modelled by including synthetic data or modelling the data for the pilot case.

The majority of EVs are located on local radial feeders behind transformers at low-voltage side. Flexibility from EV charging and discharging is a powerful tool for grid owners to defer and reduce the need of grid reinforcements and support the stability of local grids. The local EVs can help operators, such as DSOs and TSOs, to mitigate network congestion, for instance by levelling loads, providing ancillary services and much more.

Figure 3, extracted from the "T4.3 - S5.4_EV_to_Grid" document [2] depicts the required steps to reach these objectives. Starting with the raw data received from the smart meters in each charging station, to the final step that includes external signals and considers optimising the aggregated available and predicted flexibility at the moment of use. Step 1 of Figure 3, consists of receiving the data from the EV chargers. The latter contains the state of charge and power requested by the vehicle, power provided by the vehicle, the plug-in status, voltage and current at the EV side. The flexibility will depend indeed on the current state of charge, allowing a positive and negative power flexibility to be calculated for each data point.

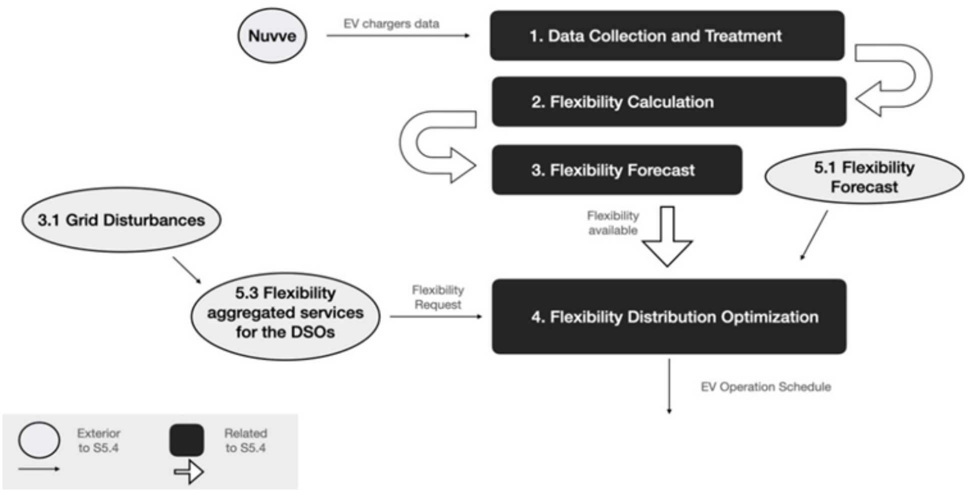


Figure 3: Algorithm scheme interaperability from UPC

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

Data Sources

For the Danish pilot, different data sources have been used to support the provision of services on the marketplace, see Figure 4. The data flow diagram was produced for the deliverable D3.1 Data acquisition protocols technologies and information models [3]. As the data sources differ from the type of communication and protocols, multiple interfaces were created to assist the correct data ingestion.

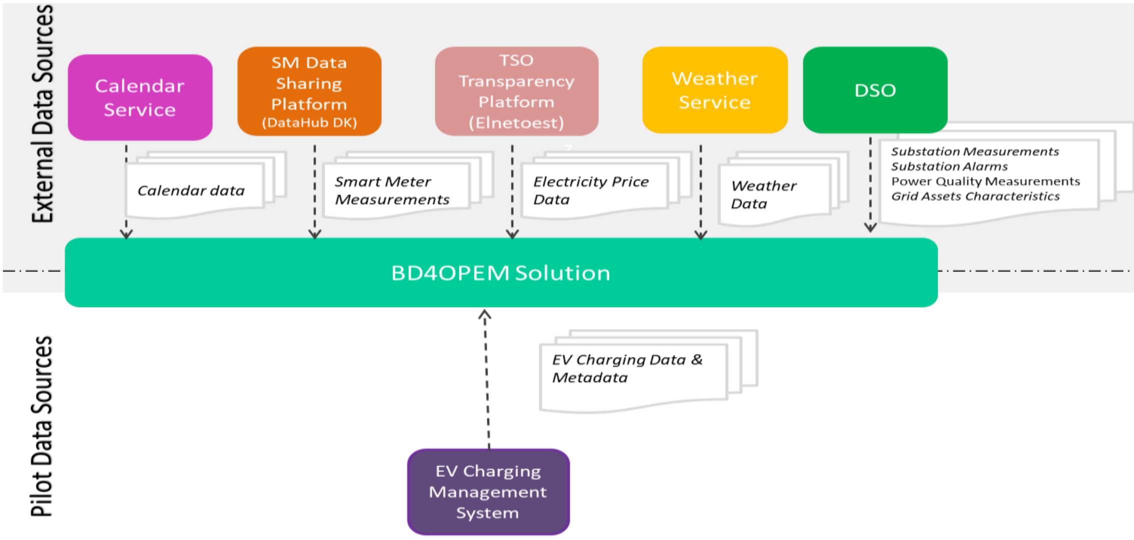


Figure 4: Nuvve data sources

The data channels for the Danish pilot have been listed in the abovementioned D3.1 [3] and depicted in Table 3 below.

Table 3: Data channels of Danish Pilot

Data Object	Offered by	System	Comm. Protocol	Data Format
EV Charging Data	Nuvve	EV Charging Management System	HTTPS(S)	JSON/CSV, Proprietary Data Model
EV Charging Metadata				
Historic Smart Meter Measurements	DSO	SM Data Sharing Platform	HTTPS(S)	CSV/xlsx
Primary Substation Measurements	DSO	SCADA	HTTPS(S)	CSV/xlsx
Substation Alarm		SCADA	HTTPS(S)	CSV/xlsx
Power Quality Measurements		GIS	HTTPS(S)	CSV/xlsx
Grid Asset Characteristics	External Data Sources	Calendar Service	HTTP	JSON

Table 4 - Data identification S5.4

Data source	Data identification	Additional description	BD4OPEM ontology	Reference to standards
EV Charging Management System	EV Charging Data	EV charging datasets of V2G units	EV_Charging_Station	SAREF:makesMeasurement
EV Charging Management System	EV Charging Metadata	EV charging datasets of V2G units	EV_Charging_Station	SAREF:measuresProperty
SM DSO Data Sharing Platform	Historic Smart Meter Measurements	DSO smart meter data with production and consumption every 15 minutes per 110 customers	Smart_Meter	bd4op:SmartMeter has not direct references to any standard but it is a subclass of bd4op:FieldDevice that is based on saref:Device, fiware:Device, fiware:DeviceModel and cim:EndDevice
DSO SCADA legacy system	Secondary Substation Measurements	PowerLab transformer technical datasets	Secondary_Substation	IEC CIM: meterMeasurements
DSO SCADA legacy system	Secondary Substation Power Quality Measurements	PowerLab transformer technical datasets	Secondary_Substation	IEC CIM: meterMeasurements
GIS Internal database	Grid Asset Characteristics	Topology of DSO local grid on Bornholm	Grid_Assets	IEC CIM
TSO DataHub	Market Data	Electricity prices DataHub [4]	Electricity_Prices	IEC CIM

The data from the Nuvve pilot are not only from the fleet’s operation, but data from the local grid were purchased by Nuvve to support the project.

a. **Fleet data**: Nuvve has resampled, modelled, anonymized and share the operational data from the V2G fleet, including power, energy, voltage, current, status. This data has be shared on a daily basis via cronjob from the Nuvve servers. The approach of sharing data would still need to be discussed with the parties involved. A possible API will be created to pull patches of data to the data-lake.

b. **DSO data**: the customer's historical data, around 110 customers for three years, have been shared by the DSO on power consumed and produced. [redacted]

c. **Transformer data**: the proposed idea was to connect the data-lake with the station data to support the development of the pilot. [redacted]. However, historically transformer technical data were shared with Nuvve and to the BD4OPEM partenrs in related services.

Grid data are available for the Danish pilot from two different resources:

- A list and a visual illustration of the components and cables of the grid topology of low voltage side of the 10/0,4kV station Bellmansvej 54, where the connection point 6 of Nuvve is, were shared by the local DSO. Moreover, three years of historical smart meter data for the customers under that station were shared by the same operator. These datasets, list the power consumed and produce by each of the smart meters. [redacted]

- The second set of grid data was received from the PowerLab Danmarks Tekniske Universitet (DTU), a research entity. These data are the Bellmansvej 54 transformer data including power, current, voltage, frequency, and others for around 3 years. The proposed idea with PowerLab was to connect with their database and possibly fetch data on more regular basis.[redacted]

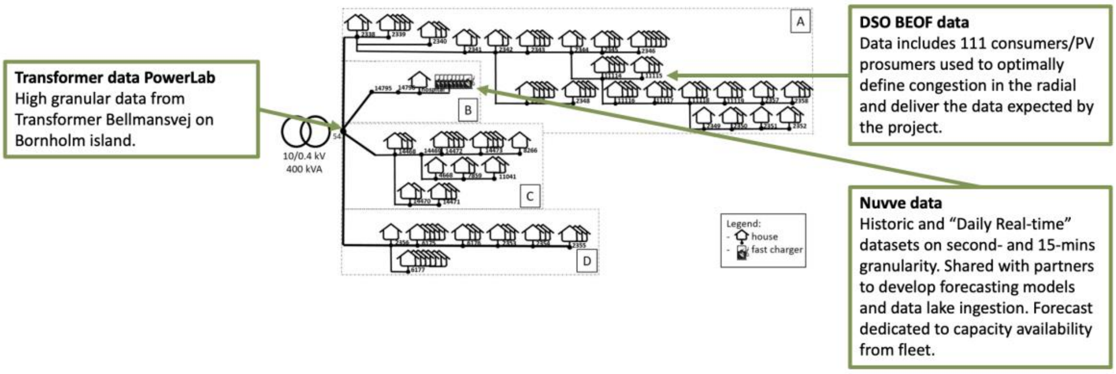


Figure 5: Data sources and simplified topology in the Danish demonstration site

IT environment

Nuvve is able to operate the fleets with high-resolution and to collect operational data through [redacted]. Nuvve has shared the data with ad-hoc tools connecting with servers but not affecting the production environment. Data have been anomized, resampled and cleansed by Nuvve before sharing, also to remove critical business operation market information.

Legal requirements (GDPR, specific national laws…)

- Grant Agreement signed permits to share data under specific ruled and with defined partners in a protected way.
- Danish Data Protection Act.
- NDA document was signed between the local DSO and Nuvve for sharing topology and grid anonymized datasets.

Specific needs in equipment (servers, sensors, gateways…)

- Fleet data: metering system with high resolution [redacted] are installed intenrall of each charging station, connected with Nuvve server with stable internet connection.

Specific needs in technical support (Data collection or interface..)

- ATOS and ICOM have supported the data ingestion process by harmonizing with the object models and creating adaptors for the correct storing of the data. Data have been harmonized from the Nuvve SFTP server to the BD4OPEM marketplace.

Constraints identified from the demonstration site

- [redacted]
- [redacted]
- Inadequate data compared to service requirements

3.3 Danish Pilot motivations (update from D7.1 OPEN DEI)

The 2021 OPEN DEI manifesto, attached for reference, outlines the motivations and decisions behind the pilot project in Denmark. The manifesto's contents remain unchanged over the past years, reflecting consistency with the company's business model and the commitments and rationale behind the pilot.

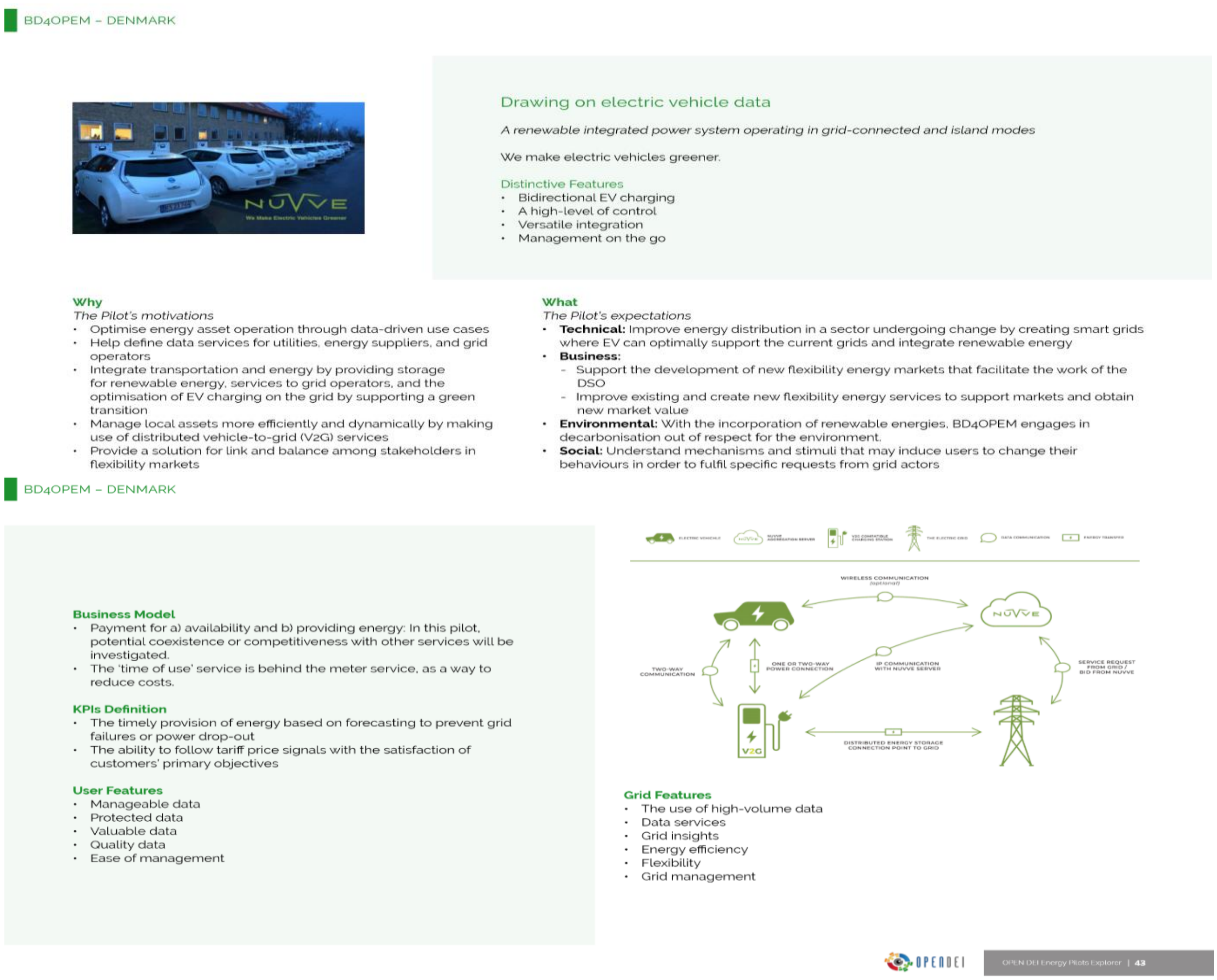


Figure 6 - 2021 OPEN DEI manifesto

3.4 Recap table of services to be implemented

Table 5: Table of services implemented in Nuvve pilot site

Service ID	Name of service	Service developer
S3.1	Grid disturbance simulations (Congestions forecast for day ahead)	UPC, WEP
S3.2	Impact study PV, EV & new loads	ODT
S5.1	Flexibility forecast (UPC approach)	UPC, ICOM
S5.4	EV to Grid	NUVVE
S8.1	Asset and investment planning	UPC, WEP

4. Services results for the Danish demonstration site

4.1 S3.1 – Grid disturbance simulations results

4.1.1 UPC approach: Congestions forecast for day ahead

4.1.1.1 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 6: Use cases for the S3.1 service

Use case	Description
UC1	As a grid analyst, you wish to know in advance the forecast of the demand you are facing in your loads for the next day
UC2	As a grid analyst, you want to know if you are going to have congestions in your lines, following the forecasted loads. This is necessary to plan the flexibility dispatch (if available) for the next day

4.1.1.2 Use Case 1

Danish pilot was a special case as they are not a distribution system operator, hence, some data used for these results had to be linearly interpolated. This service is of particular interest for the pilot as they have a deployment of EVs in the grid. Therefore, knowing the forecasted demand and possible congestions in the grid is highly useful.

Reviewing the historical demand, the service offers the deterministic forecasted demand for aggregated sources and the total amount of power in the grid for each hour, as shown in Figure 7. This is an interesting result as the analyst can know what the peak hour will be at a first glance, by using the service UI. In this example, it is obvious that the peak will occur at 10:15h. It is also possible to check and analyse the forecasted demand for each of the loads in the grid, using the dropdown on the right. The analyst can select a specific load, which can be of specific interest for the pilot, for any particular reason.

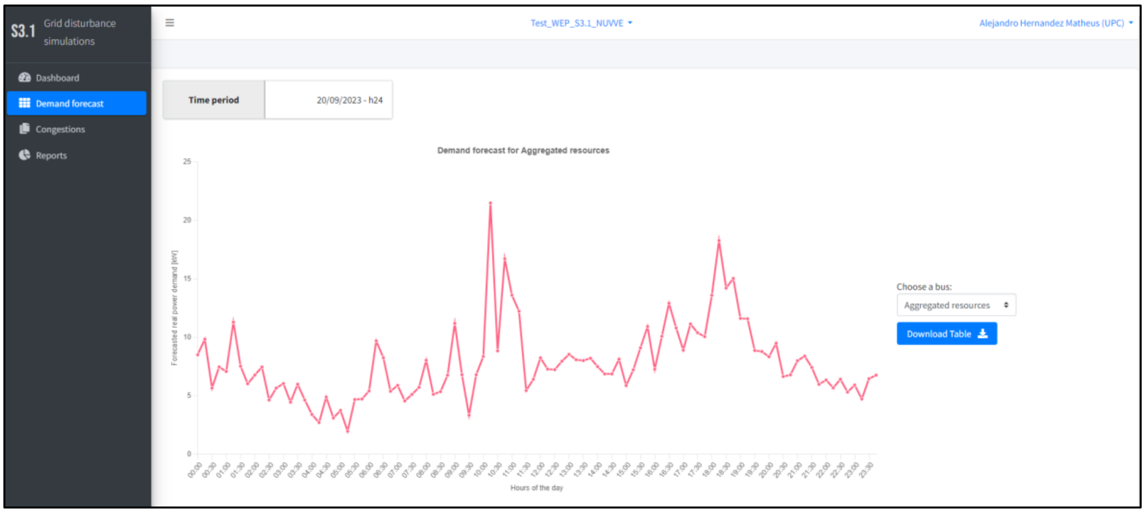


Figure 7: Aggregated demand

In Figure 8, we can observe the day-ahead profile of the load for Client 18. This can be done with any other load. Additionally, the tool allows the analyst to download the table in an spreadsheet format (i.e. excel), as demonstrated in Figure 9. This for all the results of any load in case they wish to generate more detailed reports.

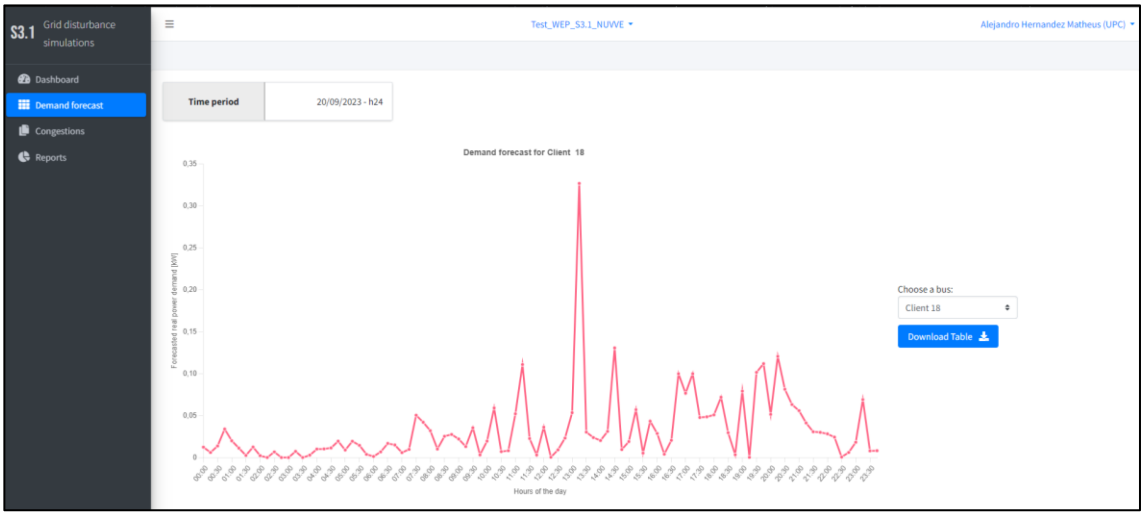
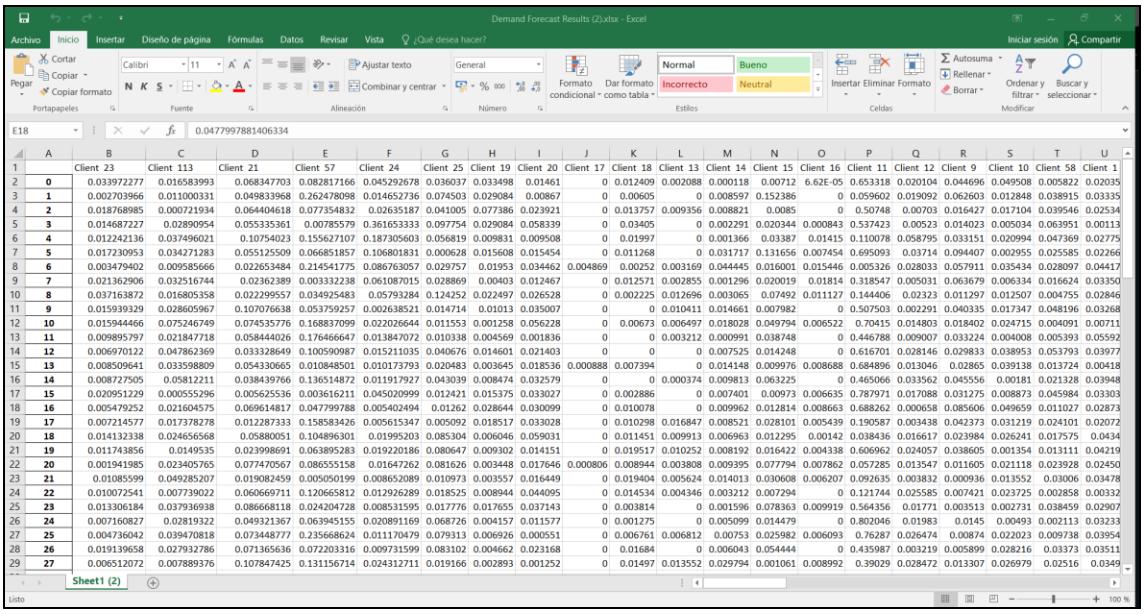


Figure 8: Forecast Demand for Load Client 18



	Client 23	Client 113	Client 21	Client 57	Client 24	Client 25	Client 19	Client 20	Client 17	Client 18	Client 13	Client 14	Client 15	Client 16	Client 11	Client 12	Client 9	Client 10	Client 58	Client 1
0	0.033972277	0.016583993	0.068347703	0.082817166	0.045292678	0.036037	0.033498	0.01461	0	0.012409	0.002088	0.000118	0.00712	6.62E-05	0.653318	0.020104	0.044696	0.049508	0.005822	0.02035
1	0.002703966	0.011000331	0.049833968	0.262478098	0.014652736	0.074503	0.029084	0.00867	0	0.00605	0	0.008597	0.152386	0	0.059602	0.019092	0.062603	0.012848	0.038915	0.03335
2	0.018768985	0.000721934	0.064404618	0.077354832	0.02635187	0.041005	0.077386	0.023921	0	0.013757	0.009356	0.008821	0.0085	0	0.50748	0.00703	0.016427	0.017104	0.039546	0.02534
3	0.014687227	0.02890954	0.055335361	0.00785579	0.361653333	0.097754	0.029084	0.058339	0	0.03405	0	0.002291	0.020344	0.000843	0.537423	0.00523	0.014023	0.005034	0.063951	0.00113
4	0.012242136	0.037496021	0.10754023	0.155627107	0.187305603	0.056819	0.009831	0.009508	0	0.01997	0	0.001366	0.03387	0.01415	0.110078	0.058795	0.033151	0.020994	0.047369	0.02775
5	0.017230953	0.034271283	0.055125509	0.066851857	0.106801831	0.000628	0.015608	0.015454	0	0.011268	0	0.031717	0.131656	0.007454	0.695093	0.03714	0.094407	0.002955	0.025585	0.02266
6	0.003479402	0.009585666	0.022653484	0.214541775	0.086763057	0.029757	0.01953	0.034462	0.004869	0.00252	0.003169	0.044445	0.016001	0.015446	0.005326	0.028033	0.057911	0.035434	0.028097	0.04417
7	0.021362906	0.032516744	0.02362389	0.003332238	0.061087015	0.028869	0.00403	0.012467	0	0.012571	0.002855	0.001296	0.020019	0.01814	0.318547	0.005031	0.063679	0.006334	0.016624	0.03350
8	0.037163872	0.016805358	0.022299557	0.034925483	0.05793284	0.124252	0.022497	0.026528	0	0.002225	0.012696	0.003065	0.07492	0.011127	0.144406	0.02323	0.011297	0.012507	0.004755	0.02846
9	0.015939329	0.028605967	0.107076638	0.053759257	0.002638521	0.014714	0.01013	0.035007	0	0	0.010411	0.014661	0.007982	0	0.507503	0.002291	0.040335	0.017347	0.048196	0.03268
10	0.015944466	0.075246749	0.074535776	0.168837099	0.022026644	0.011553	0.001258	0.056228	0	0.00673	0.006497	0.018028	0.049794	0.006522	0.70415	0.014803	0.018402	0.024715	0.004091	0.00711
11	0.009895797	0.021847718	0.058444026	0.176466647	0.013847072	0.010338	0.004569	0.001836	0	0	0.003212	0.000991	0.038748	0	0.446788	0.009007	0.033224	0.004008	0.005393	0.05592
12	0.006970122	0.047862369	0.033328649	0.100590987	0.015211035	0.040676	0.014601	0.021403	0	0	0	0.007525	0.014248	0	0.616701	0.028146	0.029833	0.038953	0.053793	0.03977
13	0.008509641	0.033598809	0.054330665	0.010848501	0.010173793	0.020483	0.003645	0.018536	0.000888	0.007394	0	0.014148	0.009976	0.008688	0.684896	0.013046	0.02865	0.039138	0.013724	0.00418
14	0.008727505	0.05812211	0.038439766	0.136514872	0.011917927	0.043039	0.008474	0.032579	0	0	0.000374	0.009813	0.063225	0	0.465066	0.033562	0.045556	0.00181	0.021328	0.03948
15	0.020951229	0.000555296	0.005625536	0.003616211	0.045020999	0.012421	0.015375	0.033027	0	0.002886	0	0.007401	0.00973	0.006635	0.787971	0.017088	0.031275	0.008873	0.045984	0.03303
16	0.005479252	0.021604575	0.069614817	0.047799788	0.005402494	0.01262	0.028644	0.030099	0	0.010078	0	0.009962	0.012814	0.008663	0.688262	0.000658	0.085606	0.049659	0.011027	0.02873
17	0.007214577	0.017378278	0.012287333	0.158583426	0.005615347	0.005092	0.018517	0.033028	0	0.010298	0.016847	0.008521	0.028101	0.005439	0.190587	0.003438	0.042373	0.031219	0.024101	0.02072
18	0.014132338	0.024656568	0.05880051	0.104896301	0.01995203	0.085304	0.006046	0.059031	0	0.011451	0.009913	0.006963	0.012295	0.00142	0.038436	0.016617	0.023984	0.026241	0.017575	0.0434
19	0.011743856	0.0149535	0.023998691	0.063895283	0.019220186	0.080647	0.009302	0.014151	0	0.019517	0.010252	0.008192	0.016422	0.004338	0.606962	0.024057	0.038605	0.001354	0.013111	0.04219
20	0.001941985	0.023405765	0.077470567	0.086555158	0.01647262	0.081626	0.003448	0.017646	0.000806	0.008944	0.003808	0.009395	0.077794	0.007862	0.057285	0.013547	0.011605	0.021118	0.023928	0.02450
21	0.01085599	0.049285207	0.019082459	0.005050199	0.008652089	0.010973	0.003557	0.016449	0	0.019404	0.005624	0.014013	0.030608	0.006207	0.092635	0.003832	0.000936	0.013552	0.03006	0.03478
22	0.010072541	0.007739022	0.060669711	0.120665812	0.012926289	0.018525	0.008944	0.044095	0	0.014534	0.004346	0.003212	0.007294	0	0.121744	0.025585	0.007421	0.023725	0.002858	0.00332
23	0.013306184	0.037936938	0.086668118	0.024204728	0.008531595	0.017776	0.017655	0.037143	0	0.003814	0	0.001596	0.078363	0.009919	0.564356	0.01771	0.003513	0.002731	0.038459	0.02907
24	0.007160827	0.02819322	0.049321367	0.063945155	0.020891169	0.068726	0.004157	0.011577	0	0.001275	0	0.005099	0.014479	0	0.802046	0.01983	0.0145	0.00493	0.002113	0.03233
25	0.004736042	0.039470818	0.073448777	0.235668624	0.011170479	0.079313	0.006926	0.000551	0	0.006761	0.006812	0.00753	0.025982	0.006093	0.76287	0.026474	0.00874	0.022023	0.009738	0.03954
26	0.019139658	0.027932786	0.071365636	0.072203316	0.009731599	0.083102	0.004662	0.023168	0	0.01684	0	0.006043	0.054444	0	0.435987	0.003219	0.005899	0.028216	0.03373	0.03511
27	0.006512072	0.007889376	0.107847425	0.131156714	0.024312711	0.019166	0.002893	0.001252	0	0.01497	0.013552	0.029794	0.001061	0.008992	0.39029	0.028472	0.013307	0.026979	0.02516	0.0349

Figure 9: Table of demand forecast in excel format

4.1.1.3 Use Case 2

For the analysis of the congestions, this tool offers a congestion monitoring where the analyst can see the forecasted current (in kiloAmpers – kA), for each of the lines in the distribution grid. As seen in Figure 10, 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 displayed, in order to know if a congestion will occur.

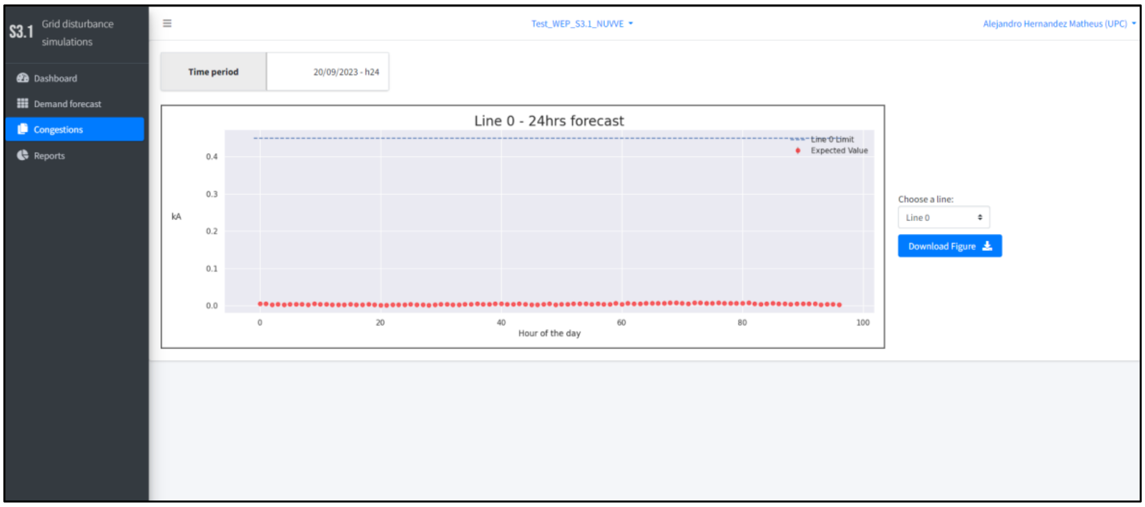


Figure 10: Line 0 forecast

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

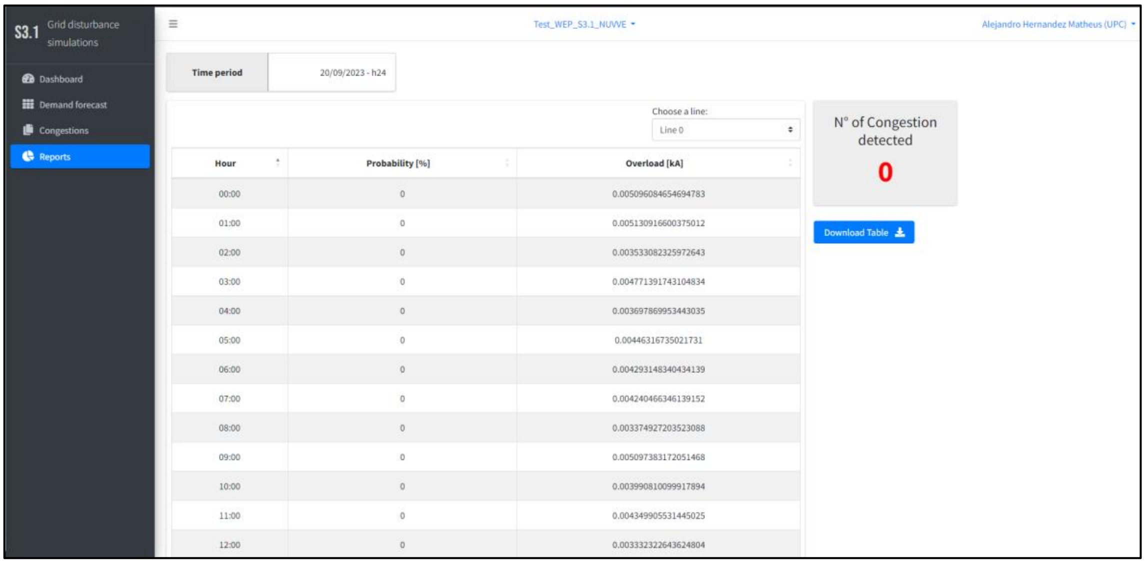


Figure 11: Report tab

4.1.1.4 Data assessment

The data required to establish the service mainly comprehends topology and 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 7.

Table 7: Data assessment for the S3.1 service

Data source needed	Mapping into CIM	Data quality assessment	Impact of the quality on the service
Grid Topology	Service_parameters	Good quality	Medium
Historical measurements	Smart_Meter	Missing values and Low energy consumptions	High

4.1.1.5 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 is an important drawback to the applicability of the service towards grids that change their topologies often. In the case of the Danish pilot, there are not many congestions historically. This demonstration site not involving a DSO but Nuvve, V2G technology provider, measuring congestions in lines and comparing results was not possible. Nonetheless, Nuvve has shared information, topology and data, from the DSO of Bornholm. Such collaboration and validation would be interesting in future works. The approach could be different by exploring voltage congestions. Additionally, the service is very data intensive, so adding features and prediction variables adds more complexity to its execution.

The results of this service could be highly useful for a company such as NUVVE, knowing in advance demand in certain points of the grid, could help to deploy energy management strategies for their EVs charger, increasing the benefit as well as the value the technology could provide to its users.

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 kiloAmperes (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 S3.2 – Impact study PV, EV & new loads results

4.2.1.1 Introduction of the service

Name: Impact Study PV, EV and new loads
Category: Planning
Task: T4.1
Location on the grid: LV

This service allows to estimate the capacity of a network to accommodate new solar photovoltaic (PV) panels, EVs, or consumers, regarding the limitations of the network (voltage excursions or overload). The second functionality of this service is to evaluate the impact of a new installation (PV, EV, or new load) by estimating the residual capacity after this installation.

Table 8: Use cases for the S3.2 service

Use case	Description
UC1	**As a:** Planning operator of the DSO **I want to**: Know the already installed production at each smart meter **So that I can:** Plan better the reinforcements in the medium voltage grid and have a simpler communication inside and outside of my structure **Acceptance criteria:** When I query a smart meter, I get the installed production instantly in kWp

Use case	Description
UC2	**As a:** Planning operator of the DSO **I want to**: Know the production / additional load capacity of all my smart meters **So that I can:** Accept a production / additional load insertion request with a given nominal value that does not exceed the maximal available capacity **Acceptance criteria:** When I query a smart meter, I get the maximal value of PV installable instantly in kWp
UC3	**As a:** Planning operator of the DSO **I want to**: Visualise the production / additional load capacity of a smart meter with respect to the phase **So that I can:** Provide the optimal phase for production / additional load insertion on each smart meter **Acceptance criteria:** When I run a new production / charge simulation with my requirements, the optimal phase is given as a result
UC4	**As a:** Planning operator of the DSO **I want to**: Simulate the installation of a new production / additional load **So that I can:** See how the new installation influences the rest of the grid **Acceptance criteria:** I can add a new production / additional load in simulation and see the residual capacity per meter. I can also add a smart meter to the waiting list, it will be considered in all subsequent simulations.

Table 8 summarizes the user story as designed and developed in the framework of WP4 and reported in D4.2 [5].

Figure 12 links all use cases together in order to better explain the workflow to the user, in the case of a PV installation.

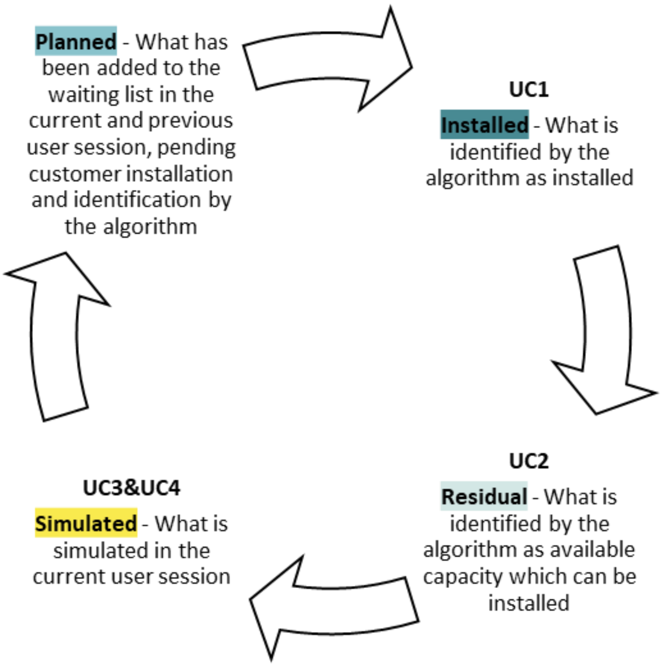


Figure 12: Impact study workflow

According to the demonstration site specificities, PV, EV and new load use cases have been adapted and deployed with the following results.

4.2.1.2 Demonstration site specificity and service deployment perimeter

In the case of NUVVE demonstration site, the perimeter of deployment of the service S3.2 has been the secondary substation Bellmansvej 54 described in 3.2. For this secondary substation the following data was used:

- load curve from smart meters
- load curve of the secondary substation
- load curve from EV charging stations
- the topology with secondary substation/feeder/smartmeter connection information

[redacted]. In its design, the optimization model behind the service S3.2 computes the simulation taking into account two different constraints:

- The addition of an installation which power is equivalent to the residual capacity must not trigger additional voltage excursions.
- The addition of an installation which power is equivalent to the residual capacity must not make the transformer go beyond its nominal capacity.

[redacted]

4.2.1.3 Use Case 1

Based on the smart meter load curves, the PV detection algorithm detected a PV installation on the meter 62. The equivalent kWp of the installation detected is 24.1 kWp.

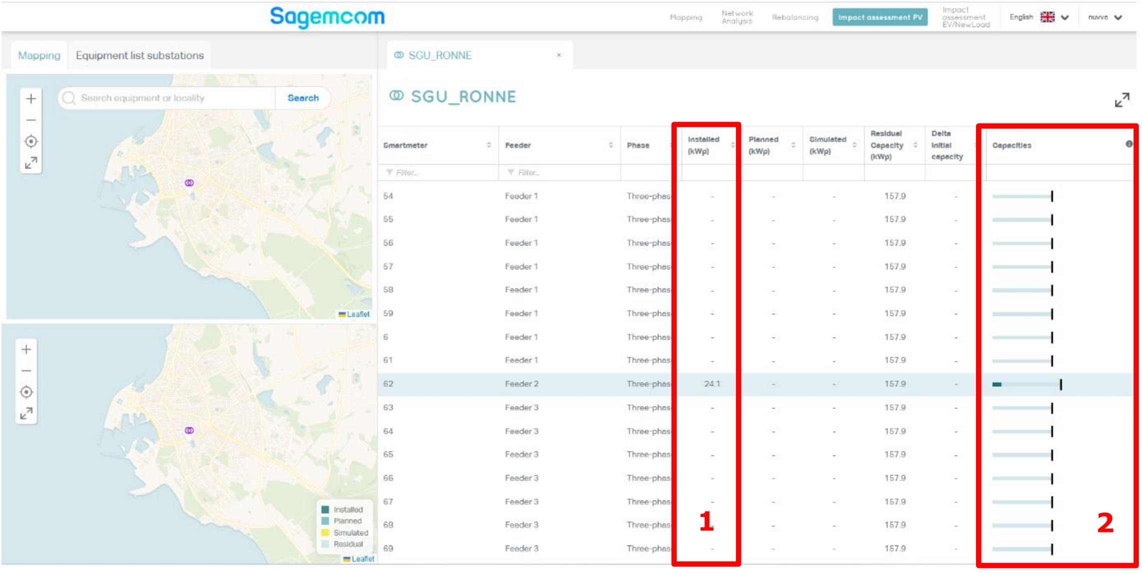


Figure 13: Installed capacity in Bellmansvej 54

The "Installed" column (red rectangle 1) and the "Capacities" column (red rectangle 2) display the capacity accordingly, in dark green in Figure 13.

Thanks to this information, the operator is aware of the current production level of a part of the grid, while other databases regarding PV installations might reflect an outdated picture (installation decommissioned without noticing the DSO), not yet valid (installation validated by the DSO but not yet commissioned) or not behaving as expected (underperforming assets compared to kWp installed due to low maintenance, shadows…). This detection, based on production data provides an accurate kWp equivalent of the installations.

4.2.1.4 Use Case 2

Upon customer's request, the operator can navigate to the associated transformer (only one in this case) and get access to the residual production capacity of the customer's smart meter. Such capacity is available in the "Residual Capacity" column (red rectangle 3) and can be visualized together with the installed capacity in column (red rectangle 2) in light blue, see Figure 14.

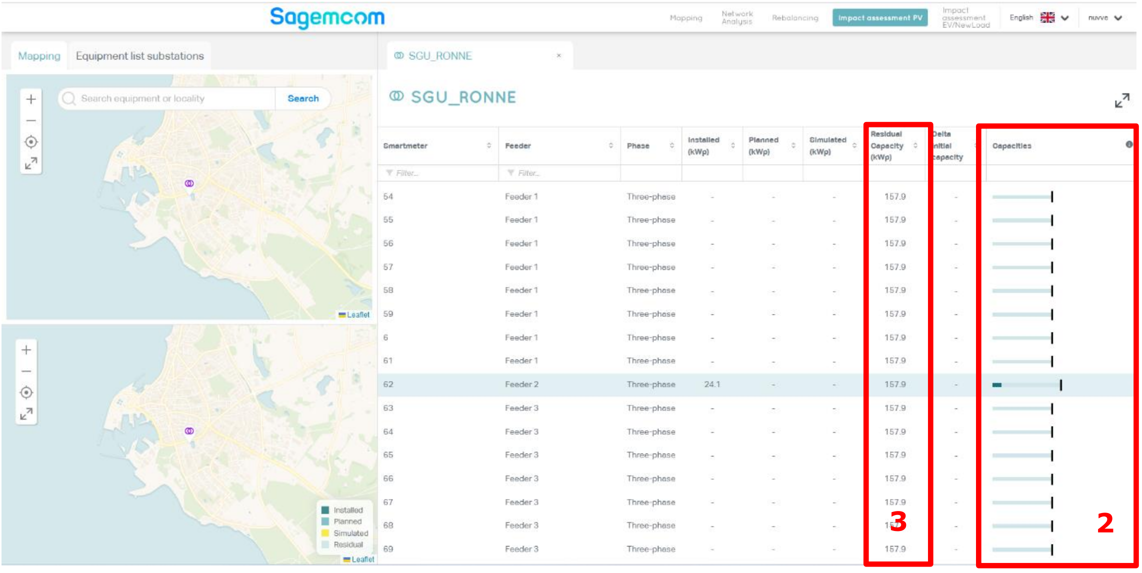


Figure 14: Residual capacity in Bellmansvej 54

It is worth mentioning that here, without taking into account the voltage excursions as a constraint as they were absent from the demonstration site dataset, residual capacity is constant across the transformer and equal to the residual capacity sized by the transformer nominal load.

4.2.1.5 Use Cases 3 and 4

By clicking on one of the smart meters in the table (red rectangle 4 in Figure 15), a modal window opens (see Figure 16).

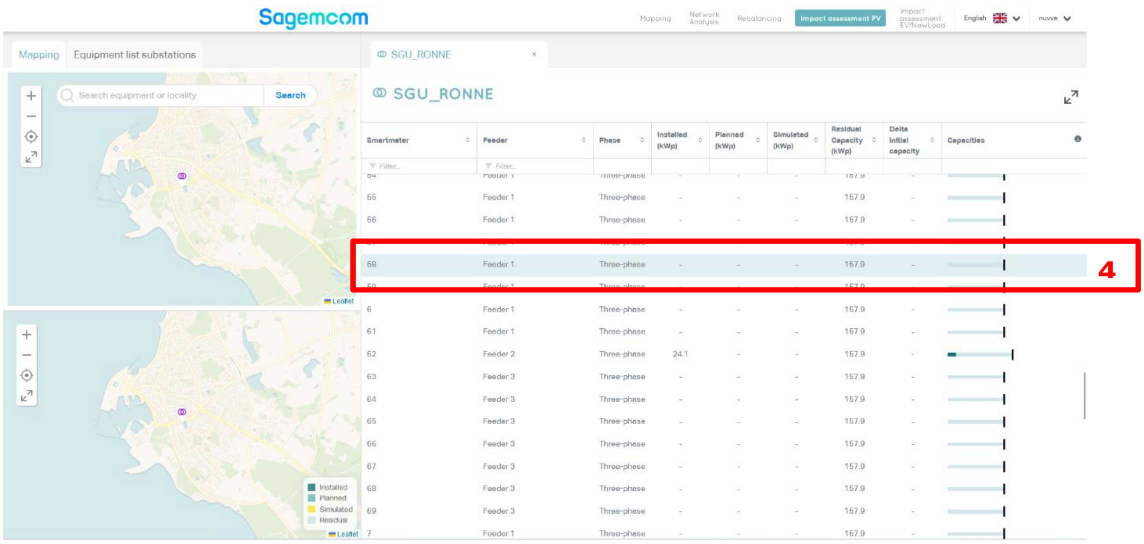


Figure 15: Access to modal window to launch the simulation in Bellmansvej 54

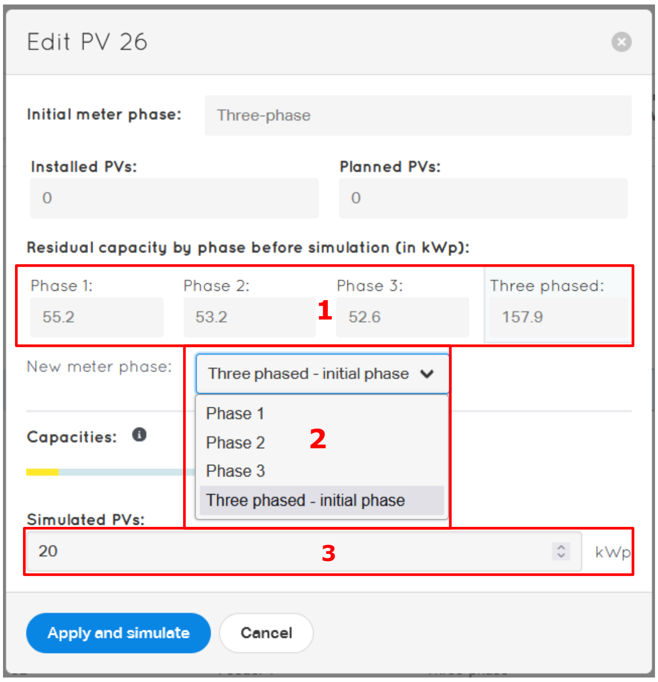


Figure 16: Modal window for phase selection and kWp configuration in Bellmansvej

This modal embeds all the different configurations possible to simulate a new installation. The service analyses the LV network under a 3-phase paradigm and not following the classical single-phase approximation for LV studies. This enables to unlock additional capacity by considering not only the available capacity of the phase on which the smart meter is connected to but also the one of other phases at the same point in the network or the one considering a three-phase installation.

From a user perspective, all capacities are displayed in the cells in red rectangle 1 (Figure 16), by default the current smart meter configuration is selected but if the user would like to perform a change, a drop-down menu (red rectangle 2) enables to change the phase or type of installation.

Once this is done, the user can enter the requested capacity (as long as it is below the computed residual capacity) and click on "Apply and simulate".

When the computation is done the "Simulated" column is updated with the new installation configured by the user. In case a change in the phase has been performed, the user interface (UI) indicates so by displaying an exclamation mark next to it (!). In the "Capacities" column, the installation can be visualized together with the installed capacity and the residual capacity in yellow (see Figure 17).

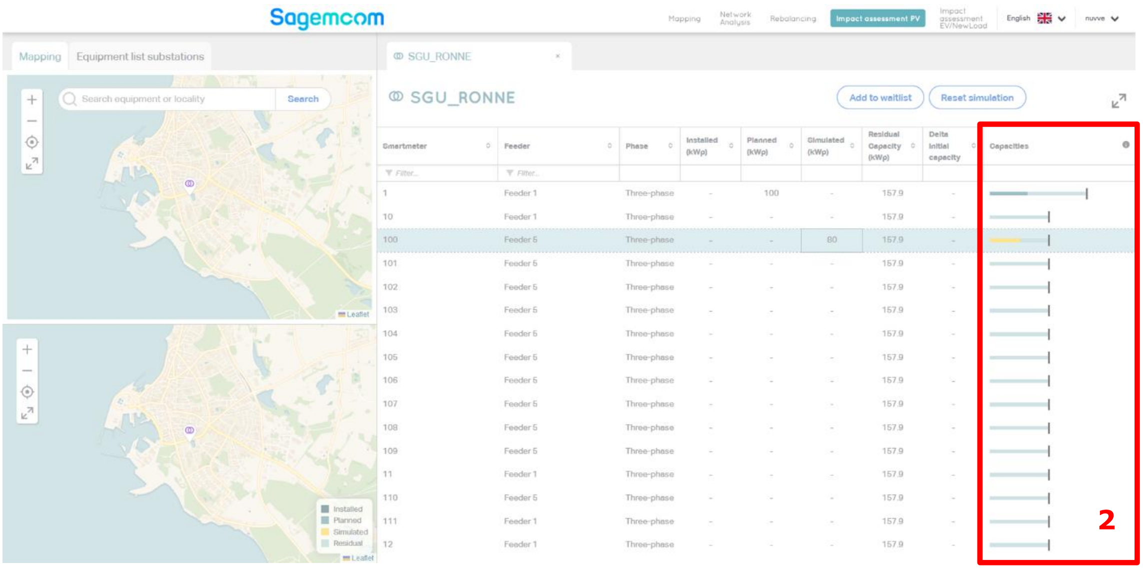


Figure 17: Simulated capacity in Bellmansvej 54

The residual capacity of all other smart meters and the delta compared to the previous situation are updated in the relevant columns.

If the user is satisfied with the simulation results, the button "Add to waitlist" enables saving the information. The simulated installation changes status to "Planned", updating the columns and switching the capacity from yellow to medium blue. This planned installation will be taken into account for future simulation and transferred to "Installed" status when installed on the field and once the algorithm identify it.

Regarding EV and new load, a dedicated tab, see red rectangle 1 in Figure 19, following the same approach has been developed and deployed. However, the workflow is slightly changed because "EV and new loads" are not predictable electrical loads, compared to PV and therefore the "Installation assessment" in UC1 is not relevant, see updated Figure 18.

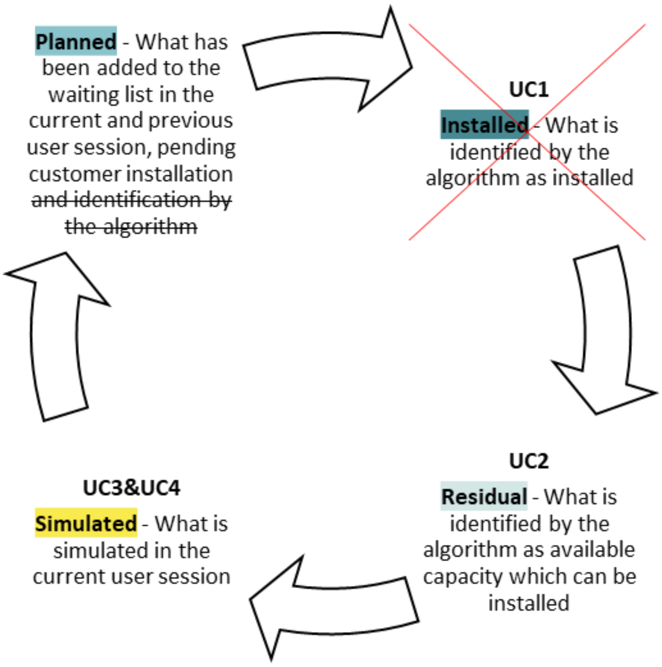


Figure 18: Workflow for EV and new loads impact assessment

The residual capacity is considered in the worst-case scenario: upon simulating a given additional load at a delivery point, the model runs the simulation with this point having a constant additional power equal to such load. The same constraints as for PV remains in the absence of voltage data: to do not make the transformer go beyond its nominal capacity.

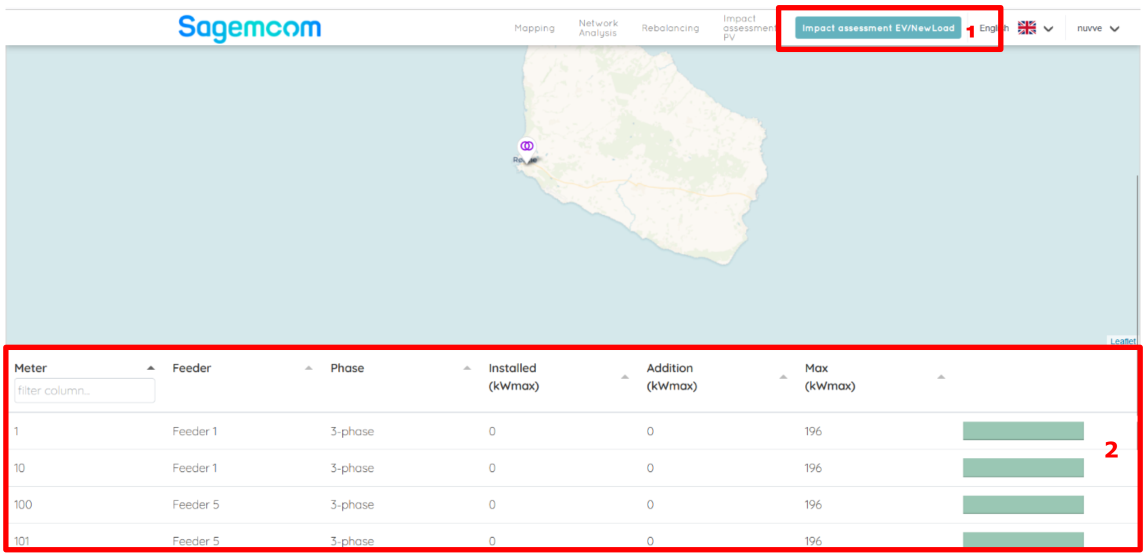


Figure 19: EV/New load tab for Bellmansvej 54

A similar table, see red rectangle 2 in Figure 19, provides the different capacities across the workflow. Upon clicking on a smart meter line, a modal window opens and enables to simulate the addition of an EV charging infrastructure (see Figure 20).

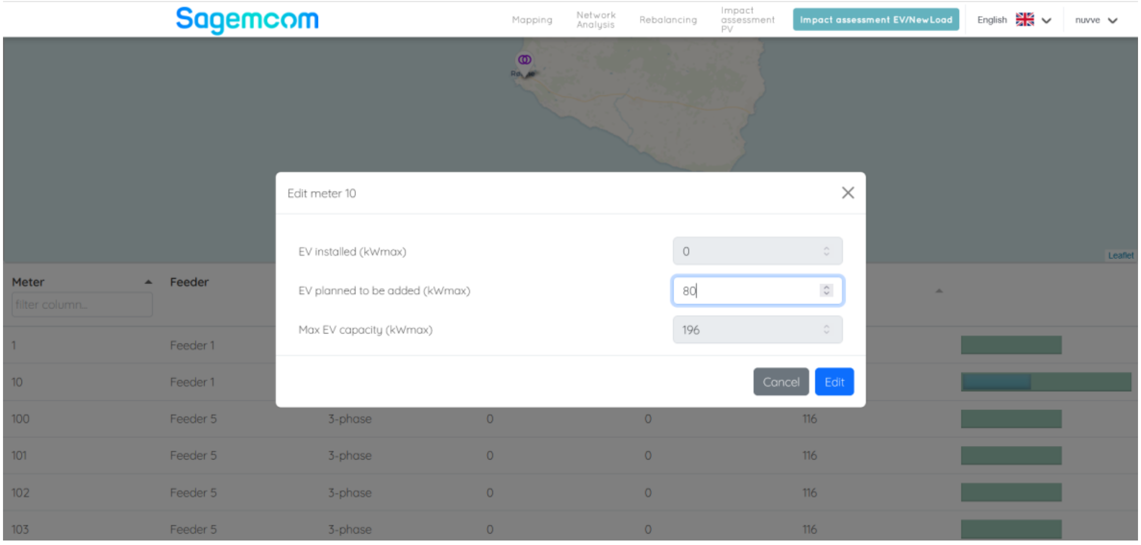


Figure 20: EV addition modal window in Bellmansvej 54

Such addition can be computed in the model and then saved for later user sessions.

4.2.1.6 Data assessment

Table 9: Data assessment table for service S3.2

Data source needed	BD4OPEM Ontology	Data quality assessment	Impact of the quality on the service
For each SM: Voltage profiles per phase	Smart_Meter	Not available	High impact Topology could be provided on this demonstration site which reduced the impact on the service
For each SM: Active power profiles per phase	Smart_Meter	Good quality EVSE were considered as smart meters here, the high frequency of the data as been resampled to be synchronized with other data points	High impact
Reactive power profile per phase (optional)	Smart_Meter	Not available	Low impact
Geographical coordinates of meters (optional)	Location	Not available	Low impact on algorithm performance

Data source needed	BD4OPEM Ontology	Data quality assessment	Impact of the quality on the service
			Reduced quality of the user experience
Substation power and voltage profiles (optional)	Secondary_Substation	Load curves: Good quality Voltage profile: not available	Low impact
Weather irradiance time series (optional)	Weather data	Not available	NA

4.2.1.7 Service conclusions

The deployment and testing of S3.2 Impact Study PV, EV and new loads in the NUVVE demonstration site offers a proof of concept of its adaptability to partial dataset. Even in the absence of the voltage data, the complete workflow can be executed to provide the service to the user. Instead of managing simultaneously voltage level and transformer load, this version in partial operation only addresses the later.

It appears though that the integration of geographical coordinates would have helped to benefit from all features and to provide a more intuitive and navigable user interface, enhancing the accessibility and clarity of the results. This appears as a key aspect in the designed service and is necessary for future deployments.

The project enabled to thoroughly test the service across different demonstration site. Future work should focus on three key aspects highlighted by the project's experience: validation, computation time and additional features.

First, a cross validation of results with on-site installation and before-after evaluation of capacities would be interesting to bring additional trust to the results. Second, the current model has long computation time which jeopardize the user experience, improving it is necessary to provide a more efficient and responsive service, with higher scalability. Finally, EVs and new load tab is not as advanced as the PV tab. This is because EVs do not benefit of the same predictability and regulatory maturity as PV does, especially when it comes to flexible behavior which are still under design in most markets. This service is a significant milestone into Odit-e's journey to address EV's related planning issues but further market research and need assessment are required. As the industry evolves, aligning the service with the growing demands and complexity of integrating new technologies such as EVs will be essential for its exploitation.

4.3 S5.1 – Flexibility Forecast results

4.3.1.1 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 10 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.

4.3.1.2 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 21 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 flexibility available mainly when people are at work (10h – 19h) or asleep, during the night.

The analyst can download the graph (it will be downloaded as in Figure 22) and the data as an excel file (as in Figure 23).

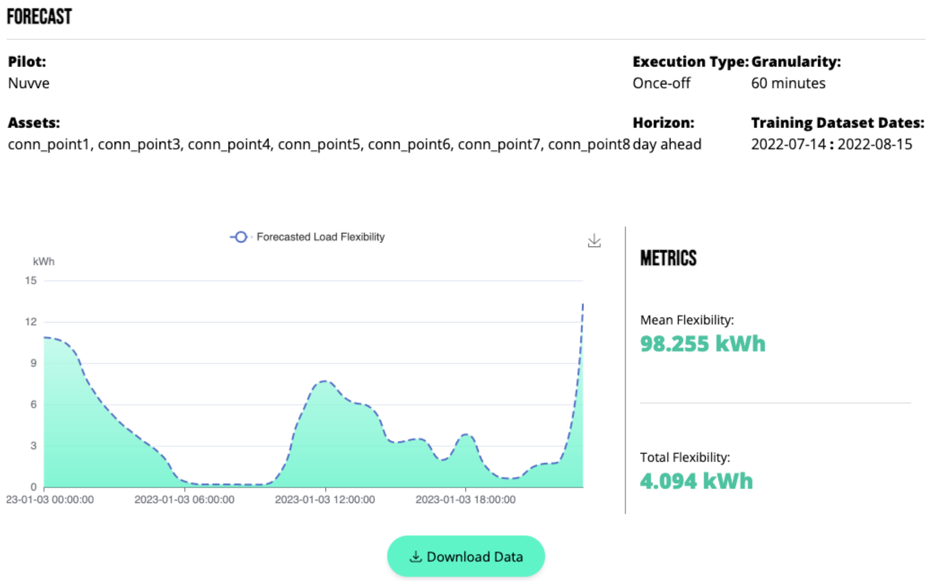


Figure 21: Forecast 24h ahead of Flexibility Availability ("Forecast" section of the UI)

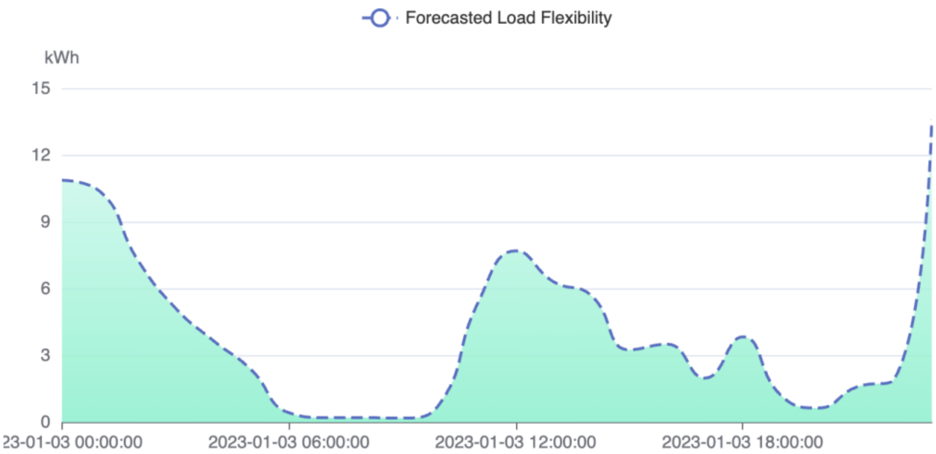
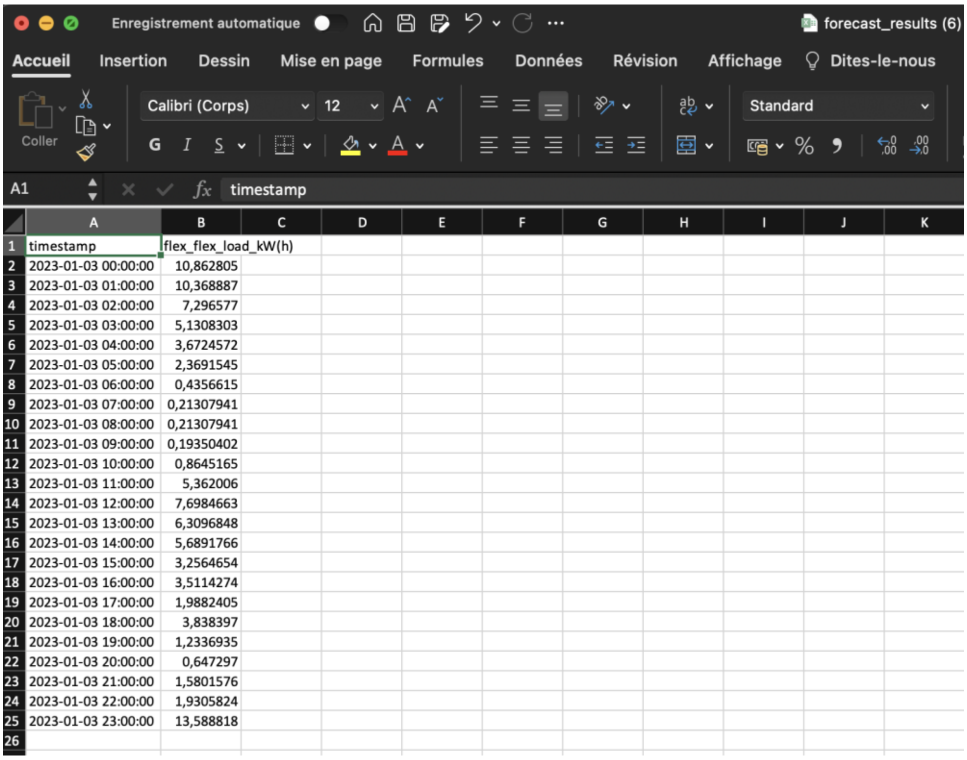


Figure 22: Plot downloaded from the UI



	A	B
1	timestamp	flex_flex_load_kW(h)
2	2023-01-03 00:00:00	10,862805
3	2023-01-03 01:00:00	10,368887
4	2023-01-03 02:00:00	7,296577
5	2023-01-03 03:00:00	5,1308303
6	2023-01-03 04:00:00	3,6724572
7	2023-01-03 05:00:00	2,3691545
8	2023-01-03 06:00:00	0,4356615
9	2023-01-03 07:00:00	0,21307941
10	2023-01-03 08:00:00	0,21307941
11	2023-01-03 09:00:00	0,19350402
12	2023-01-03 10:00:00	0,8645165
13	2023-01-03 11:00:00	5,362006
14	2023-01-03 12:00:00	7,6984663
15	2023-01-03 13:00:00	6,3096848
16	2023-01-03 14:00:00	5,6891766
17	2023-01-03 15:00:00	3,2564654
18	2023-01-03 16:00:00	3,5114274
19	2023-01-03 17:00:00	1,9882405
20	2023-01-03 18:00:00	3,838397
21	2023-01-03 19:00:00	1,2336935
22	2023-01-03 20:00:00	0,647297
23	2023-01-03 21:00:00	1,5801576
24	2023-01-03 22:00:00	1,9305824
25	2023-01-03 23:00:00	13,588818
26		

Figure 23 - Excel view of the data downloaded from the UI (actual values y and prediction)

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 on Figure 24.

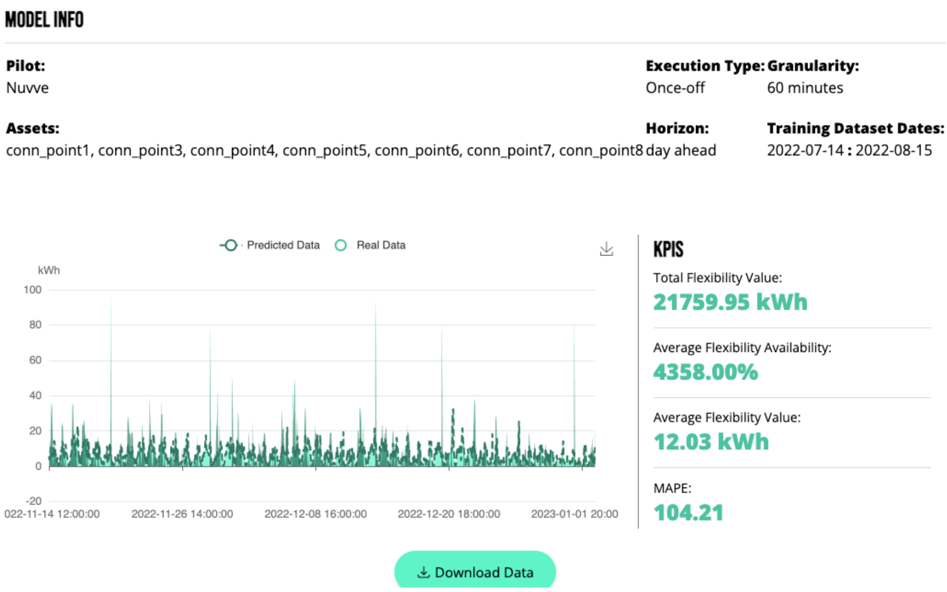


Figure 24: "Model info" section of the UI

4.3.1.3 Data assessment

Table 11 shows the data needs for the service S8.2 in the Belgian pilot and adopts the impact of potential bad data quality. The first row (Flexibility calculation on EV charging station) refers to the requisite to run the simulations, while the second row (EV charging station) is necessary data to assess the flexibility.

Table 11: Data assessment for the S5.1 service

Data source needed	Mapping into CIM	Data quality assessment	Impact of the quality on the service
Flexibility calculation on EV charging station	Point of connection (conn_point1, conn_point2…)	Good	High
EV charging station	activeEnergyImport	Good	High

4.3.1.4 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. The grid has enough EVs available to allow a real flexibility along the day. Indeed, there are only few hours by day where flexibility is available, this misleads the model in the prediction.

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.

4.4 S5.4 – EV to Grid results

4.4.1.1 Introduction of the service

Name: EV to Grid
Category:
Task: T7.5.2
Location on the grid: MV and LV grid

The transportation sector significantly contributes to greenhouse gas emissions. To address this, many countries are advancing the electrification of this sector to meet ambitious sustainability targets. This shift necessitates the appropriate deployment of charging infrastructure and the optimization of charging management. Consequently, the increased penetration of EVs can convert the added stress on the electrical grid into an opportunity to leverage flexibility services. EVs, capable of remaining connected to the grid for extended periods, can be utilized as distributed energy resources within specific electricity market zones.

The potential of V2G systems, combined with intelligent charging solutions, can alleviate the need for extensive grid expansion investments and enhance the stability of the distribution grid. The collective flexibility of charging stations can be aggregated and offered to the DSO as ancillary services, such as network congestion management, activated upon request or in response to congestion forecasts.

The aggregator plays a pivotal role in assessing available flexibility and engaging in a market that responds to grid operator requests, providing a variety of grid services from Medium Voltage (MV) to Low Voltage (LV). Specifically, at the low voltage level, the EV fleet can either absorb or inject electrical energy to aid in power system operations through congestion management services for the DSO.

The objectives of the EV to grid service include:

- Developing an algorithm to provide a comprehensive view of the flexibility available from EVs in pilot location.
- Defining a set of control signals for customers to activate flexibility.
- Enhancing the algorithm toolbox to encompass forecasting and automation.
- Delivering optimal flexibility services for congestion management.
- Delivering flexibility benefits and stacking them with energy arbitrage and carbon savings control, demonstrating the value of discharging to the DSO when electricity prices are typically high (a strategy known as "stacking") – This was added based on the KPI 2.5 of Nuvve. This KPI is aligned with Denmark Electricity Supply Act 2021 made by DanskEnergi and IntelligentEnergi [6]. The electricity grid companies must develop methods for market-based procurement of flexibility services. Activating flexibility in the electricity grid through both tariffs and flexibility services will be a cornerstone in an effective green transition for local grids and nationals power systems.

This service is designed to address congestion issues at the distribution grid level. The power provision of the fleet will be activated based on DSO requests and/or congestion forecasts, primarily focusing on exporting electricity to prevent cable overloading – or absorbing electricity to avoid under-voltage situtations - and ensure smooth grid operation.

Optimal service provision requires understanding both the current and forecasted flexibility capacities that the EV fleet can offer. Moreover, it is essential to have information about the flexibility provided upon request or trigger to assess the effective execution of the flexibility service.

Table 12: Use cases for the S5.4 service

Use case	Description

UC1	**Use Case 1: Flex Upwards - Discharge**
	
	User: Distribution System Operator (DSO or similar) an Service Provider (Nuvve)
	
	Scenario: During times of peak demand, the DSO needs access to additional resources to prevent grid overloading.
	
	Acceptance Criteria:
	
	• Nuvve would need to received a contract request.
	• The Service Provider, Nuvve, must ensure:
	    • **Availability** Nuvve commits to having the EV fleet ready for discharging power, specifying availability in defined hours over a period ranging from 1 day to 1 week.
	    • **Utilization:** Upon receiving a dispatch signal from the DSO during predefined days of congestion, Nuvve executes the discharge from the EVSE to the grid.
	• Nuvve will accept contract request from DSO based on flexibility forecast tools, coming from internal AI tools or similar.
	• The system must record and report the service provision and the KPIs.
	• In addition to providing grid services, Nuvve's discharge strategy should aim to generate savings for customers, effectively stacking the discharge with energy arbitrage and customer savings during high tariff periods. This acceptance criterion ensures that while Nuvve provides essential grid services, it also considers the financial benefits to the EV owners, creating a more attractive proposition for customer participation.

<table>
<tr><th>Use case</th><th>Description</th></tr>
<tr><td>UC2</td><td>Use Case 2: Flex Downwards Day - Charge

User: Distribution System Operator (DSO or similar) and Service Provider (Nuvve)

Scenario: During periods of low demand during the day, the DSO requires the ability to increase grid load through EV charging to maintain grid stability and efficiency.

Acceptance Criteria:
Nuvve must respond to the DSO's contract request for charging services.
Availability: Nuvve commits to having the EV fleet ready for charging, specifying availability in defined hours over a period ranging from 1 day to 1 week.
Utilization: Upon receiving a dispatch signal from the DSO on selected days, typically when there is excess renewable energy generation or low demand, Nuvve executes the charging of EVs from the grid.
Nuvve will agree to a contract request from the DSO based on flexibility forecast tools provided by internal AI tools or similar.
The system must record and report the service provision and the KPIs.
In addition to grid services, Nuvve's charging strategy during the day should maximize customer savings and take advantage of lower energy prices or other financial incentives offered by the DSO.</td></tr>
</table>

Use case	Description
UC3	**Use Case 3: Flex Downwards Night - Charge** **User**: Distribution System Operator (DSO or similar), Service Provider (Nuvve), and EV Owner **Scenario**: To balance the grid during night-time hours when demand is typically lower, the DSO seeks to encourage EV charging, which is facilitated by Nuvve with the involvement of the EV owner. **Acceptance Criteria**: • Nuvve is required to act upon a contract request from the DSO for night-time charging. • **Availability**: Nuvve ensures the readiness of the EV fleet for charging, with availability specified for defined hours across a period ranging from 1 day to 1 week. • **Utilization**: Nuvve initiates charging of the EV fleet upon the DSO's dispatch signal on predetermined nights with lower demand. • Contract acceptance will be based on predictions from Nuvve's flexibility forecast tools, utilizing internal AI or equivalent systems. • The service provision and relevant KPIs must be accurately recorded and reported. • Nuvve's strategy for night-time charging should also provide financial benefits to customers, taking advantage of lower tariffs and potentially offering additional incentives for participation in the grid services program. These use cases are crafted to ensure that they reflect the same level of detail and structure as the first use case, focusing on the availability of service and the actual utilization in response to the DSO's needs, while also considering the financial implications for the customers involved.

4.4.1.2 Demonstration site specificity and service information

Nuvve's backend system integrates a variety of data and operational components, vital for the execution of grid services and for use with the FlexTool in the outlined use cases. The system includes:

- **Congestion Events**: These are records of past FlexTool data on grid congestion, utilized to collect KPIs, operational results, and data audits for DSOs and other stakeholders.

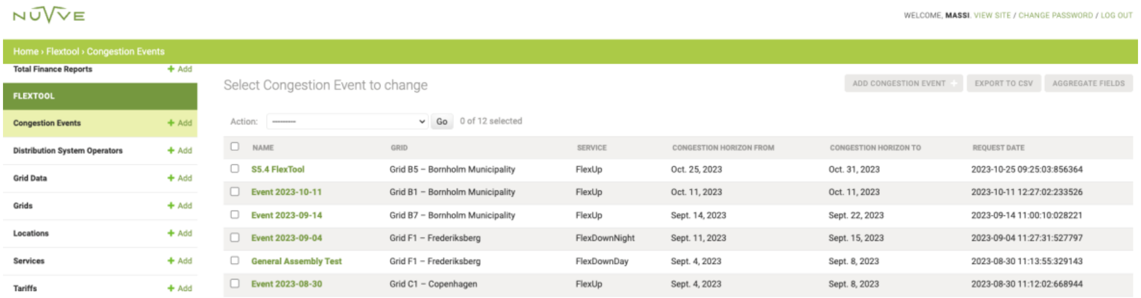


Figure 25: Congestion events

- **Distribution System Operators**: This encompasses information about the various DSOs involved, detailing their specific requirements and interaction protocols with the service provider.

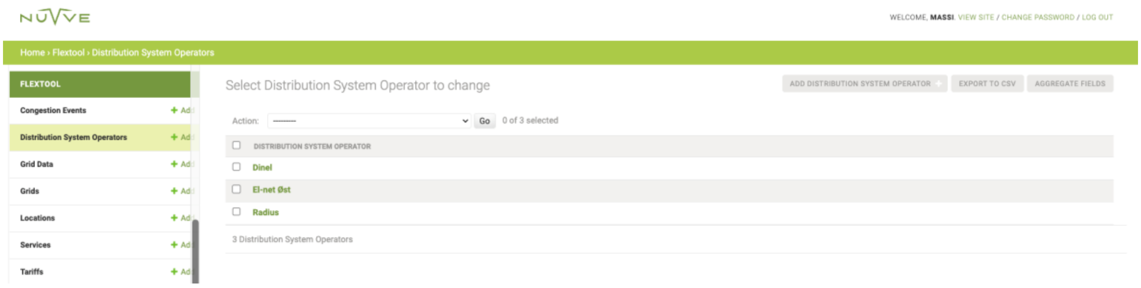


Figure 26: Distribution System Operators list

- **Grid Data**: This refers to historical data on grid operations, which are critical for monitoring and managing energy flow and for making informed decisions. These real data, originating from the DSO of the pilot site, have been reused to create synthetic grid data that is consistent across all grids for the given project.

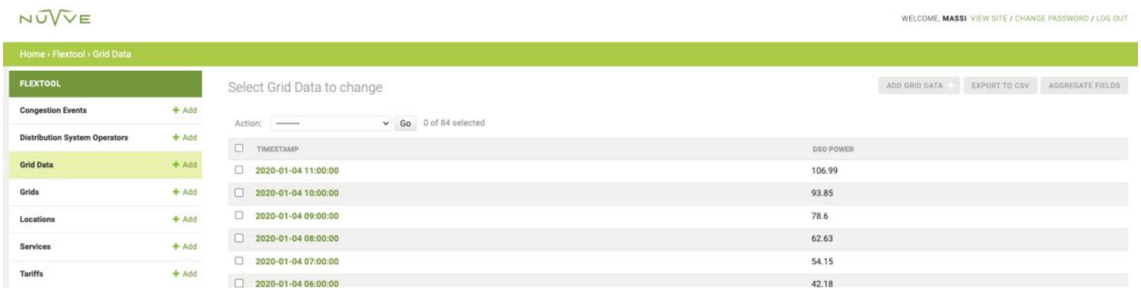


Figure 27: Grid data

- **Grids**: This includes grids and locations where the EVSEs can operate, aligned with the corresponding DSO and tariff names (connected with other databses inside the Nuvve server).

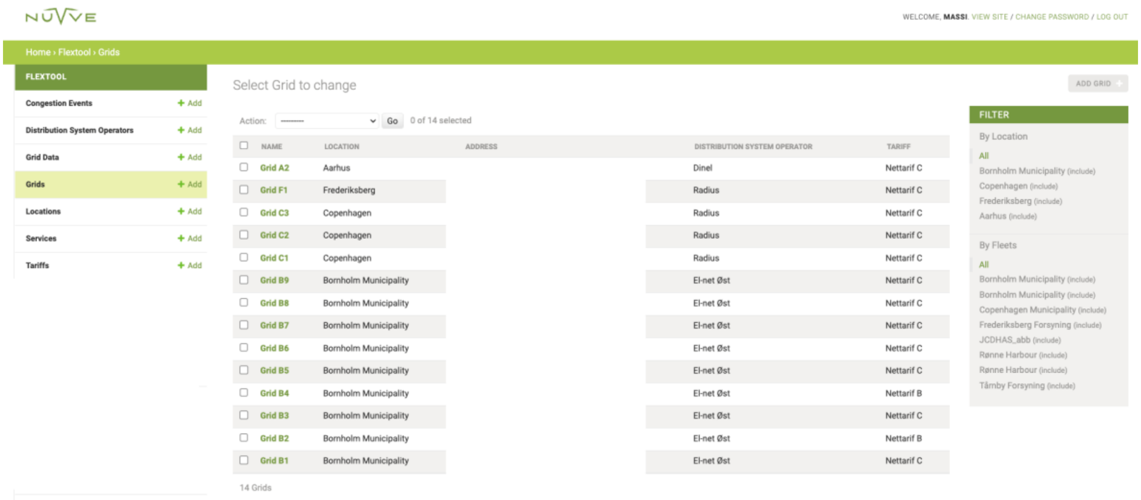


Figure 28: Grids

- **Locations**: Geographic and physical site data are provided, indicating where the grid services are implemented.

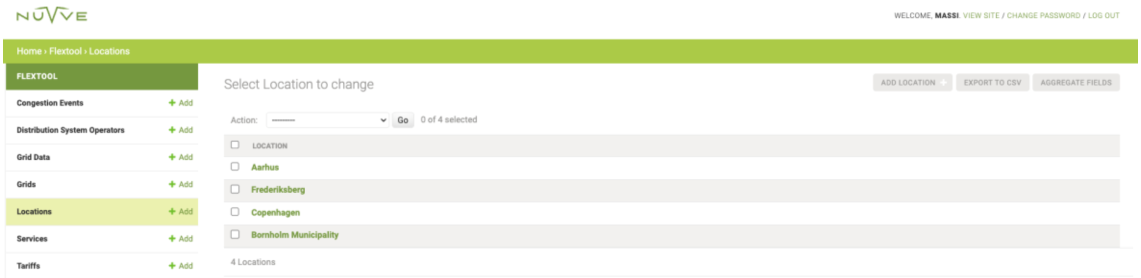


Figure 29: Locations

- **Services**: A catalog of grid services is available, featuring their specifications, conditions of use, and activation processes.
  - **Flex up:** discharging request, usually between 15 and 20
  - **Flex down - day:** charging request in the daily hours, usually between 10 and 14
  - **Flex down - night:** charging request in the night hours, usually between 0 and 4.
  - To be noted that additional services can be manually included by configuring names and hours of provision under "ADD SERVICE", depending on necessity of DSOs and utilities.

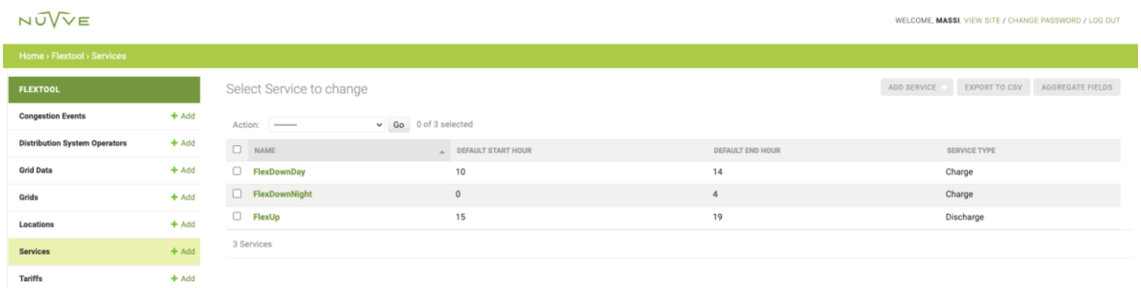


Figure 30: Nuvve grid service list

- **Tariffs**: Detailed tariff information is provided, essential for energy arbitrage, cost-saving strategies, and the financial aspects of grid services.

The backend system's architecture is thus crucial in offering a solid base for handling the intricacies of grid services, presenting a comprehensive strategy for energy management and DSO collaboration.

Note: All this information is updated with real data or maintained for use in FlexTool testing. Additional real data can be sourced via API or other mechanisms, enhancing the realism and performance of these use cases. Forecasting tools are actively used on a daily basis.

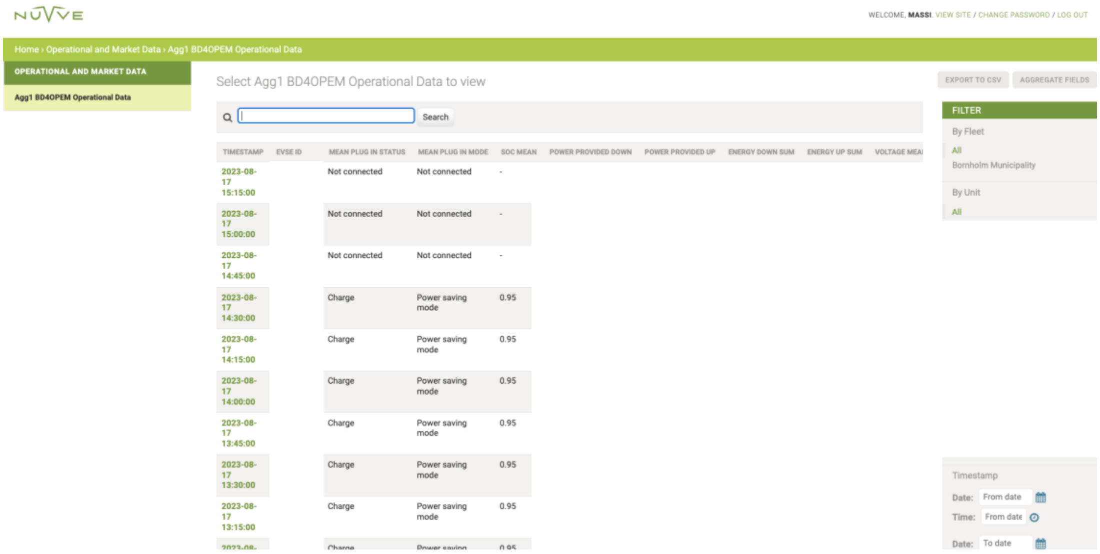


Figure 31: Operational V2G fleet data

In the backend, also the EVSE operational data are stored and used for forecasting tools with AI and utilized in FlexTool. [redacted] Internal forecasting on Grace platform tool have been implemented and used in parallel to basic values (for testing purposed) in Pre-provision FlexTool.

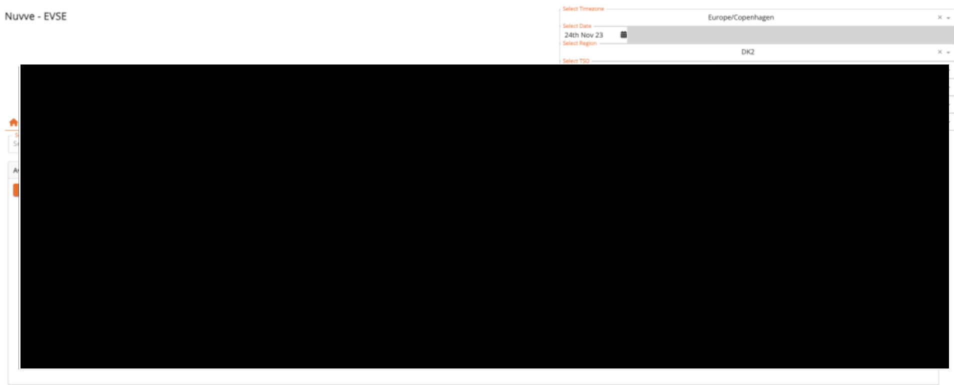


Figure 32: Grace Nuvve internal forecasting tool

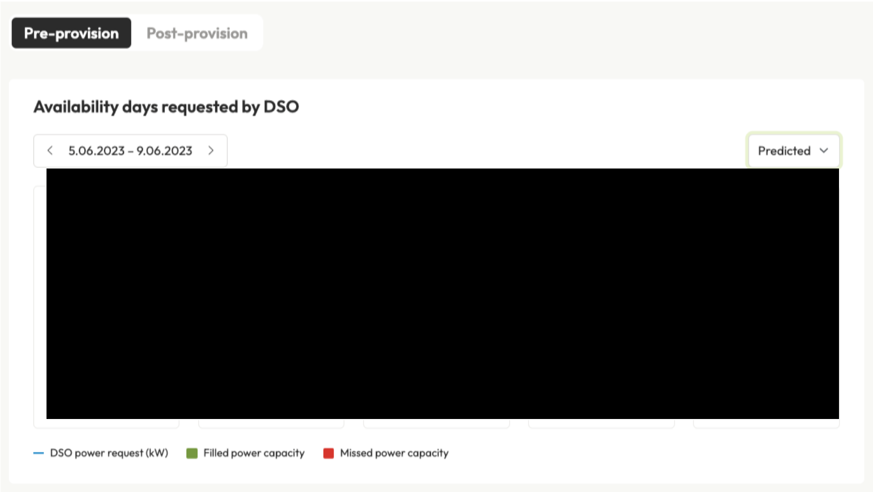


Figure 33: Forecasted capacity visualized on Nuvve FlexTool UI

4.4.1.3 FlexTool – main page on Congestion events

List of congestion events. Currently, they are manually listed, [redacted]. [redacted]

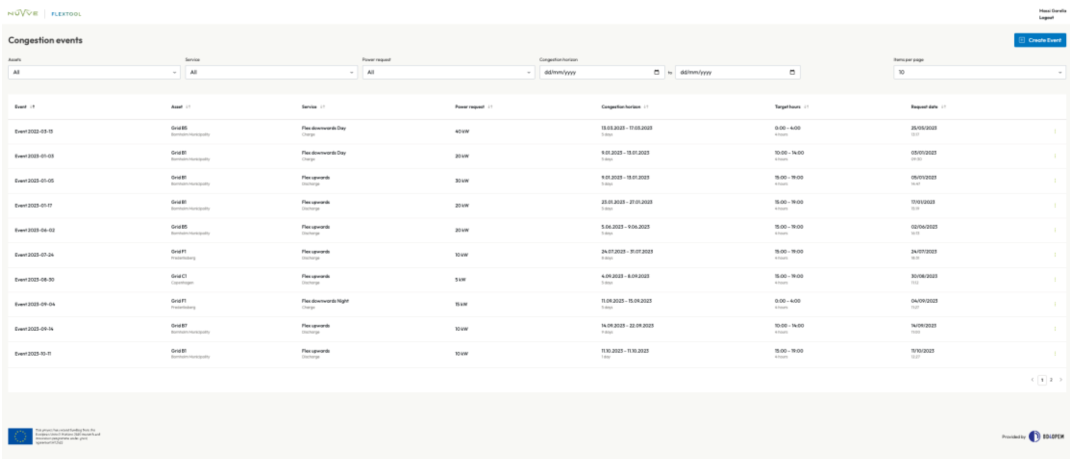


Figure 34: FlexTool Congestion Event list in main page

4.4.1.4 Use Case 1

The DSO can send a request (currently entered manually) to Nuvve after contracting on the BD4OPEM platform or similar. Under "Create Event," key details for the Flex Upwards - discharge are specified, including the requested hours and days, grid area, and location. The new event will appear as "new" in the list and be tracked in the backend. This service is dedicated to discharging and resolving issues of overloading in the local low-voltage grid.

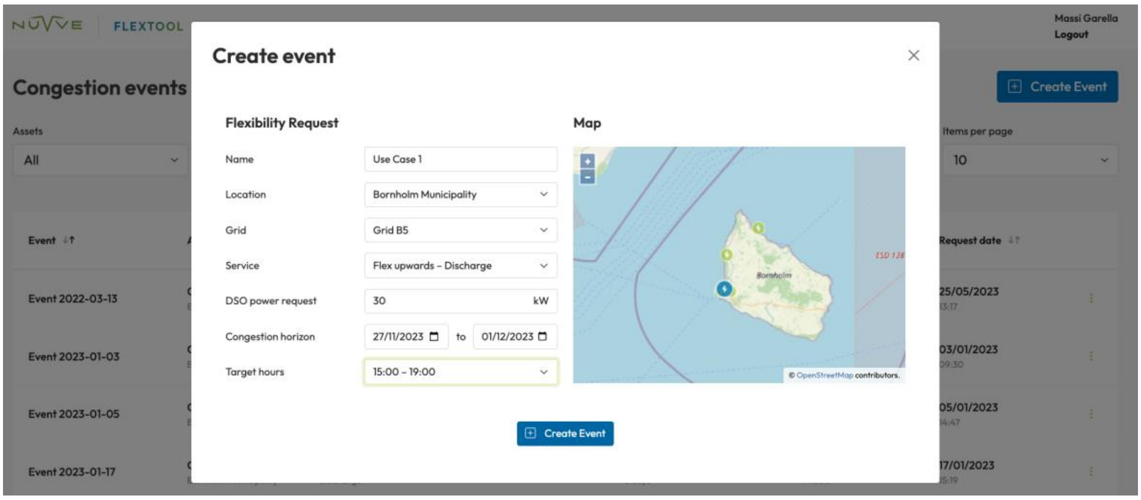


Figure 35: Create event for grid services

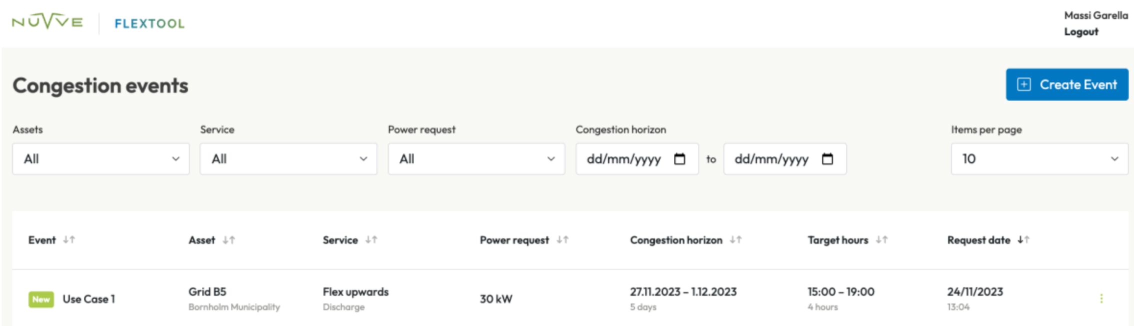


Figure 36: New DSO congestion event in main page

The service provider Nuvve will make a decision to provide the service based on the Pre-Provision tool. Essential details such as the map, location, grid details, fleet units, power capacity of each unit, maximum runtime of N hours, max energy capacity per unit, and total power capacity at the service location are considered. For the availability days requested by the DSO, the figure displays the forecasted capacity per hour for the requested days. The DSO's power request is represented by a blue line, while the green bars indicate the power forecasted. In flexibility provision, the key information that would facilitate the decision-making process includes [redacted]

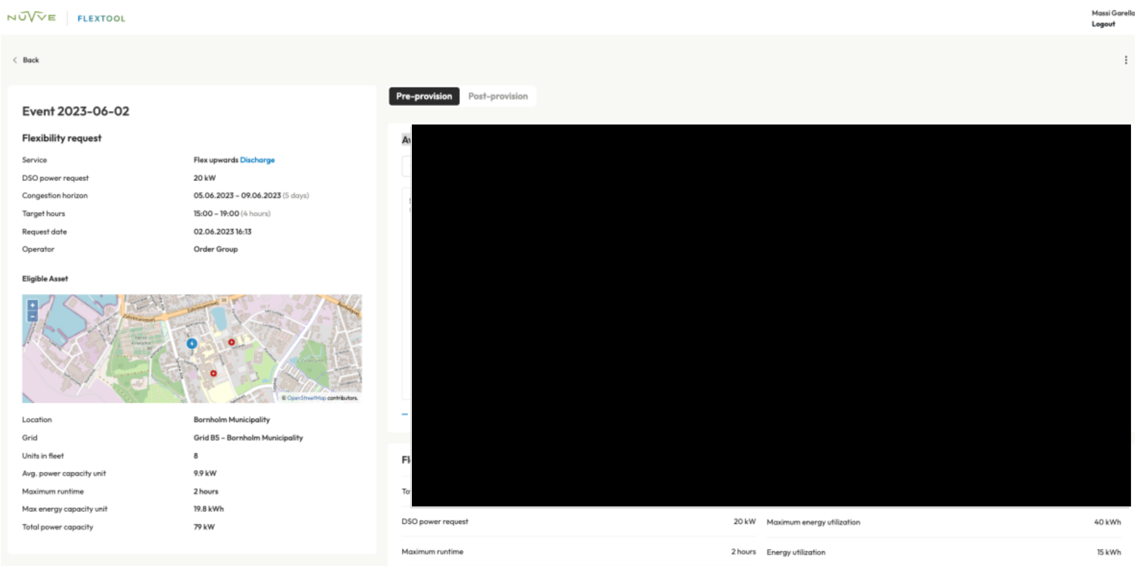


Figure 37: Pre-Provision UI in FlexTool

Once the contract is accepted and the DSO verifies Nuvve's availability in performing the service, the service is provided based on the DSO's discharge request. After the event concludes ([redacted], both the service provider and, to some extent, the DSO are permitted to review the results of the provisions. The first figure illustrates the actual capacity in relation to the DSO's request. In a practical scenario, if the service provider realizes there is insufficient capacity for a certain hour, they would notify the DSO with an unavailability notice.

Figure 38: Availability real compared with DSO request in Post-Provision

The "Flexibility Provision – Dispatch Overview" (Figure 39) displays, [redacted]

Flexibility provision – Dispatch overview

[redacted]

Total grid		80 kWh
DSO reduction	14.4 kW	57.6 kWh

Figure 39: Utilization real compared with DSO syntetic grid data in Post-Provision

The final tables feature the KPIs agreed upon in the BD4OPEM, designed for the DSO to evaluate the metrics of the service provision and the estimated revenues from performing the service. These may affect payment, as the DSO's requirements stipulate a [redacted]. An additional figure, not shown in the FlexTool, represents the cost savings that the service might have achieved.

Flexibility provision KPIs

KPI	Power availabity	Energy utilization	Limits
Flex cap volumes	20 kW	22.4 kWh	
Grid operator signal	100	149.33	100%, 65%
Provision error	< 1%	< 1%	10%, 35%

Revenues

Availability price	0.050 EUR/kW	Utilization price	0.600 EUR/kWh
Availability time	5 days – 4 h/day 20 hours	Utilization time	5 days – 0.75 h/day 3.75 hours
Availability revenue	20 EUR	Utilization revenue	9 EUR

Figure 40: KPIs and revenue etsimates in Post-Provision

4.4.1.5 <u>Use Case 2</u>

For the 'Flex Downwards Day – Charge', the DSO sends a request to Nuvve, typically contracted through platforms like BD4OPEM. In the "Create Event" section, details such as the desired hours for charging, specific days, grid areas, and locations are outlined. Once the event is created, it is labeled as "new" in the system and monitored through the backend. This service focuses on utilizing excess grid capacity during the day, encouraging EV charging to balance and efficiently manage the grid.

4.4.1.6 Use Case 3

For the 'Flex Downwards Night – Charge', the DSO sends a request to Nuvve, typically contracted through platforms like BD4OPEM. In the "Create Event" section, details such as the desired hours for charging, specific days, grid areas, and locations are outlined. Once the event is created, it is labeled as "new" in the system and monitored through the backend. This service focuses on utilizing excess grid capacity during the day, encouraging EV charging to balance and efficiently manage the grid.

4.4.1.7 Data assessment

Table 13: Data assessment table for S5.4

Data source needed	BD4OPEM Ontology	Data quality assessment	Impact of the quality on the service
EVSE data: for each meter, location, grid, and tariffs, the		Available on server	High impact
Grid data from DSO		Data from DSO only historical and not valuable as the service should be provided in respect to real congestion.	High impact, resolved with syntetic grid data. This does not mae arealistic case
Capacity forecast		Available on server	High impact

4.4.1.8 Service conclusions

The service successfully demonstrated the capability to manage grid loads by responding dynamically to the needs of the distribution system operator. Through the 'Flex Upwards – Discharge' and 'Flex Downwards – Charge' use cases, Nuvve proved that it could mitigate grid congestion during peak times and utilize excess capacity during off-peak hours. This not only aids in maintaining grid stability but also offers potential cost savings for customers by leveraging energy arbitrage opportunities.

Looking ahead, there is substantial potential for expanding the service's capabilities. Future functionality could include [redacted]

4.5 S8.1 – Asset and investment planning results

4.5.1.1 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 14: Use cases for the S8.1 service

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.

4.5.1.2 Use Case 1

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 41 provides an example of a stress test using real data from the NUVVE Network. Firstly, DSO needs to select a transformer expansion loading percentage, in this case the secondary substation Udføring 1 is increase by 500%. Then a type of power flow analysis must be selected, in this case time series power flow, from 04/02/2019 00:00 to 08/02/2019 23:00. This means that each hour a power flow is going to be calculated.

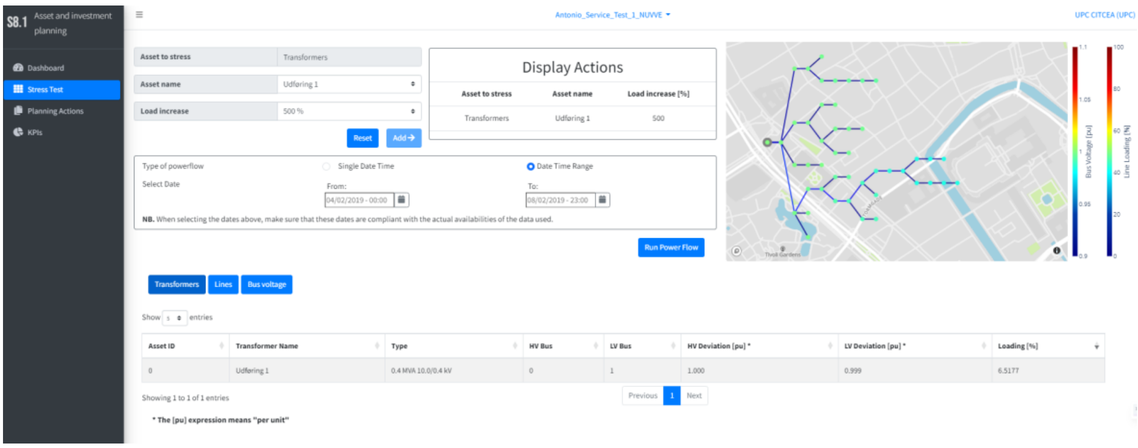
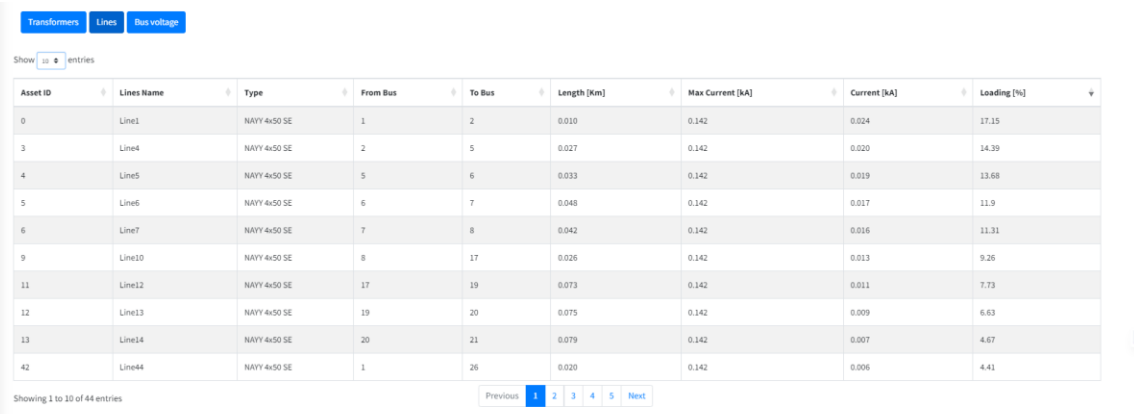


Figure 41: Stress test scenario

Figure 42 shows the results of the power flow in a table format considering the worst-case hour from the selected date time range.



Transformers | Lines | Bus voltage

Show 10 entries

Asset ID	Lines Name	Type	From Bus	To Bus	Length [Km]	Max Current [kA]	Current [kA]	Loading [%]
0	Line1	NAYY 4x50 SE	1	2	0.010	0.142	0.024	17.15
3	Line4	NAYY 4x50 SE	2	5	0.027	0.142	0.020	14.39
4	Line5	NAYY 4x50 SE	5	6	0.033	0.142	0.019	13.68
5	Line6	NAYY 4x50 SE	6	7	0.048	0.142	0.017	11.9
6	Line7	NAYY 4x50 SE	7	8	0.042	0.142	0.016	11.31
9	Line10	NAYY 4x50 SE	8	17	0.026	0.142	0.013	9.26
11	Line12	NAYY 4x50 SE	17	19	0.073	0.142	0.011	7.73
12	Line13	NAYY 4x50 SE	19	20	0.075	0.142	0.009	6.63
13	Line14	NAYY 4x50 SE	20	21	0.079	0.142	0.007	4.67
42	Line44	NAYY 4x50 SE	1	26	0.020	0.142	0.006	4.41

Showing 1 to 10 of 44 entries

Previous 1 2 3 4 5 Next

Figure 42: Power flow results of assets

Figure 43 shows that the secondary substation Udføring 1 has 6.51% of loading, which is below the maximum rated capacity. The DSO can run different scenarios to find the maximum hosting capacity for each transformer or line.

Figure 43: Transformer loading in blue color

4.5.1.3 Use Case 2

In this use case, the grid planner wants to determine the best techno-economic reinforcement strategy that mitigates congestions in lines and transformers. The main functionality of this planning service is the execution of the four planning strategies in parallel— two passive and two flexible planning alternatives, following by the obtention of the most cost-effective solution.

Figure 44 presents the planning solution results in an asset list box. In this case, no actions were needed for the test case selected, since the maximum levels that activate the planning reinforcements were not reached. Figure 45 presents the KPIs results of the decongestion rates of the assets, in this case any improvements were made since we have low energy values in the transformers. This is mainly because we have few smart meters data point and a high-capacity transformer in the NUVVE pilot network.

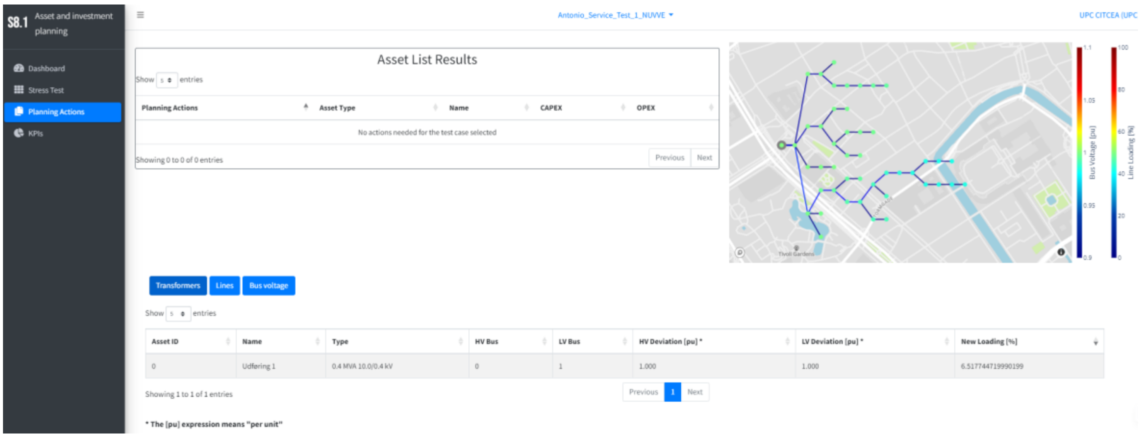


Figure 44: Execution of no planning actions

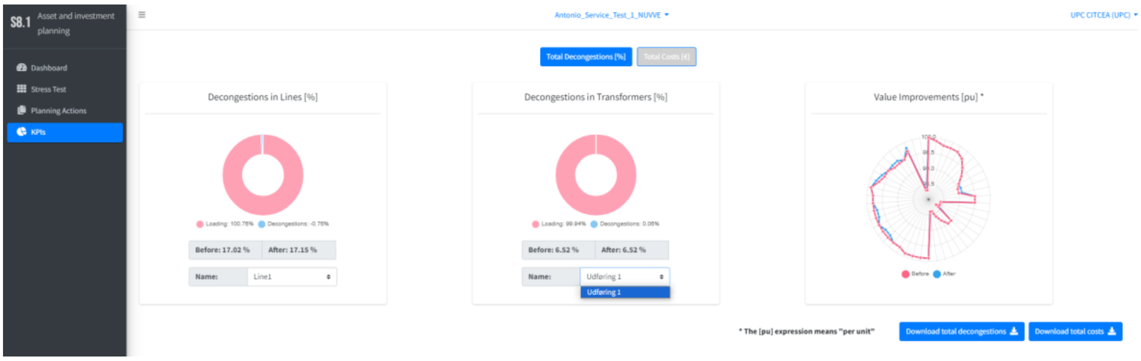


Figure 45: Asset decongestions results

4.5.1.4 Data assessment

Table 15 shows the data needs for the service S8.1 in the Danish pilot and adopts the impact of potential bad data quality.

Table 15: Data assessment for the S8.1 service

Data source needed	Mapping into CIM	Data quality assessment	Impact of the quality on the service
Grid Topology	Service_parameters	Good quality	Medium
Historical measurements	Smart_Meter	Missing values and Low energy consumptions	High
Asset Costs	Service_parameters	Missing Costs from DSOs	High

4.5.1.5 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 considers 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 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.

Feedbacks from DSOs is:

- **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.

5. Project KPIs to be monitored in this deliverable

5.1 KPI 2.1: Data coming from renewable technologies

Table 16: KPI 2.1

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 and electric vehicles, 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 idential RE Sources are connected to the transmission level and services and pilot areasare tacling 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	$\left[\frac{\sum RE\ Tech.Assets+\sum New\ Tech.assets}{No.\ services\ in\ pilot}\right]+\frac{No.of\ RE\ source\ types\ and\ new\ Tech\ types}{Services\ using\ RE\ tech.and\ new\ tech.assets\ data}>1$
Unit	Ratio
Target (Adapted)	Data available from 19 EVSE, V2G Charger, only on Bornholm pilot site location from Nuvve and 2 PV systems in the DSO grid of Bellesvej. 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

KPI Name:	Data coming from renewable technologies
Results at the end of the project	Nuvve has around 19 EVSEs for the pilot project on the Bornholm island. All these EVSE were decommissioned and a new type of V2G charger was installed over August 2023. The number has not increased. The Bellesvej transformer area includes 2 PV solar systems, collected in the smart meter from the DSO. A: No of $Renewable\ Energy\ Tech.\ assets$ +*No of* $New\ Tech.\ assets$ (19 EVSE + 2 PV) 21 B: *No of Services in pilot (2 services)* 2 C: $No\ of\ RE$ Tech $types\ and\ new\ Tech\ types$ (EVSE and PV) 2 D: $Services\ Using$ "RE Tech. and New Tech. Assets" $datas$ in pilot 2 Result : $\left[\frac{21}{2}+\frac{2}{2}\right]$ = 11.5 >1 Succeded.

5.2 KPI 2.5: New services with existing

Identify two energy services (e.g.: "congestion management", "Time-of-Use", 'Day Ahead price optmiization") to be provided for new flexibility markets, stacking behind-the-meter services.

For the congestion management service example, the KPI can be monitored by assessing if the service was performed with the requested volumes of energy and in the periods of the year requested by the DSO. Integrating DSO flexibility services with energy arbitrage and cost savings, ensure charging and discharging according to DSO requests without impacting customer costs. Two such energy services for new flexibility markets include congestion management and Time-of-Use optimization. The performance of the congestion management service, for example, can be evaluated by whether it meets the DSO's energy volume requirements and is provided during the requested times of the year.

Table 17: KPI 2.5

KPI Name:	New services with existing tools
KPI ID	KPI 2.5: New services with existing tools (NUVVE)
Global objective	Technological choice and provision of tools contributing to the Digital Marketplace for Energy

KPI Name:	New services with existing tools
Owner	Massimiliano Garella, Nuvve
Definition	This KPI assesses the performance of energy services such as congestion management and Time-of-Use optimization within new flexibility markets. The evaluation focuses on whether the services are performed in accordance with the requested energy volumes and specified time periods by the DSO, while integrating energy arbitrage and cost savings to avoid impacting customer costs.
Involved partners	Nuvve as the data provider and Nuvve as the service provider
Calculation process and Formula	The internal calculations within Nuvve's systems should ensure that we can simultaneously provide two services—performing DSO services while making certain that the operational costs of EVs are not adversely affected, base don 1) Time-of-Use and/or 2) Spot Market price, nor are the mobility needs of the users.
Unit	[-]
Target	The target is to achieve a high compliance rate with the DSO's requests, aiming for minimal deviation from requested energy volumes and periods, while not affecting the costo f EVSE operations.
Results at the end of the project	Results at the end of the project demonstrate the viability of delivering stacked services. DSO requests are generally prompted by congestion signals, which frequently coincide with periods where electricity prices are indicative of grid load levels – higher prices often reflect higher demand and vice versa. This synchronization allows for efficient service provision without impacting the operational costs of EVs or the mobility requirements of users.

6. Lessons learned & Conclusions

6.1 Lessons learned – Pilot's perspective

The pilot project has demonstrated considerable value in the capacity to create a service provision that benefits all local stakeholders. The FlexTool UI, developed for the Marketplace, delivered impressive results, showcasing the potential for advancements in flexibility services. These services provided both pre-provision and post-provision results during the pilot, showcasing a model that can be replicated in real-world scenarios.

A significant accomplishment was the execution of DSO flexibility services in the pilot with real test cases. In the pilot, flexibility up and down services were combined with Time-of-Use and Spot Market price optimization strategies, proving the 'stackability' based on KPI 2.5. These services typically correspond with periods of peak electricity prices, a factor crucial for maximizing energy arbitrage while not affecting customer costs, thus creating value for DSOs, operators, local grids, EV customers, and service providers.

Nevertheless, the pilot encountered several challenges. [redacted]

The Marketplace demonstrated intrinsic value in the data and services provided, indicating potential benefits for all participants within the electricity markets. However, translating this value into a tangible, monetizable asset remains an ongoing challenge that requires strategic solutions.

6.2 Lessons learned – Service developer's perspective

The Nuvve pilot in Denmark, situated on Bornholm Island, provides valuable lessons from a service developer's viewpoint. With a focus on V2G technology, bidirectional charging stations offer not only EV charging capabilities but also the ability to discharge batteries, contributing to grid flexibility.

The service developers navigated the complexities of integrating data from various sources, such as EV charging stations, smart meters, and other grid-related data. The lessons learned include the importance of developing adaptable data interfaces and protocols to harmonize data from diverse sources effectively. Future service developers can benefit from understanding the challenges and solutions related to data integration in a multi-faceted energy ecosystem.

An integral achievement of the project was the effective execution of DSO-directed flexibility services, particularly when integrated with pricing mechanisms like Time-of-Use and Spot Market. The alignment of service operations with periods of elevated electricity prices was key to optimizing energy arbitrage. This strategic operation did not impact the operating costs for EV users, thereby delivering multifaceted value. Solution developers crafted algorithms that not only responded to energy market signals but also maintained the delicate balance between service provision and cost containment, benefiting a broad range of stakeholders.

These lessons contribute to the continuous refinement and advancement of technologies and services, fostering a more resilient and efficient energy infrastructure.

6.3 General conclusions

The Danish pilot serves as a crucial testing ground for analyzing and implementing flexibility services, especially for the local distribution grid. The pilot's significance lies in its contribution to the development of DSO markets, mitigating local grid congestions, and exploring new services that bring value to various stakeholders. [redacted] showcased the transformative potential of controlled EV charging and discharging. This highlights V2G technology's practical capabilities in supporting grid congestion management while adding value for EV customers. The insights from this pilot are crucial for shaping future strategies aimed at improving grid flexibility, ensuring stability, and maximizing benefits across the energy system, particularly with V2G technology. The FlexTool, with its comprehensive suite of tools including power and energy flexibility information, AI-driven forecasting, bidding tools for flexibility, revenue estimations, and real value analysis in relation to DSO grid data (though based on synthetic data), will be reused and promoted to operators. This project demonstrated that technically DSOs can go digital and leverage outside resources and services to meet their needs, but the regulation is not there to incentivize them to trade on a marketplace instead of trying to meet their needs with their own internal resources. They concept of marketplace where digital services and data can be traded in a secure way is now proven, but to be attractive it needs to scale-up : a market place is only valuable as the number of market parties it encompasses, the variety and choice of data sets and services on offer as well as the number of buyers (eg DSOs).

References

[1] BD4OPEM, "D7.1: Large Scale pilots' methodology," 2022.

[2] BD4OPEM, "T4.3: S5.4 EV to Grid," 2021.

[3] BD4OPEM, "D3.1: Data acquisition protocols technologies and information models," 2020.

[4] Energinet, "DataHub," [Online]. Available: https://energinet.dk/data-om-energi/datahub/.

[5] BD4OPEM, "Deliverable 4.2 - Grid monitoring and supervision (v1.3)," 2022.

[6] IntelligentEnergi. [Online]. Available: https://ienergi.dk/ .

7. Annex A: Storylines

7.1 S3.1 – Grid disturbance simulations

7.1.1 UPC approach: Congestions forecast for day ahead

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

Service 3.1

1. Contract the service with the demanded parameters.
2. You will get your contracts on top. Select the desired to investigate

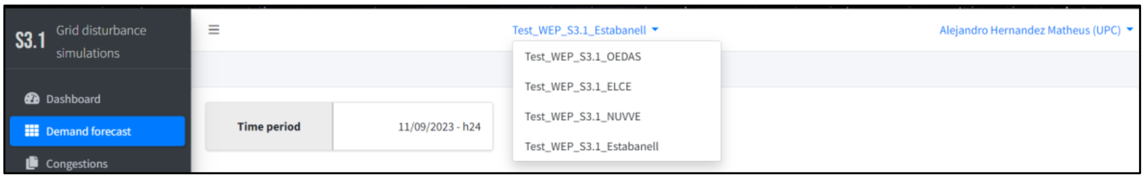


Figure 46: Demand Forecast selection in S3.1.

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

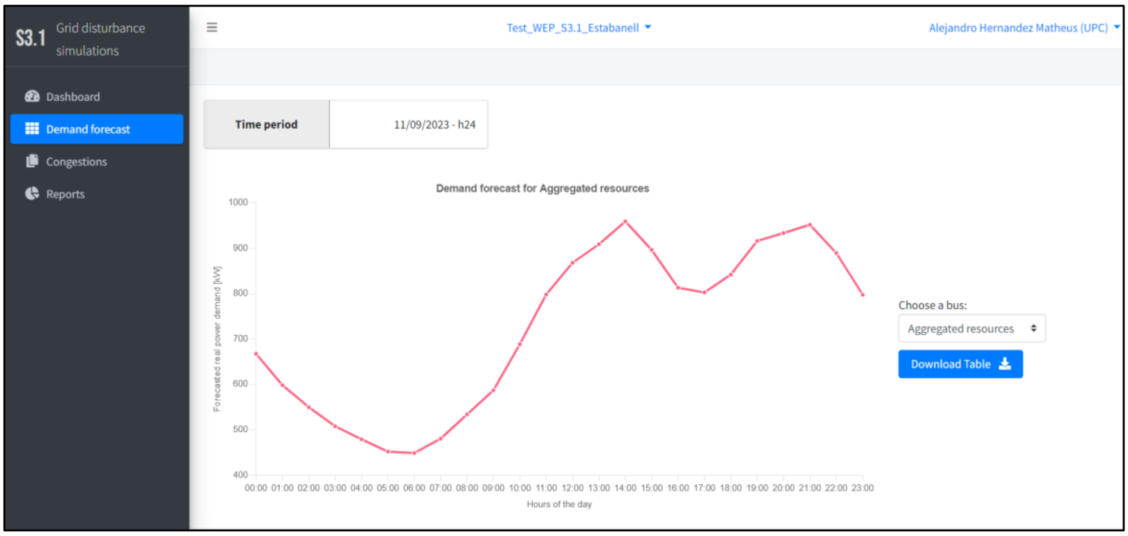


Figure 47: Demand Forecast visualization in S3.1.

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

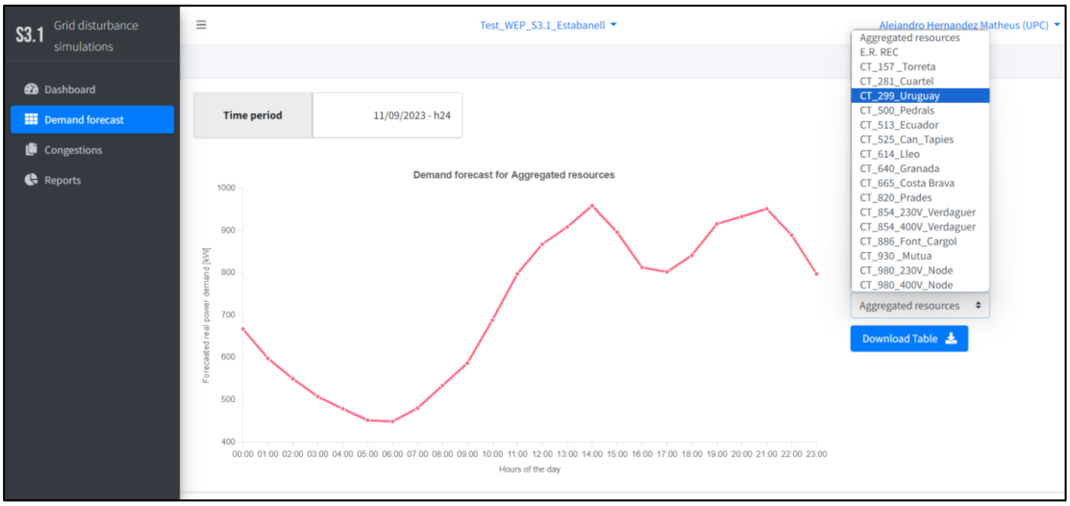


Figure 48: Demand Forecast visualization for loads in S3.1.

Figure 49: Demand Forecast visualization for selected load in S3.1.

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

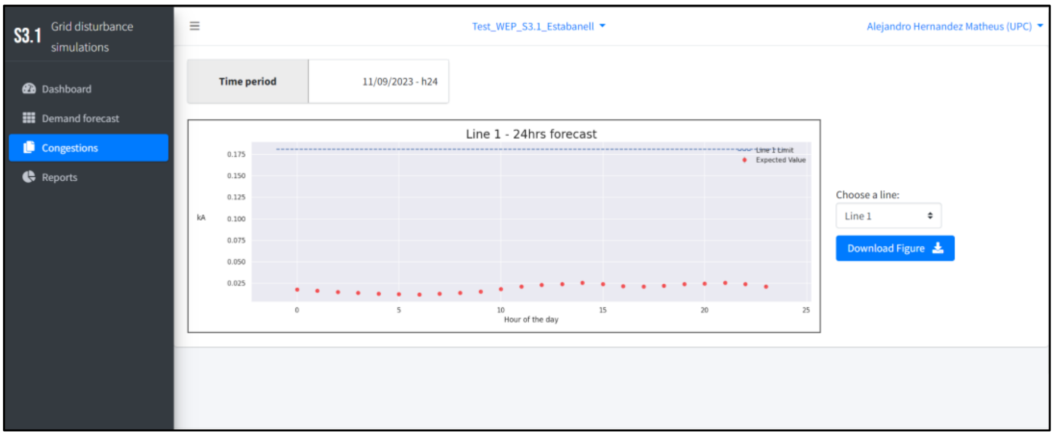


Figure 50: Congestion plot view of Line 1 in S3.1.

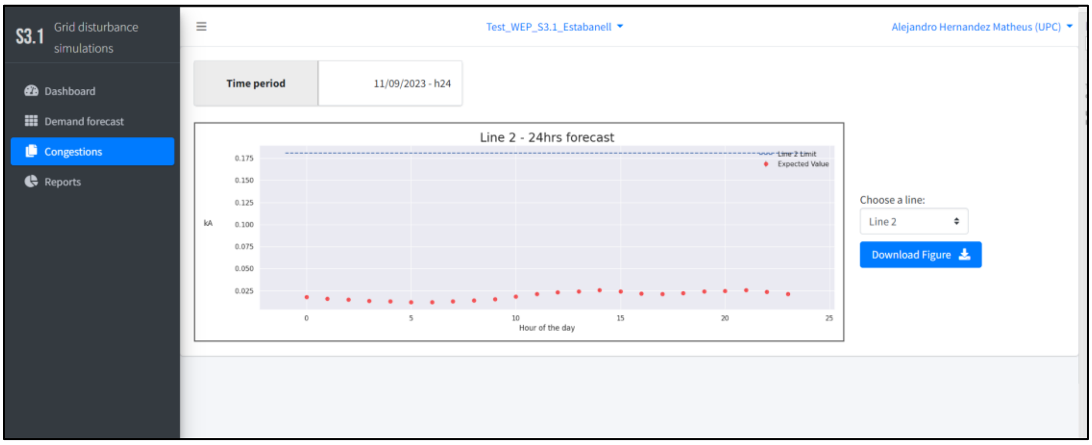


Figure 51: Congestion plot view of Line 2 in S3.1.

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.

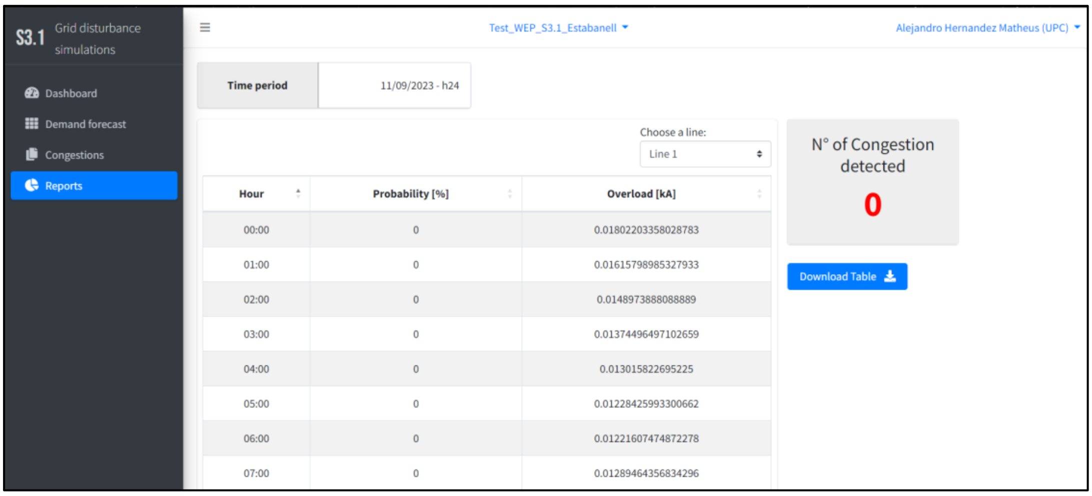


Figure 52: Report View in S3.1.

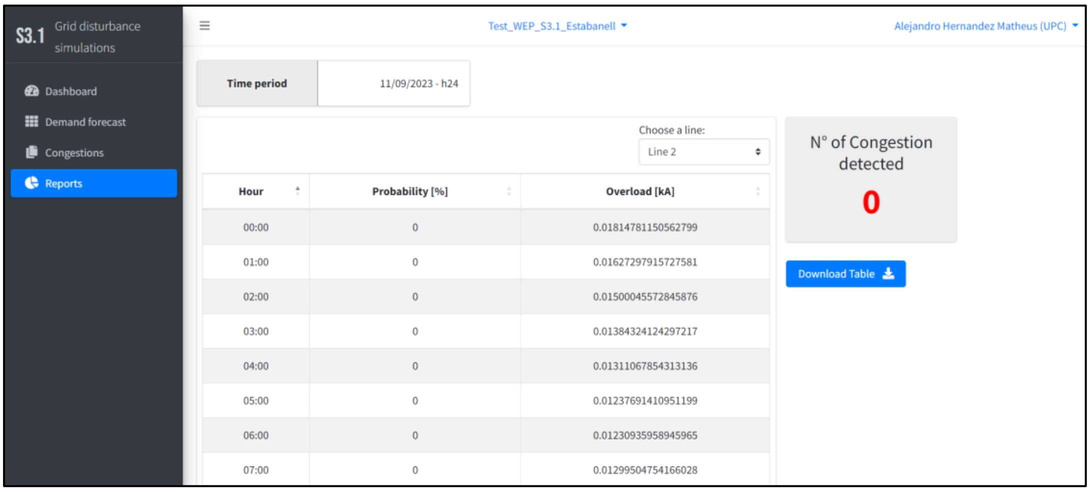


Figure 53: Congestion plot Line 1 in S3.1.

7.2 S3.2 Impact study PV, EV & new loads

Service	**S3.2 – Impact study PV, EV & new loads**
Algorithm provider	**ODT**
Solution provider	**ODT**

Contract service

1. Go to the Marketplace main page and go to the search bar and look the service "*Impact study PV, EV and new loads".*
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

Usability testing

5. After executing the service, follow the indicated steps to test several aspects.
    a. Go to https://app.staging.bd4opem.odit-e.com and try to login.

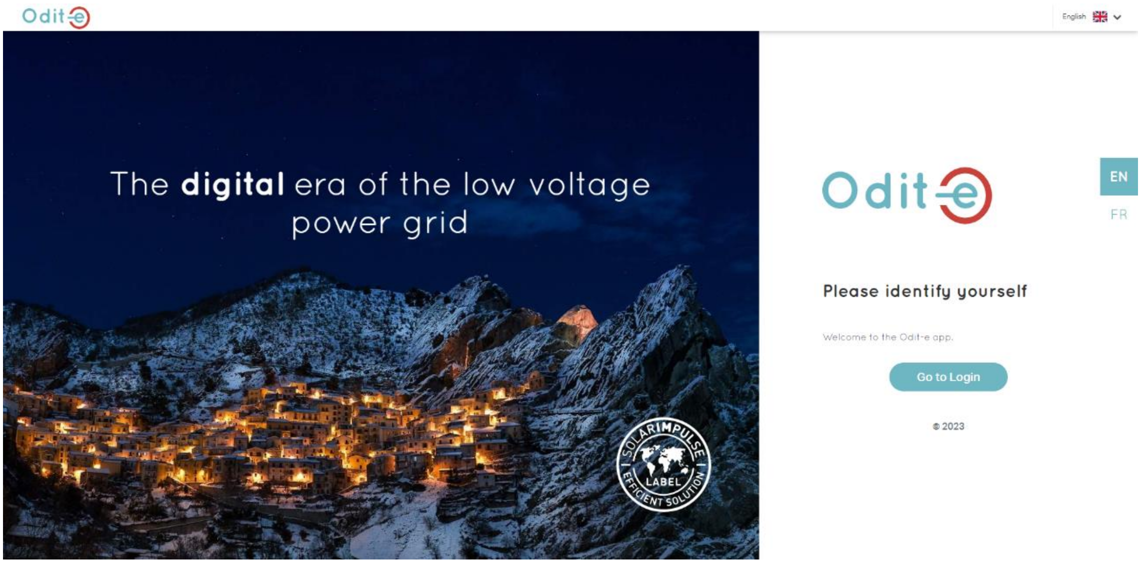


Figure 54 - Service S3.2 login portal

    b. If login succeed, you should see a map with all your secondary substations.

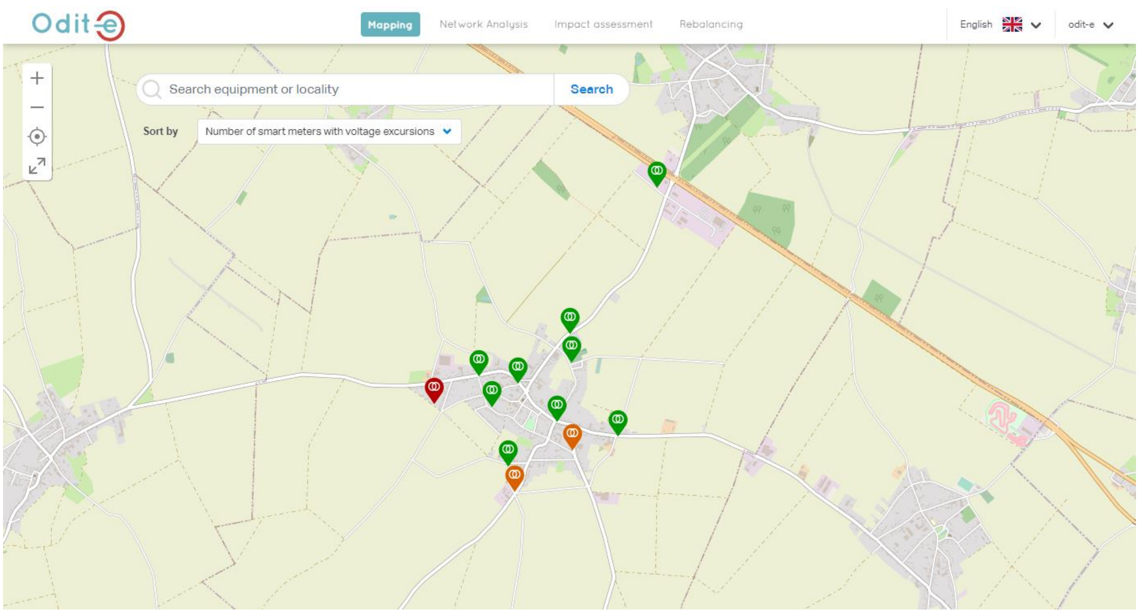


Figure 55 - Service S3.2 Substation overview map

c. Click on a substation. A panel should open and display all smart meters linked to the substation. If GPS coordinates are given, smart meters should also appear on the map.

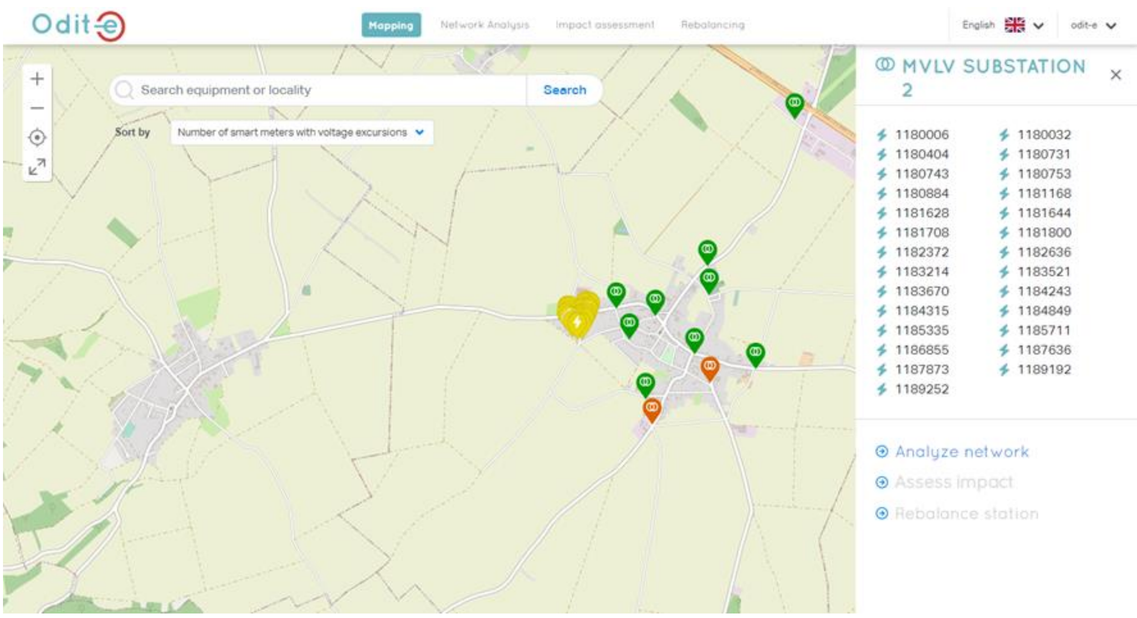


Figure 56 - Service S3.2 Example of smart meters connected to a substation

d. You can then click on "*Impact assessment*" tab, or "*Assess impact*" button, to open the impact prediction tool. On the impact study page, you should be able to:
   i. Select a substation by clicking on it.
   ii. For a selected substation, smart meters will appear on the map (if GPS coordinates are available) and a table with all smart meters and their PV capacities.

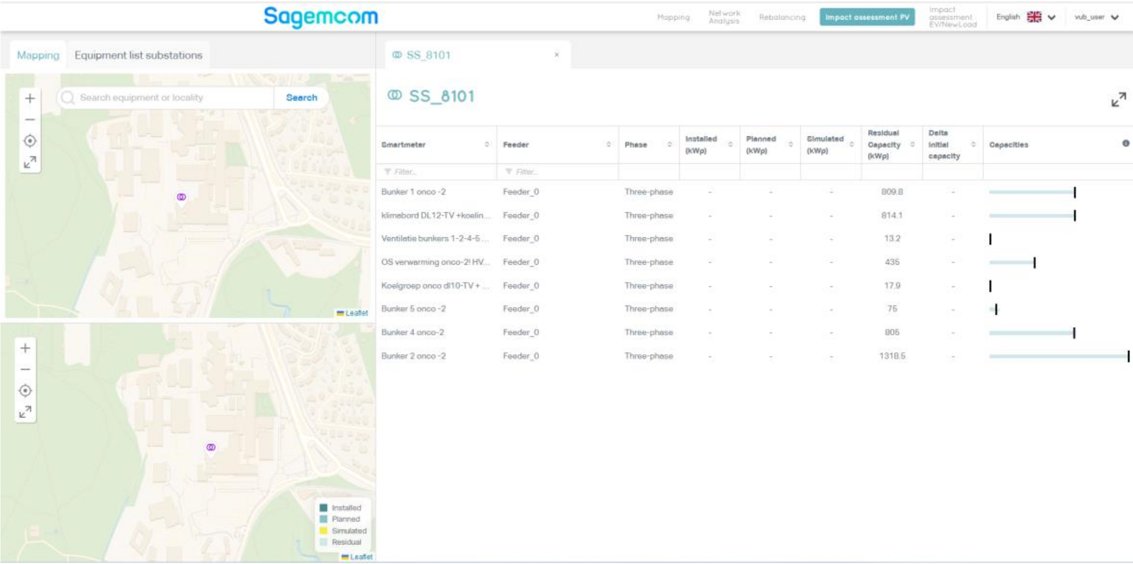


Figure 57 – Service S3.2 'Impact assessment'

iii. You can then select a smart meter from the map or in the table to add PV and click on "*Apply and simulate*" button to simulate the residual capacities for all other smart meters.

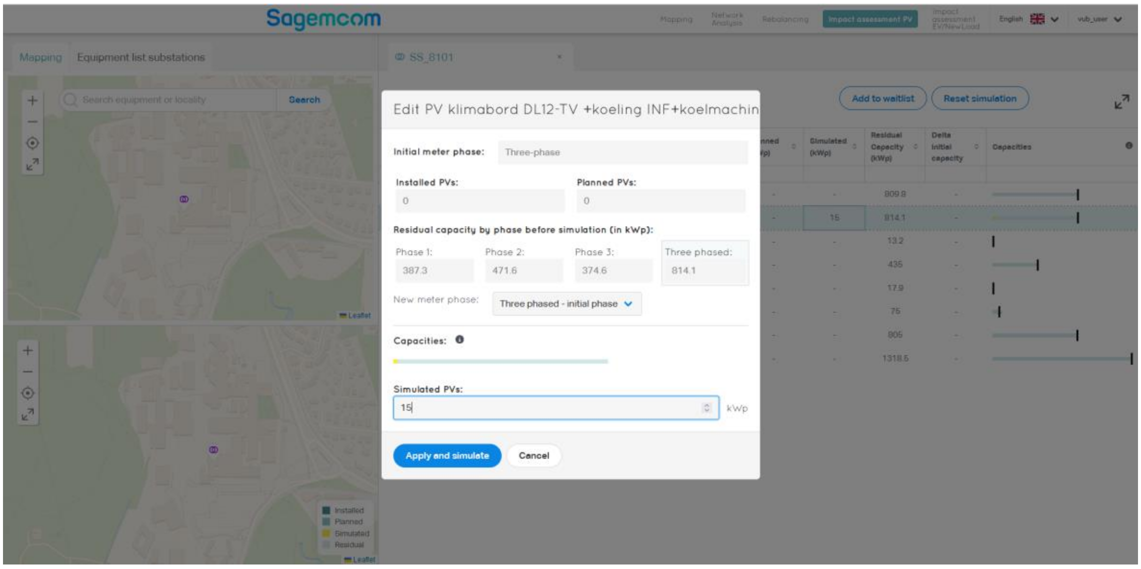


Figure 58 – Service S3.2 Simulation example

iv. You can add simulated PVs to the waiting list by clicking on the "*Add to waitlist*" button. The waiting list is persistent: you will find them again, when you will reconnect to assess the impact of a future connection. The workflow is the following:

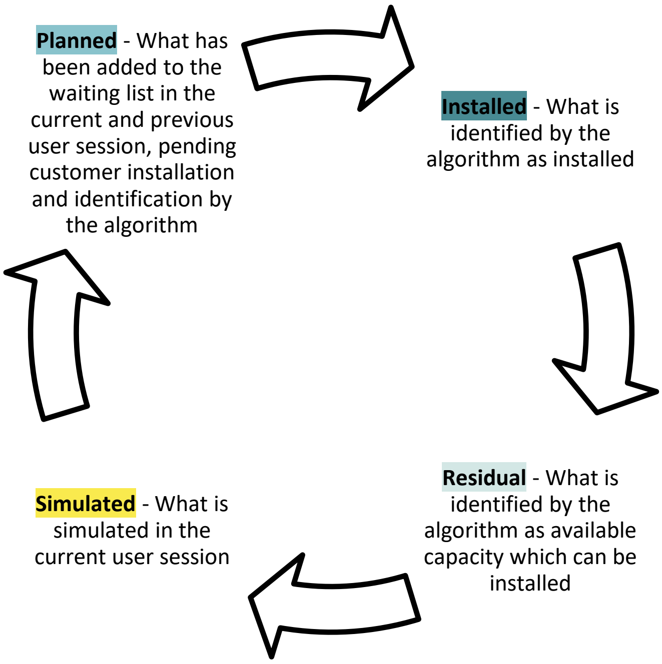


Figure 59 - Service S3.2 Workflow

e. You can finally click on *EV & New load* tab to open the impact prediction tool for EV and new loads. On this page, you should be able to:
   i. Select a substation by clicking on it.
   ii. For a selected substation, smart meters will appear on the map (if GPS coordinates are available) and a table with all smart meters and their EV or new load capacities.
   iii. You can then select a smart meter from the map or in the table to add a constant new load and simulates by clicking on "Compute" button the residual capacities for all other smart meters.

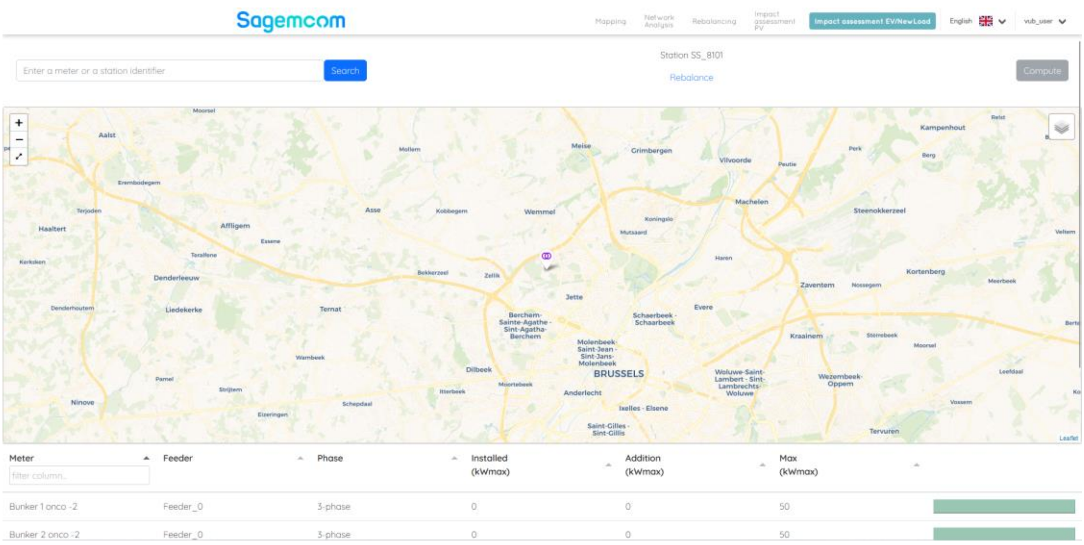


Figure 60 - Service S3.2 Impact prediction tool

6. Fill the questionnaire provide following the results and experience perceived after following the previous steps.

7.3 S5.1 – Flexibility Forecast

7.3.1 UPC approach: Flexibility forecast

Service	**S5.1 Flexibility forecast**
Algorithm provider	**UPC**
Solution provider	**ICOM**

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.
   a. Click on "Add Forecast Model".

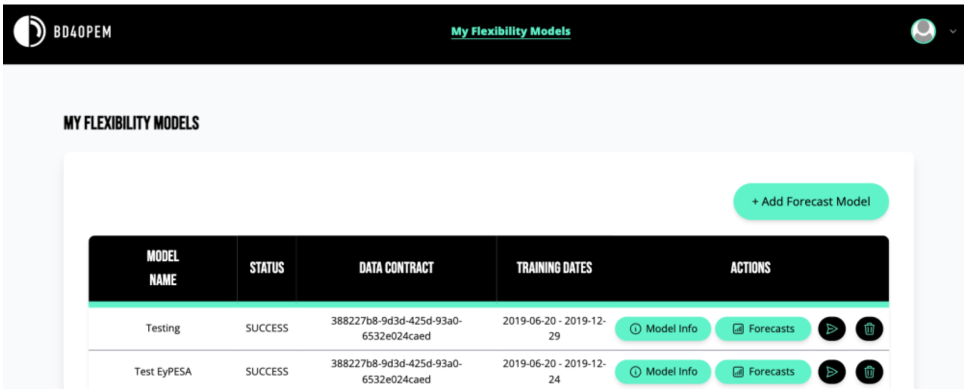


Figure 61 - Service S5.1 models

   b. Fill the following information to initiate the forecast.

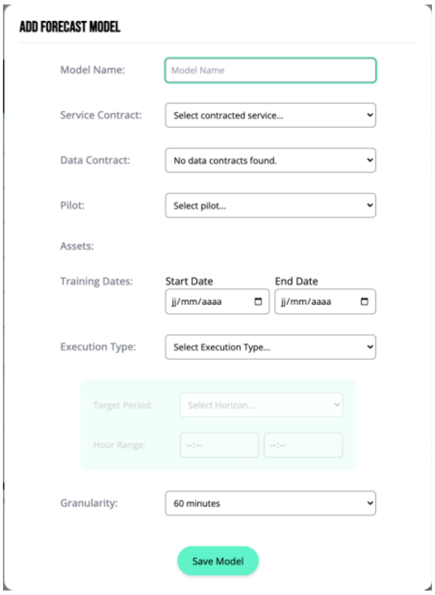


Figure 62 - Service S5.1 Add forecast models

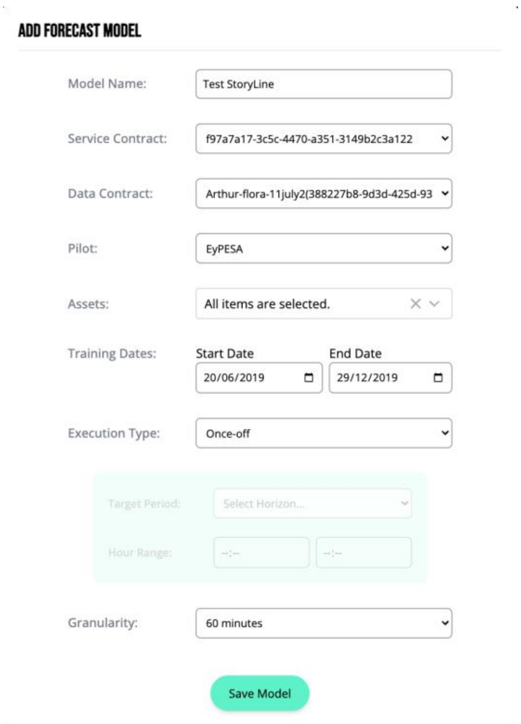


Figure 63 - Service S5.1 models - configured

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

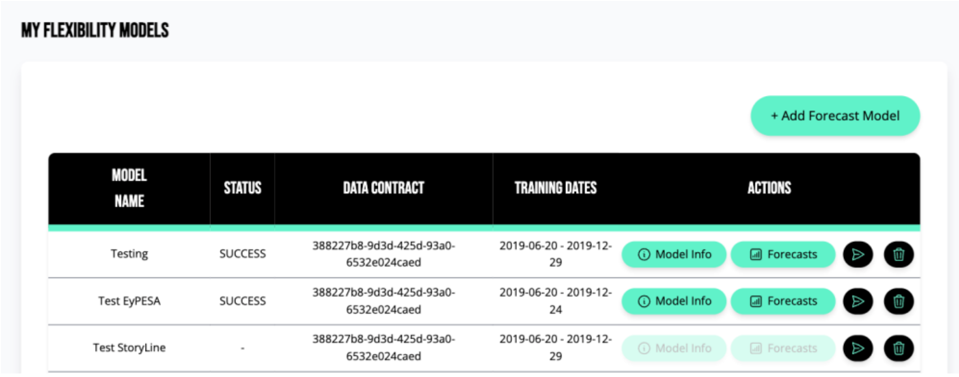


Figure 64 - Service S5.1 list with added model

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

Figure 65 - Service S5.1 model run

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

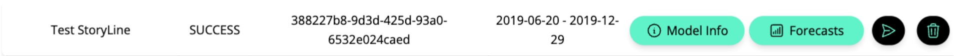


Figure 66 - Service S5.1 model enabled

6. Usability Testing: On the initial menu: check previous executions.
   a. Click on the "Model Info" tab, scroll down to discover the following:

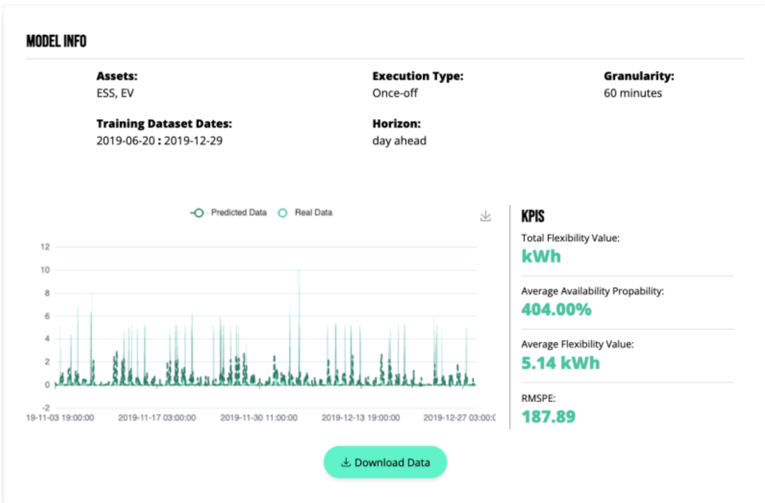


Figure 67 - Service S5.1 model info

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

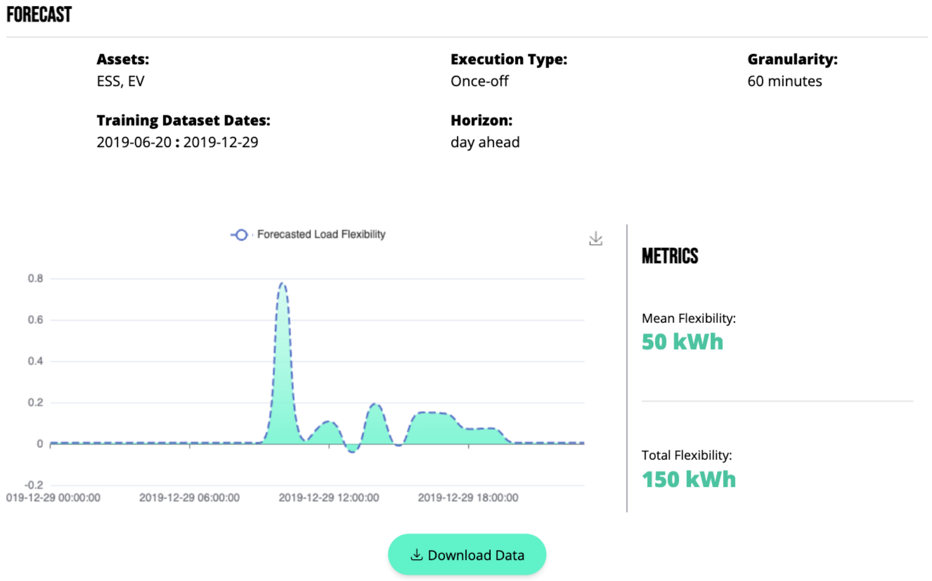


Figure 68 - Service S5.1 forecast view

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.

7.4 S5.4 – EV to Grid

Service	**S5.4 EV to Grid**
Algorithm provider	**NUV**
Solution provider	**NUV**

Service 5.4: EV to grid

This user guide provides step-by-step instructions for the management of data and service contracts, ensuring a streamlined and efficient process for both data users and service providers.

MarketPlace link: https://marketplace.bd4opem.eu/

Nuvve FlexTool link: https://data-processing.sandbox.agg2.nuvve.eu/flextool/

Persone

1. Data User: DSO
2. Data Provider: Nuvve
3. Service User: DSO
4. Service Provider: Nuvve

5. FlexTool User Interface User: DSO and Nuvve (in reality, some of them might not be visible for DSO)

DSO: Xavier Moreau,

Nuvve: Massimiliano Garella,

Use Case

The DSO wants to request flexibility from aggregation of fleets, operated by Nuvve. The DSO will want to check the data that will be used by the service for the forecasting and the capacity pulled for the flexibility (example for V2G Nuvve chargers or V1G fleets operated by Nuvve but owned by its partners). Once data will be accepted by data provider (Nuvve), the DSO will be able to request a Service Contract.

Contract data – Data User

1. Go to the *Marketplace* → *Data* → *Data User* page (access given from App)
2. [redacted]

Contract data – Data Provider

7. Go to the *Marketplace* → *Data* → *Data Provider* page
8. [redacted]
13. Download PDF

Contract service – Service User

1. Go to the *Marketplace* → *Service* → *Service User* page
2. [redacted]
9. Execution of the service

Contract service – Service Provider

1. Go to the *Marketplace* → *Service* → *Service Provider* page
2. [redacted]

[redacted]

8. Download PDF

Nuvve FlexTool

1. Go to the *FlexTool* and follow the indicated steps to test several aspects.
2. [redacted] and login.\
3. If login succeed, you should see the FlexTool Nuvve

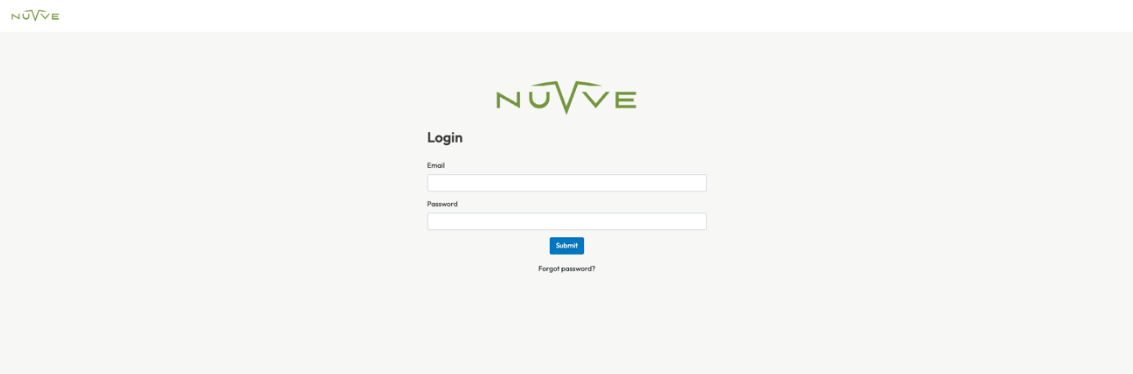


Figure 69 - Service S5.4 Login page

4. Click on a Grid Event. A panel should open and display the grid service information.

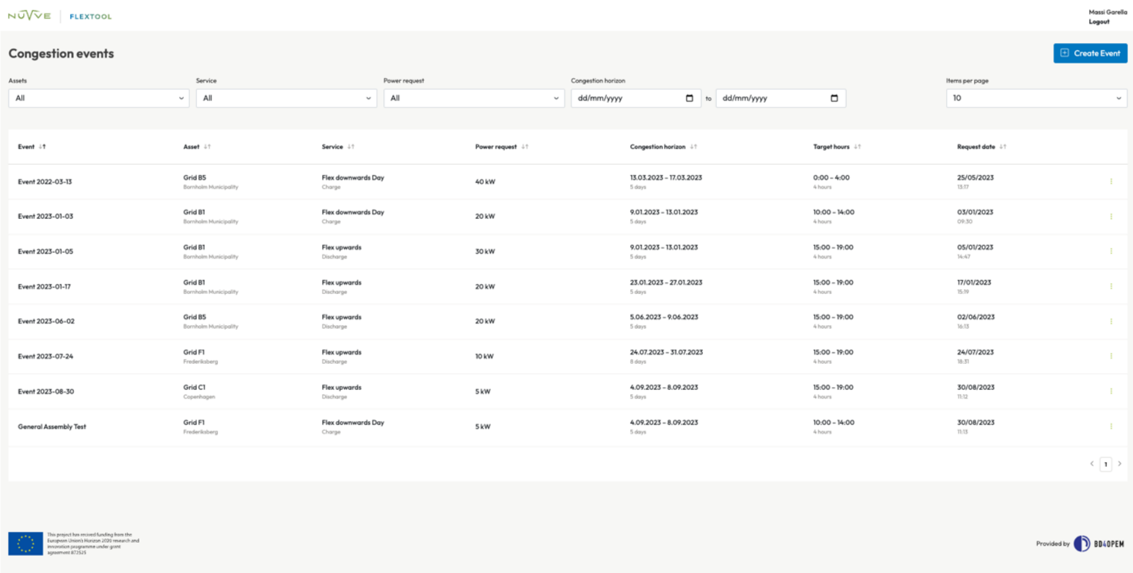


Figure 70 - Service S5.4 List of congestion events

5. You can then click on *Pre-Provision* tab to open the information on the forecasted capacity and evaluated performance available from selected

assets. Post-Provision is still not available before the end of the week of service contracted.

   a. Check units involved.
   b. Check the available capacity forecasted [redacted]

[redacted]

10. Once the event has finished (weekly basis), you can then click on *Post-Provision* tab to open the information on the performed grid service and evaluated performance and KPIs available from selected event .
    a. Check real power provided per hours of the week

[redacted]

      i. Check real energy provided on daily basis in respect to the grid (events depends on the request).[redacted]

Flexibility provision – Dispatch overview

[redacted]

Figure 73 - Service S5.4 Post-provision view of energy deliver to grid

ii. Check the KPI

Flexibility provision KPIs

KPI	Power availabity	Energy utilization	Limits
Flex cap volumes	20 kW	22.4 kWh	
Grid operator signal	100	149.33	100%, 65%
Provision error	< 1%	< 1%	10%, 35%

Figure 74 - Service S5.4 Post-provision view of KPIs

iii. Check the estimated revenues per grid service (example)

Revenues

Availability price	0.050 EUR/kW	Utilization price	0.600 EUR/kWh
Availability time	5 days – 4 h/day 20 hours	Utilization time	5 days – 0.75 h/day 3.75 hours
Availability revenue	20 EUR	Utilization revenue	9 EUR

Figure 75 - Service S5.4 Pre-provision view on revenue estimates.

7.5 S8.1 – Asset and investment planning

Service	**S8.1 Asset and Investment Planning**
Algorithm provider	**UPC**
Solution provider	**WEP**

Service 8.1: Asset and investment planning

Contracting Service:

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

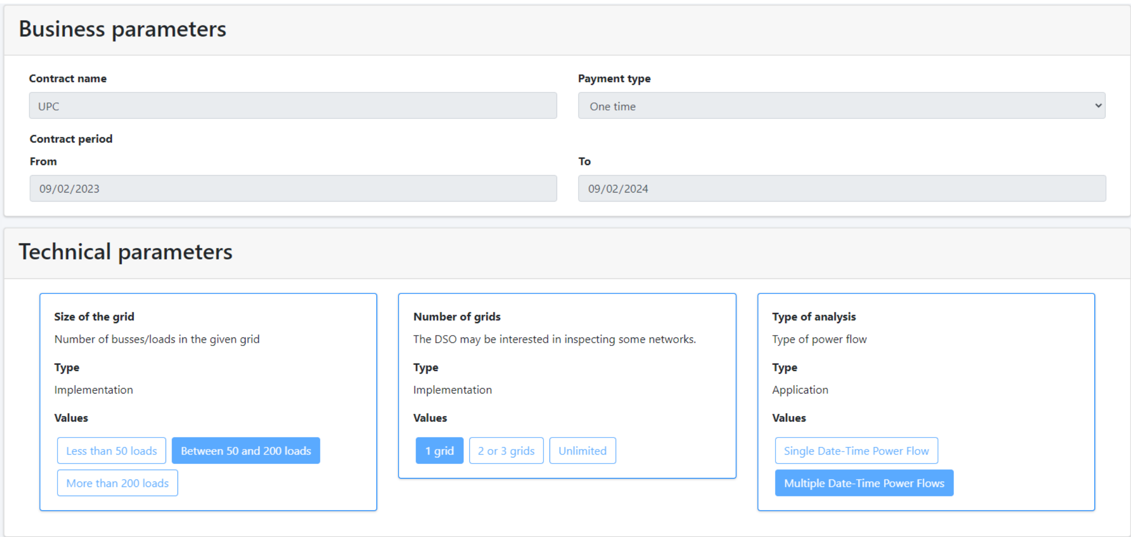


Figure 76 - Example of the UI on technical parameters for Service 8.1

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.

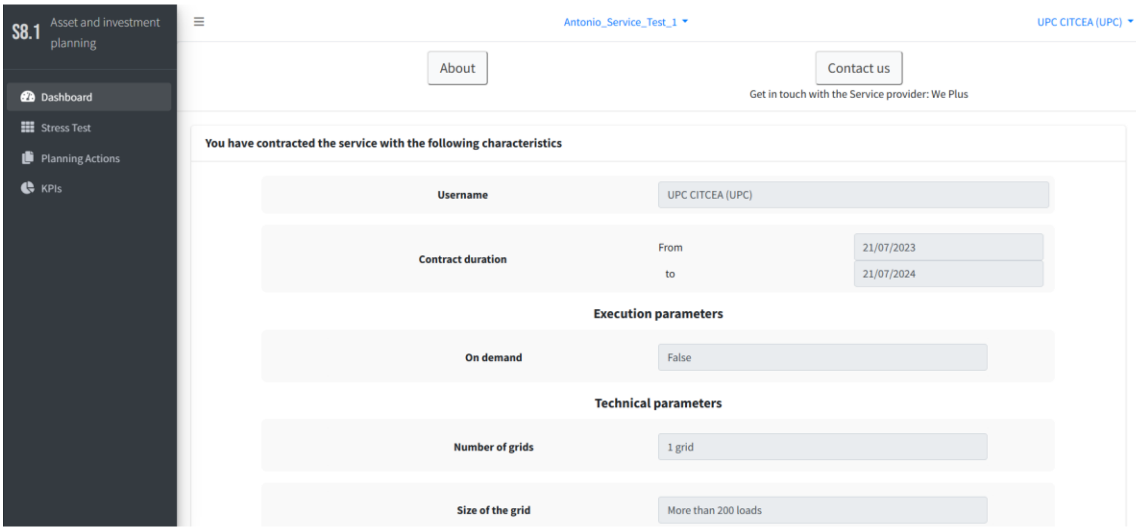


Figure 77 - Example of the User interface Contracted parameters

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

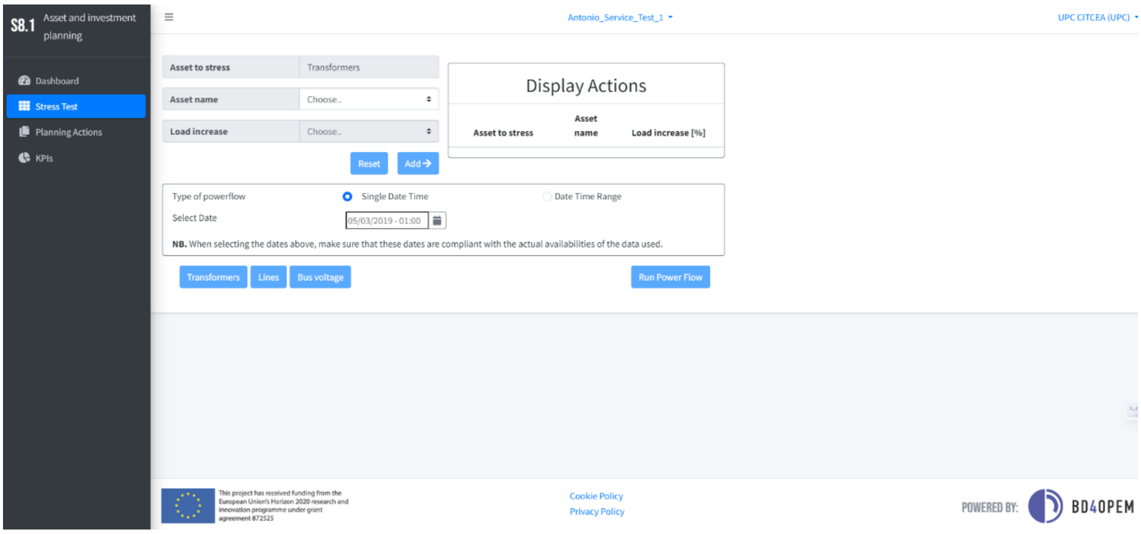


Figure 78 - Stress Test UI visualization

3. 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.4.
4. Select the Power Flow analysis Type “Date Time Range”
5. 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.
6. Click on the “Run Power Flow” push button

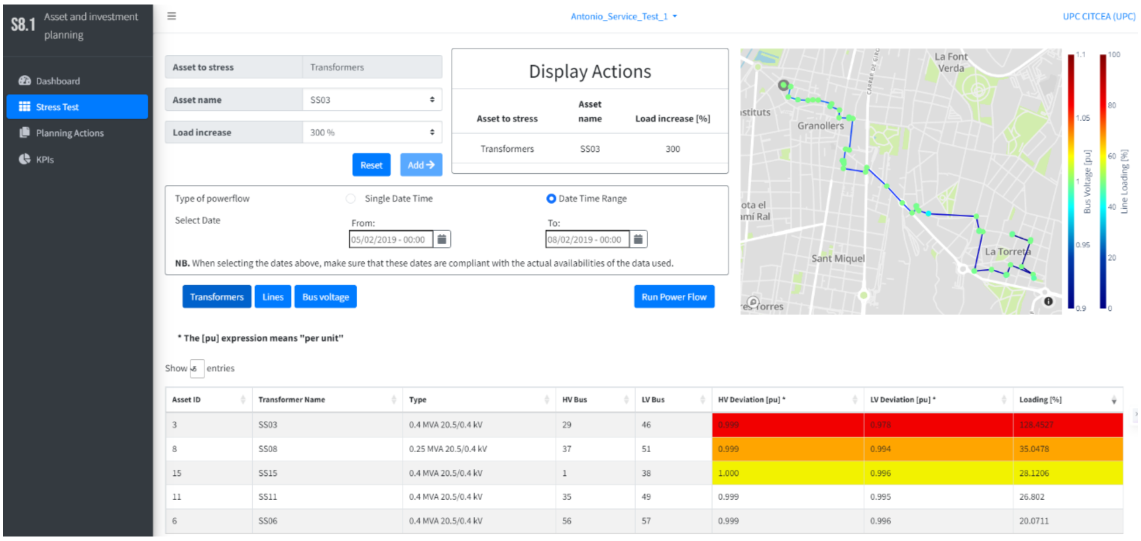


Figure 79 - Example of the results in the Stress Test

7. Go to the "Planning Actions" Tab, by clicking in the left side bar.
8. A new table of results with 3 different subtabs should be displayed, as showed in Fig.5. Verify also that the table results correspond with the GIS maps results displayed on the right side.

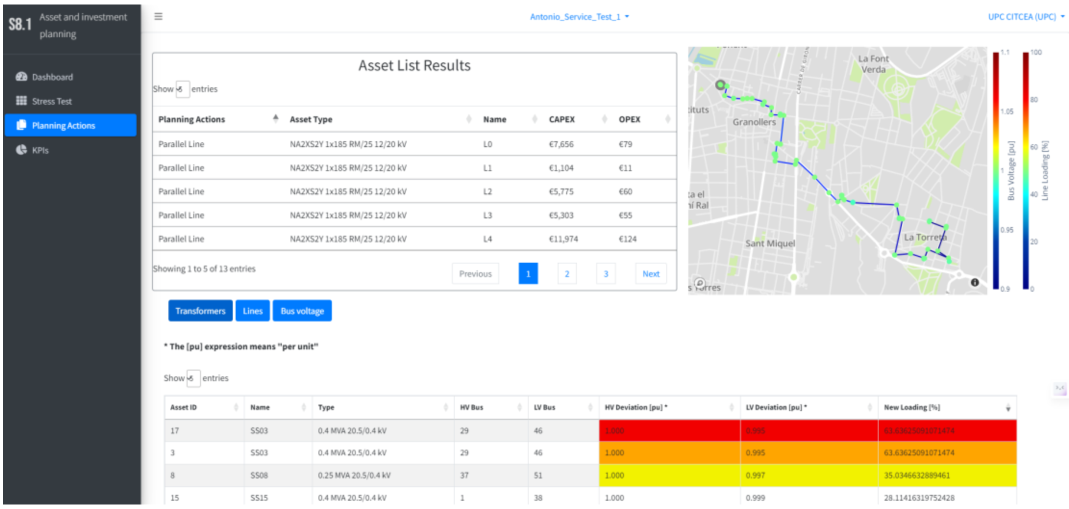


Figure 80 - Example of the results in the Planning Actions

9. 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.

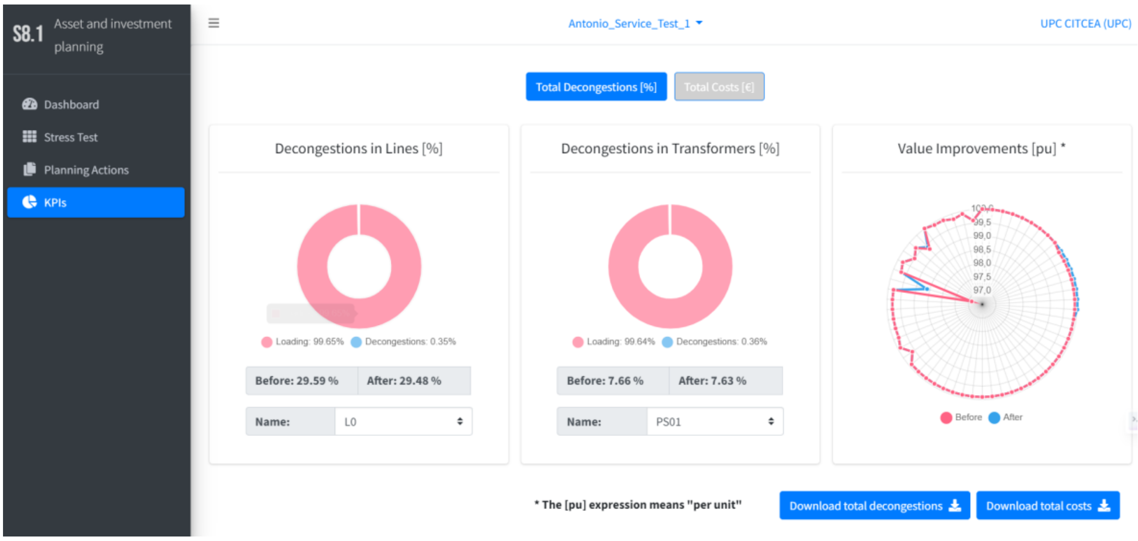


Figure 81 - Example of the results in the KPIs, Total Decongestion TAB

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

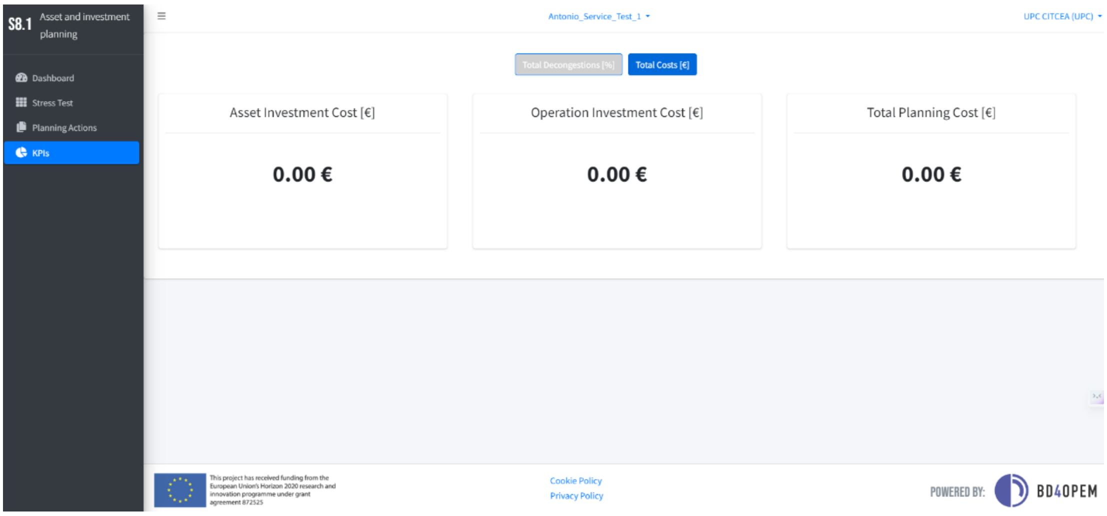


Figure 82 - Example of the results in the KPIs, Total Cost TAB

8. Appendix B. Service testing & Service KPIs

8.1 S3.1 – Grid disturbance simulations

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 18: Testing Summary Table

Pilot	Functional Test ID	Functional Test	Check	Test responsible	Comments
DENMARK	**DENMARK_S3.1_UPC_FT.1**	Data Ingestion	●		
	DENMARK_S3.1_UPC_FT.2	Review Load forecasts	●		
	DENMARK_S3.1_UPC_FT.3	Evaluate Lines behaviour	●		
	DENMARK_S3.1_UPC_FT.4	Analyse Report Tab	●		
	DENMARK_S3.1_UPC_KPI.5	KPIs	●		
	PILOT_SP.3.1_UPC_EX.1	Execution times	●		

Usability testing

Table 19: UI non-critical errors

UI Non-critical errors
Font size
Limit axis

Table 20: UI recommendations

UI Recommendations
Provide recommendations for improving the front-end UI

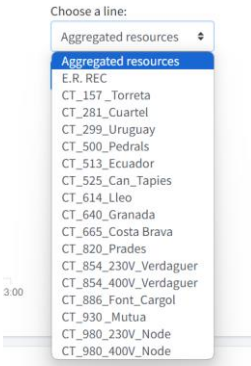
Service Functional and KPIs Testing Actions

Pilot: DENMARK

Table 21: DENMARK_S3.1_UPC_FT.1 Functional Test Task 1

<table>
<tr><th>Functional Test Description</th><th>Test Actions</th><th>Check</th></tr>
<tr><td rowspan="2">1. Data Ingestion</td><td>Make sure the data from the pilot is correctly ingested for the service.</td><td>●</td></tr>
<tr><td>Verify there are no NaN values</td><td>●</td></tr>
</table>

Table 22: DENMARK_S3.1_UPC_FT.2 Functional Test Task 2

<table>
<tr><th>Functional Test Description</th><th>Test Actions</th><th>Check</th></tr>
<tr><td rowspan="4">2. Review Loads forecast</td><td>Check Aggregated Loads forecast plot</td><td>●</td></tr>
<tr><td>Check dropdown list working
Working


Comment: The caption should be “Choose a bus” or “Choose Load”.</td><td>●</td></tr>
<tr><td>Verify Load1 button from dropdown list to plot</td><td>●</td></tr>
<tr><td>Verify Load2 button from dropdown list to plot</td><td>●</td></tr>
</table>

	Verify download file button	●

Table 23: DENMARK_S3.1_UPC_FT.3 Functional Test Task 3

Functional Test Description	Test Actions	Check
3. 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 24: DENMARK_S3.1_UPC_FT.4 Functional Test Task 4

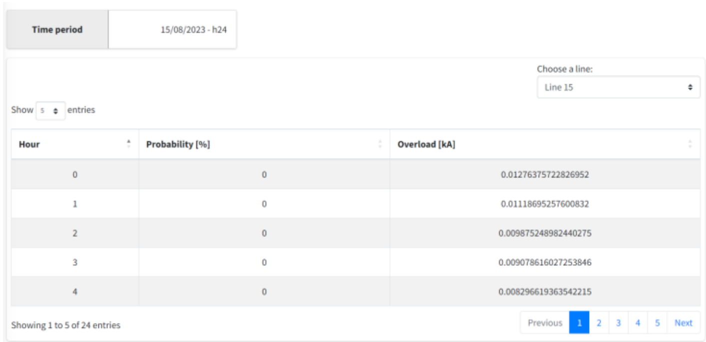
Functional Test Description	Test Actions	Check
4. Analyse Report Tab	Check *Report* tab button to be sent to new window	●
	Verify the results for all lines for all hours  Comment: I think the table should show the 24 hrs for default, instead of needing to select the number of entries. Additionally, the 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 centered.	●
	Download report in excel form	●

Table 25: DENMARK_S3.1_UPC_KPI.5Functional Test Task 5

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

Table 26: PILOT_SP.3.1_UPC_EX.1 Functional Test Task 6

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

Usability testing

UI Non-critical errors

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

Table 27: 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 28: UI Recommendations

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

ANNEX

The results show no congestions, however, this is coherent with the input data used in this version of the testing.

8.2S3.2 – Impact study PV, EV & new loads

Service	**S3.2 Impact study**
Algorithm provider	**ODT**
Solution provider	**ODT**
	Good performance ●
	Non-critical error ●
	Error detected ●
Release date	13/10/2023

Service testing summary

Marketplace testing

Table 29: S3.2 Testing Summary Table

Functional Test ID	Functional Test	Test responsible	Check	Comments
3.2_ODT_MK.1	Service contracts management	ODT	●	The complete contractual workflow is working as expected
		NUVVE	●	

Functional and KPIs testing (Responsible: Algorithm dev)

Table 30: S3.2 Testing Summary Table

Pilot	Functional Test ID	Functional Test	Test responsible	Check	Comments
DENMARK	3.2_ODT_FT.1	Active service contracts collection	ODT	●	Access to contract database has been successfully tested
	3.2_ODT_FT.2	Data collection	ODT	●	Data access through data lake has been successfully tested, tested instance on manually ingested data
	3.2_ODT_FT.3	LV networks modelling	ODT	●	Validated in expert testing session
	3.2_ODT_FT.4	Results export	ODT	●	Validated in expert testing session
	3.2_ODT_FT.5	User access	NUVVE	●	Validated in expert testing session
	3.2_ODT_KPI	KPIs validation	ODT	●	Not shared on a regular basis, offline calculation

					Computation time is long

Usability testing

Table 31: UI critical errors

UI Critical errors
NA

Table 32: UI non-critical errors

UI Non-critical errors
Issue with the display of headers

Table 33:

UI Recommendations
Include bi-directional capacity with the EVSEs

Marketplace testing

Table 34: 3.2_ODT_MK.1 Service contracts management

Marketplace Test Description	Test Actions	Test responsible	Check
7. Contract service	Found service in marketplace by searching it with one of the following keywords: • Renewable energy, modelling, integration, low voltage grid, AI, digital twin, photovoltaic, electric vehicles	ODT	•
	Select service to see details about it	ODT	•
	Contract the service	NUVVE	•
	Validate contract (data validation)	ODT	•

Service Functional and KPIs Testing Actions

Table 35: 3.2_ODT_FT.1 Active service contracts collection

Functional Test Description	Test Actions	Test responsible	Pilot	Check
8. Active service contracts	List all the active and approved contracts	ODT	Denmark	•

collection through the UnifiedAPI	Get the data tokens linked to the contracts	ODT	Denmark	🟢

Table 36: 3.2_ODT_FT.2 Data collection

Functional Test Description	Test Actions	Test responsible	Pilot	Check
9. Data collection through the UnifiedAPI	[redacted]	ODT	Denmark	🔴
	Pre-process data in Odit-e format	ODT	Denmark	🟢

Table 37: 3.2_ODT_FT.3 LV networks modelling

Functional Test Description	Test Actions	Test responsible	Pilot	Check
10. Low voltage networks modelling	Low voltage networks models (Digital Twins) trained	ODT	Denmark	🟢
	PV capacity estimation for each smart meter	ODT	Denmark	🟢
	EV or new load capacity estimation for each smart meter	ODT	Denmark	🟢

Table 38: 3.2_ODT_FT.4 Results export

Functional Test Description	Test Actions	Test responsible	Pilot	Check
11. Results export in Odit-e database and visualization	Save low voltage networks models in database	ODT	Denmark	🟢
	PV, EV and New load capacities estimations are available on the webapp	ODT	Denmark	🟢
	Webapp credentials sent to the customer	ODT	Denmark	🟢

Table 39: 3.2_ODT_FT.5 User access

Functional Test Description	Test Actions	Test responsible	Pilot	Check
12. Customer access to the results	The customer successfully connects to the webapp	NUVVE	Denmark	🟢
	The customer sees the results on the webapp	NUVVE	Denmark	🟢
	The customer can simulate PV, EV or new load insertion	NUVVE	Denmark	🟢

	The customer can add to the waiting list the simulated PV insertions	NUVVE	Denmark	●

Table 40: 3.2_ODT_KPI KPIs validation

Functional Test Description	Test Actions	Test responsible	Pilot	Check
13. KPIs (see **Erreur ! Source du renvoi introuvable.**)	All KPI are computed each week (excepted #3)	ODT	Denmark	●
	All KPI (excepted #3) are validated	ODT	Denmark	●

Table 41: S3.2 KPI list table

#	KPI	Description	Calculation	Expected value	Offline calculation
1	Runtime	Runtime of the algorithm with a substation with 100 three-phase meters and one year of data	tresults – torder	<150s	Initialization takes 3 hours (with data ingestion, preprocessing, deployment, training). Iterative simulation takes less than a minute but must be improved for better UX
2	Number of meters analysed	Total number of meters analysed by the service through the platform	∑nmeters	-	117
3	Impact prediction accuracy	[Require field intervention] Calculates the accuracy of the forecasted impacts, by training the model before or after the field intervention, then estimating smart meters voltage over the other time interval.	MAE of smart meters voltage estimation	<3V	Not applicable because no field validation
4	Digital twin accuracy	Estimation of the digital twin accuracy out of trainning regression domain	MAE of smart meters voltage estimation	<3V	Not computed

Usability testing

UI Critical errors

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

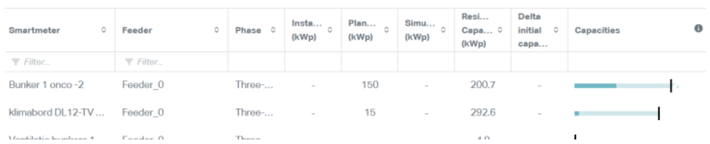
Table 42: UI critical errors

Critical errors	Screen shots and description	Reporter
NA		

UI Non-critical errors

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

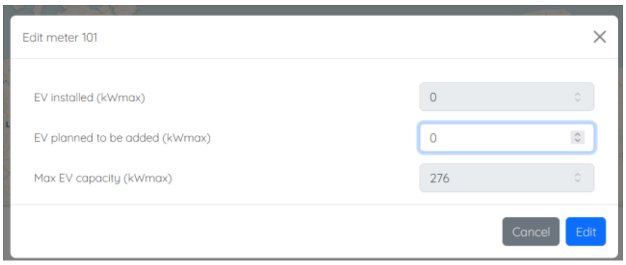
Table 43: UI non-critical errors

Non-critical errors	Screen shots	Reporter
Tables header cannot be seen completely neither be made broader		ODI

UI Recommendations

Provide recommendations for improving the front-end UI

Table 44: UI Recommendations

Recommendations	Screen shots	Reporter
[redacted]	 [redacted]	NUVVE

8.3S5.1 – Flexibility Forecast

8.3.1 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 45: S5.1 Testing Summary Table

Pilot	Functional Test ID	Functional Test	Check	Test responsible	Comments
DENMARK	DENMARK_5.1_UPC_FT.1	History	●	UPC	
	DENMARK_5.1_UPC_FT.2	Data Selection	●	UPC	
	DENMARK_5.1_UPC_FT.3	Training model results	●	UPC	
	DENMARK_5.1_UPC_FT.4	Forecast results	●	UPC	
	DENMARK_5.1_UPC_KPI.1	KPIs	●	UPC	
	DENMARK_5.1_UPC_EXEC	Execution times pilot	●	UPC	

Usability testing

Table 46: S5.1 UI critical errors

UI Non-critical errors
Font size
Limit axis

Table 47: S5.1 UI Recommendations

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

Service Functional and KPIs Testing Actions

Pilot: DENMARK

Table 48: DENMARK_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 3.	•
	Within "Forecast" functions as verified in Table 4.	•

Table 49: DENMARK_5.1_UPC_FT.2 Data selection.

Functional Test Description	Test Actions	Check
2. Data selection	Selection of "EV" and/or "ESS" from droplist	•
	Selection of either "Positive Flexibility" or "Negative Flexibility"	•
	Date selection is more than 1 year and it exists on dataset	•
	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 50: DENMARK_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 51: DENMARK_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 52: DENMARK_5.1_UPC_KPI.1 KPIs.

Functional Test Description	Test Actions	Check
5. KPI	Use case 1 - Total flexibility value: 3521.69/>0	●
	Use case 1 - Average flexibility value: 5.13/>0	●
	Use case 1 - Average flexibility availability: 1.96/[0-100%]	●
	Use case 1 - Mean Absolute Percentage Error: 143.75/[0-100%]	●
	Use case 2 - Total flexibility value: 3521.69/>0	●
	Use case 2 - Average flexibility value: 5.13/>0	●
	Use case 2 - Average flexibility availability: 1.96/[0-100%]	●
	Use case 2 - Mean Absolute Percentage Error: 147.78/[0-100%]	●

Table 53: S5.4 Execution table table

Functional Test Description	Test Actions	Execution time local/front-end	Check
6. Execution time	Executing algorithm for Use Case 1	54 min / 60 s	●

Usability testing

UI Non-critical errors

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

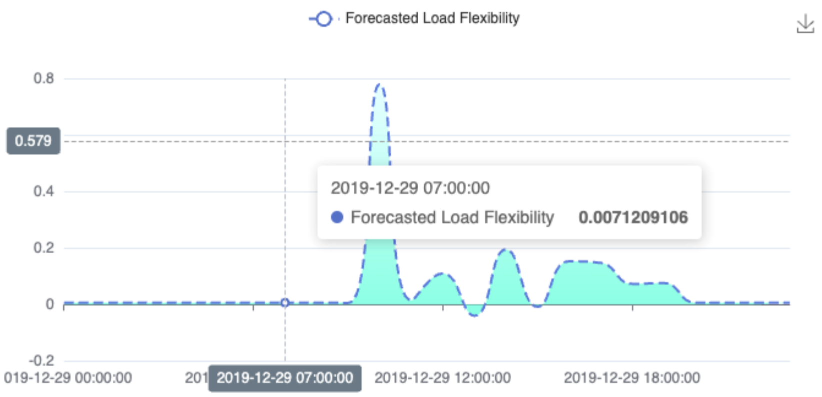
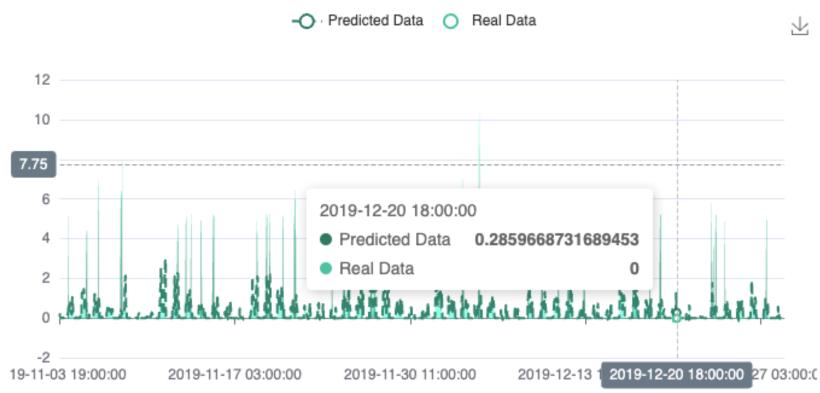
Table 54: S5.1 UI non-critical errors

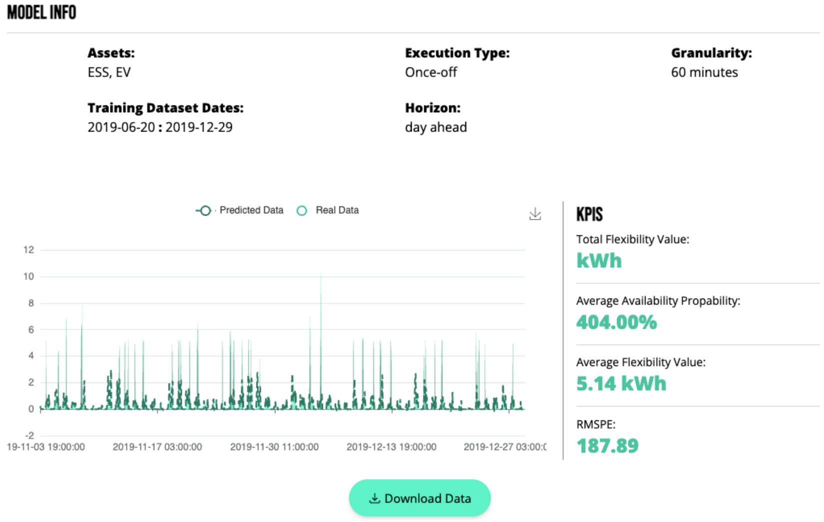
Non-critical errors	Screen shots
Font size	Nothing to declare.
Limit axis	Nothing to declare.

UI Recommendations

Provide recommendations for improving the front-end UI

Table 55: S5.1 UI Recommendations

Recommendations	Screen shots
Recommendation 1	For forecast  Add the unit on the Y axis
Recommendation 2	For model training the same 

Recommendations	Screen shots
Recommendation 3	En model and forecast, put the name of the pilot 

8.4 S5.4 – EV to Grid

Pilot: Denmark

Table 56: DENMARK_5.4_UPC_FT.1 History.

Functional Test Description	Test Actions	Check
1. History	List of previous event runs can be observed	●

	Each event run has the features as described in table 4	•

Table 57: DENMARK_5.4_UPC_FT.2 New event.

Functional Test Description	Test Actions	Check
2. New Event	Input event name	•
	Select location	•
	Select service between discharge or charge	•
	Input DSO requirement	•
	Congestion horizon date selection	•
	Target hours can be selected	•
	Client selection	•

Table 58: DENMARK_5.4_UPC_FT.3 Results.

Functional Test Description	Test Actions	Check
3. Results	Table with event summary correctly filled	•
	On the same table: additional information concerning provision is available	•
	Graphs available for selected horizon and target hours shows DSO request	•
	Table with provision data is available and filled	

Table 59: DENMARK_5.4_UPC_KPI.1 Functional Test Task 3

Functional Test Description	Test Actions	Check
4. KPI	Use case 1 - Forecasting Error: 55.37%/[0-100%]	•
	Use case 2 - Forecasting Error 38.87%/[0-100%]	•

Table 60: DENMARK_5.4_UPC_EXEC.X Functional Test Task 4

Functional Test Description	Test Actions	Execution time local/front-end	Check

5. Execution time	Training + Executing algorithm for Use Case 1	7 min/ 60 s	●

Usability testing

UI Non-critical errors

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

Table 61: S5.4 UI non-critical errors

Non-critical errors	Screen shots
Font size	
Limit axis	

UI Recommendations

Provide recommendations for improving the front-end UI

Table 62: S5.4 UI Recommendations

Recommendations	Screen shots
Recommendation 1	
Recommendation 2	

8.5 S8.1 – Asset and investment planning

Service Testing

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 63: S8.1 Testing Summary Table

Pilot	Functional Test ID	Functional description	Test Check	Comments
Denmark	Denmark_8.1_UPC_FT.1	Stress test tab display options	● (red)	The load increase button is not working. See more details in the table below.
	Denmark_8.1_UPC_FT.2	Planning Action tab display options	● (green)	
	Denmark_8.1_UPC_FT.3	KPIs results	● (green)	
	Denmark_8.1_UPC_FT.4	Download results	● (red)	I cannot open the excel file "KPI Results" (only download).
	Denmark_8.1_UPC_FT.5	Execution time	● (green)	

Usability Testing

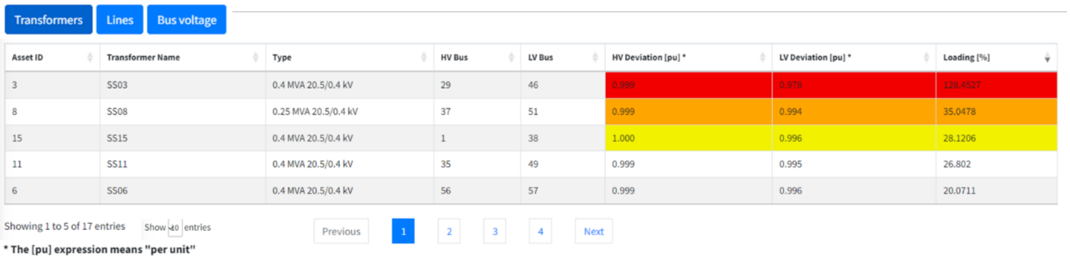
Table 64: S.8.1

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 65: S8.1

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:



Pilot: Denmark

Table 66: DENMARK_8.1_UPC_FT.1 Stress test Tab display options

Functional Test Description	Test Actions	Check
14. 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%). The issue is that when I apply 100%, 500%, or 600% of load increase the results are always the same. And the network cannot be stressed is this action is not changing.	●

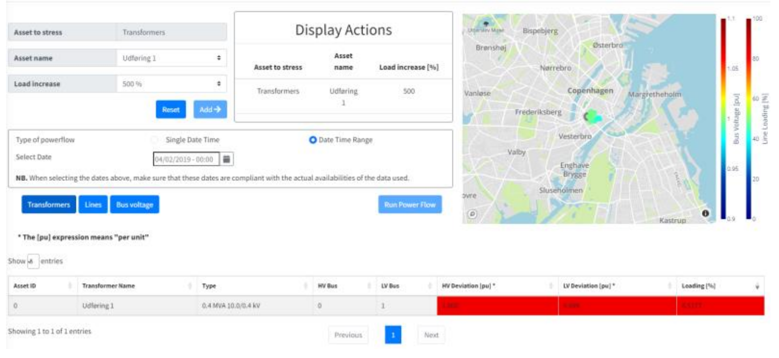
		
	Make sure that after adding (by clicking the add botton) the expansion of the asset, the planning actions must be displayed in the table located in the right side of the UI. Make sure is **displayed correctly**.	●
	Select "**Single Date Time"** in the Type of power flow options. Make sure that you can 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 67: DENMARK_8.1_UPC_FT.2 Planning Actions Tab Display Options

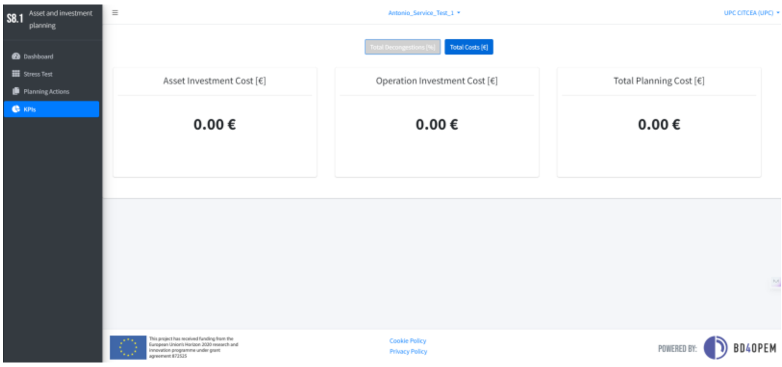
Functional Test Description	**Test Actions**	**Check**
15. Planning Actions Tab Display Options	Click the "Planning Actions" Tab (from the main left column). Make sure that there is no error in the time series or single power flow simulation.	●
	After running the power flow simulation, the planning actions 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 color 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 asset names, types and results are shown correctly.	●

Table 68: DENMARK_8.1_UPC_FT.3 KPIs results in the marketplace

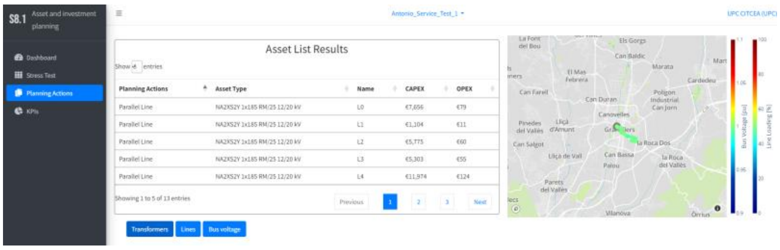
Functional Test Description	**Test Actions**	**Check**

<table>
<tr><td rowspan="2">16. KPIs results in the marketplace</td><td>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.</td><td>●</td></tr>
<tr><td>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.

Total Costs are not correct in the UI (Zero value only).



The results of should reflect in the Asset investment Cost = Sum the CAPEX for all the assets listed in the results of table below. In the Operation Investment = Sum of the OPEX for all the asset listed in the results of table below. Total Planning Costs = Asset Investment + Operation Investments.



</td><td>●</td></tr>
</table>

Table 69: DENMARK_8.1_UPC_FT.4 Download results

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

Table 70: DENMARK_8.1_UPC_FT.5 Execution time

Functional Test Description	Test Actions	Execution time local/front-end	Check

18. Execution time	Executing algorithm for Use Case 1 (Annex)	10 s/ 60 s	●

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