D6.2 - BD4NRG Pilots Synergies, Evaluation and Feedback - First Release

WP6 - Pilot Requirements and Assessment

March 2022

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Preface

BD4NRG focuses on addressing emerging challenges in big data management for energy sector with an innovative open holistic solution for smart grid-tailored, near real time, energy-specific and AI-based open Big Data Analytics modular framework. The vision is to deliver holistic services for techno-economic optimal management of Electric Power and Energy Systems value chain. Services range from optimal risk assessment for energy efficiency investments planning, to optimised management of grid and non-grid owned assets, improved efficiency, and reliability of electricity networks operation, while at the same time contributing to achieve fair energy prices to the consumers and laying the foundations for an EU-level energy-tailored data sharing economy. The BD4NRG Toolbox will be implemented and validated in real-life pilots in 12 large-scale demo sites across 8 countries for:

- Increasing the efficiency and reliability of the electricity network BD-4-NET
- Optimising the management of assets connected to the grid BD-4-DER
- De-risking investments in energy efficiency and increasing the efficiency and comfort of buildings BD-4-ENEF

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Abbreviations & Acronyms

Acronym	Description
AC	Alternative Current
AHI	Asset Health Index
AI	Artificial Intelligence
API	Application Programming Interface
APS	Advanced Pilot Stage
AUI	Asset Utilisation Index
BEMS	Building Energy Management System
BESS	Battery Energy Storage System
BPS	Basic Pilot Stage
CAIDI	Consumer Average Interruption Duration Index
CB	Circuit Breakers
CPV	Concentrated Photovoltaic
CSV	Comma Separated Value
DAS	Data Acquisition System
DB	Database
DC	Direct Current
DER	Distributed Energy Resources
DL	Deep Learning
DSO	Distribution System Operator
EPC	Energy Performance Certificate
ESCO	Energy Service Company
EV	Electric Vehicles
FFT	Fourier Fast Transform
GA	Grant Agreement

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Acronym	Description
IoT	Internet of Things
IPS	Intermediate Pilot Stage
KPI	Key Performance Indicator
LMP	Location Maintenance Project
LSP	Large Scale Pilots
LV	Low Voltage
M&V	Measurement & Verification
ML	Machine Learning
MST	Maintenance Scheduling Tool
MV	Medium Voltage
NOVAAS	NOVA Asset Administration Shell
OHL	Overhead Lines
PV	Photovoltaic
RES	Renewable Energy Sources
RoW	Right-of-Ways
Rq	Requirement
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
TSO	Transmission System Operator
Use Case	UC
VPN	Virtual Private Newtwork
WP	Work Package

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Executive Summary

This deliverable is the second deliverable under WP6 - "Pilot Requirements and Assessment". It presents the progress of the pilot demonstrators regarding both pilots' and technical activities, during the Pre-Pilot Cycle which followed BD4NRG's 1st technology release. The deliverable serves as a reporting document in order to track and monitor the ongoing progress, as well as providing feedback for the next Development Cycle and the subsequent 2nd technology release.

In the deliverable, the final Measurement & Verification (M&V) plan is reported, after being refined at M14 (January 2022) from its initial form on M8 (August 2021). The monitored progress follows the redefined M&V plan, by tracking the KPIs and the Pilot Deployment & Engagement plan (as presented in deliverable D6.1 - "Pilot Operation, Engagement and M&V Plan").

The pilots' activities are presented including information regarding their infrastructure, the Use Cases (UCs), the analytics services development and the overall progress during Pre-Pilot Cycle. Furthermore, the technical activities under WP3 - "Data Governance and Management" and WP4 - "Data Modelling & Open Modular AI-based edge-level Analytics Toolbox" in respect to the pilot demonstrators are presented, as part of the early data-driven experimentation. These activities will be used as feedback loops for the technology advancements in the following Development Cycle. It is expected that the following Development Cycle will be deployed to all pilot demonstrators, in contrast to the Pre-Pilot Cycle where a subset of pilots was considered for the testing activities.

The initial evaluation based on the redefined M&V plan is presented, by reporting the status of the General and Pilot Specific KPIs, reflecting on the activities held during the Pre-Pilot Cycle. An assessment of the Pre-Pilot Cycle in multiple tracking categories is also reported in order to capture the full view of the Pre-Pilot Cycle activities.

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1 Introduction

1.1 Objectives of the deliverable

Deliverable D6.2 - “Pilots Synergies, Evaluation and Feedback - First Release” presents the activities held during the Pre-Pilot Cycle. Following the Measurement & Verification (M&V) plan with the corresponding KPIs, the pilot operation and engagement plan under D6.1 - “Pilot Operation, Engagement and M&V Plan”, the baseline analysis and the preparation activities under D7.1 - “Baseline Analysis Report and ‘BD-4- NET’ Large Scale Pilots Preparation”, D8.1 - “Baseline Analysis Report and ‘BD-4- DER’ Large Scale Pilots Preparation” and D9.1 - “Baseline Analysis Report and ‘BD-4- ENEF’ Large Scale Pilots Preparation”, this report aims to present the progress so far and future activities, in combination with the advancements of the technical Work Packages (WPs) of BD4NRG.

Moreover, this report is a reference document for advancing the activities of BD4NRG in phase 2 of BD4NRG’s Development Cycle (M14-M26), towards the 2nd Technology Release (M21) and use the feedback for a successful rollout of Pilot-Cycle 2 (between M22 and M26) and its functional implementation.

In a nutshell, the main objectives of deliverable D6.2 - “Pilots Synergies, Evaluation and Feedback - First Release” are outlined as followed:

- Report of the progress within pilots during Pre-Pilot Cycle.
- Report of the deployment of BD4NRG’s technical components following the 1st Technology Release during the Pre-Pilot Cycle.
- Provision of information and feedback derived from Pre-Pilot Cycle activities for the 2nd phase of BD4NRG Development Cycle.
- Provide an initial analysis of potential synergies between the pilot demonstrators.
- Provide an evaluation of the Pre-Pilot Cycle and potential issues.

1.2 Structure

The document is organised in 7 different sections as follows:

Section 1 includes the objectives of the deliverable, the connection with other WPs and the updates on the M&V plan.

Section 2 provides the pilot activities held withing the Pre-Pilot Cycle.

Section 3 presents the technical activities and deployment towards the pilot demonstrators during the Pre-Pilot Cycle.

Section 4 presents the status of the General and Pilot Specific KPIs as recorded in the end of the Pre-Pilot Cycle.

Section 5 presents an overall evaluation of the Pre-Pilot Cycle.

Section 6 presents an initial analysis for potential synergies between Large Scale Pilots (LSPs).

Section 7 summarises the document and outline the next steps.

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1.3 Connection with other WPs

This report is heavily linked with other WP activities, as it encapsulates information regarding pilot and technical activities and how they are interconnected during the Pre-Pilot Cycle.

More specifically, it has a close connection with WP2 - “System Requirements and Specifications”, as the proposed UCs of the LSPs, their implementation and the BD4NRG technical components adaptability to them, are driven from the WP2 activities and reports.

Deliverable D6.2 has also connection with both WP3 - “Data Governance and Management” and WP4 - “Data Modelling & Open Modular AI-based edge-level Analytics Toolbox”, since it presents the activities undertaken during the Pre-Pilot Cycle of these WPs, in respect to the LSPs’ needs and their deployment status. It should be noted that integration between pilot demonstrators and WP5 - “Marketplaces for realizing EU-level Energy Data Economy” is also expected, but these activities were not considered during the Pre-Pilot Cycle. For WP3, the focus is on the integration activities between the LSPs and BD4NRG infrastructure and as for WP4, the focus is on the analytics services’ development and deployment towards the LSPs. For both WPs, D6.2 also provides a reference point and substantial feedback for the technical activities to advance towards the 2nd technological release (through the Pilot Deployment Template, as presented in deliverable D6.1 - “Pilot Operation, Engagement and M&V Plan”, and used during the Pre-Pilot Cycle for collecting information).

Finally, D6.2 is closely connected with WP7 - “‘BD-4-NET’ Large Scale Pilots: Increasing the Efficiency and Reliability of the Electricity Network”, WP8 - “‘BD-4-DER’ Large Scale Pilots: Optimizing the Management of Assets (DER-Distributed Energy Resources) Connected to the Grid” and WP9 - “‘BD-4-ENEF’ Large Scale Pilots: De-Risking Investments in Energy Efficiency and Increasing the Efficiency and Comfort of Buildings”. It captures the status and progress held by the LSPs during the Pre-Pilot Cycle, provides the progress of the M&V plan and demonstrates the Pilot Deployment Template’s efficiency in coordinating and monitoring the LSPs progress in a unified way. D6.2, based on the pilots’ baseline analysis and their preparatory activities, proceeds with the evaluation of the Pre-Pilot Cycle, through the KPIs and the overall advancements made in each LSP in respect with their starting points, as reported in D7.1 - “Baseline Analysis Report and ‘BD-4- NET’ Large Scale Pilots Preparation”, D8.1 - “Baseline Analysis Report and ‘BD-4- DER’ Large Scale Pilots Preparation” and D9.1 - “Baseline Analysis Report and ‘BD-4- ENEF’ Large Scale Pilots Preparation”.

1.4 Recap of deliverables D6.1, D7.1, D8.1 and D9.1

D6.1 - “Pilot Operation, Engagement and M&V Plan” presented the general framework of Pilot operation. In D6.1, the methodology to establish an evaluation process of pilot activities was designed, through the M&V Plan. Two sets of KPIs were proposed, the General KPIs which derive from the GA and the Pilot Specific KPIs, which were proposed by the LSP partners. These KPIs provide the ability to evaluate the analytics services of the BD4NRG in their UCs. Furthermore, the Pilot Operation & Engagement Plan was proposed, under which the Pilot Deployment Template was introduced as the method to ensure the tracking of pilot activities (both technical and LSP related) in a personalised manner. The Pilot Deployment Information Template and the list of KPIs can be found in the APPENDIX I and APPENDIX II respectively (although the List of KPIs is updated, see section 1.5 for updates on the M&V plan)

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Deliverables **D7.1 - "Baseline Analysis Report and 'BD-4- NET' Large Scale Pilots Preparation"**, **D8.1 - "Baseline Analysis Report and 'BD-4- DER' Large Scale Pilots Preparation"** and **D9.1 - "Baseline Analysis Report and 'BD-4- ENEF' Large Scale Pilots Preparation"**, present the next steps of the pilot process and the preparatory activities. In the baseline analysis, the "as is" status of the LSPs infrastructure has been recorded (i.e., before the start of BD4NRG and the pilot tasks) and reflected in the General and Pilot Specific KPIs baseline values. Furthermore, the calculation methods of the Pilot Specific KPIs have also been presented in order to provide the ability to justify their measurement and evaluation throughout the project's lifecycle.

1.5 Updates on M&V Plan

The M&V plan would take its final form in M14 (February 2022). Although the majority of the plan has been established and reported in D6.1 - "Pilot Operation, Engagement and M&V Plan", few changes occurred between M8 (submission date of D6.1) and M14. These updates refer to few KPIs alterations in LSP1 - "Integrating off-grid Data with Condition based Monitoring for Enhanced Predictive Asset Maintenance and the timeline of User Satisfaction methodology. It should be noted that changes in User Satisfaction methodology were mandatory due to delays of technical activities, however, this had been considered, as reported in deliverable D6.1 - "Pilot Operation, Engagement and M&V Plan" (section 2.4 - "Risk Factors during Progress Monitoring")

1.5.1 BD4NRG General Context

The methodology to measure and verify the BD4RNG general context, relies to the use of KPIs, namely General and Pilot Specific KPIs. The approach has no major updates from a high point of view. The General KPIs derive from the GA, thus, they cannot be changed in any type of way. However, for LSP1 the Pilot Specific KPIs have been modified (specifically two KPIs were removed), based on the activities held between the submission of D6.1 - "Pilot Operation, Engagement and M&V Plan" on M8 and the submission of D7.1 - "Baseline Analysis Report and 'BD-4- NET' Large Scale Pilots Preparation" on M10. These changes were reported in deliverable D7.1, consequently the M&V plan must be updated to reflect them. The updated list with all the Pilot Specific KPIs can be found in APPENDIX II.

1.5.2 Infrastructure and Digital Technologies

No major updates needed to report in Infrastructure and Digital Technologies for the final M&V plan. The templates created and reported in D6.1 - "Pilot Operation, Engagement and M&V Plan" (Data Gathering Template, Analytics Services Template and Pilot Infrastructure Template) are utilised to provide information for technical activities and the initial tracking of the General KPIs and will be used as tracking documents for pilot monitoring.

1.5.3 User Satisfaction

The User Satisfaction methodology was planned to start at the beginning of the Pre-Pilot Cycle (M11), created in cooperation with technical WPs upon the finalisation of the subset of pilots selected for the "1st cycle assessment for pilots' completion (early data-driven experimentation)" (MS4, M13). However, due to the delay of the 1st Technology Release, the User Satisfaction methodology was

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postponed. Although the methodology's rationale was the ability to collect feedback from as many parties (internal or external) as possible, in this first Pilot-Cycle the delay does not deem as a major drawback. This is justified by the fact that the first iteration of the User Satisfaction methodology was planned to take place internally within the LSPs who part of the early data-driven experimentation were. However, since the timeline is affected, the M&V plan should be updated to reflect this change and proceed with a new timeline for the methodology, albeit the methodology itself will be similar (i.e., questionnaires handed to users, beneficiaries and pilot actors during the iterative process of the BD4NRG's Development Cycles).

The updated User Satisfaction Methodology timeline is presented:

- Between M11-M20 (November 2021-August 2022) initial work on identifying a pool of questions for the questionnaires takes place. These will be the backbone of the User Satisfaction questionnaires and will cover pilot related requirements.
- Between M22-M26 (October 2022-February 2023) within the Full Pilot Cycle, the questionnaires of the first iteration will be created for the of pilots. Cooperation with the technical WPs will be held in order to define the questions, based on the pool of question identified from the pilot related corresponding to the developments of the 2nd technology release. The goal is to gather feedback from the users of the BD4NRG services so as to evaluate the tools and the results and use it for the development of the final technology release.
- Between M29-M32 (May 2023-August 2023), the final Pilot Evaluation will take place along with the final stage of the user satisfaction methodology. A final round of questionnaires will be handed to the identified beneficiaries for the tools and services. The process of creating the questionnaires will be similar with the previous cycle of the user satisfaction methodology. In the final evaluation period, 3 workshops are also envisioned to take place under task 6.4 – "Pilots' Validation and assessment and Stakeholders' Feedback", where live demonstration will take place to the targeted audience of BD4NRG. Although it is possible for the workshops to be held in a previous cycle too, at this early stage of the project it is considered to be pushed towards the end of the project, addressing potential mobility limitation and ensuring technological maturity of BD4NRG tools and services.

Nonetheless, during the months between the first version of M&V plan (D6.1 - "Pilot Operation, Engagement and M&V Plan"- M8) and the final M&V plan, activities under WP6 - "Pilot Requirements & Assessment" were proceeding by identifying a pool of questions which can be used in the User Satisfaction questionnaires as a first step, before the consultation with the pilot and technical partners and their finalisation. The identified questions so far are presented in Table 1 and derive both from the requirements as presented in deliverable D2.1 - "Big Data Value Chain and Requirements" as well as the identified UCs and the corresponding KPIs.

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Table 1: User Satisfaction Questions per LSP

LSP	Question
LSP1	How do you rate the accuracy of identifying the transmission towers type? (Rq_01) How do you rate the accuracy of identifying the condition of transmission towers? (Rq_02)
LSP2	Are the developed tools sufficient to support the maintenance scheduled process? (Rq_03) How do you rate the automated outage proposal plan? (Rq_05) Are the additional optimisation constrains and criteria for future planning sufficient? (Rq_06) How do you rate the accuracy of classifying and type identification of circuit breaker recorded incidents? (Rq_07)
LSP3	How do you rate the charging stations availability of the service? (Rq_11) How do you rate the accuracy of the forecasts?
LSP4	How do you rate the ability to reduce the number of interruptions provided of the service?
LSP5	How do you rate the agents' performance? How do you rate the demand response mechanisms?
LSP6	How do you rate the flexibility forecasting on demand and generation profiles? Is the flexibility of the transformer's nominal power sufficient to cover the DSO needs? How do you rate the financial outcomes for the prosumer using the provided models?
LSP7	How do you rate the identification of underperformance areas? (Rq_19)
LSP8	How do you rate the scheduling of the water pumps? How do you rate the loads offered for the service? (Rq_20)
LSP9	How much space is saved from using components that have edge computing capabilities? (Rq_13) How do you rate the maintenance scheduling system? How do you rate the accuracy of the forecasts?
LSP10	How do you rate the EPC labelling service? (Rq_15) How do you rate feedback sharing back to the system based on new results obtained for EPCs? (Rq_16)
LSP11	How do you rate the thermal comfort efficiency? (Rq_10)
LSP12	How do you rate the energy savings calculator? How do you rate the investments classification service?

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2 Pilot Activities

In this section the pilots' activities during the Pre-Pilot Cycle are presented. It aims to capture the progress between M11 and M13 and present the status of the UCs.

2.1 LSP1 (REN & RDN): Integrating off-grid Data with Condition based Monitoring for Enhanced Predictive Asset Maintenance

A checklist deriving from the Pilot Deployment Information Template is presented below, to provide the status of the progress in several areas related to LSP1.

Table 2: LSP1 Checklist

Type	Information
Status of pilot infrastructure	Pilot data infrastructure is functional
Test cases/Scenarios	Evaluation of fault classification on a holdout fault dataset Evaluation of accuracy of modules comprised in the Fault Analysis service, in a truth table. Evaluation of results. Evaluation of tower classification algorithms on a holdout dataset
Service status	Described in detail in the below sections
Stakeholders involved	REN (Portuguese TSO)
Technologies Used	Python, Jupyter Notebooks
BD4NRG Tools	n/a
Next Steps	Generation of simulated faults in laboratory to enrich fault classification training dataset with rarer fault events Procurement of additional data for RoW corridors

UC1: AI methods applied to Condition-based monitoring of Circuit Breakers

UC1 is related with AI methods applied to condition-based monitoring and maintenance of Circuit Breakers (CB). The end goal of this UC is to derive condition-based monitoring strategies for the circuit breaker assets of TSOs. With this global scope in mind, the objectives can be broken down into:

- Perform automatic fault analysis: generating fault reports with key incident statistics and fault class identification.
- Asset level timespan and insight analysis, using statistics extracted at incident level, with historical data.
- Categorisation of cause of faults using unsupervised methods, integrating off-grid data.
- Estimation of likelihood index of failure (or performance reduction) based on asset status.

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These individual sub-goals have been also guiding the service development of the UC. During the Pre-Pilot Cycle, the services developed responded to the first two of these goals.

The Fault Analysis service developed takes in pre-processed COMTRADE data, ingested from the COMTRADE parser developed, and can automatically detect any fault or disturbance, evaluate and classify the fault and report key statistics on the go (e.g., CB response times, elimination times, faulted current). In section 3.2.1 details regarding the Fault Analysis service can be found.

Below, the summary table for UC1 is presented:

Table 3: LSP1 UC1 Pre-Pilot Cycle Summary

Use Case 1	
Pre-Pilot Target	Pre-process the COMTRADE data (development of a COMTRADE processing tool) and generate incidents dataset Develop Fault Analysis Service with accurate fault classification and reporting and Asset Analytics Service for retrieval of performance time-series Integration of Services
Status Summary	The COMTRADE data has been fully processed (functional COMTRADE processing tool has been developed) Two key services of the UC have been developed Integration of services with project infrastructures has been started: data ingestion from project DB and integration of Fault Analytics Service in the project infrastructures

UC2: Semi-Automatic Maintenance Plan for Right-of-Ways in Overhead Lines

UC2 regards the Semi-Automatic Maintenance Plan for Right-of-Ways (RoW) in Overhead Lines (OHL). The goal of this UC is similar to UC1, to derive monitoring strategies for the Overhead Line asset class, and in general for the RoWs of TSOs. The objectives of the UC are:

- To perform classification of Overhead Line towers existent in the field, through supervised or unsupervised methods.
- Usage of unstructured flight inspection data (e.g., LiDAR point clouds, image and video) to assess OHL tower and RoW corridor condition automatically.
- Generate automatic maintenance plans for Overhead Lines based on status assessment.

The main dataset employed for the development of the use case has been, at this first stage, the LiDAR point cloud inspection data of transmission towers (Figure 1).

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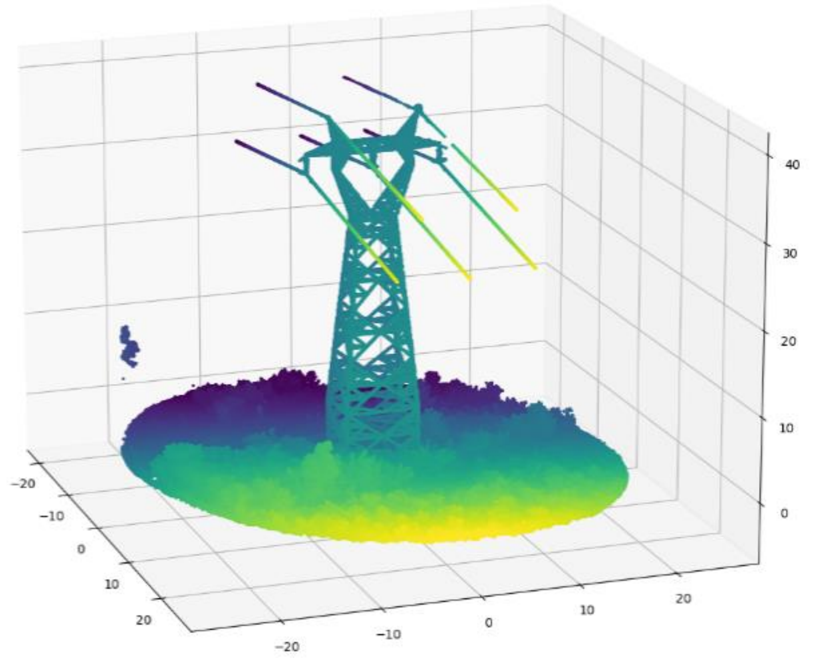

Figure 1: LiDAR transmission tower scan sample (LSP1)

Due to the heavily unstructured and heterogeneous nature of this data, a LiDAR Processing engine was developed. The goal of this tool is to perform basic data cleaning and structuring, as well as performing geometric adjustments to the point clouds, in the forms of recentring and projection alignment of towers, as described in Figure 2.

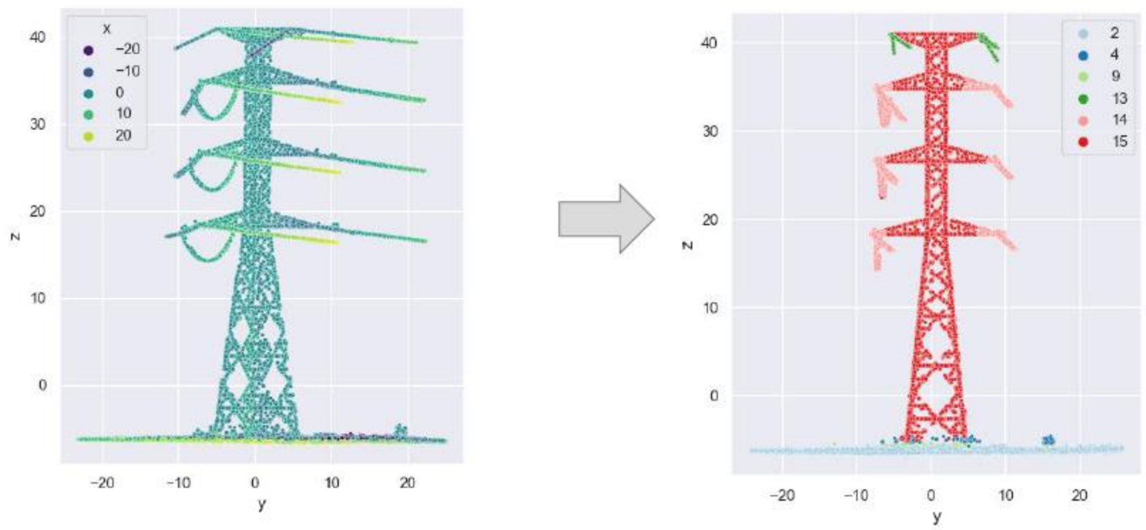

Figure 2: LiDAR data processing: extraction of tower profile (LSP1)

In section 3.2.1 details regarding the OHL transmission tower classification can be found. Below, the summary table for UC2 is presented:

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Table 4: LSP1 UC2 Pre-Pilot Cycle Summary

Use Case 2	
Pre-Pilot Target	Pre-process the LiDAR data (development of a COMTRADE processing tool) Generate training labelled dataset comprised of a representative set of LiDAR towers, which comply to a minimum quality in terms of resolution and homogeneity Develop initial models for tower identification Evaluate the usage of the processed LiDAR data for condition monitoring activities
Status Summary	LiDAR processing tool developed and fully functional A set of ML models available for identification of OHL tower families is functional and has been tested No integration activities ongoing so far

2.2 LSP2 (ELES): Cross-functional Integration of Grid Operation with Predictive Asset Management

A checklist deriving from the Pilot Deployment Information Template is presented below, to provide the status of the progress in several areas related to LSP2.

Table 5: LSP2 Checklist

Type	Information
Status of pilot infrastructure	Identified data of interest is prepared in a form, required by the developed tools. Tables are defined and populated to be accessed by service developers. Third party access to DB is tested. Initial versions of Maintenance Scheduling Tool (MST) and asset indices estimation tool are defined and first run results are available.
Test cases/Scenarios	In a pre-pilot phase initial run of tools is successfully preformed: In case of Maintenance Scheduling Tool (MST) a manual run of the tool was performed, using the initial asset database and, to some extent, generic parameters for ranking and boundary conditions definition. In case of indices estimation, a manual run of the tool was performed, utilising the batch of historical data.
Service status	Developed services are currently in a prototyping phase, providing initial results in order to allow debugging of the tools and validation (and possible extension) of provided inputs.
Stakeholders involved	The service is not yet suitable for any stakeholder as it is still in the developing phase.
Technologies Used	SCADA, MS SQL, IBM Maximo.
BD4NRG Tools	MST and asset indices estimation tools prototypes, developed under the scope of WP4.
Next Steps	Initial result analysis Tools debugging Dataset improvement and manipulation Process automatisation

BD4NRG project has received funding from the European Union's Horizon 2020 Research and Innovation programme under grant agreement No 872613.

UC1: Maintenance Plan Optimisation

LSP2 deals with the cross-functional integration of grid operation with predictive asset management. An advanced, condition-based maintenance scheduling algorithm is being developed under this scope, supported by analytic tools for asset indices estimation.

Figure 3 presents the workflow to be followed within LSP2:

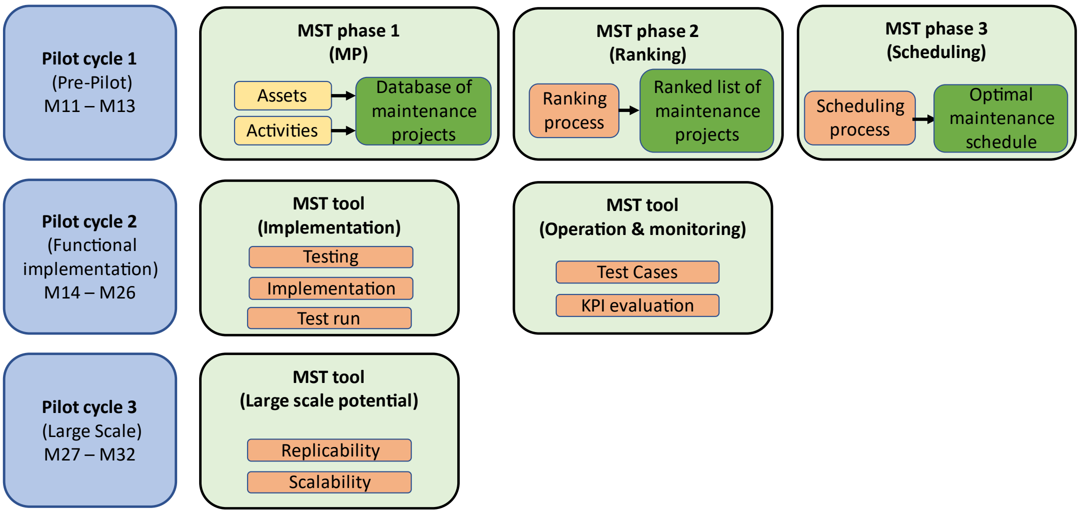

Figure 3: LSP2 workflow

In the Pre-Pilot Cycle, LSP2 partners have identified the requirements which would fulfil the goals of the developed tools within the analytics services' development (presented in section 3.2.2). The tools require specific inputs, such as data related to asset specifications, maintenance procedures and timeframes for various types of assets, identification of dependencies among different assets, operational data etc. General distinction between the various inputs is shown in Figure 4 together with the conceptual workflow of the developed tools.

In the beginning of the Pre-Pilot Cycle, LSP2 partners had identified the data required for the development of the tools. Further on, procedures were established and executed to extract such data from ELES databases and provide it to partners in a form, suitable for development of initial version of the developed tools.

Because of the vast variety of data sources used in the pilot, including operational data from SCADA, asset data from IBM Maximo, maintenance data from PSA etc., a lot of effort has been put into establishing and maintaining the necessary intersystem connections, are needed for various queries and procedures to be used by the developed tools. Furthermore, many queries, functions and procedures in terms of asset information, grid connectivity and daily operation were already prepared for the initial version of the tools and continue to be added as the development of the tools progresses.

To assure security, integrity and operational speed of various production databases, all necessary data for the project were and continue to be replicated into a dedicated MS SQL database. Each of the replicated data types are put through a thorough quality control process within which all inconsistencies were and continue to be identified and rectified. Due to organisational security protocols, currently, all data is provided to partners in a spreadsheet format. In the next phases, LSP2 partners will have direct access to various queries, procedures, and functions, through a secure VPN tunnel based on their needs and security clearance (covered internally).

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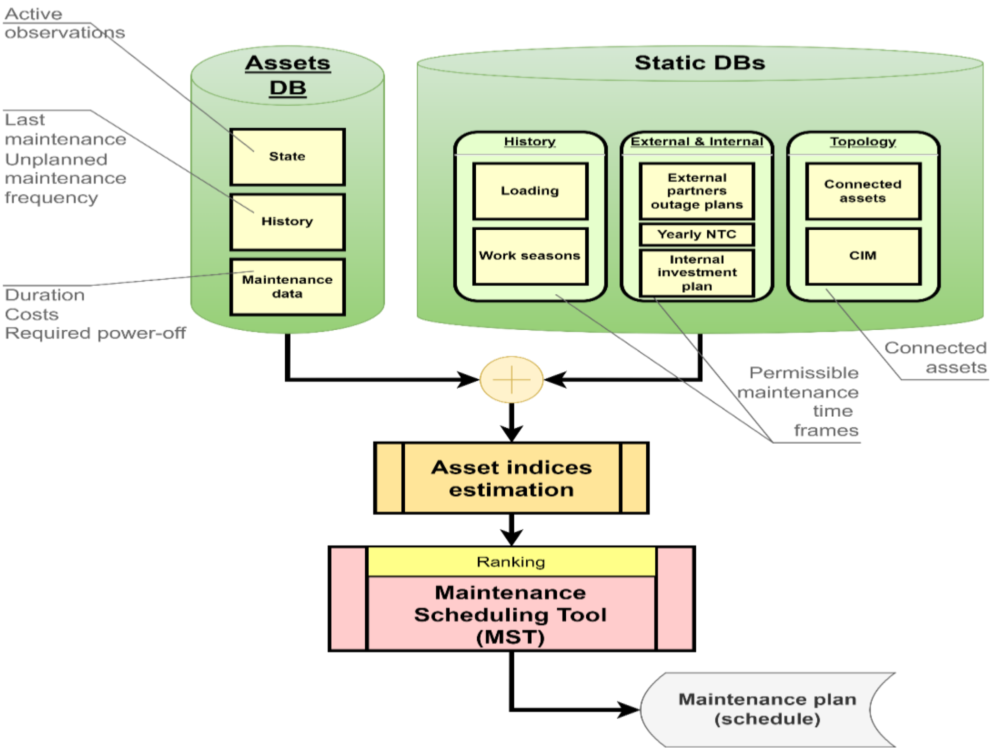

Figure 4: LSP2 conceptual diagram of developed tools

During the Pre-Pilot Cycle, the initial versions of the tools ran successfully, utilising the sample data, with the first results being available. The purpose of the initial runs was to test the cooperation among the various parts in the methodology development, rather than provisioning results. Results are planned to be achieved in the next phases, along with further improvements of the tools. Improvements in terms of input datasets is also foreseen. It is also planned to increase the level of automation in all stages, from data acquisition to tools execution and the end results provision and interpretation.

Below, the summary table for UC1 is presented:

Table 6: LSP2 UC1 Summary

Use Case 1	
Pre-Pilot Target	Development of the first version (a methodology prototype) of the MST tool
Status Summary	Task administration: Monitoring the activities in order to stay on track, regular weekly meetings between the LSP2 partners to quickly resolve any challenges, reporting to BD4NRG partners. Data preparation: Identification, extraction, pre-processing and improvement of relevant data: asset databases, diagnostics data, maintenance data, operational measurements etc., investigation of missing/erroneous data, automation of data extraction process as much as possible, establishment of secure path for accessing the data by all LSP2 partners. Tool definition: Definition of workflow, based on current procedures and literature review (multi-criteria optimisation), definition of required inputs, boundaries, and possible outputs, definition of ranking process, preliminary run of initial tool, using the sample data in order to prove the concept Indices calculation: AUI and AHI estimation workflow definition, definition of input dataset, preliminary indices estimation using the initial export of historic data.

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2.3 LSP3 (ASM): Cross-Domain Cross-functional Integration of Predictive Asset Management and Grid Operation while coordinating with EVs smart charging

A checklist deriving from the Pilot Deployment Information Template is presented below, to provide the status of the progress in several areas related to LSP3.

Table 7: LSP3 Checklist

Type	Information
Status of pilot infrastructure	The infrastructure has been fully defined and much of it has been installed on site. Currently it is missing to install the acoustic and environmental sensors in the electrical substations for UC2, but this activity will be completed in the following months.
Test cases/Scenarios	During Pre-Pilot Cycle, for the UC1 the analysis of the approach on studying the impact of electric mobility has been defined. Preliminary data exploration and technical understanding of the data to be used has been made. For UC2 we will study the aging analysis for different types of transformers, with different age and characteristics.
Service status	After several meetings with technical partners the definition of services is completed and for UC1 data exploration, pre-training activities and model development has taken place. For the UC2 the exchange of data is in progress in order to be able to later perform the analysis on them.
Stakeholders involved	DSO EV operator Ancillary service provider
Technologies Used	-
BD4NRG Tools	Load and production forecasting
Next Steps	Installation of all components will be completed shortly, and data will be shared with technical partners. In the next period, using real time and historical data we will train the machine learning models and evaluate the benefits that can be achieved.

UC1: Efficient management of flexibility resources for supporting grid operation & UC2: Anticipated prediction of asset failures

In LSP3 each use case has a different infrastructure, adapted to the purpose of the use case. The main activities during the Pre-Pilot Cycle were to define and install the appropriate infrastructure in order to start the data gathering process.

In UC1, the goal is to study the coordination between EV and RES in the electrical distribution network, an energy district connected to the grid through two secondary substations is used, where both the district's electrical consumption and the renewable generation through a PV plant are present. In this

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portion of the network there are charging stations, whose management must be optimised to perform services for the electricity grid.

In UC2, the goal is to predict in advance the failures that occur in the transformers of the electrical distribution network. Secondary substations are monitored by power quality analysers, smart meters, acoustic, temperature and humidity sensors in order to collect all relevant data and find a correlation between this parameters and fault risk.

The components that will be used in LSP3 have been identified as follows:

- Electrical sensors: 41 sensors that monitor the electrical parameters (active power, reactive power, voltage) of some nodes of the network, in particular the consumption of the ASM headquarter, the production of the PV plant and 10 secondary substations are monitored. Sensors used are smart meters and power quality analysers. These sensors will be used for both UC1 and UC2.
- Electric vehicle supply equipment: three 22 kW AC charging stations and two 50 kW DC charging stations, equipped with Raspberry Pi 3 for real-time monitoring and remote management. These components will be used for UC1.
- Electric vehicles: six Renault ZOE, three Nissan LEAF and one Hyundai Kona equipped with on-board diagnostic devices for real-time monitoring. These will be used for UC 1.
- A 185kW photovoltaic system. This will be used for UC1.
- Secondary substations of the electricity distribution grid. 10 of these will be used for UC2
- Acoustic sensors for monitoring the sound intensity and frequency of sound emission from electrical power transformers. The acoustic sensors are based on the component at the following link: 10 of these will be used for UC2.
- Environmental monitoring sensors, used inside secondary substations. 10 sensors will be used for UC2.

The data management of the Distribution System Operator is done by ASM through the communication with MQTT protocol with the SCADA system, which collects all the data and transmits them in real time to partners. Data of the charging stations and electric vehicles are provided to the partners by EMOT through an eMobility Platform, using MQTT protocol as well. Data from the sensors are transmitted in real time through MQTT protocols to the central data management platform of ASM and EMOT respectively, which then are shared with partners.

The data inside ASM's SCADA System is partially processed to provide the most important information and is all downloadable by subscribing to ASM's MQTT Broker. In addition, ASM's data management platform also allows for the download of historical data through a SQL database.

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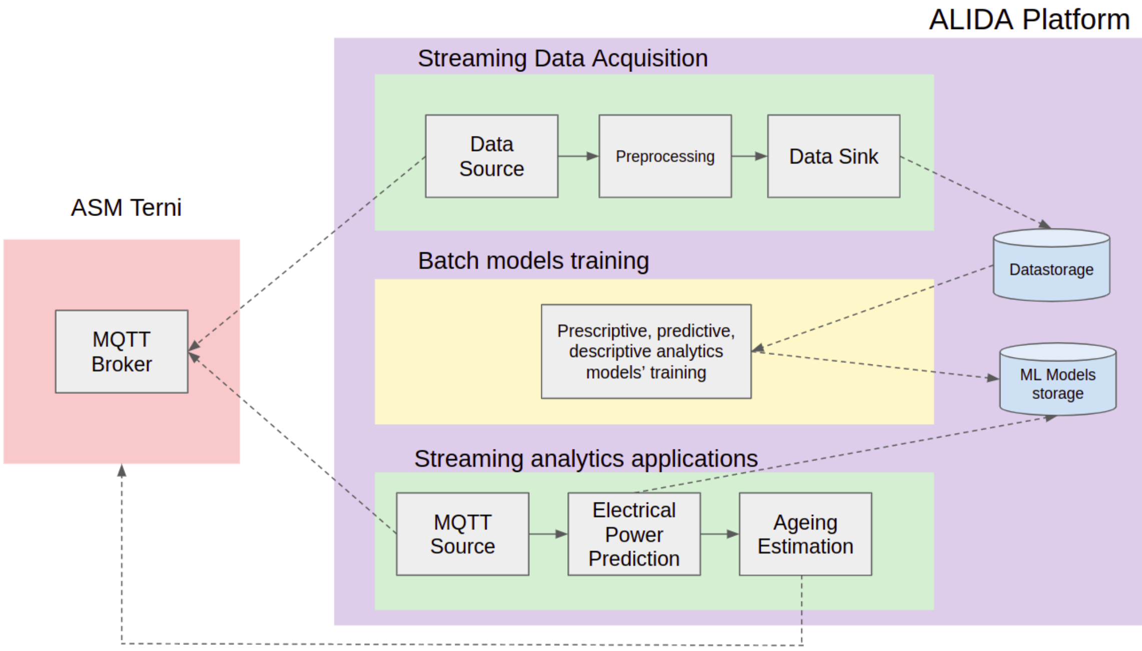

Figure 5: LSP3 General methodology

Below, the summary tables for UC1 and UC2 are presented:

Table 8: LSP3 UC1 Pre-Pilot Cycle Summary

Use Case 1	
Pre-Pilot Target	Fully define the UC, identifying technical partners and completing the infrastructure.
Status Summary	For UC1 several activities have been carried out, in order to completely define the UC and its goals, i.e., the infrastructure has been defined in agreement with the needs of the technical partners. Several data have been shared in order to do pre-training on the Machine Learning models that will be used in the UC. The infrastructure has been completely defined and the data sharing with the technical partners is in progress.

Table 9: LSP3 UC2 Pre-Pilot Cycle Summary

Use Case 2	
Pre-Pilot Target	Fully define the UC, identifying technical partners and completing the infrastructure.
Status Summary	For UC2 several activities have been carried out in order to completely define the use case and its goals, i.e., the infrastructure has been defined in agreement with the needs of the technical partners. Literature searches have been carried out in order to find existing models and algorithms suitable for the purposes of the UC. The infrastructure has been completely defined and all components will soon be completed. Data sharing activities with the technical partners is in progress for data-driven experimentation.

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2.4 LSP4 (OEDAS): Cross-functional Predictive Asset Management for MV Grid Planning

A checklist deriving from the Pilot Deployment Information Template is presented below, to provide the status of the progress in several areas related to LSP4.

Table 10: LSP4 Checklist

Type	Information
Status of pilot infrastructure	Required datasets for exploration are investigated. Dedicated middleware with API connection under development. VPN for secure access to the corresponding server is under development. Several communication protocols are established (HTTPS, FTP, 61850, 104, etc.)
Test cases/Scenarios	No test cases during Pre-Pilot
Service status	Initial data exploration
Stakeholders involved	DSO
Technologies Used	-
BD4NRG Tools	No BD4NRG tools used during Pre-Pilot Cycle.
Next Steps	API development for integration of data services to middleware and BD4NRG platforms. Different APIs to be developed in order to enable the provision of data sharing. Internal components to be deployed in LSP IT infrastructure. Different services should be deployed in the local server farm of the LSP. Collecting and evaluating historic data of maintenance activities/ Collecting and evaluating historic data of faults. Assessments of related data for interpretation before predictions. Anonymisation/masking of data. Fulfilling of the requirements of data privacy. Data harmonisation, orchestration and synchronisation.

UC1: Predictive maintenance and fault prediction for MV grid and cross functional predictive asset management

Main activities held during Pre-Pilot Cycle for LSP4 were consisted of identifying the exact location in which data would be available to perform predictive maintenance service. Furthermore, internal activities for data collection and processing, so as to allow data sharing, have taken place.

In UC1, the aim is to predict in advance the failures that could occur in the transformers of the electrical distribution network. Power quality analysers, smart meters, acoustic, temperature and humidity sensors are monitored to collect all relevant data and use them for fault risk analysis. Data can be collected from the flexible assets from SCADA and AMR system, power quality analysers and other related infrastructures. The exact sensors and parameters measured vary among different types of assets and device manufacturers.

Due to national data protection regulations and the current GDPR regulation, data must be accessed via a dedicated API. To comply with data regulation and privacy issues, LSP4 develops the middleware to drag the data to a corresponding server and then can be made available to the project via REST APIs.

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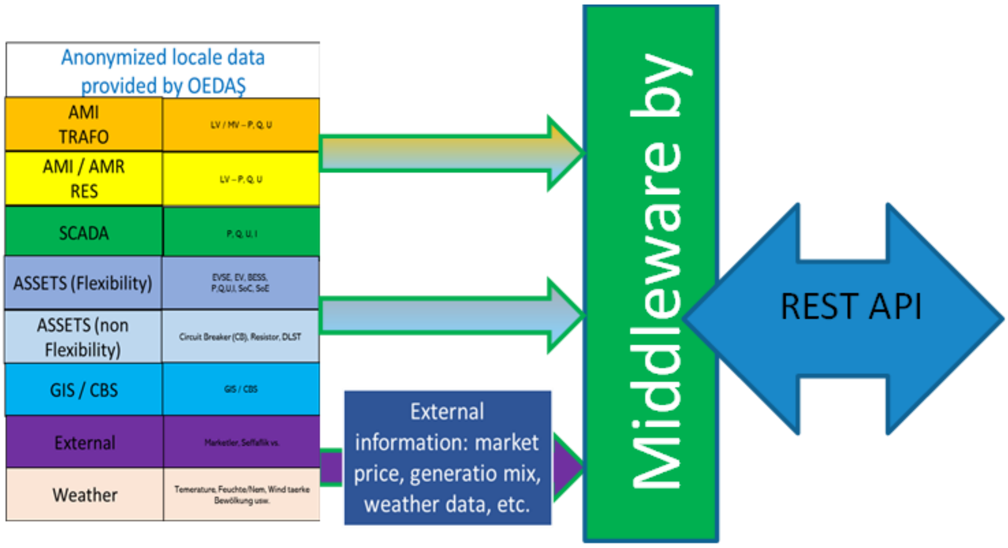

Figure 6: LSP4 Internal middleware architecture

The internal components that have been identified for use in LSP4 UC, are the OEDAS Energy Monitoring Platform which consists of Power Quality Measurement Data, GIS data in which the whole distribution network (LV and MV lines) and grid asset characteristics are geographically available, SAP data containing asset information & management, workforce management and detailed grid fault record.

Below, the summary table for UC1 is presented:

Table 11: LSP4 UC1 Pre-Pilot Cycle Summary

Use Case 1	
Pre-Pilot Target	Definition of the locations and the appropriate datasets. Definition and implementation of data collection and sharing middleware. Definition of optimal scheduling of maintenance operations to reduce unnecessary maintenance. Design and specification of internal IT infrastructure for data sharing activities.
Status Summary	During the pre-pilot phase, operational meetings were held with the system operations, GIS and SCADA departments to classify the data or actionable data that will be required for the demo area and its use case.

2.5 LSP5 (CENTRICA): Cross-stakeholder Transfer Learning for Flexibility Assets Forecasting and Dispatching

A checklist deriving from the Pilot Deployment Information Template is presented below, to provide the status of the progress in several areas related to LSP5.

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Table 12: LSP5 Checklist

Type	Information
Status of pilot infrastructure	The gateways and measurement devices are in place at the assets' location. The infrastructure to communicate securely with the gateways is also in place.
Test cases/Scenarios	Test the transfer learning and grid-friendly dispatch algorithms on a collection of hot water tanks.
Service status	The services are currently under development in WP4. No progress to be mentioned in terms of the implementation or testing of the services.
Stakeholders involved	Centrica IMEC home lab TNO Hybrid Energy System Integration Lab
Technologies Used	API, asset provisioning, monitoring and data collection
BD4NRG Tools	At this moment of development, no tools from BD4NRG are being used.
Next Steps	The main development is needed in the policy training with transfer learning block, the interaction with the database of Centrica's residential asset portfolio and FSP grid data, and possible changes in the existing communication between the local gateway and the adapted pool controller.

UC1: Controlling residential demand response assets using transfer knowledge in MDP setting & UC2: Using residential DR assets to retrieve local grid information and activate aggregations

During the Pre-Pilot Cycle activities were focused on preparing the relevant infrastructure for data sharing and initial testing of the algorithms on a subset of pilot data.

LSP5 partners have jointly discussed and identified the requirements of the UCs in order to fulfil the goals of the developed tools and infrastructure presented before. Two UCs are considered in LSP5: (i) Validation of the developed cross-context transfer learning algorithms for residential flexibility asset profiling with a view to reduce the time necessary for model training and hence optimise management of asset and (ii) Proof-of-concept setup of using residential DR assets to retrieve local grid information and use this information in the aggregation activations.

Below, the summary table for UC1 and UC2 is presented:

Table 13: LSP5 UC1 & UC2 Pre-Pilot Cycle Summary

Use Case 1 & 2	
Pre-Pilot Target	Set up and make the infrastructure ready to implement the cross-stakeholder transfer learning and grid-friendly dispatch algorithms for testing.
Status Summary	Centrica shared representative asset data with UGent/IMEC for the development of the transfer learning algorithm. Assets are onboarded on Centrica's platforms, communication and control infrastructure are in place, assets are monitored, and data are collected.

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2.6 LSP6 (EKL, BORZEN & CS): Coordinating grid-owned and behind-the-meter assets management prediction for improved grid operation and near real time power market operation settlement

A checklist deriving from the Pilot Deployment Information Template is presented below, to provide the status of the progress in several areas related to LSP5.

Table 14: LSP6 Checklist

Requirements	Progress
Status of pilot infrastructure	10 sets of sensors were delivered
Test cases/Scenarios	Test of the connectivity, information transmission, if successful.
Service status	UC1 is close to the stage of technology implementation.
Stakeholders involved	DSO Market operator IT technology provider.
Technologies Used	Sensors
BD4NRG Tools	-
Next Steps	Implementation and first test on data provision.

UC1: Identification of flexibility potential, based on near-real time data & UC2: Independent aggregator flexibility activation, quantification and settlement

For LSP6 initial activities regarding analytics services and model development have taken place during the Pre-Pilot Cycle. Data exploration and preliminary tests of the analytics services were performed, thus allowing to identify the appropriate data which will be used.

The grid segment selection was finished and confirmed at the start of the Pre-Pilot Cycle. It comprehends a geographically bounded cluster of 10 MV/LV transformer stations facing with time limited overloads. The data provided from all sensor infrastructure will be aggregated on a 1 min sampling period. That means that also existing smart meters will be reprogrammed for this time period, with all measurements transmitted to a particular data processing centre.

Below, the summary table for UC1 and UC2 is presented:

Table 15: LSP6 UC1 & UC2 Pre-Pilot Cycle Summary

Use Case 1 & 2	
Pre-Pilot Target	Selection of the distribution grid segment involved in the pilot and installation of new equipment allowing data aggregation, not only from the already present smart meters, but also additionally installed temperature and humidity environmental sensors.
Status Summary	In the Pre-Pilot Cycle, EKL organised several internal operational meetings necessary to

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	organise the installations of new sensors. While regarding the transformer stations with housing the installation of new sensors was straightforward and the devices were installed near to the transformer, there were several issues with the transformers without housing. BORZEN has performed assessment of reference models for independent aggregator and existing practices for the design of demand response market. The key implementation considerations of aggregator model that will serve as a basis for flexibility provisioning in the pilot phase were consolidate. In addition to the research process and coordination with project partners, the work focused on determination of possible optimal settlement models and scenarios. CS participated to several meeting with pilot partners to list the requirements for model implementation and specify integration between EKL infrastructure, data storage and analytics backend of BD4NRG.

2.7 LSP7 (ENELX): Predictive Analytics Forecasting of storage optimised operation for improved market reserve participation

A checklist deriving from the Pilot Deployment Information Template is presented below, to provide the status of the progress in several areas related to LSP7.

Table 16: LSP7 Checklist

Requirements	Progress
Status of pilot infrastructure	Architecture Design of the data retrieval system for 2 kinds of device Deployment of the data retrieval system is ongoing
Test cases/Scenarios	Design, deploy and test the data retrieval system
Service status	No substantial progress
Stakeholders involved	-
Technologies Used	-
BD4NRG Tools	At this moment of development, no tools from BD4NRG are being used.
Next Steps	Data retrieval system deployment (remaining devices) Developing of the Digital Twin infrastructure Training of the algorithms

UC1: Predictive Analytics Forecasting of storage optimized operation for improved market reserve participation

For LSP7 during the Pre-Pilot Cycle, activities were focused on designing and deploying the data retrieval architecture, to allow the data sharing capabilities. The environment in which the UC will be operating is presented the following figure.

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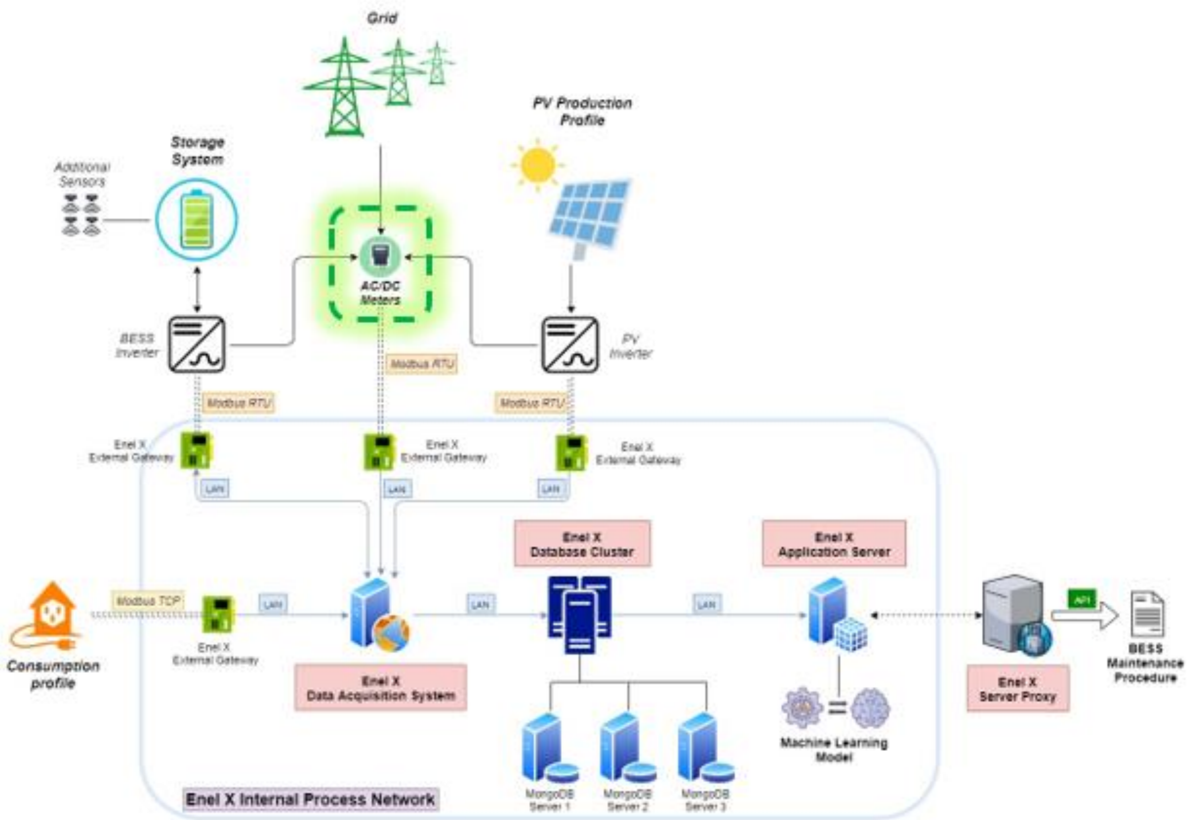

Figure 7: LSP7 Internal components

Each physical component is interfaced with the data acquisition system through an external gateway directly connected. According to the type of asset, the connection with the external gateway could be implemented using two different Modbus protocols:

- Modbus TCP using ethernet connection.
- Modbus RTU using serial connection.

At this stage AC/DC meter interfaces using Modbus RU serial connection have been developed and tested. Each external gateway has been connected to data acquisition system via LAN, through the Enel X internal process network, in order to collect and store all the parameters into MongoDB database.

The deployment diagram of LSP7 is presented in following figure.

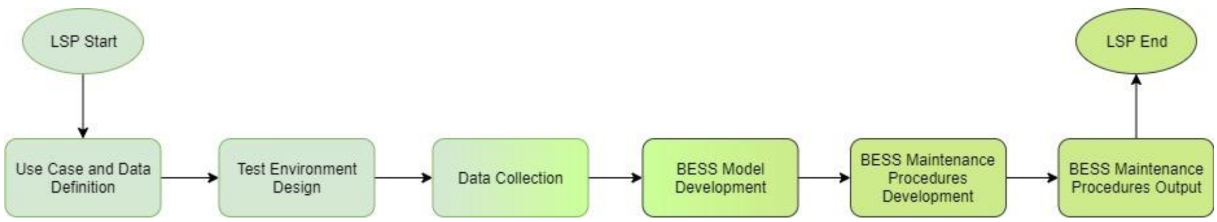

Figure 8: LSP7 UC1 Deployment diagram

Below, the summary table for UC1 is presented:

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Table 17: LSP7 UC1 Pre-Pilot Cycle Summary

Use Case 1 & 2	
Pre-Pilot Target	Design and Deployment of the Data Retrieval Architecture
Status Summary	Asset defined (AC meter, DC meter) and installed (one of a kind) including network connection with Data Acquisition System. Database Cluster development with installation of MongoDB instances on 3 physical servers. Implementation of device connectors using Python in order to read asset registers and store the information into the No-SQL database.

2.8 LSP8 (UNIWA/TILOS): Predictive Demand and Generation Forecasting for Optimised Local Energy Community Management

A checklist deriving from the Pilot Deployment Information Template is presented below, to provide the status of the progress in several areas related to LSP8.

Table 18: LSP8 Checklist

Requirements	Progress
Status of pilot infrastructure	A pool of engaged assets has been defined and activated locally (island of Tilos), with the parallel upgrade of existing monitoring equipment and a renewed, end-to-end solution and architecture of data acquisition, storage, processing, visualisation and sharing. GRAFANA platform for data monitoring and sharing is up and running. API development for data sharing with BD4NRG under test, sharing actual anonymised data from a household.
Test cases/Scenarios	Implementation of the first test of analytics services Apply different models and algorithms for the development of local-community services, with the deployment of local assets (pool of loads and DERs). Assess initial results of the KPIs.
Service status	Data gathering and storage infrastructure is currently in a production stage. APIs for data sharing are in a testing stage.
Stakeholders involved	Island Local Municipalities
Technologies Used	VPNs for data acquisition, supervision & data sharing RESTful APIs with JWT authentication for data sharing TimescaleDB (over PostgreSQL) for measurement storage
BD4NRG Tools	At this moment of development, no tools from BD4NRG are being used.
Next Steps	Development of prosumer / residential energy management services. Further population of the pool of engaged end-users. Investigation of aggregation services for local end-users.

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UC1: Optimal management strategies for cross-infrastructure flexibility resources to support higher RES shares at the island community level

For LSP8, activities during the Pre-Pilot cycle further built on the initial streams of work related to the exploitation of data from local water network (pumping stations) and DER assets, with the development of services at the local community level (load shifting and peak shaving strategies) supported by predictive demand and generation forecasting techniques.

The initial pool of engaged loads was populated with the integration of a group of end-customers (residential and public domain buildings), and a dedicated API connection was established between the pilot manager (UNIWA) and the service provider (NTUA) and is currently under testing. Testing of the API connection so far has been made on the basis of data queries for a limited set of assets (single household loads), sufficient to demonstrate functionality and evaluate robustness of an end-to-end solution between the pilot infrastructure and the service provider.

At the same time, and apart from the work for the finalisation of the deployment approach and architecture (Figure 9 and Figure 10), effort was dedicated to the internal organisation of the pilot hosting database and data visualisation (Figure 11 and Figure 12).

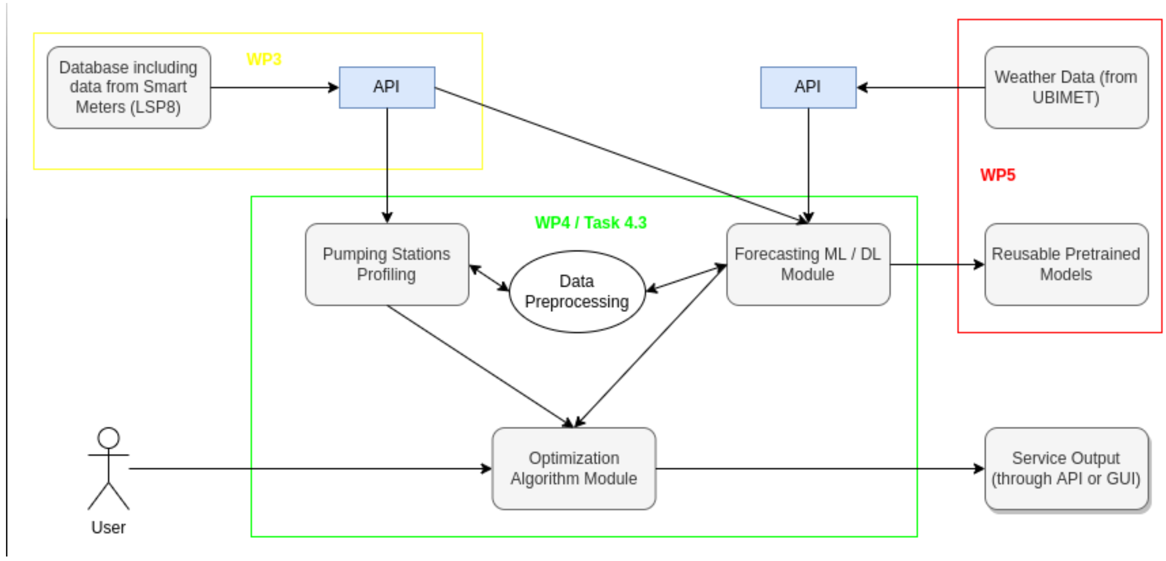

Figure 9: LSP8 Deployment approach

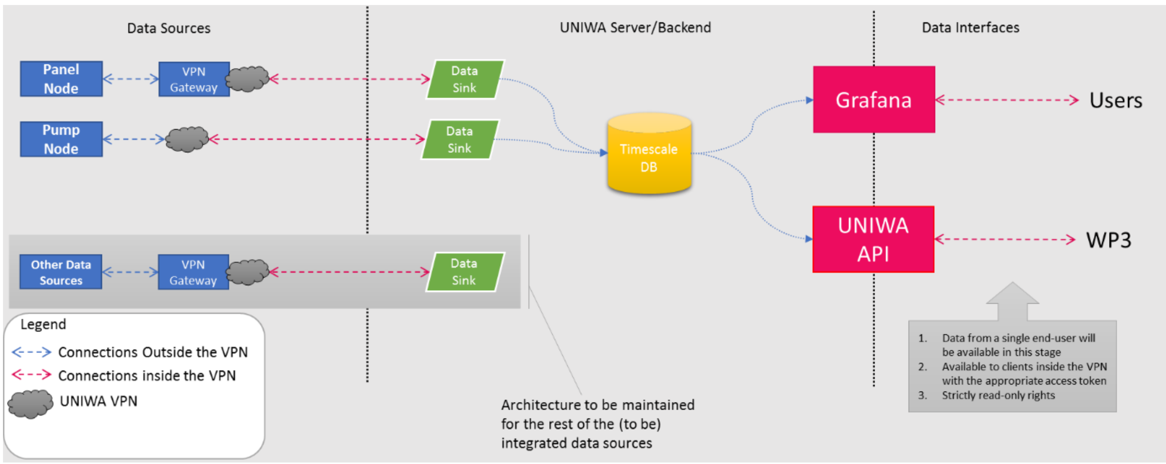

Figure 10: LSP8 Deployment architecture

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Figure 11: LSP8 Grafana visualisation (single pump dashboard example)

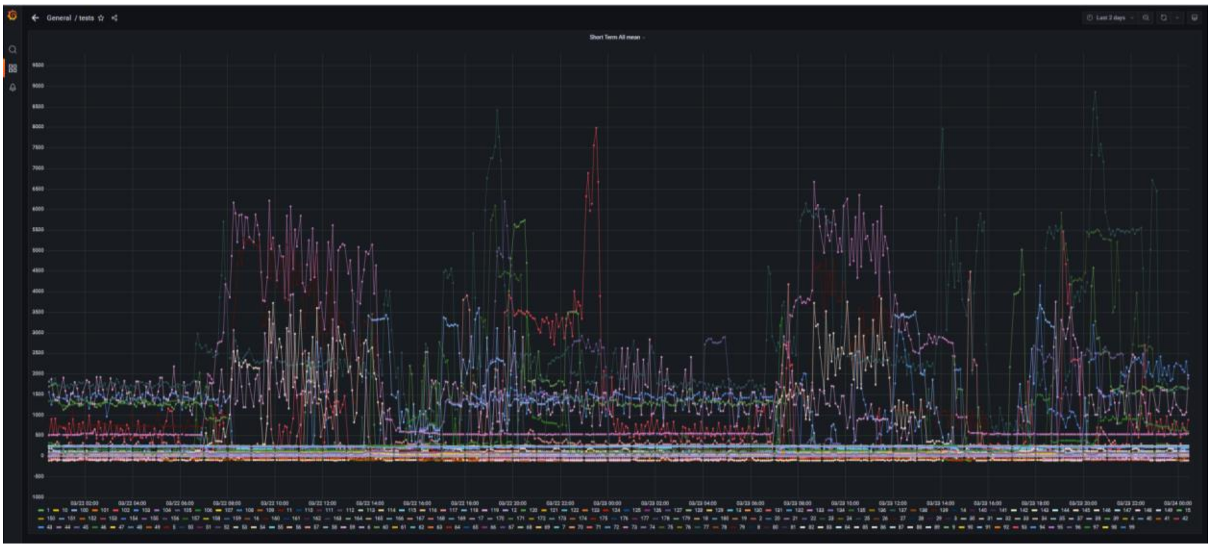

Figure 12: LSP8 Grafana visualisation (end-users' test-dashboard)

Below, the summary table for UC1 is presented:

Table 19: LSP8 UC1 Pre-Pilot Cycle Summary

Use Case 1	
Pre-Pilot Target	Finalisation of design phase and implementation of the full, end-to-end solution for data management and sharing, establishing connection between the pilot manager and the services' provider.
Status Summary	The architecture of the system has been conceptualised, realised and is now being tested for robustness. To this point we can safely conclude that no further changes will be needed in the architecture. Data are being retrieved from several sites, leveraging the security of the VPN network deployed for this purpose. The (anonymised) measurements are displayed graphically in GRAFANA and data from a specific household are provided from a secure API (currently accessible by NTUA).

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2.9 LSP9 (ENERC): Collaborative Aggregated Energy Generation Prediction

A checklist deriving from the Pilot Deployment Information Template is presented below, to provide the status of the progress in several areas related to LSP9.

Table 20: LSP9 Checklist

Information	Progress
Status of pilot infrastructure	Architecture Design of the data retrieval system for 2 out of 3 PV/CPV sites is completed (the remaining one is ongoing) Deployment of the data retrieval system is ongoing
Test cases/Scenarios	Testing of the asset administration shell system and the service algorithms using historical data for 3 years of PV generation and for a single CPV unit
Service status	Analytical services are currently in a developing phase.
Stakeholders involved	The service is not yet suitable for any stakeholder as it is still in developing phase.
Technologies Used	APIs, asset administration shell (NOVAAS)
BD4NRG Tools	At this moment development no tools from BD4NRG are being used.
Next Steps	Data retrieval system deployment Testing of the NOVASS on the field Training of the algorithms Developing of the Digital Twin infrastructure of UC2

UC1: Optimizing and improving management and prediction of DER production & UC2: Energy sector digital twin

In the Pre-Pilot Cycle, the work of the partners of LSP9 is divided into the following workstream focused on architecture alignment, connectivity and connection points as well as full alignment with technologies planned.

- Analytical services initial development
  - Gathering historical data for data structure and data sizing.
  - Gathering operational requirements and relevant operational data regarding maintenance, costs, current infrastructure.
  - Identifying and classification CPV/PV system faults.
  - Initial development of the algorithms for the necessary services.
- Data retrieval system
  - Gathering requirements for the current infrastructure (assets information, systems' connectivity, location, etc.).

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- Designing the intended architecture for the retrieval system (equipment, software applications, interface connections).
- Communication with the PV/CPV operators (2 complete, 1 in conversation).
- Adaptation and testing of the asset administration shell for the system (NOVAAS).

Two distinct architecture data retrieval systems were designed for the PV/CPV sites that make the LSP9 infrastructure, as presented in Figure 13 and Figure 14.

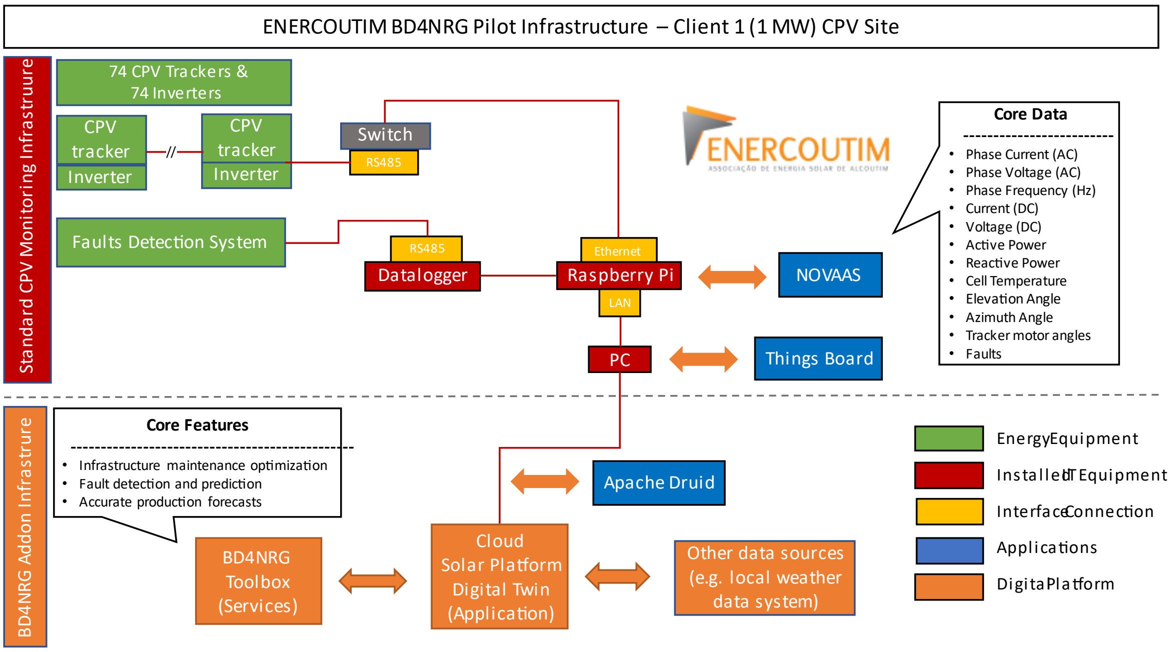

Figure 13: LSP9 Infrastructure – Client 1 (1MW) CPV Site

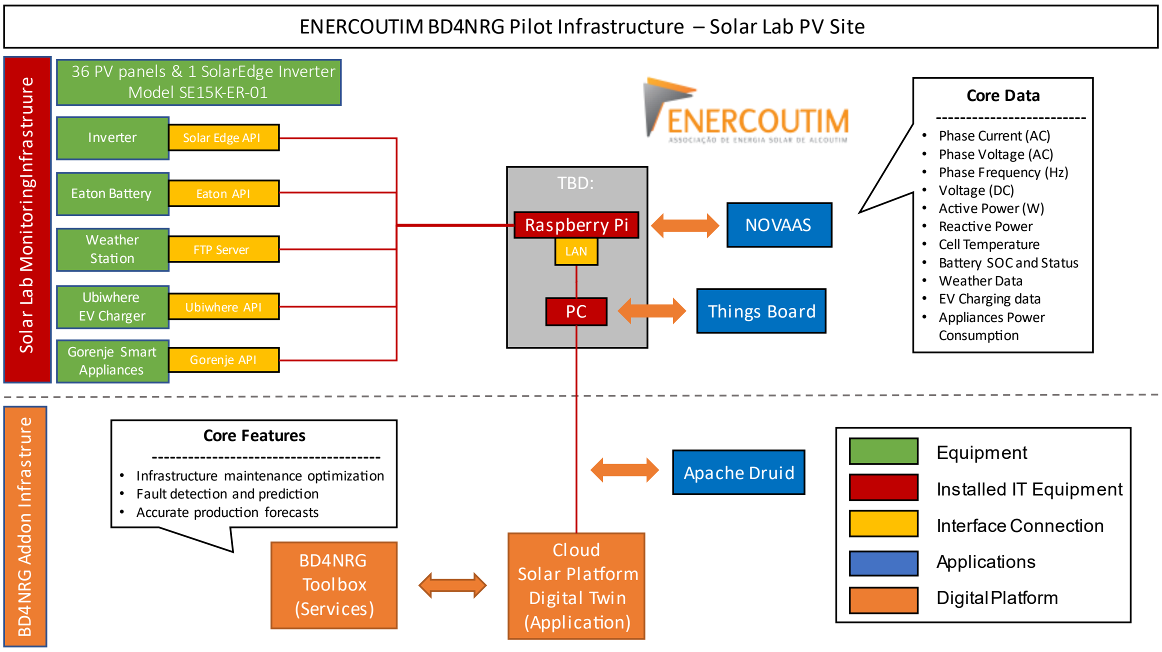

Figure 14: LSP9 Infrastructure - Solar Lab PV site

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It is still in discussion to use a single PC to run the necessary system for the Solar Lab site, being entirely cloud-based, or if a device (Raspberry Pi) will be used at the edge of the system. The infrastructure for the remaining pilot CPV site that is in ongoing discussion may be similar to the one presented, but it is not finalised yet.

Below, the summary table for UC1 is presented:

Table 21: LSP9 UC1 Pre-Pilot Cycle Summary

Use Case 1	
Pre-Pilot Target	Design of the data retrieval architecture. Initial data exploration and analytics services specifications. Review of CPV and PV faults similarities
Status Summary	A plan for the data retrieval architecture has been devised for two of the sites as well as the start of the work in the analytical services needed for the UC1. Consistent communication with the CPV operators in order to define requirements for the data retrieval system, maintenance operations and overall KPIs. Identification, extraction, and improvement of relevant data: Asset information, maintenance data, historical data of from one CPV unit. Definition of requirements for the analytical services. Regular meetings between the LSP9 partners (Uninova and NTUA) to develop the data retrieval architecture and analytical services. Definition of required inputs, boundaries, and possible outputs Preliminary run of initial tool (NOVAAS), using the sample data for proof of concept.

The focus during Pre-Pilot Cycle was on UC1, as it was prioritised to deploy the retrieval infrastructure on the different PV and CPV sites before UC2 (Digital Twin infrastructure) is considered.

2.10 LSP10 (CARTIF & VEOLIA): Predictive and Prescriptive Analytics for improved Energy Performance Certificates Reliability

A checklist deriving from the Pilot Deployment Information Template is presented below, to provide the status of the progress in several areas related to LSP10.

Table 22: LSP10 Checklist

Information	Progress
Status of pilot infrastructure	Connection driver to the monitoring system is being developed Static information has been downloaded
Test cases/Scenarios	No test/cases scenarios to be tested during Pre-Pilot Cycle
Service status	The service is not totally implemented
Stakeholders involved	ESCOs

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Technologies Used	Python, PostGIS
BD4NRG Tools	n/a
Next Steps	Data needed in this LSP come from different sources and it has been necessary to identify the relation of the buildings from the different datasets processing the building identifiers in each dataset. Initial testing of the analytics services Model and algorithm training Considerations about the aggregation, confidentiality issues and potential inconveniences to be considered.

UC1: Predictive and Prescriptive Analytics for improved Energy Performance Certificates Reliability

The focus for UC1 of LSP10 during Pre-Pilot were in activities regarding data collection and internal pilot infrastructure along with the identification of requirements of scenarios to develop and train the models to be used within the analytic services (see section 3.2.6).

Most of the data to be used in LSP10 are static or semi-static data which have been collected and are being analysed and processed. More specifically cadastral data is available through ATOM services. Given the low information update rate (yearly), the simplest procedure is to download it through a controller and then work with the file. Data of the regional registry of EPCs for Castilla y León can be directly integrated into a database through a procedure for this, which carries out periodic consultations through the API. For the early stages of the project, the data will be previously downloaded in order to work directly with the files. Meteorological information (meteorological data, Copernicus) can be directly integrated by developing a procedure for it, which makes periodic information requests through the API.

To dump information from BEMS/HEMS/DEMS, CARTIF is working on the development of a communication controller that accesses the information and can dump it into a database, with the desired update rate. Specifically, information from the monitoring system will be collected using a driver developed for this scope. The monitoring network connects with the exterior of the network thought a router (IQ4E connector) that allows the communication with the devices using BACnet over IP. Then the router provides real time communication with the devices using the corresponding commands of the BACnet protocol. Once the data is collected by the driver, it can be used for the services or can be stored in the corresponding database. The security of the data access and transfer is achieved via the use of VPN. Similarly, historical information can be exported from files.

There are three main components for the LSP10, related with three different analytics presented in this LSP.

The first component will be in charge of the energy prediction based on monitored and historic data in combination with historical and forecasting weather information. These predictions and calculation will be used for the comparison of the EPCs information, and the energy consumption information offered from the public buildings in Castilla y Leon in order to correct and/or validate them.

The second component is related with the knowledge extracted from the EPCs public registry for

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Castilla y Leon in combination with information from the Spanish cadastre. This information will be used to create a model that can be applied to all the buildings of the region and in this way to estimate the main values of the EPCs (heating and cooling energy demand, consumption and CO_2 emissions) for these buildings. This information can also be compared with information from the EPCs, and the energy consumption offered by the public buildings in Castilla y Leon, in order to adjust the energy performance values.

The third component has the objective to estimate the energy prediction in future periods, considering climate change impacts. This estimation of the evolution of the energy consumption can help to evaluate if the energy conservation measures to apply to the building could be effective enough.

In the figure below, the LSP9 deployment diagram is presented.

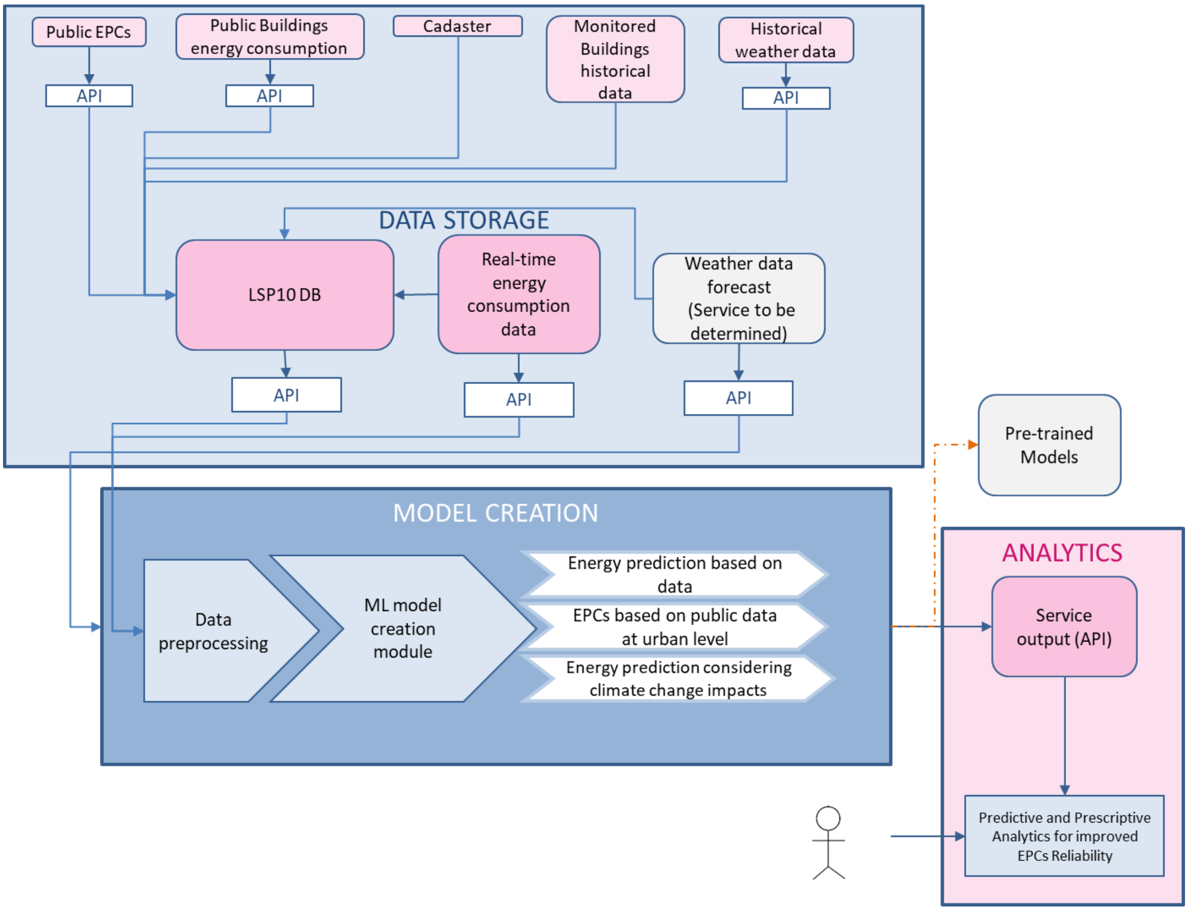

Figure 15: LSP9 Deployment diagram

Below, the summary table for UC1 is presented:

Table 23: LSP10 UC1 Pre-Pilot Cycle Summary

Use Case 1 & 2	
Pre-Pilot Target	Recollecting data and pre-processing the data in order to relate the information from the different sources to the corresponding building
Status Summary	Implementation during the pre-pilot cycle:

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	Data preparation. Files from cadastre have been collected for all the provinces in Castilla y Leon. This data has been filtered and gathered in one file and subsequently stored in a database Data processing of Cadastral information in Castilla y Leon, EPCs information in EPCs registry of Castilla y Leon and other datasets (public information for energy system in Castilla y Leon and public building energy consumption information) Driver generation for the connection with the monitoring system Data analysis for the preparation of the analytics

2.11 LSP11 (AJSCV & VEOLIA): Weather-enhanced building thermal comfort prediction to enable energy efficiency reliable forecasting

A checklist deriving from the Pilot Deployment Information Template is presented below, to provide the status of the progress in several areas related to LSP11.

Table 24: LSP11 Checklist

Requirements	Progress
Status of pilot infrastructure	Connection driver to the monitoring system is being developed (each building has different ways of connection) Static information has been downloaded
Test cases/Scenarios	No test cases used during this phase.
Service status	The implementation of the service has no started
Stakeholders involved	ESCOs, public bodies, building owners, inhabitants, building users, energy communities.
Technologies Used	n/a
BD4NRG Tools	n/a
Next Steps	Start the analysis to the third building monitoring infrastructure Define the analytics to be implemented in each building To define the functionalities expected by the user Diverse type of data that will be used in the current pilot should be firstly harmonised. The database will be dynamic, with real time information and historical data to feed the AI algorithms and their predictive models. Meteorological information (meteorological data) can be directly integrated by developing a procedure for it, which makes periodic information requests through the API.

UC1: Building energy efficiency optimisation with thermal comfort considerations

During the Pre-Pilot Cycle, activities for LSP11 were focused on the internal infrastructure and data

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collection and processing procedures. The data to be used have been identified for the three buildings and the architecture for data collection and processing is under development. It should be noted that during the Pre-Pilot Cycle, the main partner of LSP11 declared that there are internal organisational issues which would prevent from dedicating the necessary resources for the pilot demonstrator. A restructure of the effort is in progress, in order to allow the ability to proceed with the technical and pilot related activities for LSP11.

Two of the three buildings of the LSP11 are currently under renovation, with the installation of their own renewable energy production systems and a BEMS for their control and monitoring. This is the case of the School of Pins del Valles and the Mira-Sol Cultural Center buildings. On the other hand, the third of the buildings, the Sant Cugat Town Hall building, already has a self-production system of renewable energy managed by an outdated and out-of-market BEMS.

Information from the monitoring system of VEOLIA will be collected using a driver developed with for this scope. The monitoring network connects with the exterior of the network thought a router (IQ4E connector) that lets the communication with the devices using BACnet over IP. Then this router lets the real time communication with the devices using the corresponding commands of the BACnet protocol. Once the data is collected by the driver can be used for the services or can be stored in the corresponding database. The security of data access and transfer is achieved via the use of VPN.

For the three separate buildings to be used in LSP11, a brief description of the data sources along with technical information is outlined below.

School of Pins del Valles & Mira-Sol Cultural Centre

The future architecture of the monitoring system will provide dynamic data associated with the new installation. This installation includes sensors in the building (room temperature, windows, presence, temperature...) and data from the PLCs of the energy production and distribution systems (temperatures, heat energy meters, electric meters, fluid flows, etc.). The frequency of the data is variable, from 1 to 15 minutes and they are stored in a BEMS solution stored on the cloud. The data can be viewed from a web portal and downloaded in CSV and XLS format.

Sant Cugat Town Hall building

- BEMS: Dynamic data, which can be flexibly updated every 1 hour. Data includes weather variables (temperature and humidity), operating temperatures for building uses and spaces, operating temperatures for each HVAC machine and lighting manager. Data is saved in a SQL database, but it can also be downloaded in XLS format from BEMS. The BEMS is not friendly, out of the market and limited in terms of the operability of the installation.
- RES production: Semi-static data, the renewable energy production data can be consulted and downloaded via a web portal or through an API specialised in the monitoring of photovoltaic installations. The data can be obtained with variable frequency (daily, weekly, monthly or yearly) and the download of the historic values generates a XLS file.
- Energy consumption: Dynamic data. 2 electric meters measure the electricity consumption of the building. The data is stored on local servers and there is no application for real-time visualisation. Data download allows exporting in XLS or CSV format.

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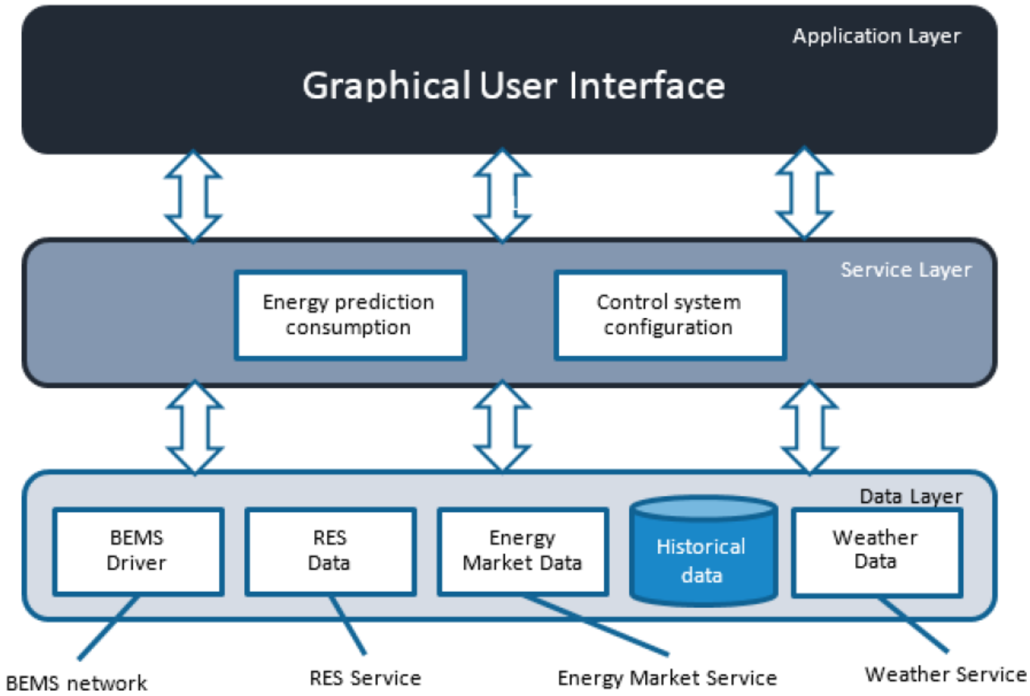

Figure 16: LSP11 Deployment diagram

Below, the summary table for UC1 is presented:

Table 25: LSP11 UC Pre-Pilot Cycle summary

Use Case 1	
Pre-Pilot Target	Recollecting data and pre-processing the data in order to relate the information from the different sources to the corresponding buildings.
Status Summary	Implementation during the pre-pilot cycle: Data preparation: Some files with historical data have been collected with the aims to analyse the variables to be used and the periodicity of these variables Data processing: In order to dump information from BEMS of Mira-Sol Cultural Centre, CARTIF is working on the development of a communication controller that accesses the information monitored through an API, with the desired update rate. Similarly, historical information can be imported from files. School of Pins del Valles currently stores information in a BEMS solution on the cloud using a frequency from 1 to 15 minutes. This data can be downloaded from a web portal in form of files. Dynamic info. For Sant Cugat Town Hall building an analysis of the installed BEMS and all the variables monitored is still pending. Data analysis for the preparation of the analytics

2.12 LSP12 (LEIF): Predictive Analytics for Energy Efficiency Investments de-risking

A checklist deriving from the Pilot Deployment Information Template is presented below, to provide the status of the progress in several areas related to LSP12.

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Table 26: LSP12 Checklist

Information	Progress
Status of pilot infrastructure	The descriptions of energy efficiency projects monitoring system datasets are translated from Latvian to English. Data is provided in .xlsx format.
Test cases/Scenarios	There are no test cases/scenarios that are tested during the Pre-Pilot Cycle. However, before the realisation of the project, the energy audits with expected savings are made. These planned savings can be compared with the savings after renovation.
Service status	The service gathers previous implemented projects of renovation and data from smart meters.
Stakeholders involved	The services are not taken their final form. Services cannot be used by stakeholders/beneficiaries at this stage of development.
Technologies Used	Python, Jupyter notebooks
BD4NRG Tools	n/a
Next Steps	Finalise the services. Fine tune and test the algorithms. Expansion to the new buildings. Finalise and test the full methodology of the Energy assessment service.

UC1: De-risking energy efficient investments

Activities for LSP12 during the Pre-Pilot Cycle, were focused on data preparation and collection in order to be fed for the analytics services. The main work was held in the development of the analytics services (can be found in section 3.2.7)

Below, the summary table for UC1 is presented:

Table 27: LSP12 UC Pre-Pilot Cycle Summary

Use Case 1	
Pre-Pilot Target	Collecting historical data and systematisation of obtaining data from smart meters is the main Pre-Pilot target in LSP12. Testing and deployment of AI models for the analytics services.
Status Summary	Provided data from KPFI (The climate change financial instrument) database, EKII (The Emission Allowance Auction Instrument) database and smart meters installed in buildings. KPFI and EKII database has historical with information about monthly energy consumption before refurbishment project implementation, energy efficiency investments and monthly energy consumption after refurbishment project implementation. Data from smart meters has more accurate information about energy consumption. Smart meters are collecting hourly data from about 15 objects. There are renovated buildings and non-renovated buildings. It was decided to include non-renovated buildings during Pre-Pilot Cycle. Those buildings are in evaluation stage for receiving refurbishment investment and some of them are planned to be renovated during BD4NRG project. Data from smart meters before and after renovation for buildings will be included in LSP12.

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3 Technical Deployment Towards Pilots’ implementation

In this section, the early data-driven experimentation of BD4NRG’s tools and components is presented. Based on the technical activities of WP3 - “Data Governance and Management” and WP4 - “iz & Open Modular AI-based edge-level Analytics Toolbox”, the deployment of these components towards the pilot demonstrators is presented. The section is divided in two sub-section to reflect the progress of the two technical WPs.

3.1 Data Governance and Management Deployment

WP3 components tested during the Pre-Pilot Cycle derive from the advancements of the 1st technology release (MS3, M10). Three pilot demonstrators were selected for initial testing, LSP1, LSP8 and LSP9, based on their infrastructure status and the ability to deploy the first technology enablers. As the technical components of this WP and on the current phase of the project are designed in a general way, their deployment is in an initial stage as well. This means that the components are in the process of being personalised to cater to the LSPs requirements and specifications.

3.1.1 LSP1 (REN & RDN): Integrating off-grid Data with Condition based Monitoring for Enhanced Predictive Asset Maintenance

3.1.1.1 Data Governance and Management Components Deployment

Within WP3 an overall architecture has been designed to effectively describe the middleware layer to be developed, i.e., to identify the core components/services and their relationships during the process of exchanging data between the BD4NRG system and the pilot’s assets. Considering, this architecture as starting point, Figure 14 depicts the main components/services that are part of the first technological release of the WP3 middleware for LSP1.

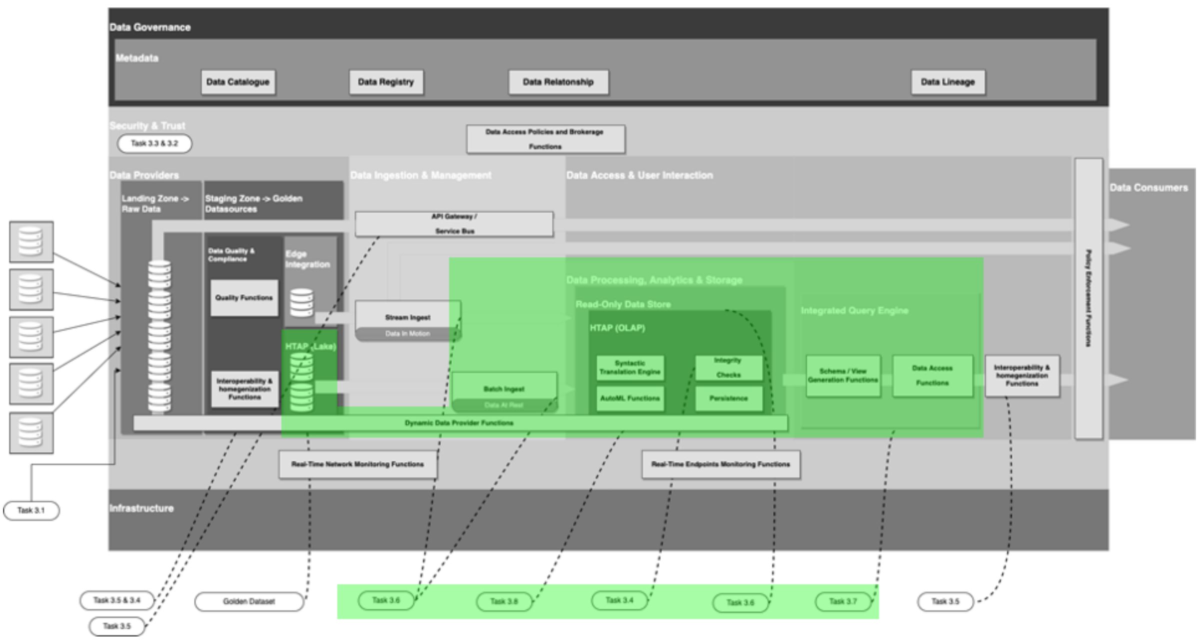

Figure 17: WP3 middleware architecture and related components overview for LSP1

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The list of components/services of WP3 that are going to be instantiated for LSP1, with the corresponding task in which the components are being developed, are the following

- HTAP (Lake) - T3.6
- Data Ingestion & Management - Batch Ingestion of golden data sources - T3.6
- Dynamic local metadata catalogue - T3.8
- Active metadata discovery - T3.8
- Pipeline adaptation engine - T3.8
- HTAP (OLAP) - T3.6
- Integrated Query Engine - T3.7

A detailed description of these components and their functionality are presented in the following table:

Table 28: Description of the WP3 middleware components/services relevant for LSP1

ID	Component	Description	Category	Dependencies	Notes
#DPM1	HTAP (Lake)	The storage used to collect and centralise the data that comes from the LSPs.	Storage	n/a	The storage is essentially used for "Data-at-rest", in the case of "Data-in-motion" streaming mechanism are used
#DPM2	Data Ingestion & Management - Batch Ingestion of golden data sources	The whole set of mechanisms and tools to enable the batch ingestion of the dataset in the Staging Zone.	Ingestion	#DPM1	This component is a set of extensions and/or plug-ins to be installed within the HTAP (OLAP) for ingesting data in batch
#DPM3	Active metadata discovery	Active Metadata Discovery component which monitors the datasets inserted in HTAP and sends metadata to the dynamic local metadata catalogue.	Metadata Ingestion	#DPM1 #DPM4 #DPM6	-
#DPM4	HTAP (OLAP)	A real-time database specifically designed and deployed to power analytics on Big Data.	Data Processing, Analytics & Storage	#DPM1	-

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ID	Component	Description	Category	Dependencies	Notes
#DPM5	Integrated Query Engine	Allowing users to explore, combine and express complex queries on BD4NRG datasets efficiently and effectively.	Data Access	#DPM4	-
#DPM6	Dynamic local metadata catalogue	Metadata catalogue, stores metadata in a knowledge graph and allows searching capabilities.	Storage	#DPM4	-
#DPM7	Pipeline adaptation engine	React to changes in ingestions specification as stored in the Dynamic local metadata catalogue and chose ingestion strategy suitable for the current situation.	Control	#DPM2 #DPM4 #DPM6	-

3.1.1.2 Connection with Pilot Infrastructure

At the current stage of implementation, WP3 components are not directly connected to LSP1 infrastructure. LSP1 data that is going to be stored and accessed from the WP3" middleware, are provided as static files and formatted into csv format. These files are the result of the application of a pre-processing process on the top of COMTRADE standard files. Therefore, they are considered as "golden data sources" and stored as-is, within the HTAP Lake in the "Staging Zone".

3.1.1.3 Deployment Status

According to deliverable D2.1 - "Big Data Value Chain and Requirements", the UCs proposed by REN and R&D Nester in the context of the LSP1 are aimed to better monitor the transmission system operation, by assessing the condition of the CBs and OHLs to implement the optimal condition-based maintenance plans and incident characterisation and classification. Considering the above description, together with the list of requirements for the WP3 components provided in Deliverable D3.1 - "BD4NRG GOVERNANVE - 1st Technology Release", the WP3 middleware components/services have been designed to meet the following list of requirements as presented in Table 29. The requirements below are non-functional requirements and are of type "Data" (as described in Table26 of deliverable D2.1), which WP3 technical components should support.

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Table 29: Technical requirements addressed by WP3 components for LSP1

Requirement	Description	Category	Status
Rq_24	Data set should have historical operation data	Data Persistence	Supported
Rq_26	Incident report data should integrate information from different data sources	Data heterogeneity	Supported
Rq_30	Asset monitoring data that are needed for calculation of AHI and AUI need to be available	Batch Ingestion	Supported
Rq_37	Historic data of maintenance must be collected and evaluated for being implemented in predictive maintenance	Batch Ingestion	Supported
Rq_38	Historic data of faults must be collected and evaluated for being implemented in predictive maintenance	Batch Ingestion	Supported
Rq_46	Data must be pre-processed before integration	Data Pre-processing	Partially Supported
Rq_55	The system must collect data provided by the storage	Batch Ingestion	Partially Supported

3.1.2 LSP8 (UNIWA/TILOS): Predictive Demand and Generation Forecasting for Optimised Local Energy Community Management

3.1.2.1 Component Deployment

WP3 - "Data Governance and Management" related activities for LSP8, were focused on the testing of the Integrated Query Engine under task T3.7. Sample LSP8 data are stored to a local PostgreSQL database on NTUA's and are accessible the Integrated Query Engine component. The Integrated Query Engine provides the user with querying capabilities through APIs or through a user interface powered by Apache Superset. Hence users can either query the requested data from their services through API calls or through Apache Superset user interface, to perform visual analytics and customised reports and dashboards.

The API mentioned is called periodically (on a weekly basis), and the acquired data is stored to a relational (PostgreSQL) database once a week. The provided data do not include any personal information that would identify the data subject. However, LSP8 has granted access only to NTUA as the technical partner responsible for testing purposes during the Pre-Pilot Cycle.

Figure 18 illustrates the provided user interface (powered by Apache Superset) for creating a query for a dataset provided by LSP8, and the results for the specific query.

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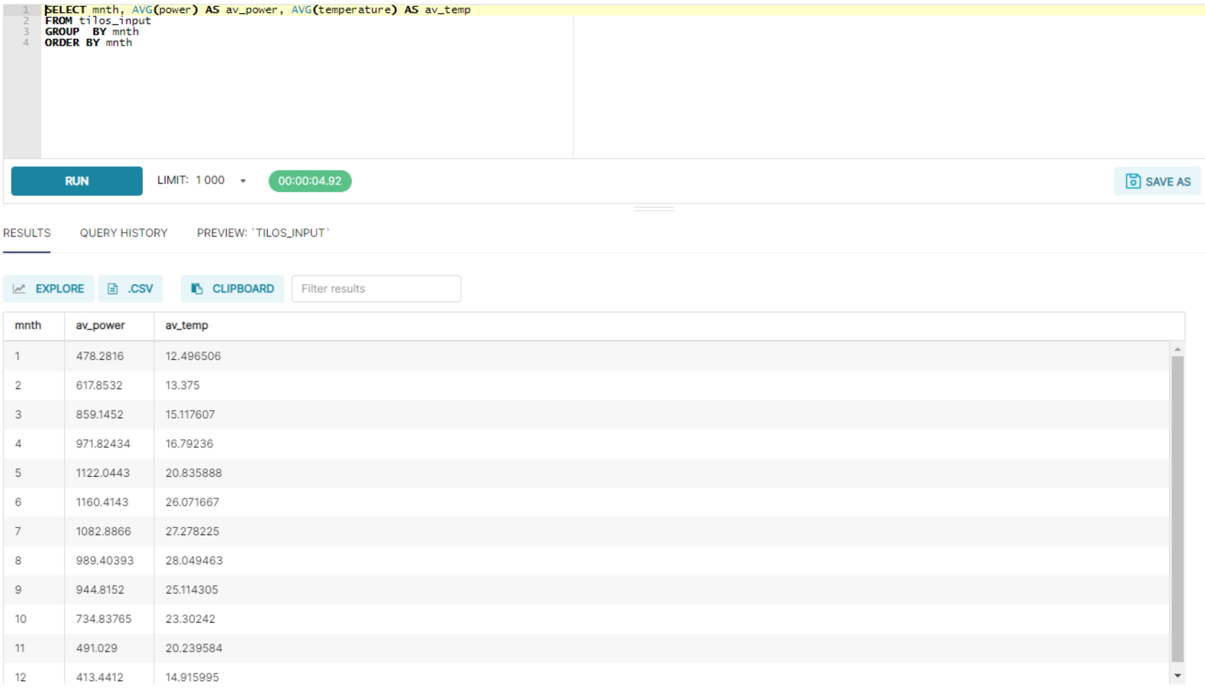

mnth	av_power	av_temp
1	478.2816	12.496506
2	617.8532	13.375
3	859.1452	15.117607
4	971.82434	16.79236
5	1122.0443	20.835888
6	1160.4143	26.071667
7	1082.8866	27.278225
8	989.40393	28.049463
9	944.8152	25.114305
10	734.83765	23.30242
11	491.029	20.239584
12	413.4412	14.915995

Figure 18: Integrated Query Engine user interface for LSP8

As a next step, data from LSP8 will be stored to the HTAP component which is being developed under the context of T3.6. Moreover, metadata about the datasets of LSP8 will be stored to the dynamic local metadata catalogue (T3.8) to facilitate metadata search capabilities.

Another important issue is the addition of access control to the dataset at hand, securing that only authenticated users that have permissions to access the requested resources will have access to data.

3.1.2.2 Connection with Pilot Infrastructure

To execute queries or other data management services, data from LPS8 should be available to the aforementioned services. To this end, a connection with the pilot infrastructure has been established. Specifically, LSP8 provided an API endpoint which enables the acquisition of data for a specified time period. Accessing this API, connection to the VPN of the pilot infrastructure is required.

For now, this API is available only to NTUA team as the technical partner responsible for LSP8 and this justifies the reason why LSP8 data has not been stored also to HTAP component.

3.1.2.3 Deployment Status

Considering LSP8 UC and specifications, together with the list of requirements for the WP3 components provided in Deliverable D3.1 - “BD4NRG GOVERNANVE - 1st Technology Release”, the WP3 middleware components/services have been designed to meet the following list of requirements as presented in Table 30. The requirements below are non-functional requirements and are of type “Data” (as described in Table26 of deliverable D2.1), which WP3 technical components should support. It should be noted that since there is no integration of the WP3 middleware with LSP8, the specified requirements in the following table, derive from the work carried out under T3.7. The full technical requirements addressed by WP3 components will be further elaborated and defined in later stages.

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Table 30: Technical requirements addressed by WP3 components for LSP8

Requirement	Description	Category	Status
Rq_20	Existing platform should be reconfigured to host the final pool of involved loads (municipal, residential, commercial loads, EV charger and distributed RES)	Data Persistence	Supported
Rq_44	Systems need availability of contextual data	Data availability	Supported
Rq_50	Data harmonisation, orchestration and synchronisation should be performed	Data Harmonisation and Interoperability	Not Supported
Rq_51	Weather data should be provided for weather forecasting.	Data availability	Supported
Rq_52	Historical RES data must be provided	Data availability	Partially Supported (provided by pilot infrastructure)
Rq_54	Systems must receive and analyse smart meters data for IoT	Data Ingestion	Partially Supported (provided by pilot infrastructure)
Rq_62	Data must be anonymised according to GDPR	Data anonymisation	Provided data could not be used for inferring identities
Rq_65	Access to residential electricity data must be allowed	Data sharing	
Rq_67	Smart meters data collection should apply security aspects for data accessing	Data sharing	Partially Supported (provided by pilot infrastructure)

3.1.3 LSP9 (ENERC): Collaborative Aggregated Energy Generation Prediction

3.1.3.1 Data Governance and Management Components Deployment

Similar to the approach of LSP1, Figure 19 depicts the main components/services that will be part of the first technological release of the WP3 - “Data Governance and Management” middleware for LSP9.

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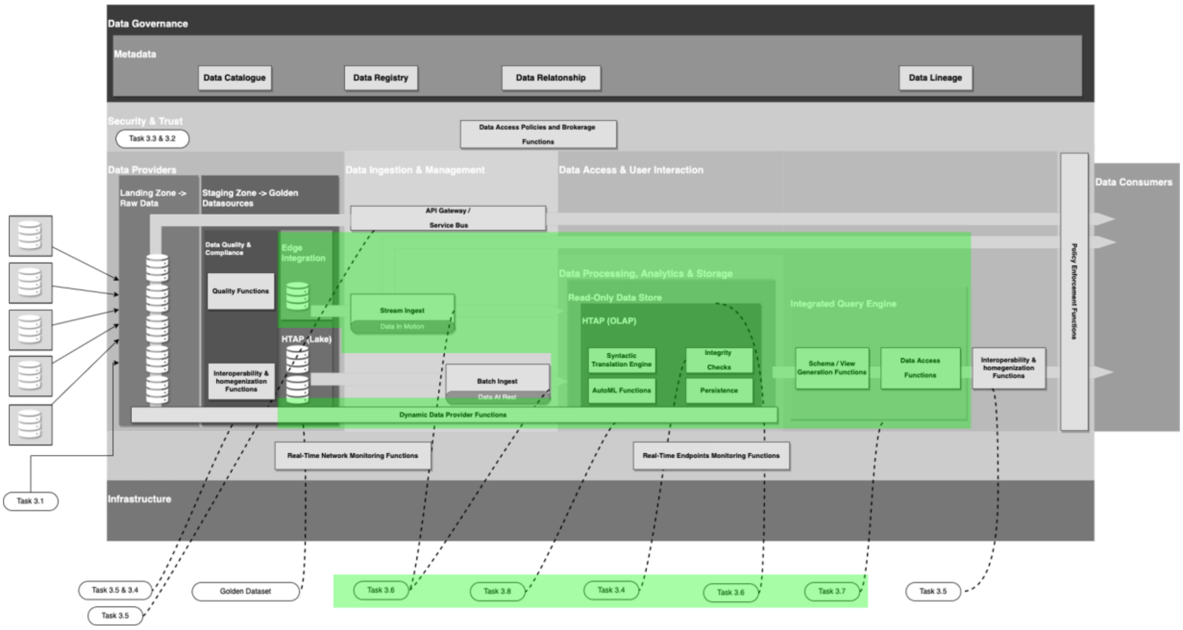

Figure 19: WP3 middleware architecture and related components overview for LSP9

The list of components/services of WP3 - "Data Governance and Management" that are going to be instantiated for LSP1 are the following, with the corresponding task in which the components are being developed:

- Edge Integration - T3.6/T4.1
- Data Ingestion & Management - Batch Ingestion of golden data sources - T3.6
- Dynamic local metadata catalogue - T3.8
- Active metadata discovery - T3.8
- Pipeline adaptation engine - T3.8
- HTAP (OLAP) - T3.6
- Integrated Query Engine - T3.7

A detailed description of these components and their functionality are presented in the following table.

Table 31: Description of the WP3 middleware components/services relevant for LSP9

ID	Component	Description	Category	Dependencies	Related Tasks-Notes
#DPM3	Active metadata discovery	Active Metadata Discovery component which monitors the datasets inserted in HTAP and sends metadata to the dynamic local metadata catalogue.	Metadata Ingestion	#DPM8 #DPM4	-
#DPM4	HTAP (OLAP)	It is a real-time database specifically designed and	Data Processing,	#DPM8	-

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ID	Component	Description	Category	Dependencies	Related Tasks-Notes
		deployed to power analytics on Big Data	Analytics & Storage		
#DPM5	Integrated Query Engine	it is responsible for allowing users to explore, combine and express complex queries on BD4NRG datasets efficiently and effectively	Data Access	#DPM4	-
#DPM6	Dynamic local metadata catalog	Metadata catalog stores metadata in a knowledge graph and allows metadata searching capabilities.	Storage	#DPM4	-
#DPM7	Pipeline adaptation engine	React to changes in ingestions specification as stored in the Dynamic local metadata catalog and choses ingestion strategy suitable for the current situation.	Control	#DPM4, #DPM6 #DPM9	-
#DPM8	Edge Integration	The data collectors that collect raw data from the field and convert them into a structured digital data format.	Edge Device	n/a	NOVAAS is an implementation of the RAMI4.0 Asset Administration Shell concept enabling interoperability between applications in a manufacturing production system
#DPM9	Data Ingestion & Management - Streaming Ingestion of golden data sources	A message delivery tool that provides all the mechanisms to distribute the data from the edge to the WP3 middleware components	Ingestion	#DPM8	This component is a set of extensions and/or plug-ins to be installed within the HTAP (OLAP) for ingesting data in batch

3.1.3.2 Connection with Pilot Infrastructure

The connection between the LSP9 infrastructure and BD4NRG components (through the WP3 - "Data Governance and Management" middleware) is guaranteed by NOVA Asset Administration Shell (NOVAAS). NOVAAS is an implementation (Figure 20) of the Reference Architecture Model for the Industrie 4.0 (RAMI) Asset Administration Shell (AAS) concept. The AAS implements the Digital Twin for Industry 4.0 and represents the data image of an asset. An asset is in turn, an object that needs to be integrated into the information world of Industry 4.0. As so, the AAS is expected to contain all the information that defines characteristics and behaviour of an asset.

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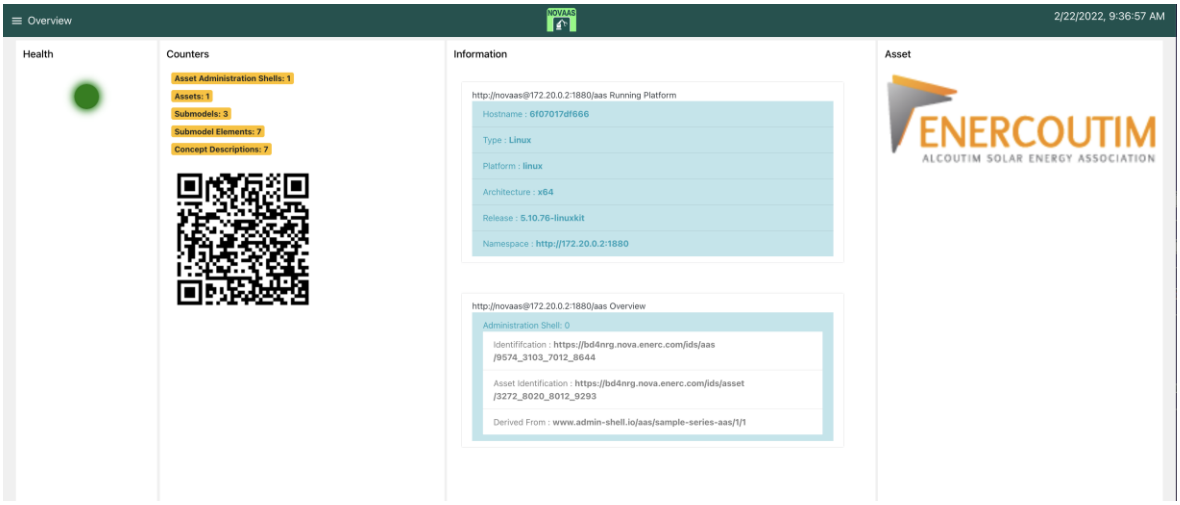

Figure 20: LSP9 NOVAAS main screen

At the current stage of implementation, WP3 - "Data Governance and Management" components will be connected to the LSP9 infrastructure through NOVAAS, acting as an edge gateway. Therefore, all the specific pilot data that is going to be stored and accessed from the WP3 - "Data Governance and Management" middleware are provided as events to the WP3 - "Data Governance and Management" message broker. These events follow the RAMI4.0 specifications for event messages sent or received by the AAS during an I4.0 interaction pattern.

By using NOVAAS, variables from the environment can be selected by the user and be sent WP3 - "Data Governance and Management" middleware in the form of events generated each second. Since the events follow a specific structure and definition they can be considered as "golden data sources" and stored as they are within the HTAP OLAP component.

Finally, at this stage NOVAAS is not yet connected to real pilot's assets, but it embeds a small process that allows to continuously generate energy production data. However, for the component's testing activities, data used are documented in deliverable D2.3 - "BD4NRG Semantification & Interoperability" and are the in the same format as the data which ENERCOUTIM will provide for use.

3.1.3.3 Deployment Status

According to the deliverable D2.1 - "Big Data Value Chain and Requirements", the UCs proposed in LSP9 aim to develop newer tools and value-added services for improving the overall process of extracting, collecting, loading, and analysing the data from the solar power plant. The main objective and consequence will be the improvement of the overall system performance and efficiency thanks to data-informed decisions. During this process other sources of data will be also considered and combined with real-time data from devices to improve the quality of machine learning models. Considering the above description together with the list of requirements for the WP3 components provided in deliverable D3.1 - "BD4NRG Governance - 1st Technology Release", the WP3 middleware components/services have been designed to address certain requirements as presented in Table 32. The requirements below are non-functional requirements and are of type "Data" (as described in Table26 of deliverable D2.1 - "Big Data Value Chain and Requirements"), which WP3 technical components should support.

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Table 32: Technical requirements addressed by WP3 components for LSP9

Requirement	Description	Category	Status
Rq_13	Components with Edge computing Capabilities	Streaming Ingestion	Supported
Rq_24	Data set should have historical operation data	Data Persistence	Supported
Rq_42	Historic Data of Faults	Data Persistence	Supported

3.2 Analytics Services and Model Development Deployment

WP4 - "Data Modelling & Open Modular AI-based edge-level Analytics Toolbox" components to be tested during the Pre-Pilot Cycle consists of the progress made under WP4 activities regarding AI-model development and analytics services. In this section the progress of these methods is presented based on the LSP UCs. As the framework in which the services will be integrated is under development the work carried out is mainly held internally, i.e., in partners premises. The migration of the under-development methods is expected to take place in the next stages of the project, in order to allow the BD4NRG components and tools to be deployed into the Pilot demonstrators.

3.2.1 LSP1 (REN & RDN): Integrating off-grid Data with Condition based Monitoring for Enhanced Predictive Asset Maintenance

3.2.1.1 UC1: AI methods applied to Condition-based monitoring of Circuit Breakers

3.2.1.1.1 Data

Table 33: LSP1 Data considered during Pre-Pilot Cycle

Type of Data	Volume
Historical COMTRADE files (event based)	2GB
Oscillography time-series	
Channel voltages and current	
Further COMRADE data not to be disclosed (e.g., substation location and manufacturer data) due to security and privacy issues	

A pre-processing engine, built using knowledge on the COMTRADE Standard and field data interpretation, was developed. The output is a set of time-series, measured at variable sampling rates and with a variable number of samples, which should be considered for the database storage.

3.2.1.1.2 Analytics Services Development

For the fault analysis service of UC1, its methodology is presented in Figure 21.

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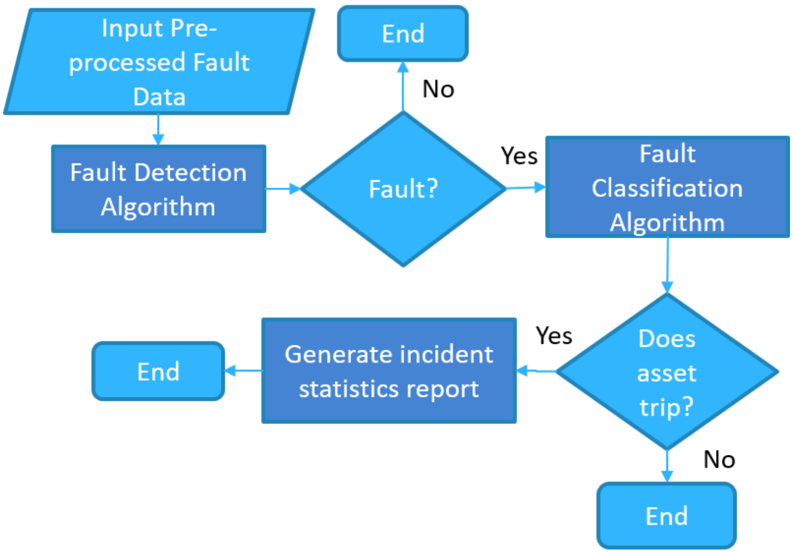

Figure 21: LSP1 Fault Analysis Service Methodology

From this methodology the following modules are highlighted:

- Fault Detection module: Detects the existence of a failure in a COMTRADE, since these files typically include other events such as planned CB openings or can simply be recorded in normal functioning conditions. The implementation was performed using a combination of the Hilbert Transform with the PELT algorithm.
- Fault Classification module: Perform classification of the fault under analysis (e.g., single line to ground short circuit). The implementation was performed, on a first stage, using a rule-based system based on piece wise analysis of the oscillography signals. Currently, this module is being re-implemented using ML models (LightGBM, XGBoost) trained on labelled incident data to perform classification.
- Incident Statistics Module: Computation of key incident statistics to asset management departments, using data extracted using signal processing techniques (e.g., FFT, wavelet transforms) on voltage and current analogue time-series data. Figure 22 shows an example output for a given incident.

Incident	12218_15_46_SP1 (2020/11/08)
Fault Detection Time	14.976 ms
Fault Elimination Time	58.172 ms
Fault Duration	73.148 ms
Reconnection Time	921.776 ms
Maximum Faulted Current	17.124 kA
Incident type	A-G
I2T	10725145 A^2s
Earth Fault Factor	0.924
Asset activation	100

Figure 22: LSP1 Example incident report

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With respect to the asset analysis, the service is currently able to go through historical data and derive asset intervention statistics for the assets identified in the dataset. This means that for a given asset within a substation/panel, a list of time-tagged performance measures can be retrieved, and performance insights and trends can be derived (such as response time evolution or correlation between performance metrics). For example, one the measures of the stress a CB was subjected over a time interval, is the max interrupted current for the fault it was involved in – which is a key predictor of potential CB performance degradation. Figure 23 shows the evolution of these values for a given asset.

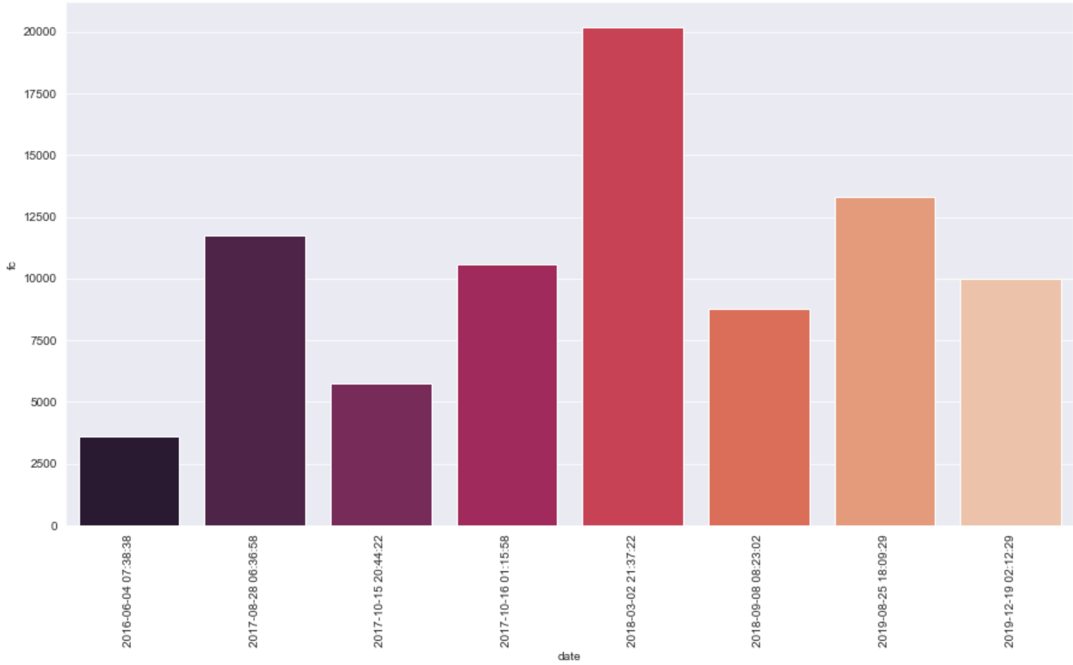

Figure 23: LSP1 Asset Analysis Service – Faulted Current example

3.2.1.2 UC2: Semi-Automatic Maintenance Plan for Right-of-Ways in Overhead Lines

3.2.1.2.1 Data

Table 34: LSP1 Data considered during Pre-Pilot Cycle

Type of Data	Volume
LiDAR sensed point clouds of REN overhead line assets	400GB
Metadata on the location of line segments and other asset specific information	
3D point cloud coordinates	

UC2 data consists of LiDAR sensed point clouds of REN overhead line assets. This data is obtained in a specific format (LAS), which aside from the point clouds themselves, includes metadata on the location of line segments and other asset specific information. In this sense, only the data of the 3D point cloud coordinates is extracted from these input files and stored in csv format.

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3.2.1.2.2 Analytics Services Development

The processed LiDAR data has been used to fully develop an OHL transmission tower classification service, which comprises a set of models which can be used to cluster and/or classify tower models in the field.

The trained models are divided into two categories:

- Clustering models: Usage of a set of feature engineering transformations to the processed point clouds (e.g., computation of point centroids to a pre-set 3D grid, at different scales) to train unsupervised clustering algorithms. Among the models developed, the best results (in terms of V-Measure), were obtained with PCA + Agglomerative clustering. Figure 24 shows an example output.
- Supervised Similarity based algorithms: Development of a modified version of the k-Nearest Neighbors (kNN) algorithm for point-cloud data, introducing alternative distance metrics for neighbour finding process (Chamfer and Hausdorff distances). This method consists of using labelled tower data to build a training set consisting of different reference towers -each label is represented by a reference tower, which is obtained by merging a set of similar point clouds to a single higher resolution tower. The towers are classified directly, with no feature engineering involved, by voting on the k-closest reference towers to a given test sample.

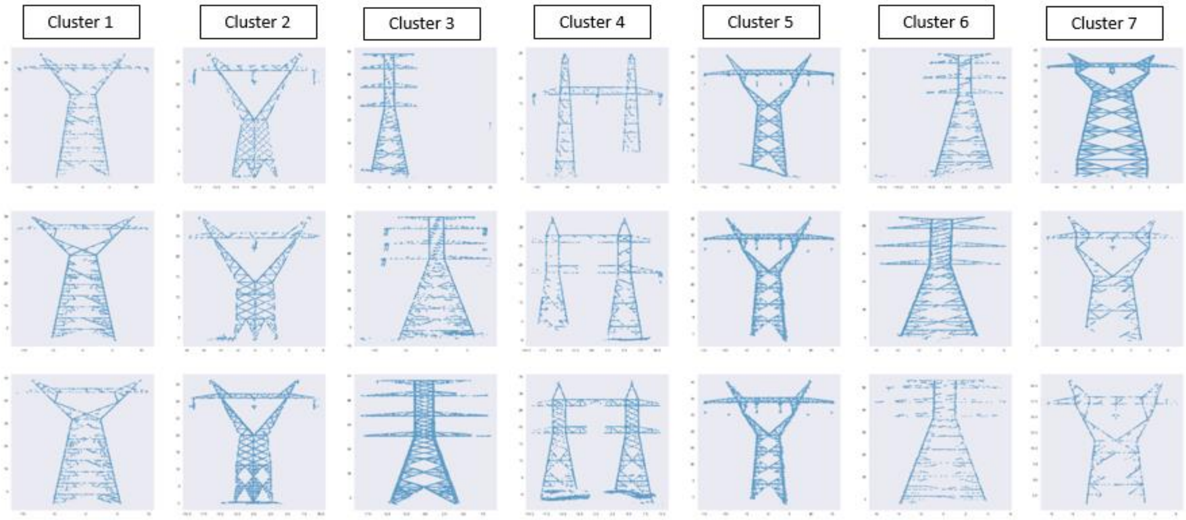

Figure 24: LSP1 Sample of tower families identified using PCA & Agglomerative clustering

3.2.2 LSP2 (ELES): Cross-functional Integration of Grid Operation with Predictive Asset Management

3.2.2.1 UC1: Maintenance Plan Optimisation

3.2.2.1.1 Data

ELES uses IBM MAXIMO platform for asset management of technical assets. Most of the assets' technical data, maintenance records and measurements are stored within the platform database in the MS SQL. The database consists of more than 100,000 assets and 50 GB of data.

In the asset selection phase, the pilot focuses on operational 110 kV to 400 kV Power Transformers

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and Overhead lines. From the grid operation point of view the overhead line should be understood as overhead line systems. This means that the LSP2 pilot focuses on around 260 selected assets. Additionally, electrically connected assets on the location are also considered. They are included in the minor extend with less technical data.

Table 35: LSP2 Data considered during Pre-Pilot Cycle

Type of Data	Volume
Technical data	50 GB
Connected assets	
Maintenance plan	
Maintenance activities	
Maintenance history	
Inspection records: Asset (ID, location, voltage level, asset type etc.) Deficiency finding (ID, asset ID, deficiency classification, finding date, closed, required outage, urgency etc.)	
Diagnostics measurement	
Priority lists	
External outage requests	

Active inspection records

PSA mobile system is the system designed inhouse for supporting the inspectors on the field. PSA and IBM MAXIMO inspection records were checked. The aim was to filter active/existing deficiency findings for selected and processed assets.

The information of the inspection records includes ID, asset ID, deficiency classification, finding date, closed, required outage, urgency etc.). Findings are reported to pilot selected assets, their sub-assets or connected assets. In the data preparation process, the findings are attributed to the asset of interest (for example selected assets).

Currently three remedy urgency levels are implemented, urgent, required and planned. Urgent findings are expected to be remedied within one week, required findings within three months and planed within one year (or more). Finding date, required outage and urgency level define interval for planned maintenance outage.

Asset maintenance activities/measures

The existing maintenance database collects information about assets' historical data and maintenance activities in the past. It includes information about when the asset was purchased and implemented, required maintenance interval, the date of last and next maintenance together with exact location info

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of the asset. The detailed maintenance service history for each asset type is also stored for the last maintenance performed. It includes last maintenance date, asset type, location and location type, last maintenance order ID and location of work in the location. Total costs per work order are calculated, together with each subcategory cost such as personnel cost, materials cost, tools and external services costs. Additionally, maintenance duration and average duration for this asset type is defined together with average personnel maintenance crew size.

Operational data

Operational data is collected, processed, and stored by different systems as SCADA, ADVANCE etc. in the separated inhouse local area network. Due to security reasons and simplicity the operational data is processed there and only averaged hourly measured values are provided. It is estimated that hourly average is currently sufficient for the pilot.

External signals

External signals are currently received in non-digitalised form once a year. Required deviations to the annual plan is coordinated on demand.

3.2.2.1.2 Analytics Services Development

The Pre-Pilot cycle includes data collection, processing of the required data and the MST development by individual building blocks:

- Asset selection (which will be part of the scheduling process).
- Preparation of the asset database, asset maintenance measures, related costs, and duration of the maintenance projects.
- Creation of maintenance project database with all selected assets, measures, maintenance requirements (time frame for maintenance measure, measures needed, etc.) and measure costs.
- Preparing the ranking methodology of the maintenance projects by several criteria (priority, health indexes of the asset, utilisation index of the asset, importance index of the assets)
- Creation of the ranking maintenance projects database.
- Scheduling process, where multi criteria optimisation is performed on the maintenance database to successfully arrange and schedule maintenance for the grid assets with consideration of the additional external or internal fixed requests.
- Final outage maintenance schedule proposal.

In the local MS SQL server, the dedicated database has been established. Special views were set according to the required data sets. The datasets during the Pre-Pilot Cycle exported from the ELES Database in .xls format, which enabled combining the information, gathered from several sources to be combined in the asset database and maintenance information database.

For the development of the MST, three key components are defined and described in this section: Asset database, Ranking process and Scheduling process.

Asset information introduction (asset selection and databases):

At first, the available assets, which would be scheduled were identified. The maintenance planning includes TSO assets, installed in the transformer station locations and power line systems. In addition

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to the main assets, namely power line, and the transformer, both have a lot of surrounding equipment and instruments that is subject of the maintenance and diagnostics process as well. To this end, the final group of assets includes, transformers, power lines, current, voltage and combined measurement auxiliary diagnostic transformers and switches and CBs.

For each of the locations and installed assets, several databases were utilised to prepare data, which is to some extent already used in initial version of the MST tool, while the rest of it will come with the further upgrades of the MST application.

In the asset database, all the investigated assets have detailed description about their location where main asset is installed, and type of the location. Main location is then divided further into detailed first and second level location, where voltage levels, connections and further descriptions are stored.

In the asset maintenance database, the records on the assets history are stored. Each asset's information includes year of manufacture, year of installation, asset location and information about historical maintenance actions. The date of last maintenance defines when the asset was serviced most recently, under which work order and how many personnel and time was needed for completion of this action. Additionally average values for service actions for this type of asset are calculated and exported as well. Last group of information contains service intervals, and suggested date of the next maintenance. In addition to this data, the regular monitoring off the devices results in additional field observations database, where findings from the visual inspection of the asset on the field are stored.

Priority list of the assets is the third database, which is currently established for the power lines and defines the ranking of individual power line systems.

External outage request database is prepared on a yearly basis for the next planning year. All planned activities of the connected power plants and other key network elements, owned by the external actors are listed here. For each location it defines the planned maintenance with required outage of the connected asset of the TSO, with location and date information of the external maintenance actions.

For the development of MST, the databases above regarding asset and maintenance information are used in the initial version of the tool, while the rest of the functionalities, such as external request and other priority lists will be implemented in later stage of the development.

Ranking process

For asset ranking, 3 criteria were defined: Asset Health Index (AHI), Utilisation Index and Importance

AHI values are already defined and calculated in the TSOs database for the transformer assets, while power lines ranking is based on priority list and field observations, where Power line system condition is evaluated.

The Asset Health Index (AHI) is an assessment of the condition of each asset in the TSOs fleet. At this stage, ELES already calculates AHI values for the transformers, which are also included in MST asset selection. It provides information on the equipment condition, level of weariness and aging process of the unit and status of the individual components of the assets. AHI is evaluated based on field operation observations, field diagnostics and inspections, together with field and laboratory stress tests and other aspects. Each parameter is numerically evaluated within defined range and weighted according to the importance of the parameter. Parameters, generally considered in the process of the power transformer AHI calculation consists of age, electrical measurements (insulation resistance,

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partial discharge measurement (currently not fully implemented), loss factor and capacitance measurements, bushing loss factor and capacitance measurements tests, excitation current measurements, etc.), infrared thermography, Dissolved Gas Analysis (DGA), Furan analysis, oil quality tests, etc. The calculation process is presented in Figure 25.

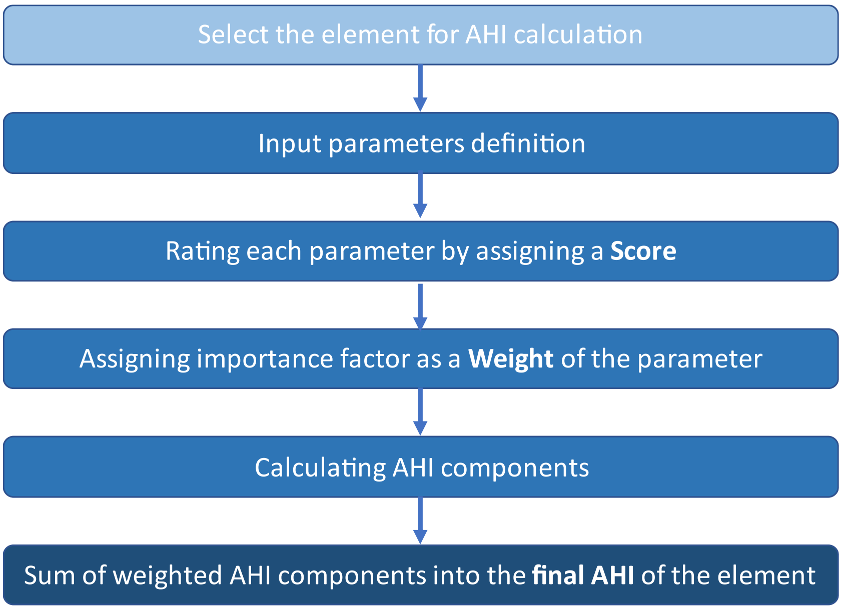

Figure 25: LSP2 General asset health index calculation process

Asset Utilisation Index (AUI) is the second of the individual asset's ranking criteria. It indicates the extent to which the asset is being used, utilised or at what capacity it is operating. It includes measured data of the asset, collected by the monitoring equipment that is part of the TSO's grid. The AUI is calculated from the historical operational data measured in the transformer and line bays. The measured data is provided in hourly resolution for the historical dataset 1.1.2017 - 31.12.2021.

Based on the annual profile of AUI values for each asset, the time intervals with a high expected loading levels can be identified and used in the scheduling process. As a result of this information, the most favourable time window is considered when multiple options for maintenance date are available or when multiple assets compete for the same maintenance time window. The AUI calculation provides hourly values that can be averaged later in the process to a longer period, day, week, or other interval.

Asset importance index is based on the ranking list of the TSO's assets. It currently includes different power line sectors. They are divided in 3 categories:

- Category 1: 21 power line connections with highest priority on 400 – 110 kV voltage level
- Category 2: 29 power line connections on 220 and 100 kV voltage levels
- Category 3: rest of the power line connections

Scheduling process

Scheduling part of the MST application presents the core functionality of the tool. It combines the data, which is stored or calculated in TSO databases. The detailed asset information and available maintenance historical data present the basic needed information for preparation of the maintenance schedule plan for the following year or otherwise defined interval. It additionally includes boundary

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conditions of the process such as externally planned, non-flexible maintenance outages and takes into consideration the TSO maintenance crew organisations and limitations.

The result of the scheduling process is a backbone yearly maintenance plan, which enables easier preparation for the time based, preventive maintenance scheduling plan. The TSOs standard practice is to have all the asset scheduled and checked once per year. For the assets, which are located on a single location, a location maintenance project (LMP) is defined since all the assets are investigated and repaired on the same common planned outage interval. The defined LMPs are then scheduled accordingly to their priority lists and maintenance crew availability. The result is a weekly list or schedule of the locations, which are planned for yearly maintenance.

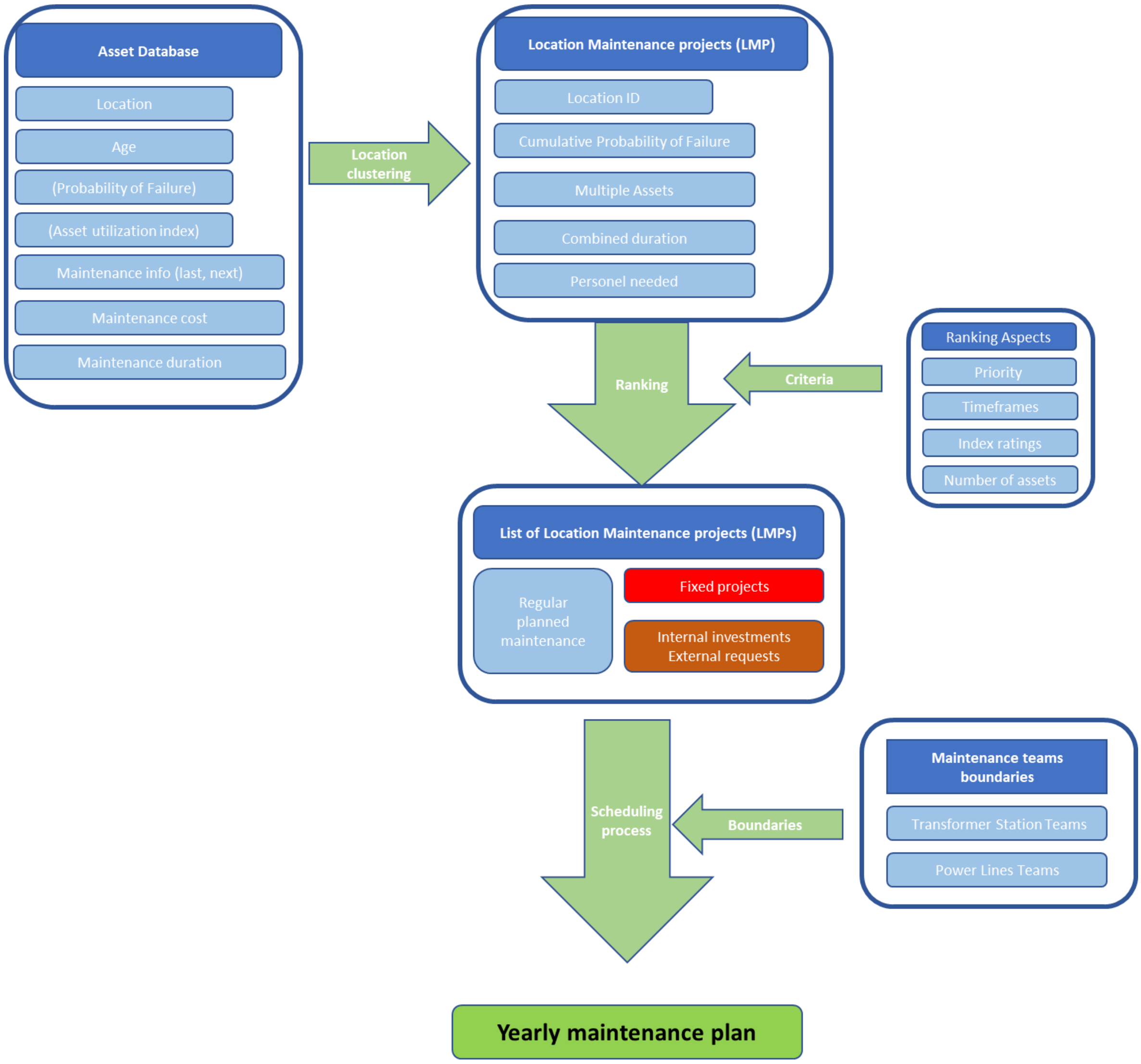

Figure 26: LSP2 MST flowchart

In the first version of the MST in the Pre-Pilot Cycle, no AI model development has taken place. However, in later stage of the project, after the evaluation of MST, it might be necessary to also introduce ML to find a correlation between the various inputs that classical parametric based algorithms might not provide. The general flow of the ML model is shown in Figure 27 and can be adapted as needed.

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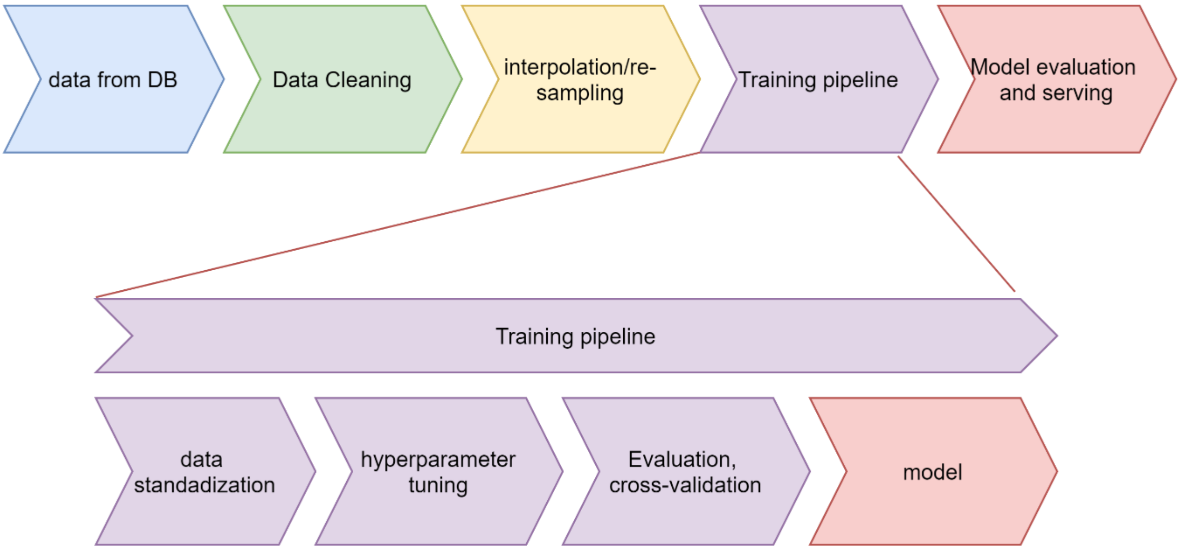

Figure 27: LSP2 ML model creation flow

The development phase of the scheduling algorithm and sample results of the MST are presented below. The TSOs databases were imported in MathWorks MATLAB software environment, where development and test runs were performed. The calculation process is presented in Figure 28 below. After initial import of the data, the MST applies the location clustering of the imported assets and list of LMP is generated. This list proceeds with the ranking and scheduling process afterwards. Once the LMPs are ranked, they are scheduled according to their priority, outage duration and maintenance crew availability. The results of the calculations are, the weekly vectors with information about the asset that is maintained, and duration of the outage for that location.

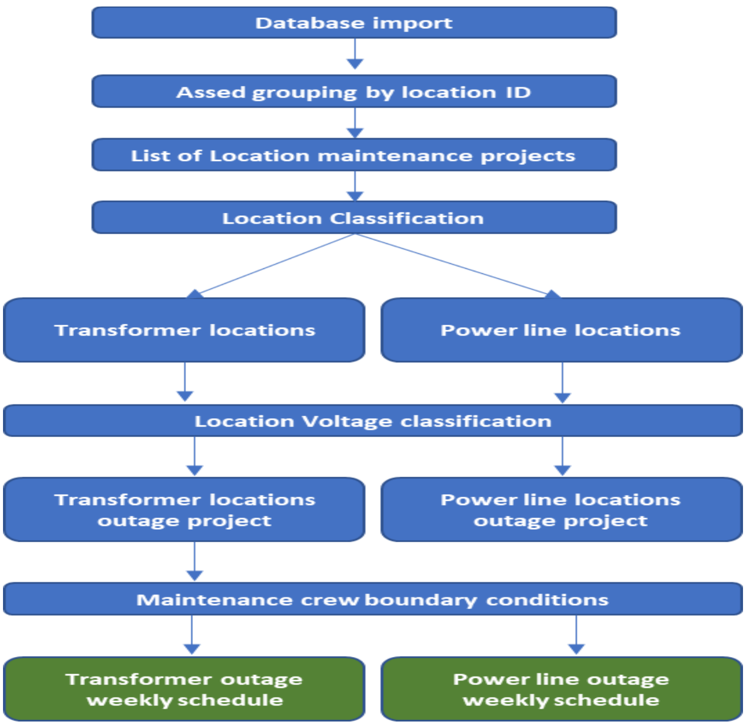

Figure 28: LSP2 Scheduling process

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The scheduling process also includes the TSO maintenance crew boundary conditions:

Maintenance crew information

MST was designed to assist the planner in the yearly maintenance plan creation for the TSO's owned assets in the energy system. The assets involve power delivery transformers and power lines, together with installed equipment in the transformer or power line field. Preventive maintenance actions are based on the maintenance intervals and are subjects of the scheduling process.

While scheduling the maintenance outages for the assets, several boundary conditions and limitations are present:

- externally scheduled outages of the assets, where location is deenergised due to request of other organisation/company. This includes maintenance of connected assets, owned by other utilities, DSOs, generator units etc.
- internal fixed project, such as new construction or major work/update on the location

Location structure

Fields are locations where TSO assets are installed. Based on the main asset installed, it falls into two categories: Transformer type or Power line system type. In addition to the main asset, each location has two fields with equipment, which is installed to connect and monitor the main asset.

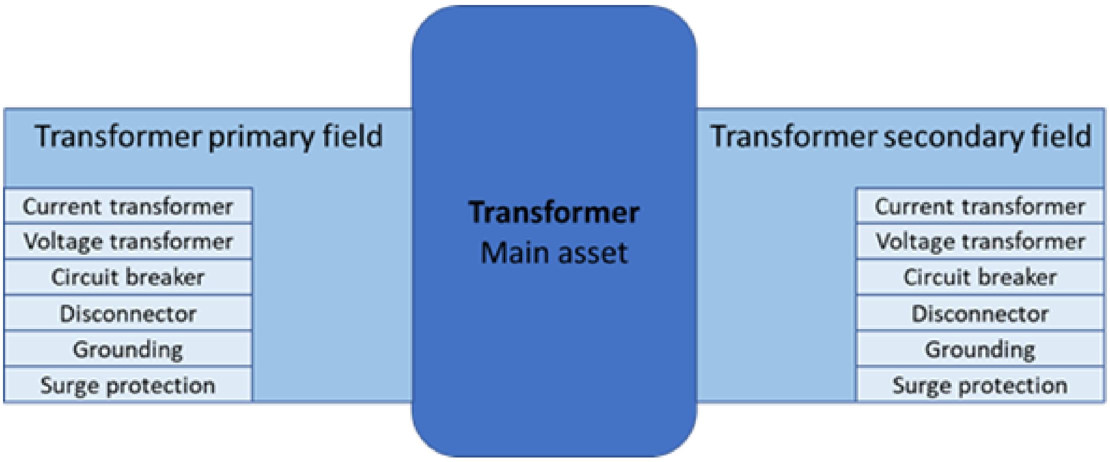

Figure 29: LSP2 Transformer field structure

All the assets are maintained on the same occasion as the main asset, so their review, inspection, diagnostics and repair times are taken into consideration as well. When preparing the schedules for the maintenance work several parameters are considered: the planned outage of the location, number of teams, working on the main asset in each category and on the connecting fields. Key requirements in terms of reserved time and required crew size, which are assumed in the pre-pilot phase, are shown in Table 36. The values were obtained from the past maintenance schedules and are subjected to slight adjustments during the following phases of the project.

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Table 36: LSP2 Reserved asset maintenance time and workforce

Location Type/Voltage Level	Information Transformer	Power line
110 kV	3-day	3-day shutdown
220, 400 kV	5-day shut down	5-day shut down
Main asset	2 teams	2 teams
Field equipment	2 teams	2 teams

Results from the test runs

In Figure 30, an example of transformer station locations scheduling calculation is presented. As observed, the scheduling process has a lot of available flexibility due to several factors:

- Only 41 Transformer stations are subject of the scheduling process.
- No external outage request was implemented in this informative schedule, which serves only for the tool validation.
- No link to other, disconnected assets was considered as well: i.e., when power line is shut down, also the supplying transformer must be shut down.

Figure 30: LSP2 Example of transformer schedule

For the powerlines, similar outage durations were taken into consideration in the testing phase of the MST development. As the standard TSO practice dictates, the planned outage is on maximum duration to have location available for full diagnostics and repairs, which means that the location is potentially over-planned, and the duration of the actual work is shorter than planned. As a result of this safe approach of planning, the initial powerline outage plan is evenly distributed throughout the yearly interval, as seen in results in Figure 31.

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LOC id	1	2	3	4	5	6	7	8	9	10
12	1	0	0	0	0	0	0	0	0	0
13	1	0	0	0	0	0	0	0	0	0
34	1	0	0	0	0	0	0	0	0	0
37	1	0	0	0	0	0	0	0	0	0
42		1	0	0	0	0	0	0	0	0
43		1	0	0	0	0	0	0	0	0
44		0	1	0	0	0	0	0	0	0
45		0	1	0	0	0	0	0	0	0
46		0	0	1	0	0	0	0	0	0
47		0	0	1	0	0	0	0	0	0
48		0	0	0	1	0	0	0	0	0
49		0	0	0	1	0	0	0	0	0
50		0	0	0	1	0	0	0	0	0
51		0	0	0	0	1	0	0	0	0
52		0	0	0	0	1	0	0	0	0
53		0	0	0	0	1	0	0	0	0
54		0	0	0	0	1	0	0	0	0
55		0	0	0	0	0	1	0	0	0
56		0	0	0	0	0	1	0	0	0
57		0	0	0	0	0	1	0	0	0
58		0	0	0	0	0	1	0	0	0
59		0	0	0	0	0	0	1	0	0
60		0	0	0	0	0	0	1	0	0
61		0	0	0	0	0	0	1	0	0
62		0	0	0	0	0	0	1	0	0
63		0	0	0	0	0	0	0	1	0
64		0	0	0	0	0	0	0	1	0
65		0	0	0	0	0	0	0	1	0
66		0	0	0	0	0	0	0	1	0
67		0	0	0	0	0	0	0	0	1
68		0	0	0	0	0	0	0	0	1
69		0	0	0	0	0	0	0	0	1
70		0	0	0	0	0	0	0	0	1
71		0	0	0	0	0	0	0	0	0
72		0	0	0	0	0	0	0	0	0
73		0	0	0	0	0	0	0	0	0
74		0	0	0	0	0	0	0	0	0

Figure 31: LSP2 Power line outage plan

3.2.3 LSP3: Cross-Domain Cross-functional Integration of Predictive Asset Management and Grid Operation while coordinating with EVs smart charging

3.2.3.1 UC1: Efficient management of flexibility resources for supporting grid operation

3.2.3.1.1 Data

Table 37: LSP3 UC1 Data considered during Pre-Pilot Cycle

Type of Data	Volume
ASM Headquarter electrical consumption	53.7 GB
ASM PV plant production (2 PV panels)	6.7 GB
Weather Data	673 MB

3.2.3.1.2 Analytics Services Development

The developed service involves accurate forecasting of the hourly production of PV generated power based on ML and DL models. Hourly data from a selected photovoltaic system, along historical weather data for the exact location of the photovoltaic system have been used in order to provide data-driven, weather-based forecasting models. Several models have been developed and evaluated, including decision tree models and gradient boosting techniques, which have been implemented in Python 3.0 environment. Moreover, a DL approach based on a stacked Long Short-Term Memory model is being

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developed. The selected features of these models have been extracted based on a model comparison process of comparing and transforming variables (feature engineering), resulting in the following highly related features: (a) solar irradiance, (b) cloud coverage, (c) air temperature and (d) seasonal patterns (month of the year, hour of the day). Finally, transfer learning capabilities are inspected by NTUA under WP4 activities. The envisioned outcome of this work is to provide pre-trained reusable and scalable models from PVs located in other countries and to exploit them for providing accurate predictions in the case of newly installed solar plants with insufficient data for training conventional models from scratch.

3.2.3.2 UC2: Anticipated prediction of asset failures

3.2.3.2.1 Data

Table 38: LSP3 UC2 Data considered during Pre-Pilot Cycle

Type of Data	Volume
Acoustic data from 10 secondary substations	Real time data
Electrical data from 41 electrical sensors (Power quality analysers and smart meters) related to secondary substation	1 year of historical data and real time data
Temperature of 10 secondary substations	Real time data
Humidity of 10 secondary substations	Real time data

3.2.3.2.2 Analytics Services Development

The aim of UC2 of LSP 3 is to create a system capable of estimating how the electrical transformers, installed on the secondary substations of the electricity distribution grid, are ageing. To estimate ageing, both transformers' electrical power measure over time and information about the transformers' characteristics are needed.

While electrical sensors can measure electrical power, their cost might be prohibitive for some applications; in contrast acoustical sensors have much lower price, hence, it is easier to install them on a large scale inside the secondary substations containing the transformers. The first goal of the algorithms is to identify a correlation between noise and electrical power of the electrical transformer. If this correlation is strong enough, audio signals to predict electrical power over time could be exploited, getting the same result as with the electrical sensors, but with acoustical sensors of a significant lower cost.

To find this correlation, widely used deep learning models for audio classification will be exploited, while applying the proper modifications to them. These pre-trained models have been trained on Big Data datasets, hence they can be extremely effective on extracting raw features of an audio signal and are released as open source. For UC2, the goal is not audio classification, but the prediction of a continuous variable (electrical power). A solution might be to change the last layers of the chosen DL, adding some fully connected layers and a final layer of size one. After the modifications the model needs to be retrained on the domain specific data.

While applying this model can help knowing how much power is produced by the transformers over

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time, further considerations can be done also on how variable the electrical power trend is, and how much stress this variability can cause on the system. This information needs to be fed into an electrical model capable of estimating the ageing of the transformer. Further considerations can also be done on how to forecast transformer usage over time. While it is not possible to forecast in years the service life of a transformer, due to lack of historical data, comparison between transformers usage can be done exploiting forecasting ML models.

3.2.4 LSP6 (EKL, BORZEN & CS): Coordinating grid-owned and behind-the-meter assets management prediction for improved grid operation and near real time power market operation settlement

3.2.4.1 UC1: Identification of flexibility potential, based on near-real time data & UC2: Independent aggregator flexibility activation, quantification and settlement

3.2.4.1.1 Data

Table 39: LSP6 Data considered during Pre-Pilot Cycle

Type of Data	Volume
Power quality meters (basic voltage and current measurements and calculated electrical parameters) (10 locations)	2,57 GB historic data, 10 min data collection for the period of 3 years (max)*
Smart metering data (voltage, current, power, energy) (633 metering points out of which 611 represent households, 19 represent consumers with self-production, and 3 represent standalone production locations)	2,63 GB historic data, 15 min data collection for the period of 1 years (max)**

**The data from all transformer stations is collected via LTE communication infrastructure and aggregated in real-time.*

***The amount of historic data refers to raw data collected from AMI infrastructure, before cleansing and missing data approximation; collected on the field using the Power Line Communications.*

3.2.4.1.2 Analytics Services Development

The UCs of LSP6 deals with flexibility assessment related to power quality requirements and grid assets conditions. The overall aim is to develop the service for DSO flexibility requests forecasting, establish means for the provision of flexibility via the behind-the-meter (i.e., customers' premises) assets/devices, and introduce analytics driven remuneration scheme for service provisioning.

The developed analytics services can be categorised as (1) flexibility needs assessment for improved grid operation, (2) localised flexibility forecasting based on demand and generation profiles applied to grid topology, (3) baseline models development and users clustering based on profile and types of behind-the-meter assets, and (4) flexibility provisioning estimation based on discrimination between baseline and actual consumption/generation measurements.

During the Pre-Pilot Cycle research process, determination of possible optimal settlement models and scenarios and initial testing for the abovementioned services has taken place.

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3.2.5 LSP8 (UNIWA/TILOS): Predictive Demand and Generation Forecasting for Optimised Local Energy Community Management

3.2.5.1 UC1: Optimal management strategies for cross-infrastructure flexibility resources to support higher RES shares at the island community level

3.2.5.1.1 Data

Table 40: LSP8 UC1 Data considered during Pre-Pilot Cycle

Type of Data	Volume
PV Production (2 photovoltaic panels)	6.92 GB
Island's load consumption	7.56 GB
Weather Data (Temperature, Solar Irradiance, Cloud Coverage, Wind Speed)	1.57 GB
Water pumping systems consumption in 7 different spots (hourly data)	40GB

3.2.5.1.2 Analytics Services Development

LSP8 UC focuses on the optimal load shifting of the island's loads in order to exploit electricity produced by Renewable Energy Sources (RES). The developed analytics can be divided in four categories. The first category includes forecasting the energy production from PVs. The predictions were based on weather data and autoregressive indices (same hour previous day, same hour previous week). The second category involves forecasting the total demand of Tilos island. This prediction module was fed with historical data, exploiting patterns driven from the hour of the day, the day of the week and the season (winter or summer). Both those categories of analytics were implemented with decision trees and gradient boosting regression algorithms. More specifically, ensembles of several models, such as Decision Tree Regressor of Sklearn, XGBoost and LightGBM, were utilised to provide one-week-ahead forecasts in an hourly basis. The third sub-service involves the pattern extraction from the water pumping stations of the island. More specifically, a monthly profile was designed for each pump, according to patterns identified in the past years. The operating hours of each pumping station for each month were extracted and fed to the optimisation algorithm.

Figure 32: LSP8 Peak shaving approach

Finally, all the above subservices were used as an input for the fourth analytics category, which is the optimisation scheduling algorithm. This algorithm uses certain rules in order to provide the optimal scheduling program (in terms of operating hours) for the water pumping stations of the island. Two different scenarios are facilitated, including continuous programming and unrestricted programming. In the first scenario we focus on providing the scheduling of the pumps based on the assumption that

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the operating hours must be continuous, while in the second scenario the pumping stations can operate any hour.

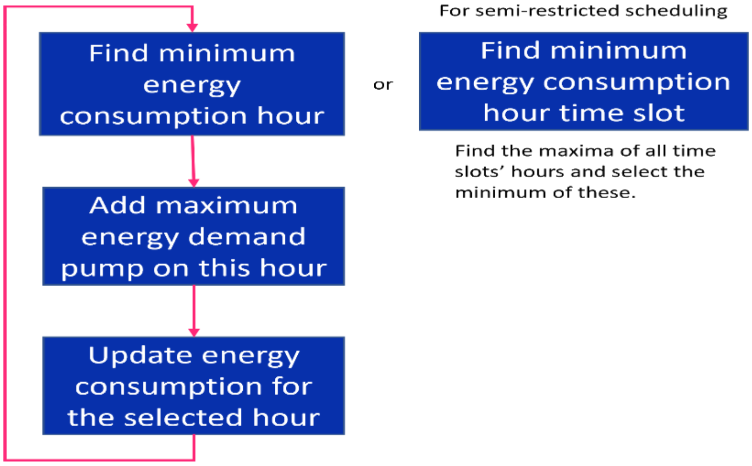

Figure 33: LSP8 Optimisation scheduling algorithm

As a complementary tool to facilitate exploratory analysis for the development of AI and ML models for LSP8, the Integrated Querying Component and the Visual Analytics service have been employed.

Integrated Querying component is used to execute queries to different and heterogeneous databases and combine their results. In LSP8 use case, it is used to combine data from smart meters with weather data for the specific region. For the time being, joins between different datasets are available only through API calls, and not from the UI, but this will be addressed during the next Development Cycle.

Visual Analytics Engine provides an easy way for aggregating different attributes of a dataset, as well as combine them and present the result as useful data visualisations. Data from LSP8 come at an hourly basis and Visual Analytics engine facilitated the visual representation of timeseries data for different attributes, as illustrated in the figure below.

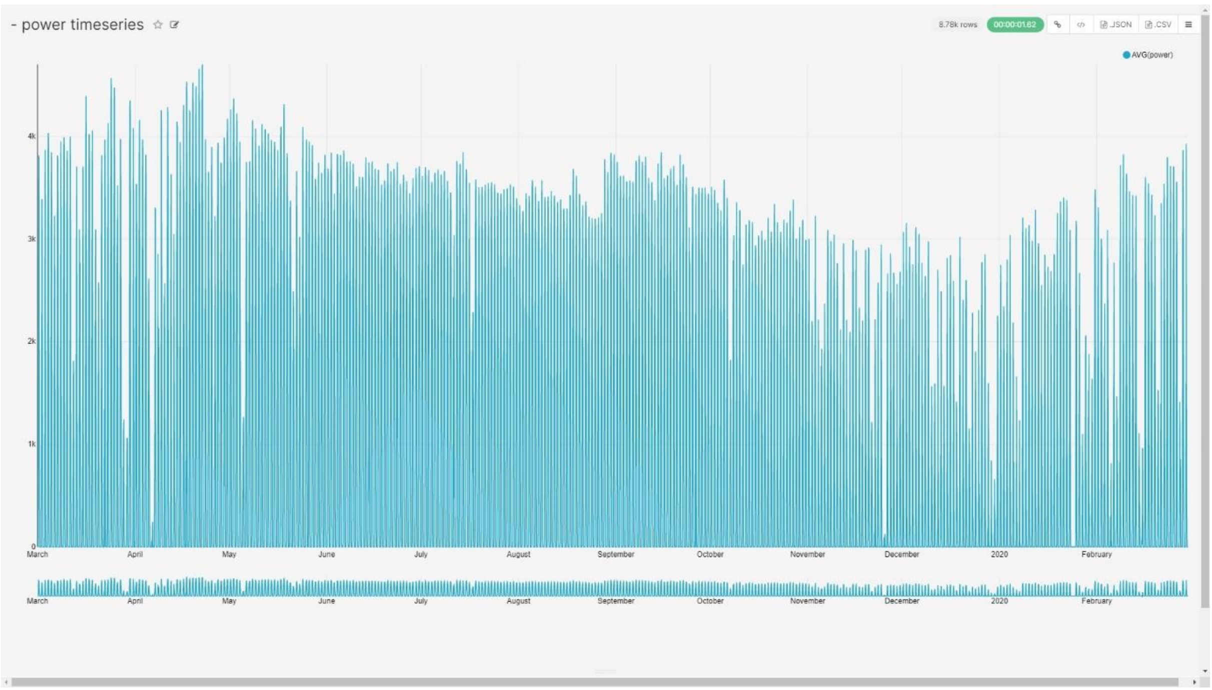

Figure 34: LSP8 Visual Analytics demonstration

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The previous figure is too detailed for the first steps of the analysis, when more generic information is more useful. Therefore, Visual Analytics engine facilitated the creation of aggregations per day (average power per day) as presented in the following figure.

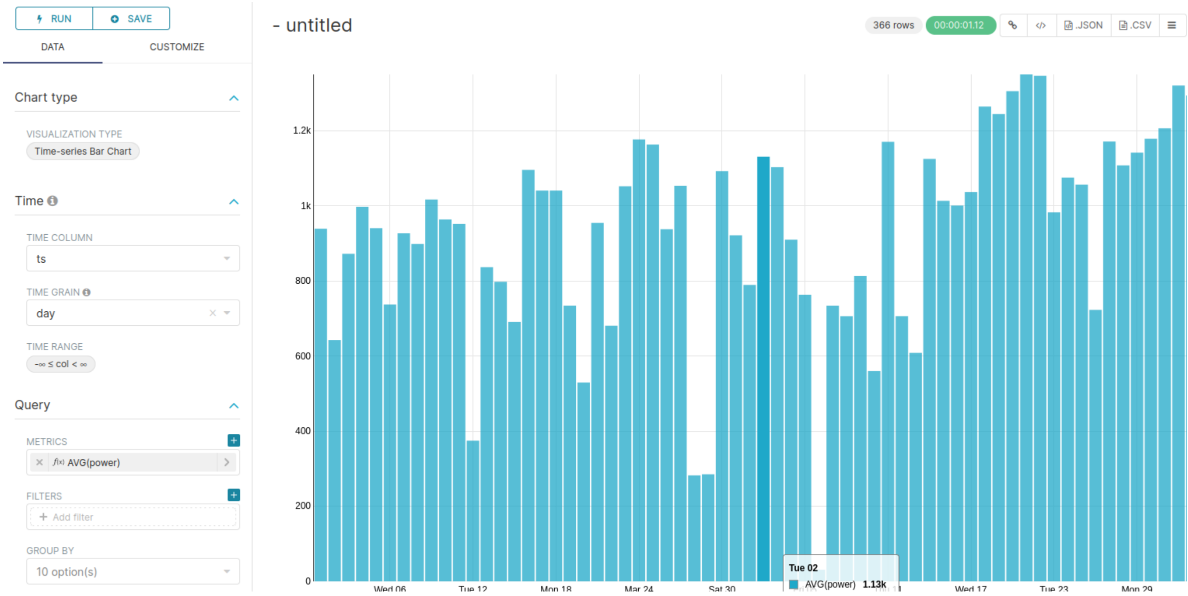

Figure 35: LSP8 Visual Analytics Average Power per day

Another important issue for the analysis how other variables like temperature impacts electrical power evolve over time, in comparison with the latter. Therefore, in the following figures present electrical power per day in comparison with temperature and wind speed.

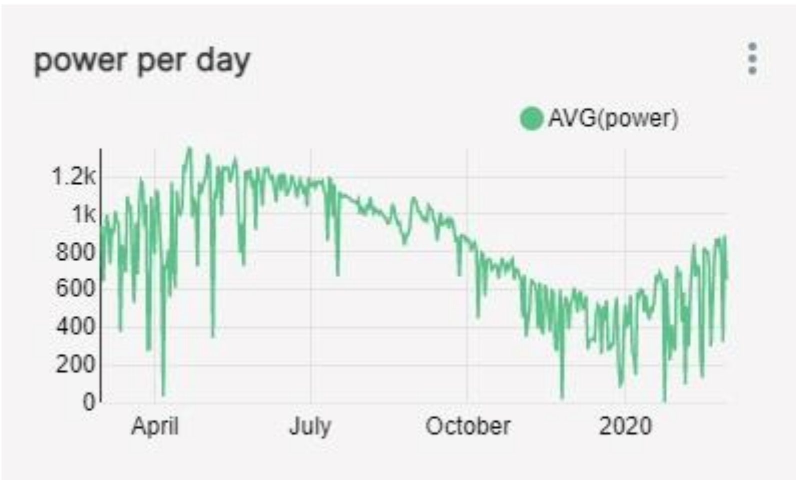

Figure 36: LSP8 Average Power over time

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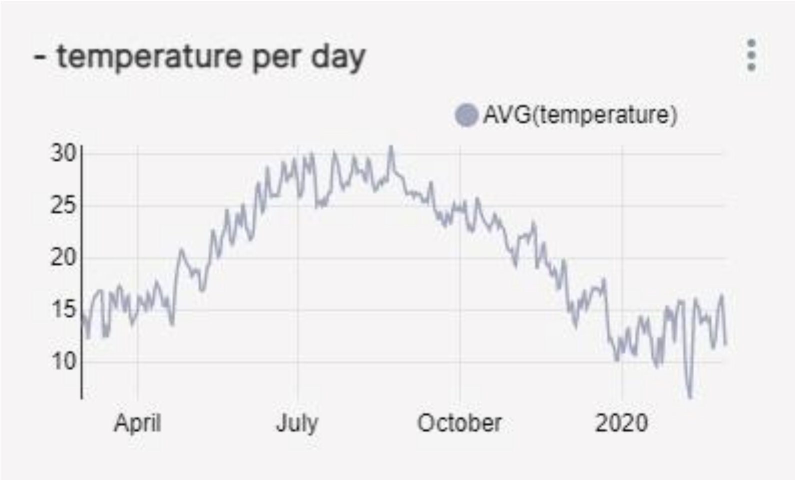

Figure 37: LSP8 Average temperature

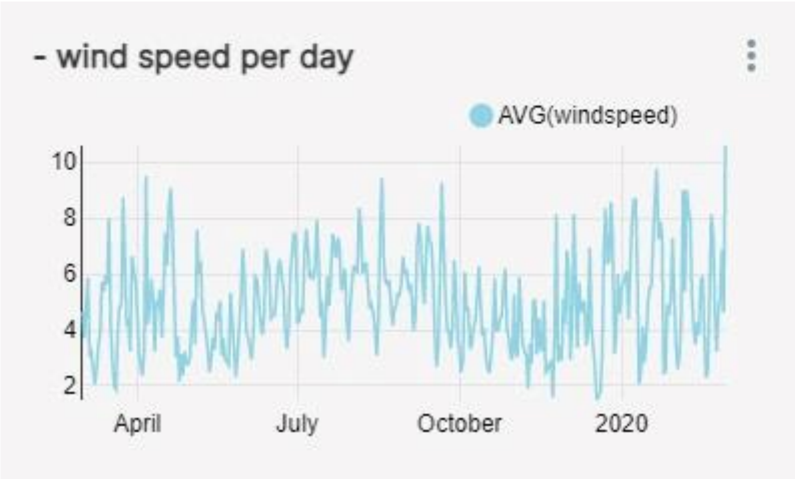

Figure 38: LSP8 Wind speed per day

It is worth mentioning that this information is useful also for the pilot operators as it makes AI models more understandable to them. To this end, Visual Analytics Engine was used to create dashboards and reports for the LSP8 operators. An example of a dashboard is illustrated in the following figure.

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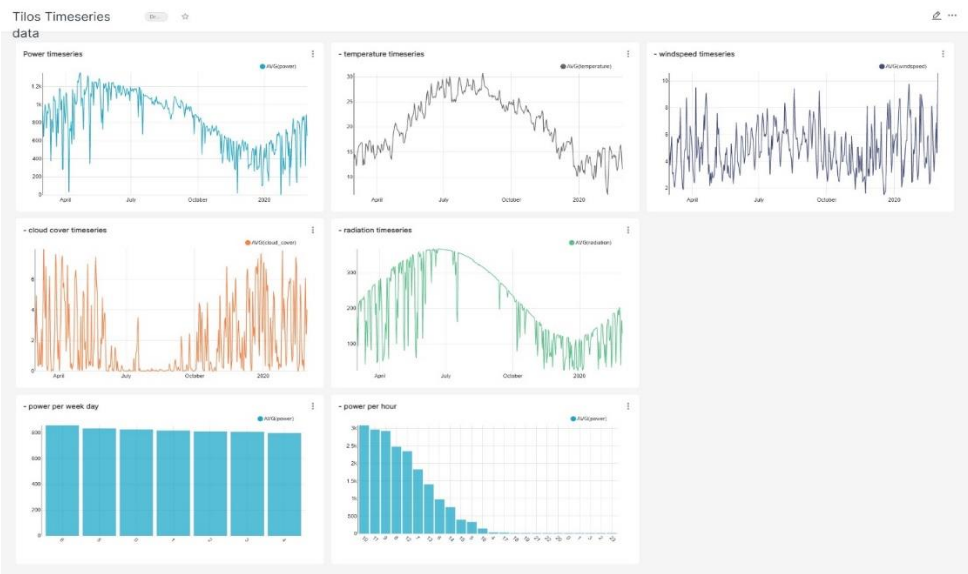

Figure 39: LSP8 Visual Analytics dashboard

3.2.6 LSP10 (CARTIF & VEOLIA): Predictive and Prescriptive Analytics for improved Energy Performance Certificates Reliability

3.2.6.1 UC1: Predictive and Prescriptive Analytics for improved Energy Performance Certificates Reliability

3.2.6.1.1 Data

Table 41: LSP10 Data considered during Pre-Pilot Cycle

Type of Data	Volume
Spanish Cadaster	36,7 GB
Public EPCs from Regional Register of Castilla y Leon	791 MB
Public building energy consumption information	418 MB
Public information for energy system in Castilla y Leon	1MB
Historic monitored data: Temperature and Humidity	Samples
Dynamic data form BEMS	Samples
Weather data AEMET (historical)	2-3MB
Weather data AEMET (forecasting)	2-3MB
LiDAR DATA	Samples
COPERNICUS SoDA weather data	10MB
COPERNICUS C3S data. UERRA regional reanalysis	Samples

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3.2.6.1.2 Analytics Services Development

Energy Prediction

For the development of energy prediction models, it has been identified that the following data are needed:

- Public buildings energy consumption information
- Monitoring building consumption data (historical and real-time information)
- Weather data (historical and forecasting)
- Contextual information (type of building, occupation patterns…)

Energy Performance Calculation based on public data at urban level

For the estimation of EPCs using data from public sources, it has been identified that the following data are needed:

- Cadastral data
- Public EPCs
- LiDAR data

Energy prediction considering climate change impacts

For the medium to long-term prediction of the energy demand of buildings based on climate data, it has been identified that the following data are needed:

- Climate data (historical and future, extracted from COPERNICUS)
- Cadastral data. Buildings geometrical information (gml, shapefile)
- LiDAR data (this may depend on the pilot dimension)

At this stage, no interactions with WP4 components have been tested. However, the general flow of the ML models' development is included below:

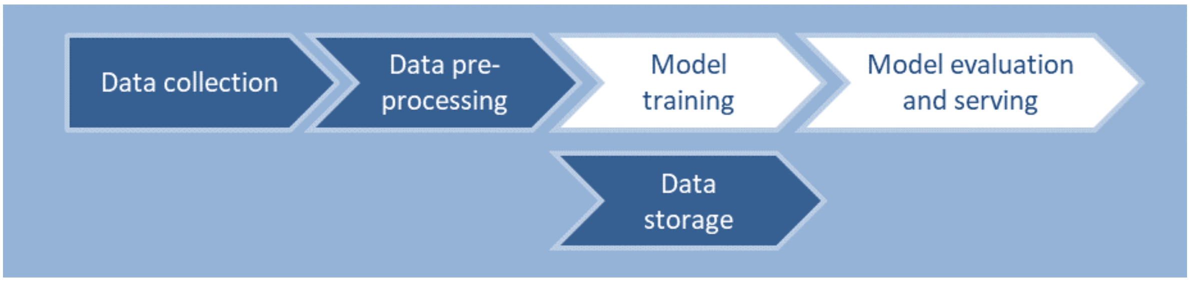

Figure 40: LSP10 ML model creation flow

The first three blocks in Figure 40 represent the necessary steps for data collection, processing, so that they can be used (cleaning and error correction), to finally be stored and fed to the models. These steps would be associated with the work that falls on the BD4NRG Governance layer. That information is now ready to train ML models (post processing may be necessary, such as information standardisation).

Three scenarios are identified to develop and train the models to use within the analytic services.

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- The energy prediction based on data will be based on different ML algorithms. A forecasting module needs to be implemented, including different algorithms, to make it possible to compare the accuracy of different models.
- For the Energy performance calculation based on public data the combination of the cadastral information with data from the public EPCs files will be used. Using classification and regression techniques, models for the consumption demand and CO_2 emission for each use and typology will be created. This model will be compared with other sources in order to check the accuracy of the estimations
- The energy prediction considering climate change impacts uses different statistical downscaling algorithms and regression techniques for bias correction

3.2.7 LSP12 (LEIF): Predictive Analytics for Energy Efficiency Investments de-risking

3.2.7.1 UC1: De-risking energy efficient investments

3.2.7.1.1 Data

Table 42: LSP12 Data considered during Pre-Pilot Cycle

Type of Data	Volume
Energy Efficiency Investments Data	8.39 MB
Weather Data	3.5 GB

3.2.7.1.2 Analytics services development during Pre-Pilot Cycle

For LSP12, two analytics services are being implemented. The first analytics service involves the categorisation of energy efficiency investments in discrete classes based on their characteristics, using a pool of past energy efficiency investments to train the models. The second analytics service includes the calculation of actual energy savings of a renovation action in buildings based on estimating the adjusted baseline consumption.

For the first analytics service (Figure 41), the presented methodology aspires to provide a grant financing recommendation for future energy efficiency projects by learning from a pool of already implemented projects with similar characteristics.

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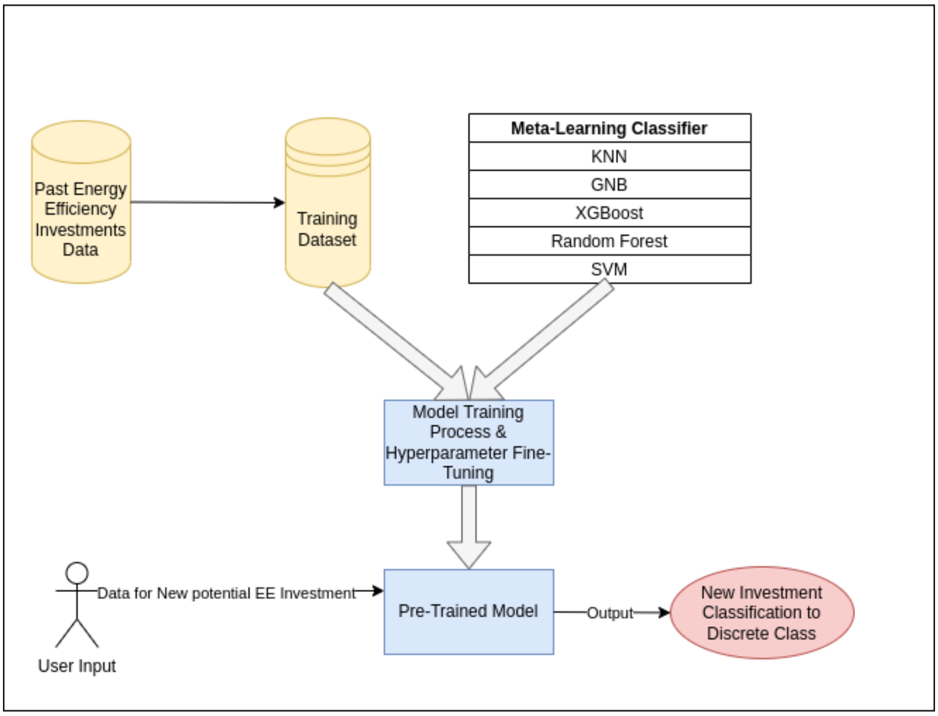

Figure 41: LSP12 Energy efficiency investments assessment service

The basis of the proposed approach is a stacking ensemble classification model that builds on five baseline ML classification methods, namely k-Nearest Neighbours, Gaussian Naive Bayes, Extreme Gradient Boosted Trees, Random Forest, and Support Vector Machine. The train set of the classifiers is a set of projects stored in the decision-support system's database that involves information about the renovations performed in a variety of buildings during the last decade. This includes data that was originally available before implementing the renovation (used as features) and data recorded after the investment has been completed (used for labelling). Specifically, the features of the investment involve specific attributes of the projects that, in our case, are the renovated building's age, number of apartments, total heating area, and current energy consumption, the expected CO_2 decrease, and the renovation cost. The output of the baseline classifiers are probabilities that the investment belongs to each discrete class among the following three: Class A: The project should be financed, Class B: The project should be partially financed and Class C: The project should not be financed. An indicative scheme of the proposed methodology is presented below:

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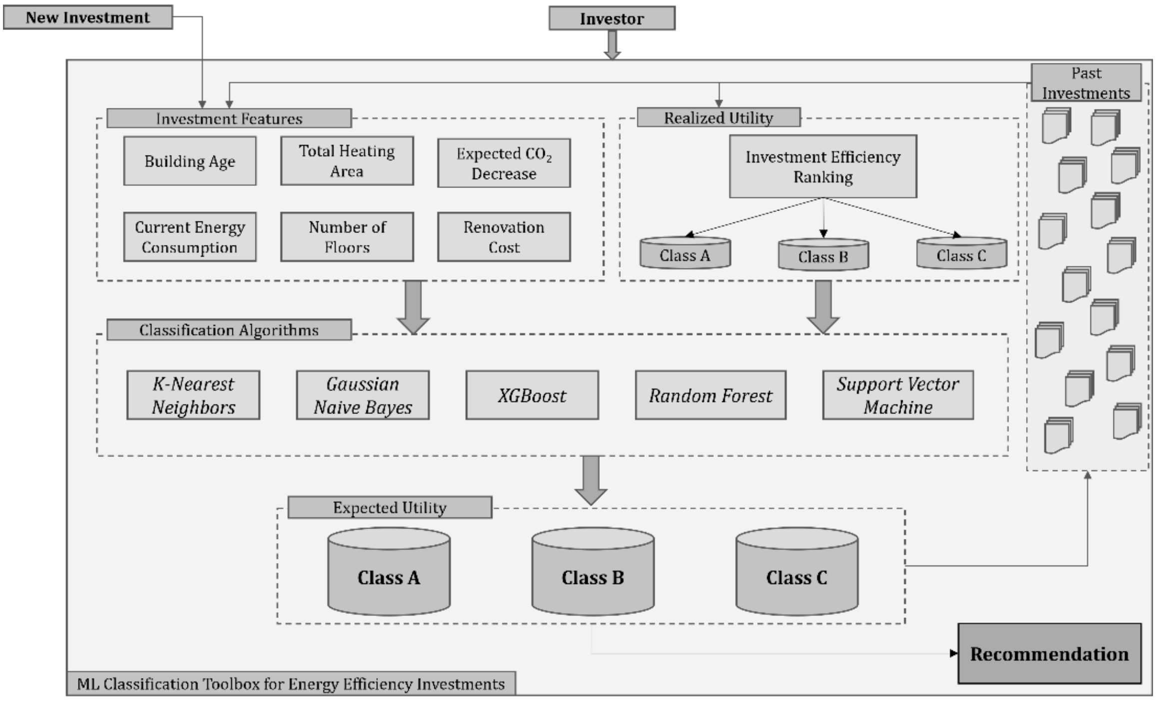

Figure 42: LSP12 Grant financing service methodology

The second methodology (Figure 43) regards energy savings calculation after Energy Conservation Measures in buildings have taken place. This service aims to give accurate forecasts about adjusted baseline energy based on hourly or daily data before the renovation took place. The proposed algorithms for this service are some well-known regression algorithms such as the decision trees and gradient boosting trees (including the scikit-learn, XGBoost and LightGBM libraries) in order to address the problem. The most important variables to be exploited are the consumption of the building during the baseline period (before ECM implementation), weather data – mainly air temperature- and occupancy data for the building (vacation periods, weekly patterns, etc.). This service is under development and will be finalised and tested in several Latvian buildings with data provided by LSP12.

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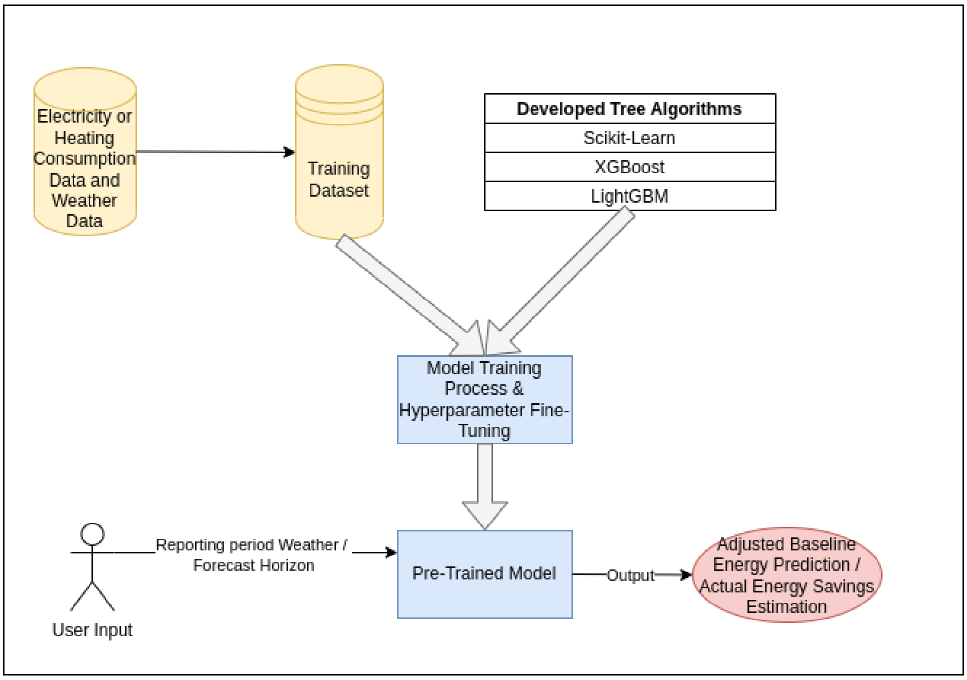

Figure 43: LSP12 Energy savings calculation service

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4 KPIs Tracking and Progress

In this section, the KPIs status as part of the M&V plan is presented to monitor the progress held. A concentrated table with all the values of the KPIs for each General KPI is presented. In APPENDIX III, detailed tables for each LSPs can be found with the corresponding values and a brief explanation. Detailed tables with the Pilot Specific KPIs and the progress made during the Pre-Pilot Cycle are also presented for each pilot demonstrator.

4.1 General KPIs

The General KPIs as described in deliverable D6.1 - "Pilot Operation, Engagement and M&V Plan" are the following:

G01: Seamless and smooth data transition from different types of **sensors**

G02: Seamless and smooth data transition from different types **of data resources**

G03: Resources

G04: Type of **data sources**

G05: Identification and interoperability with well-known **open data sources**

G06: Datasets used

G07: Digital Technologies integrated in the energy system

G08: Big data availability for real life research

Table 43 presents an overview of each KPI per pilot. As part of the M&V plan, the General KPIs should be monitored in every stage of the project, so to allow to properly track their status, their integration (based on the baseline values recorded in D7.1, D8.1 and D9,1), identify in timely manner potential deviations and assess if measures and actions need to be taken for mitigation.

Table 43: General KPIs status during Pre-Pilot Cycle

KPI	LSP1	LSP2	LSP3	LSP4	LSP5	LSP6	LSP7	LSP8	LSP9	LSP10	LSP11	LSP12
G01	0	2	5	3	8	3	2	11	778	2	2	2
G02	0	5	7	0	13	3	2	2	2	3	3	4
G03	0	10	6	6	12	3	33	21	26	48	76	8
G04	2	7	8	4	1	8	1	5	2	3	3	4
G05	0	0	0	0	0	0	0	0	0	3	0	1
G06	2	300	50	500	3	10	4	5	2	4505	28	5
G07	-	0	0	0	0	0	0	0	0	0	0	0
G08	402GB	50 GB	3.75TB	10GB	8.75TB	14.6GB	100MB	55GB	0.5TB	39.7GB	200MB	13,2GB

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4.2 Pilot Specific KPIs

In this section, the progress in the Pilot Specific KPIs is reported. Based on the progress of the analytics services, the aim is to track the progress made within the Pre-Pilot Cycle for each LSP. Further explanations of the Pilot Specific KPIs, regarding their formulation process, definition, baseline values and formula to be measured can be found in deliverables D6.1, D7.1, D8.1 and D9.1.

4.2.1 LSP1 (REN & RDN): Integrating off-grid Data with Condition based Monitoring for Enhanced Predictive Asset Maintenance

At this point, the implementation of the services developed to specifically respond to some of the KPIs defined has allowed to update the progress, as well as to fulfil some of the targets defined.

Table 44: LSP1 Pilot Specific KPIs progress

KPI	Baseline	Target	Progress
1101: Percentage of switching operations identified	0	90%	Not tackled yet
1102: Fault categorisation accuracy	0	90%	87.14%
1103: Incident cause categorisation accuracy	0	85%	Not tackled yet
1104: Accuracy of circuit breaker incident reports	0	90%	92.85% (for the asset trigger detection component of reports)
1201: Accuracy identifying the tower type	0	85%	88.2% (with the Similarity based algorithms developed)
1202: Accuracy identifying the number of structural elements in the tower	0	TBD	Not tackled yet
1203: Number of different types of tower and RoW features/entities identified	3	4	Not tackled yet
1204: Meshed ground profile along the RoW	0	TBD	Not tackled yet
1205: Vegetation index mass	0	TBD	Not tackled yet

For KPIs 1202, 1204 and 1205, the target is still under investigation, since no automatic solution has been developed in the past. Based on the analytics services under BD4NRG, the goal is to first develop an automatic method instead a manual one, and then evaluate the results.

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4.2.2 LSP2 (ELES): Cross-functional Integration of Grid Operation with Predictive Asset Management

There wasn't any progress in terms of pilot specific KPI improvement in the pre-pilot cycle. As mentioned, the main goal of the first cycle was to develop the basic version of the tools and make initial runs with the provided database. Result analysis will follow in the next months in order to improve the workflow.

Table 45: LSP2 Pilot Specific KPIs progress

KPI	Baseline	Target	Progress
2101: Planned outage duration	23,863.55 h/year	0.5% decrease	Not tackled yet
2102: Number of planned outages	1,086/year	0.5% decrease	Not tackled yet
2103: AHI level (per asset and per fleet)	78 (dimensionless)	0 (unchanged)	Not tackled yet
2104: Faster outage plan	128 h	50 h	Not tackled yet

4.2.3 LSP3 (ASM): Cross-Domain Cross-functional Integration of Predictive Asset Management and Grid Operation while coordinating with EVs smart charging

The development of the analytics has not been finished, so no substantial progress to be reported on the pilot specific KPIs tracker.

Table 46: LSP3 Pilot Specific KPIs progress

KPI	Baseline	Target	Progress
3101: Reverse power flow	24.9 GWh	23.6 GWh	Not tackled yet
3102: Amount of flexibility energy exchanged	0 %	5 %	Not tackled yet
3103: Number of customers included in the local flexibility mechanism	0 (# customers)	10	10
3104: Self-consumption	65 %	70%	Not tackled yet
3105: Power losses in the distribution grid	4.50 %	4.27 %	Not tackled yet
BO1: CAIDI	20 min/(customers*years)	16 min/(customers*years)	Not tackled yet
BO2: SAIDI	35 minutes/(customers*year)	28 minutes/(customers*year)	Not tackled yet
BO3: SAIFI	1.75 # interruptions/(customer*year)	1.4 # interruptions/(customer*year)	Not tackled yet

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KPI	Baseline	Target	Progress
EIO1: Cost for asset maintenance and management reduction	0 €/year	30 %	Not tackled yet
3201: Asset lifetime	60 years	42 years	Not tackled yet

4.2.4 LSP4 (OEDAS): Cross-functional Predictive Asset Management for MV Grid Planning

The development of the analytics has not been finished, so there is no progress to be reported on the pilot specific KPIs tracker.

Table 47: LSP4 Pilot Specific KPIs progress

KPI	Baseline	Target	Progress
BO2: SAIDI	583.24 mins/customers*year	20% decrease	Not tackled yet
BO3: SAIFI	5.21 mins/customers*year	20% decrease	Not tackled yet
4101: Reduction of faults	100% (#faults/year)	5% decrease	Not tackled yet
4102: Productive maintenance/preventing unnecessary maintenance	0% (#interventions/year)	3% decrease	Not tackled yet
4103: Number of components replacements	100% (#components replaced/year)	5% decrease	Not tackled yet

4.2.5 LSP5 (CENTRICA): Cross-stakeholder Transfer Learning for Flexibility Assets Forecasting and Dispatching

The development of the analytics has not been finished, so no progress to be reported on the pilot specific KPIs tracker.

Table 48: LSP5 Pilot Specific KPIs progress

KPI	Baseline	Target	Progress
BO4: DER Flexibility	85% per year	5% decrease	Not tackled yet
5101: Number of days of historical samples required for training to fulfil the minimum cost saving target or related threshold	50 days training data	30	Not tackled yet
5102: Number of transfer learning agents deployed in staging/production environment	0 number of assets	50	Not tackled yet

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KPI	Baseline	Target	Progress
5201: Number of grid secure disaggregation agents deployed in staging/production environment	0 number of assets	50	Not tackled yet

4.2.6 LSP6 (EKL, BORZEN & CS): Coordinating grid-owned and behind-the-meter assets management prediction for improved grid operation and near real time power market operation settlement

The development of the analytics has not been finished, so no progress to be reported on the pilot specific KPIs tracker.

Table 49: LSP6 Pilot Specific KPIs progress

KPI	Baseline	Target	Progress
6101: Reliability and efficiency of the power network	TBD (SAIDI, CAIFI)	TBD	Not tackled yet
6102: Cost reduction for management and maintenance of the power network assets	6% (savings/costs per year)	>6%	Not tackled yet
6103: Number of flexible prosumers	0.125 (Real/potential)	>0,125	Not tackled yet
6104: Contracted/activated flexible power provided to cover the DSO needs	0.1 (Flex. MW/Transformer nominal power)	>0,1	Not tackled yet
6201: Impact on final asset (consumer / producer) for different possible models	0 €	>0	Not tackled yet
6202: Scalability of models (including equipment needs)	0 (# of end-users)	>0	Not tackled yet

For KP1 6101, once the full infrastructure of the pilot is established it will be able to be analysed. As the pilot will be focused on part of the grid, the SAIFI and SAID parameters will be considered for the observed part of the grid.

4.2.7 LSP7 (ENELX): Predictive Analytics Forecasting of storage optimised operation for improved market reserve participation

The development of the analytics has not been finished, so no substantial progress to be reported on the pilot specific KPIs tracker.

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Table 50: LSP7 Pilot Specific KPIs progress

KPI	Baseline	Target	Progress
EI01: Cost of asset maintenance and management	TBD	TBD	Not tackled yet
7101: Number (percentage) of DAS measures collected by physical equipment	95% per day	>95% per day	First tranche of connectors developed
7102: BESS under performance areas identification	65% (#identified up areas/total up areas)	>65%	Not tackled yet
7103: Reaction time before system under performance event	3 h	>=3h	Not tackled yet

For KPI EI01 the cost of asset maintenance and management has not been estimated yet. Once the pilot infrastructure will be set up, and the specific assets to be used within the pilot will be identified, the cost analysis and subsequently the desired effect of the analytics services will be estimated.

4.2.8 LSP8 (UNIWA/TILOS): Predictive Demand and Generation Forecasting for Optimised Local Energy Community Management

Progress made during the Pre-Pilot Cycle is presented below.

Table 51: LSP8 Pilot Specific KPIs progress

KPI	Baseline	Target	Progress
EI04: Network management improvement	n/a	20%	Not tackled yet
EI05: Use of renewable energy	15% (RES/Total)	30% increase	30% increase
8101: Specific cost savings	0.2€ per kWh	Up to 5% decrease	3% decrease
8102: Load Demand Volatility	148.4 kWh	Up to 5% decrease in standard deviation	2.5% decrease
8103: Availability of Renewable Energy Sources	900 h	Up to 5% increase in operating hours	Not tackled yet
8104: Annual RES Shares	44%	Up to 10% increase in annual RES shares	15% increase
8105: Specific CO_2 Savings	700 $kgCO_2/MWh$	Up to 5% decrease in specific emissions	3% decrease

4.2.9 LSP9 (ENERC): Collaborative Aggregated Energy Generation Prediction

There wasn't any progress related to the pilot specific KPI improvement in the pre-pilot cycle. The main

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goal was to design and deploy the data retrieval system and to fine tune the requirements for the UC1 analytical services.

Table 52: LSP9 Pilot Specific KPIs progress

KPI	Baseline	Target	Progress
EI01: Cost of asset maintenance and management	25€ per kW/year	-	Not tackled yet
EI06: Energy efficiency increase	0	3% decrease	Not tackled yet
9101: Number of equipment faults	9-10 per site/year	10% decrease	Not tackled yet
9102: Number of maintenance interventions	36-39 per site/year	5% decrease	Not tackled yet
9103: Number of replacements and repair interventions	2 per site/year	-	Not tackled yet
9104: Number of cleaning operations and the related resources activation optimisation	2-3 per site/year	-	Not tackled yet
9105: Number of enabled edge components	0	>1	Not tackled yet
9201: Digital twins setting up and performance optimisation	0	>1	Not tackled yet
9202: Data streams (energy production, energy consumption, building energy efficiency, energy related carbon footprint)	2	>4	Not tackled yet

For KPIs EI01, 9103 and 9104, the target is still under investigation, and the goal is to first develop the analytics services and subsequently the desired effects of the analytics services will be estimated.

4.2.10 LSP10 (CARTIF & VEOLIA): Predictive and Prescriptive Analytics for improved Energy Performance Certificates Reliability

The development of the analytics has not been finished, so no progress to be reported on the pilot specific KPIs tracker.

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Table 53: LSP10 Pilot Specific KPIs progress

KPI	Baseline	Target	Progress
B06: EPC gap reduction	n/a	20%	Not tackled yet
10101: EPCs calculated	0 (#)	1000 EPCs	Not tackled yet
10102: Building typologies included in the next generation EPCs	0 (#)	6	Not tackled yet
10103: Trust on Energy Performance Certificates	n/a	3-4 Likert Scale	Not tackled yet
10104: Maximum refresh rate reached	-	1/hour	Not tackled yet

4.2.11 LSP11 (AJSCV & VEOLIA): Weather-enhanced building thermal comfort prediction to enable energy efficiency reliable forecasting

The development of the analytics has not been finished, so no progress to be reported on the pilot specific KPIs tracker.

Table 54: LSP11 Pilot Specific KPIs progress

KPI	Baseline	Target	Progress
B05: Building comfort conditions	30%	40%	Not tackled yet
1101: Energy Savings from Thermal Comfort Actions/ Measures	114 kWh per working day (spring period)	Up to 10% reduction	Not tackled yet
1102: Energy Efficiency Measures Proposed	0 (#)	>0	Not tackled yet
1103: Number of Buildings Involved	1 (#)	3	3

4.2.12 LSP12 (LEIF): Predictive Analytics for Energy Efficiency Investments de-risking

The development of the analytics services has not been finished, so no substantial progress to be reported on the pilot specific KPIs tracker.

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Table 55: LSP12 Pilot Specific KPIs progress

KPI	Baseline	Target	Progress
B07: Energy efficiency investment de-risking	490€/MWh	20% reduction	Not tackled yet
12101: Investment in energy efficiency	0.96 kWh/€/year	1.5 kWh/€/year	Not tackled yet
12102: Grant financing in energy efficiency	1.95 kWh/€/year	2.5 kWh/€/year	Not tackled yet
12103: Investment CO_2 efficiency	0.26 $kgCO_2$/€/year	0.5 $kgCO_2$/€/year	Not tackled yet
12104: Grant financing CO_2 efficiency	0.52 $kgCO_2$/€/year	0.75 $kgCO_2$/€/year	Not tackled yet
12105: Renewable energy efficiency	3.17 kWh/€/year	5 kWh/€/year	Not tackled yet
12106: House heating / cooling efficiency	69 kWh/m^2	50 kWh/m^2	65 kWh/m^2

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5 Pre-Pilot Cycle Assessment

Activities that took place under the Pilot Deployment & Engagement Plan are reported, to showcase that the effective communication and engagement under the Pilot Deployment & Engagement Plan is ensured. The initial activities regarding pilot synergies & collaborations are also presented. A general evaluation summarising the information gathered and the activities held from both pilots and technical partners, in respect with advancements and progress of deployment procedures is reported.

Data privacy issues deriving from the measures taken, to guarantee that security in data sharing procedures in accordance with the Data Management Plan and deliverables of WP11 - "Ethics Requirements" (namely deliverables D11.1 - "H - POPD - Requirement No. 1" and D11.3 - "NEC - Requirement No. 3)" and are also presented.

Finally, a risk assessment is reported by presenting an update of the risk factors identified in D6.1 and highlighting potential issues (along with potential mitigation actions) that should be considered during the BD4NRG's 2nd Development Cycle based on insights gathered during the Pre-Pilot Cycle. This process is aiming to be used as feedback for the upcoming 2nd validation cycle, Full-Scale Pilot Implementation, which will lead to the next WP6 deliverable (D6.3 - "BD4NRG Pilots Synergies, Evaluation and Feedback - Second Release").

5.1 Pilot Deployment & Engagement Plan

The core concepts of the Pilot Deployment & Engagement Plan were the creation of the Pilot Deployment Information Template and the communication activities between pilot partners in order to keep engagement with the BD4NRG technical activities.

To this end, the Pilot Deployment Information Template was used as an information collecting document as intended during the Pre-Pilot Cycle. Due to the technical tasks' activities and the delay of the 1st technology release, this document was reduced to a simplified version in order to easily and effectively collect the necessary information. It is also used as a reference document by the technical WPs, providing the overview of the status of each LSP and use it as feedback for the implementation of the technical components towards the pilot demonstrators.

Regarding the Pilot Engagement Plan, there were two major meetings facilitated under task T6.2 - "Pilot Monitoring and Coordination", where pilots and technical partners were able to exchange information and discuss the progress in each LSP. The first meeting was held in December2021 (in the middle of the Pre-Pilot Cycle). By taking on from the progress of the 2nd Plenary Meeting (October 2021) as well, the Pilot-Technical Mapping document was presented (APPENDIX IV). This document served as a reference point between the LSP needs and the technical capabilities of BD4NRG and aimed to kickstart the personalisation of the technical tools under WP3, WP4 and WP5. In this meeting, the Pilot Deployment Information Template was also introduced and discussed by all partners in order to discuss its format and understand how the information will be requested. The second meeting was held in February 2022 (after the end of the Pre-Pilot Cycle) and its scope was to facilitate the process of providing information with the Pilot Deployment Information Template and identify potential issues. The simplified version of the Pilot Deployment Information Template was introduced, and the feedback required to proceed with the assessment was brought into the conversation. Furthermore, bilateral communications between pilot and technical partners via emails and meetings were held when deemed necessary or requested.

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5.2 General Evaluation

In this section a general evaluation of the Pre-Pilot Cycle is presented, in order to reflect the activities that took place and provide feedback for the next Development Cycle.

As reported in deliverable D6.1 - "Pilot Operation, Engagement and M&V Plan" and the Pilot Deployment Plan (section 4.1), the monitoring activities of pilot demonstrators will be split in three stages, the Basic Pilot Stage (BPS), the Intermediate Pilot Stage (IPS) and the Advanced Pilot Stage (APS), which will follow the three iterative Development Cycles of BD4NRG. The early data-driven experimentation and the Pre-Pilot Cycle stage is aligned with the BPS for the pilots that would be selected for the experimentation and the first BD4NRG tools and services to be tested. This process is monitored through the Pilot Deployment Information Template in order to evaluate the stage in which the pilot demonstrators are in.

To this end LSP1, LSP8 and LSP9 have reached the BPS, as the technical activities have been tested to them. Several components of WP3 - "Data Governance and Management" (section 3.1) are in the implementation and testing phase in order to support the requirements and needs of these pilot demonstrators. It should be noted that no integration activities have taken place as of yet, but the approach taken is a more generic one before starting to personalise the components to fit into the pilot demonstrators.

This is more evident for WP4 - "Data Modelling & Open Modular AI-based edge-level Analytics Toolbox", in which the analytics services are implemented on premises at this stage and before the migration into BD4NRG's infrastructure take place. In this context, several pilot partners have proceeded with the development of their services and can demonstrate progress, either in design or the actual model development (section 3.2). As the technical activities will be deployed towards the remaining pilot demonstrators, they will also reach the BPS. It is expected that all pilot demonstrators will have reached the IPS by the end of the 2nd evaluation period in M26 (Full Pilot Cycle/Functional Implementation).

Regarding the KPIs evaluation, during the Pre-Pilot Cycle, where the scope is to initially test the technologies, tools and services of BD4NRG based on the 1st technology release, the values only represent the progress and aim to act mainly as feedback of activities. Reaching the targets of the KPIs, is intended to take place towards the end of the project.

Moreover, the successful and efficient evaluation of the Pre-Pilot Cycle was performed using the Pilot Deployment Information Template, the meetings held between pilot and technical partners and the Pilot-Technical mapping document (APPENDIX IV). These activities enable the use of several insights so as to proceed with a successful 2nd technology release and the next evaluation period, Pilot Cycle 2/Functional Implementation (M22-M26).

5.3 Data Privacy

Within Pre-Pilot Cycle, data sharing activities were foreseen to allow the early data-driven experimentation.

Security and privacy requirements are enabled by the technological components of BD4NRG and more specifically by the data governance and management components. During the Pre-Pilot Cycle, no integration between pilot demonstrators and BD4NRG took place. However, data sharing activities held, in order to preliminary test the components and the analytics services before integration and deployment.

Several proactive measures have been held according to deliverable D6.1 (and follow the guidelines of BD4NRG's Data Management Plan, deliverable D1.2) and all partners ensured that they were sufficiently followed accordingly. Specifically, data samples from pilot partners are stored in dedicated folders within the MS Teams repository (per LSP). Monitored by the Pilot Coordinator (NTUA), any party who wishes to be granted access, an agreement among the LSP leader, the Pilot Coordinator and the Project Coordinator (ENG) must be reached. This process is designed only for the early stages of the project before the actual data sharing is made available, through the connection with the pilot demonstrators and the deployment of the technical components of BD4NRG.

Below, a summary of the status regarding data sharing activities for each pilot demonstrator is presented:

LSP1: Internal data handling mainly within the pilot. For WP3 activities, the COMTRADE files are provided for testing purposes and then are pre-processed into csv format types.

LSP2: Internal use of data during the Pre-Pilot Cycle.

LSP3: Internal use of data during the Pre-Pilot Cycle mainly. Data samples are also made available via APIs. Access is granted by pilot leader (ASM) with the corresponding data management policy requiring that any partner interested in the data must agree not to disclose the data without agreement with ASM, and not to provide others with credentials to access ASM's servers.

LSP4: Internal use of data during the Pre-Pilot Cycle.

LSP5: Internal use of data during the Pre-Pilot Cycle mainly. Data samples are shared for initial testing of model development.

LSP6: Internal use of data during the Pre-Pilot Cycle.

LSP7: Internal use of data during the Pre-Pilot Cycle.

LSP8: Data sharing activities with data samples were held during the Pre-Pilot Cycle. The process is enabled by WP3 activities under task T3.7 through API connection and VPN access (see section 3.1.2.2 for details). As of now this connection is used by NTUA for testing purposes of WP3 and WP4 activities.

LSP9: Data sharing activities have started under WP4 activities mainly. Although, WP3 - "Data Governance and Management" components have been tested for LSP9, no actual data have been used. Instead, the description of the data to be provided by LSP9 has been used to generate look-alike data and test the functionalities of the components (see section 3.1.3.2). For WP4 activities, data sharing activities are held using LSP9 dedicated MS Teams folder (data sampling uploading).

LSP10: Internal use of data during the Pre-Pilot Cycle.

LSP11: Internal use of data during the Pre-Pilot Cycle.

LSP12: Data sharing activities under WP4 have taken place. The data are made available using LSP12 dedicated MS Teams folder (data sampling uploading).

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5.4 Risk Assessment

Deliverable D6.1 (section 2.4) presented risk factors identified that could affect the progress towards pilot deployment. The first factor identified as the workflow structure based on the iterative cycles and how information can be shared, in order to proceed with the technical activities. The second factor identified as the COVID-19 situation, that affect the feedback between BD4NRG and its target groups. An overview of these factors and mitigation actions taken are presented below. Finally, further factors identified based on insights gathered during the Pre-Pilot Cycle, are also presented, along with the appropriate mitigation measures required.

The Pre-Pilot Cycle is an evaluation period, aiming to be used as feedback for advancing the technical activities during the second Development Cycle. To this end, risk factors that could possibly affect the progress are presented in this section:

- Workflow Structure: As anticipated, at the first stages of the project, different levels of maturity were faced towards pilot demonstrators and deployment. This fact along with delays in the technical activities, posed a risk, but eventually the Pre-Pilot Cycle validation proceeded as planned, with the initial data-driven experimentation. Activities under WP6 (i.e., Pilot Deployment Information Template, Pilot-Technical Mapping, Engagement Plan) aim to advance the progress of the LSPs, with the view by the end of the 2nd validation cycle (M26), all pilot demonstrators will be ready to reach the APS.
- COVID-19: The situation with the pandemic did not pose eventually major drawbacks in the activities. In D6.1, the identified risk concerned the User Satisfaction methodology and the mitigation action proposed, was to keep the first iteration internally. However, this was not eventually a problem, since delays in the technical activities pushed the methodology for later stages (see section 1.5.3). However, as things seems to be getting better and mobility not expected to by as limited, activities that require external participation are foreseen to be taking place physically. This concerns mainly the envisioned three workshops (under T6.3 - "Pilots Synergies and Collaborations) and the deployment of the User Satisfaction methodology for external validation. These activities are planned to take place towards the end of the project as per D6.1, in order to minimise the risk of limited mobility posed by COVID-19, with the hope that there will not be any further outbreaks.
- Personalisation: As there are 12 different pilot demonstrators, the process of development BD4NRG's tools is very complex, with different requirements per LSP needed to be addressed. Activities under WP6 (e.g., Pilot - Technical Template, coordination of meetings with pilot and technical partners) aim to clarify all the unique aspects, specifications, and requirements, and bridge the gap, by bringing together the relevant BD4NRG partners for seamless exchange of information.

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- KPIs achievement: The General KPIs are tracked continuously to offer an overview as well as the Specific Pilot KPIs to achieve the expected impact. However, since BD4NRG is a project which will produce innovative services and R&D activities, there might be a difficulty to reach Pilot Specific KPIs. By using innovative tools and analytics services that BD4NRG envisions towards the pilot demonstrators UCs, the risk of being overambitious and unachievable is identified. This possibility, although at this stage is not considered high, it is still a risk, based on the vision that pilot partners have set for their UCs. The Pilot Deployment Information Template used for monitoring, is the proposed method to track the progress of the pilots' progress and thus the KPIs status, in order to identify possible issues.
- Partner Alignment: Although engagement of the first months of the project and during the Pre-Pilot Cycle from pilot partners was high, the large number of organisations increases the risk of inefficient engagement. This is effectively under control with the Pilot Engagement Plan and by proposing regular meetings and communications between pilot and technical partners.

A SWOT analysis to summarise the feedback and insights gathered during the Pre-Pilot Cycle is presented below:

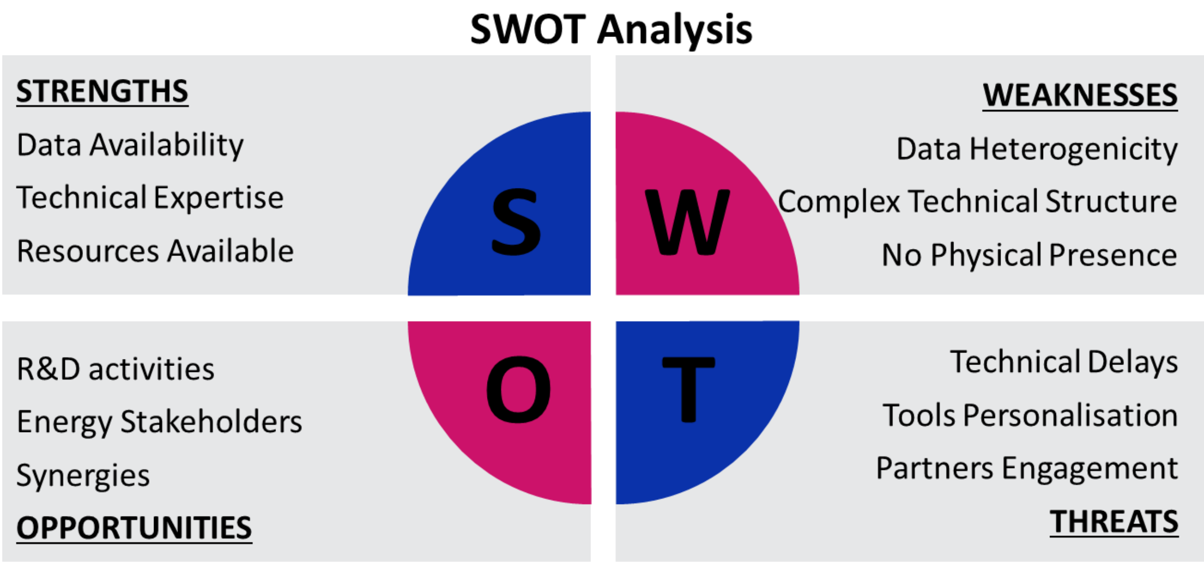

Figure 44: SWOT Analysis after Pre-Pilot Cycle

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6 Pilots Synergies

Under WP6 and specifically task T6.3 - "Pilots' synergies analysis and collaborations" the procedures to personalise BD4NRG tools and services in each pilot demonstrator will take place. These activities focus on establishing a dialogue and continuous exchange, in order to exploit synergies between pilot partners and other stakeholders. In the current phase of development, however, only preliminary activities have taken place, as the pilot and technical activities are not so mature for meaningful exchange of information. An initial analysis of potential synergies has taken place during the Pre-Pilot Cycle. Analysis of the UCs, the envisioned beneficiaries and pilot actors for each pilot demonstrators have been conducted in order to find similarities and common points across all pilot demonstrators. The scope of this analysis is to identify connections and to allow an efficient connection among the relevant stakeholders that would be benefited by BD4NRG's pilot demonstrators' activities, tools and services. These activities will be further elaborated during the next Development Cycle of BD4NRG and will be reported in more detail in the next deliverable of WP6, deliverable D6.3 - "BD4NRG Pilots Synergies, Evaluation and Feedback - Second Release"

In this section, the results of the preliminary analysis are presented. It is based on the connections found on D6.1 - "Pilot Operation, Engagement and M&V Plan", D7.1 - "Baseline Analysis Report and 'BD-4- NET' Large Scale Pilots Preparation", D8.1 - "Baseline Analysis Report and 'BD-4- DER' Large Scale Pilots Preparation", D9.1 - "Baseline Analysis Report and 'BD-4- ENEF' Large Scale Pilots Preparation" and the Pilot Deployment Information Template used for information collection of pilot activities during the Pre-Pilot Cycle.

The notation followed is SXY, where X and Y are the number of pilot demonstrators (e.g., S12 represents a potential synergy between LSP1 and LSP2).

S12: In both LSPs the main beneficiary is the TSO, and each actor has a corresponding department for asset management. The already developed MST (LSP2) can assist in the maintenance planning of the examined grid assets in LSP1 (OHLs & CBs). Moreover, for UC2 of LSP1, LiDAR scan data of overhead line corridors and towers has been used to develop a ML classification system that will be used to group and identify tower models. It is possible that data such as manufacture year, maintenance history of said towers provided by LSP2 resources can further boost the accuracy of the ML model (modified version of the k-Nearest Neighbors) developed in LSP1.

S34: A synergy could be developed between LSP3 UC2 actors (technical providers, manufacturers) and LSP4 actors (DSO department) as in both cases the main beneficiary is the DSO. In both LSP3 UC2 and LSP4 the used infrastructure consists of several distribution transformers with different nominal power and the electrical data is stored in the according SCADA System. The acoustic and environmental sensors installed in the secondary substations of LSP3 UC2 can also be used in the substations of LSP4 if there is correlation between the transformer degradation and the measured parameters. Moreover, the ML models to be developed in LSP3 can be enhanced and/or trained, validated, replicated with the use of the LSP4 data and vice versa.

S35: Even though the mentioned beneficiaries are different for each LSP, common ground can be found between the actors. One of the actors in LSP3 UC1 are EV managers and at the same time there are residential consumers in LSP5 that own EV chargers. Also just like in the S34, the actors in LSP3 UC2 and LSP5 UC are somewhat similar and concern the DSO. The services to be developed in LSP5 aim at improving the efficiency of learning control policies for residential assets to provide flexibility and

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energy services to the system in a grid-friendly way. This flexibility of the residential assets and therefore the flexibility of the energy demand of the households could be integrated into the predictive asset management of the DSO in LSP3. Moreover, EV charging is examined as a grid asset (public charger) in LSP3 UC1 while examined as a residential asset (home charger) in LSP4. Insights from these cases can be used together to form a better evaluation of the demand response.

S36: In both LSPs one of the beneficiaries is the DSO. As for the actors, RES producers can provide crucial information to improve the coordination between EV and RES which is the UC1 of LS3. One more connection is that between the EV managers (LSP3 UC1) and the market operators (LSP6). Real time power market operation settlement that will be provided from LSP6 can help define a flexible economic incentive for EV users who participate in the grid balancing mechanism (LSP3 UC1).

S37: The ESCOs in LSP7 need to improve the reliability of the examined BESS which can be further improved by incorporating data provided by the EV managers in LSP3. Even if the charging stations that will be used in LSP3 UC1 may not offer V2G charging capabilities, it is possible that EV charging could be used as a dynamic BESS that can help the traditional BESS with reducing critical events and thus increasing their reliability.

S38: For both LSP3 and LSP8 one of the main beneficiaries is the DSO. Technical providers of LSP3 utilise data from RES to make their predictions, while at the same time there is available data from private RES actors/prosumers that participate in LSP8. In both LSPs, there will be a forecast of distributed generation so exchanging information regarding the models that will be used could be useful. Furthermore, in LSP8 the integration of EV chargers may become available within BD4NRG. Insights from the optimal charging sessions scheduling of EVs that will be done in LSP3 could further reduce the load demand volatility.

S56: The main focus in LSP5 is the definition of adequately control policies for different residential assets in order to provide flexibility and energy services to the system in a grid-friendly way. These policies could also be used in the LV grid of LSP6 that also consists of residential customers with their own assets.

S58: In both LSP5 and LSP8 one of the main actors are the residential or end users. The energy demand from end users in LSP8 could become more flexible by incorporating the control policies defined in LSP5.

S79: One of the main beneficiaries in both LSP7 and LSP9 are the aggregators and at the same time actors in both LSPs involve ESCOs. Infrastructures used in both LSP7 and LSP9 consists of Energy Storage Systems, PV plants and End user data. The goal of the first one is to improve BESS reliability and, consequently, improve plant performance while reducing operating maintenance costs. Simultaneously, one of the goals of LSP9 is the optimal scheduling of maintenance operations for PV plants.

S89: In LSP9 the main beneficiaries are the RES operators and the aggregators, while in LSP8 private RES actors/prosumers are engaged. In both LSP8 and LSP9 UC1, there is a need to forecast power generation from RES (PV stations, panels) and to optimise their management. Transfer learning can be used between them or information about the data features that are used can be shared to improve the respective ML models.

S812: KPIs in LSP8 such as specific cost savings and specific $C0_2$ savings in combination with the project general information could provide sufficient information to be used in LSP12.

S911: Energy data from buildings that will be gathered through smart sensors in LSP9 can also be used in LSP11 to validate the predictive models that will be implemented and vice versa.

S1011: Actors such as data providers and public entities participating in LSP10 can also be utilised in LSP11 to support the main beneficiary which are the building owners. The data and infrastructure used in LSP10 UC2, which contain building information and public buildings energy consumption information can also be used in LSP11 to validate the predictive models that will be implemented and vice versa.

S1112: Building owners which are the main beneficiaries in LSP11 can also be used as actors in LSP12 in order to provide more information for the investors, which are the beneficiaries. The data and data analytics services of LSP11 can also be used in LSP12 if there is also information about the investments that took place.

The following table presents the mapping of the potential synergies between LSPs along with the intended target groups:

Table 56: Potential Synergies between LSPs

LSP	LSP1	LSP2	LSP3	LSP4	LSP5	LSP6	LSP7	LSP8	LSP9	LSP10	LSP11	LSP12	Target Groups
LSP1		X											TSO
LSP2	X												TSO
LSP3				X	X	X	X	X					DSO
LSP4			X										DSO
LSP5			X			X		X					Aggregators
LSP6			X		X								DSO, Grid Users, Market Operators
LSP7			X						X				Aggregators
LSP8			X		X				X			X	DSO
LSP9							X	X			X		RES/Grid operators, Aggregators, Energy Suppliers
LSP10											X		ESCOs
LSP11									X	X		X	Building owners
LSP12								X			X		Investors

As mentioned above, the activities held present an initial analysis. As the technical activities progress and they UCs are realised, the process of identifying the synergies between the LSPs will be clearer. Furthermore, synergies and collaboration should be sought with external stakeholders to maximise the value of BD4NRG's services. This will be enhanced by the three workshops envisioned under T6.3 s per the GA:

- Increasing efficiency and reliability of electricity network (TSOs, DSOs).
- Optimising management of assets connected to the grid (Generators, Suppliers, Aggregators).

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- Integrating energy efficiency financing risk assessment with real life energy and comfort monitoring and trade off (Consumers, such as municipalities and building operators, third parties, such as ESCOs, IFIs, banks, off-grid data/solution providers, etc.).

These workshops are foreseen to take place towards the end of the projects. By analysing the potential synergies between pilots, it will allow to target efficiently external stakeholders and demonstrate BD4NRG's solutions. The next steps would be to further identify the connection points between LSPs, as well as the technical solutions that will be deployed. Connection with WP10 - "Dissemination, Exploitation and Standardisation" activities also deem necessary in latter stage, in order to maximise the reach, once the solutions are materialised from a technical point of view.

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7 Conclusions and Next Steps

This deliverable presents the progress of pilot demonstrators during the Pre-Pilot Cycle. The activities held upon the 1st technology release of BD4NRG and the deployment status to each pilot demonstrator is reported. More specifically, it captures the internal pilot activities, the progress of WP3 - "Data Governance and Management" and WP4 - "Data Modelling & Open Modular AI-based edge-level Analytics Toolbox" activities in respect to pilots and the status of the KPIs, as part of the M&V plan. The D6.2, apart from monitoring the progress, aims to provide feedback to be used in the second Development Cycle. Detailed information for each pilot demonstrator is reported based on the Pilot Operation & Deployment Plan methodology, which aim to allow the activities under technical WPs to be further developed. The final M&V plan is also reported, by taking into consideration the necessary changes made between M8 and M14. This finalises the framework based on which the pilots' demonstrator activities will be tracked, monitored, reported and finally evaluated. Finally, the initial progress of activities regarding the potential synergies between pilot partners and external stakeholders are also reported.

Future activities are as follows:

- Continuous monitoring of pilot activities and technical integration towards the 2nd technology release.
- Finalisation of User Satisfaction questionnaires for the deployment of the respected methodology.
- Further elaboration of the potential synergies based on the initial analysis reported.
- Preparation for the second evaluation period, Pilot Cycle 2/Functional Implementation, and the subsequent 3rd deliverable of WP6, namely D6.3 - "BD4NRG Pilots Synergies, Evaluation and Feedback - Second Release", to be submitted at M28 (April 2023).

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APPENDIX I: Pilot Deployment Information Template

Topic	Sub-topic	Description
Overview	Goals and objectives	Description of the scope of the service, the stakeholders and beneficiaries for the current stage
	Use Case summary	Description of the identified UC of the service
	Action Plan	List of the mandatory activities for the iteration cycle
Requirements	Assumptions	Description of the expected results when the iteration cycle is over
	Dependencies	Description of interactions with other developed services or components (or pre-requisites)
	Risks	Description of the most likely situations or factors that may limit the functions or prevent the deployment of the service
Readiness	Deployment diagram	Summary of the necessary steps for deployment
	Deployment preparation	Description of the requirements for the components and the underlying infrastructure
	Deployment assessment	Assessment of the completeness of the preparation and the mitigation of the possible identified risks
Data Handling	Data Population	Description of the process for populating the databases required for the operation of the services
	Algorithm Training	Description of procedures for ML/AI training with the relevant datasets, include validation mechanisms
Activities	Previous cycle	Summary of the achievements and main actions of previous stages and the identified next steps
	Current cycle	Summary of the main actions of the current stage, and how they fulfil the recommendations of the previous iteration cycle

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Topic	Sub-topic	Description
	Future cycle	Summary of next steps and what needs to be achieved by the next cycle for improvements, optimisations or refinement (if identified)
Documentation	Training documents	Creation of documents that explain the main functionalities of the service and how to use it
	Developer documents	Creation of documents that extensively covers the main parts of the service, and facilitates the integration of new services or derivative works
	Operation and Maintenance	Creation of documents that covers the procedures for usage, start and restart of the services

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APPENDIX II: List of KPIs (updated)

LSP1	LSP2	LSP3	LSP4	LSP5	LSP6	LSP7	LSP8	LSP9	LSP10	LSP11	LSP12
1101	2101	BO1	B02	BO4	6101(BO2/BO3)	EIO1	EI04	EIO1	BO6	BO5	BO7
1102	2102	BO2	B03	5101	6102(EI01)	7101	EI05	EIO6	10101	1101	12101
1103	2103	BO3	4101	5102	6103(EI02)	7102	8101	9101	10102	1102	12102
1104	2104	EI01	4102	5201	6104	7103	8102	9102	10103	1103	12103
1201		3101	4103		6201		8102	9103	10104		12104
1202		3102(BO4)			6202		8103	9104			12105
1203		3103(EI02)					8104	9105			12106(EI06)
1204		3104					8105	9201			
1205		3105						9202			
		3201									

In parenthesis, the suggested KPIs by pilots that could indirectly measure the BO and EI KPIs is being shown.

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APPENDIX III: General KPIs (Pre-Pilot Cycle)

Table 57: LSP1 General KPIs (as recorded during Pre-Pilot Cycle)

KPI	Value	Explanation
G01: Seamless and smooth data transition from different types of sensors	0	Not used during the Pre-Pilot Cycle
G02: Seamless and smooth data transition from different types of data resources	0	Not used during the Pre-Pilot Cycle
G03: Resources	0	Not used during the Pre-Pilot Cycle
G04: Type of data sources	2	COMTRADE data and LiDAR point cloud data
G05: Identification and interoperability with well-known open data sources	0	Not used during the Pre-Pilot Cycle
G06: Datasets used	2	COMTRADE data and LiDAR point cloud data
G07: Digital Technologies integrated in the energy system	0	n/a
G08: Big data availability for real life research	402GB	UC1: 2GB UC2: 400GB

Table 58: LSP2 General KPIs (as recorded during Pre-Pilot Cycle)

KPI	Value	Explanation
G01: Seamless and smooth data transition from different types of sensors	2	Network operational meters, asset specific diagnostic sensors
G02: Seamless and smooth data transition from different types of data resources	5	Network operational data, technical data, internal priority lists of assets, maintenance related data, external actors' data
G03: Resources	10	Apparent power, active power, manufacture year, installation data, maintenance History, location tags, workforce limitations, assumed maintenance timeframes. external outage requests

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G04: Type of data sources	7	SCADA, IBM MAXIMO, Microsoft Dynamics AX, Online transformer monitoring, PSA - platform for maintenance Static outage plans
G05: Identification and interoperability with well-known open data sources	0	n/a
G06: Datasets used	300	Datasets from abovementioned resources for different assets.
G07: Digital Technologies integrated in the energy system	0	The tools are still in the laboratory development phase. Integration is expected in after a successful development.
G08: Big data availability for real life research	50 GB	As LSP2 is the process of tools development, only crucial data was used. This amount is expected to rise in the following phases of the project.

Table 59: LSP3 General KPIs (as recorded during Pre-Pilot Cycle)

KPI	Value	Explanation
G01: Seamless and smooth data transition from different types of sensors	5	Power quality analysers, Electrical smart meters, PMUs, environmental conditions sensors, acoustic sensors
G02: Seamless and smooth data transition from different types of data resources	7	Weather, energy sensors, energy production, energy consumption, charging stations, RES and acoustic sensors
G03: Resources	6	Humidity, temperature, solar radiation, electricity generation, electricity consumption, noise emissions
G04: Type of data sources	8	Secondary substation humidity, secondary substation temperature, solar irradiance, smart meters, RES production, PMUs, charging stations consumption, acoustic level in secondary substations
G05: Identification and interoperability with well-known open data sources	0	n/a
G06: Datasets used	50	Datasets regarding electrical measurements, phasor unit measurements, environmental measurements, audio measurements

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G07: Digital Technologies integrated in the energy system	0	
G08: Big data availability for real life research	3.75TB	3.75TB are available but a sample of data was used during the Pre-Pilot Cycle

Table 60: LSP4 General KPIs (as recorded during Pre-Pilot Cycle)

KPI	Value	Explanation
G01: Seamless and smooth data transition from different types of sensors	3	Electrical smart meters (AMR/AMI), quality analyser measurement units, environmental sensors
G02: Seamless and smooth data transition from different types of data resources	0	n/a
G03: Resources	6	Humidity, temperature, electricity consumption, electricity generation
G04: Type of data sources	4	PMUs, environmental sensors, RES production plants and meteorological databases (for humidity, temperature and radiation).
G05: Identification and interoperability with well-known open data sources	0	Interoperability with open access data sources is not foreseen in the moment
G06: Datasets used	500	Approximately 500 smart meters.
G07: Digital Technologies integrated in the energy system	0	n/a
G08: Big data availability for real life research	10 GB	In terms of data quantity (G08) that at least between a few to 10 GB of raw data will be processed is estimated.

Table 61: LSP5 General KPIs (as recorded during Pre-Pilot Cycle)

KPI	Value	Explanation
G01: Seamless and smooth data transition from different types of sensors	8	Residential demand-response assets: frequency meter, voltage meter, power meter, Grid measurements: reactive and active power, voltage, total harmonic distortion (THD), current
G02: Seamless and smooth data transition from different types of data resources	13	Data of residential demand response assets, grid data
G03: Resources	12	Demand response assets (power, frequency, voltage, SoC, asset

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		availability, power setpoint), Grid data resources (reactive power, active power, voltage, THD, current, DSO assets grid location, yearly residential production volume, standard year volume)
G04: Type of data sources	1	Historical residential demand response asset metering data and historical grid data
G05: Identification and interoperability with well-known open data sources	0	n/a
G06: Datasets used	3	Historical residential demand response asset metering data and historical grid data
G07: Digital Technologies integrated in the energy system	0	n/a
G08: Big data availability for real life research	8.75TB	8.75TB are available but a sample of data was used during the Pre-Pilot Cycle

Table 62: LSP6 General KPIs (as recorded during Pre-Pilot Cycle)

KPI	Value	Explanation
G01: Seamless and smooth data transition from different types of sensors	3	Surface temperature sensors, transformer's oil temperature sensors, temperature sensors for ambient temperature
G02: Seamless and smooth data transition from different types of data resources	3	Weather, electricity consumption and devices (installed technology on the power network) properties
G03: Resources	3	AC meters, current and forecast weather data (7)
G04: Type of data sources	8	Historical meter data, real time meter data, current weather, weather forecast data, real time temperature data, electrical current and voltage data
G05: Identification and interoperability with well-known open data sources	0	n/a
G06: Datasets used	10	Several data sets, estimated more than 10, e.g., electrical basic values A,

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		V in real time, energy real time, asset's data, location,
G07: Digital Technologies integrated in the energy system	0	n/a
G08: Big data availability for real life research	14.6GB (40Mb/day streaming considering 1 year data)	Data considered during the Pre-Pilot Cycle

Table 63: LSP7 General KPIs (as recorded during Pre-Pilot Cycle)

KPI	Value	Explanation
G01: Seamless and smooth data transition from different types of sensors	2	AC grid meter, DC PV meter
G02: Seamless and smooth data transition from different types of data resources	2	PV Production, Grid power
G03: Resources	33	AC meter (22 parameters), DC meter (11 parameters)
G04: Type of data sources	1	CSV
G05: Identification and interoperability with well-known open data sources	0	n/a
G06: Datasets used	4	PV Production, Grid power
G07: Digital Technologies integrated in the energy system	0	n/a
G08: Big data availability for real life research	100 Mb	For testing purposes during Pre-Cycle available data is around 4.2GB

Table 64: LSP8 General KPIs (as recorded during Pre-Pilot Cycle)

KPI	Value	Explanation
G01: Seamless and smooth data transition from different types of sensors	11	2 PV Production Sensors – 7 Sensors for Pump Consumption – 1 Sensor for the whole consumption of Tilos Island, 10 household / building smart meters and 40 sub-meters at the household / building load level, 1 weather station, 6 sensors (wind speed, wind direction, solar radiation at horizontal plane, relative humidity, atmospheric pressure, temperature).

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G02: Seamless and smooth data transition from different types of data resources	2	Energy Production – Energy Consumption (Total & subsystems' consumption and PV production) & weather data from UBIMET and local weather station
G03: Resources	21	Energy Production (2 x PVs), Energy Consumption (7 x Water pumping stations, 10 x households / buildings), 1 weather station / 1 weather service
G04: Type of data sources	5	PV data, historical and local weather data, weather forecast data, pumps consumption, households/buildings consumption
G05: Identification and interoperability with well-known open data sources	0	n/a
G06: Datasets used	5	PV Production, Island Total Consumption, Pumps Consumption, end-users' consumption, weather data
G07: Digital Technologies integrated in the energy system	0	n/a
G08: Big data availability for real life research	55GB of historical data used API connection ~100Mb/day (limited for testing purposes)	55GB of historical data used - currently, active data traffic of ~1GB/day

Table 65: LSP9 General KPIs (as recorded during Pre-Pilot Cycle)

KPI	Value	Explanation
G01: Seamless and smooth data transition from different types of sensors	778	3 total (1 CPV Inverters, 1 CPV suntrackers, 1 PV inverter)
G02: Seamless and smooth data transition from different types of data resources	2	1 (1 energy sensoring data type source, 1 Sun tracking data type source)
G03: Resources	26	13 from 5 sources - Inverters (6 parameters), Trackers (2 parameters), Solar Lab (5 parameters)
G04: Type of data sources	2	2 (Solar Edge API, CPV data)

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G05: Identification and interoperability with well-known open data sources	0	n/a
G06: Datasets used	2	2 – Solar Lab Inverter data and historical data from a CPV unit
G07: Digital Technologies integrated in the energy system	0	n/a
G08: Big data availability for real life research	0.5TB	1.1GB from a single CPV unit for 1 year generation

Table 66: LSP10 General KPIs (as recorded during Pre-Pilot Cycle)

KPI	Value	Explanation
G01: Seamless and smooth data transition from different types of sensors	2	Indoor temperature sensor, humidity sensor
G02: Seamless and smooth data transition from different types of data resources	3	Building information, Public EPCs, Public buildings energy consumption information
G03: Resources	48	Several types of resources, 26 from Spanish cadastre, 17 from EPCs of Castilla y Leon and 5 from Public buildings energy consumption information
G04: Type of data sources	3	Spanish Cadastre information, EPC Regional Register of Castilla y Leon, Energy DataHub
G05: Identification and interoperability with well-known open data sources	3	Spanish Cadastre information, EPC Regional Register of Castilla y Leon, Energy DataHub
G06: Datasets used	4505	Weather datasets, building information datasets, EPCs datasets, public buildings energy consumption information
G07: Digital Technologies integrated in the energy system	0	n/a
G08: Big data availability for real life research	39,7GB	Data considered during the Pre-Pilot Cycle

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Table 67: LSP11 General KPIs (as recorded during Pre-Pilot Cycle)

KPI	Value	Explanation
G01: Seamless and smooth data transition from different types of sensors	2	Indoor temperature sensor, humidity sensor
G02: Seamless and smooth data transition from different types of data resources	3	Weather information, Building Indoor conditions, BEMS information
G03: Resources	76	Several type of resources, such as outdoor/indoor temperatures, energy consumption, system temperatures, wind speed, indoor humidity, motion conditions from three separate buildings
G04: Type of data sources	3	Three building's data
G05: Identification and interoperability with well-known open data sources	0	n/a
G06: Datasets used	28	BEMS information, Sensor measurements
G07: Digital Technologies integrated in the energy system	0	n/a
G08: Big data availability for real life research	33.33 MB	Building related data and weather data, 3 years and 925.65 kB/month)

Table 68: LSP12 General KPIs (as recorded during Pre-Pilot Cycle)

KPI	Value	Explanation
G01: Seamless and smooth data transition from different types of sensors	2	Temperature sensors, Humidity sensors
G02: Seamless and smooth data transition from different types of data resources	4	Weather (historical), Energy sensoring, production and consumption
G03: Resources	8	3 variables from weather data, 3 variables from energy sensoring, production and consumption data
G04: Type of data sources	4	KPFI (The climate change financial instrument) database, EKII (The Emission Allowance Auction Instrument) database, Data from Smart meters, Weather data

G05: Identification and interoperability with well-known open data sources	1	Data from Latvian Environment, Geology and Meteorology Centre
G06: Datasets used	5	Weather data (7 places 1 for year) Energy consumption (projects financed by KPFI and EKII, Gulbene town detailed data (7 places 1 for year)
G07: Digital Technologies integrated in the energy system	0	n/a
G08: Big data availability for real life research	13,2 GB	Data considered during the Pre-Pilot Cycle

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APPENDIX IV: Pilot -Technical Mapping

Table 69: Pilot - Technical Mapping table (Pre-Pilot Cycle findings)

WP	LSP1 REN RDN	LSP2 ELES	LSP3 ASM	LSP4 OEDAS	LSP5 CENTRICA	LSP6 EKL BORZEN CS	LSP7 ENELX	LSP8 UNIWA TILOS	LSP9 ENERC	LSP10 CARTIF VEOLIA	LSP11 AJSCV VEOLIA	LSP12 LEIF
WP3	Internal handling of data Data may be used by other partners for testing Connection with T3.6 -OLAP (UNINOVA)	Internal handling of data	Need to share data in order external service providers to run the analytics, DLT/blockchain- T3.1 (ENG)	Data sharing can be available via dedicated API from pilot	Internal Data Handling	Internal data handling Weather data can be used	Internal data handling	Connection of pilot API for data transmission provided by UNIWA,	Connection with pilot for data sharing, connection with T3.6 – HTAP component (UNINOVA) Weather data from UBIMET	Data sharing for regularly updated data	Internal data handling from 3 different BMS buildings Data sharing for regularly updated data.	Connection with LSP data, ensuring data protection and governance for the shared datasets (both static data and smart meters data)
WP4	T4.5 - RDN will run the analytics	UNILJ will run the analytics. Analytic tool for AUI and AHI developed	Energy forecasting, EV scheduling (T4.3-NTUA). Asset predictive maintenance		T4.3 - Federated learning (CENTRICA, TNO) T4.4 - Transfer Learning (CENTRICA-TNO)	T4.5 - Baseline models of flexibility assets (CS)		T4.3 - Operational activity optimisation & coordination (NTUA)	T4.3-T4.5 - PV production, operational activity optimisation (NTUA)		T4.3-T4.5 - Thermal comfort analytics (NTUA)	T4.3 - Energy Demand Forecasting & investment classification (NTUA)
WP5	Planning to release data to the marketplace	Weather data Applications of developed methodologies (models, algorithms)	Weather data (UBIMET), Geo-images (TS)		Model sharing (transfer learning) for several assets	Share or/and combine models of the flexible assets		Weather data (UBIMET) Model sharing of PV models, flexibility assets	Model sharing, data sharing	Weather data (UBIMET)	Model sharing, data sharing	Weather data (UBIMET)

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