Platone

PLATFORM FOR OPERATION OF DISTRIBUTION NETWORKS

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PLATform for Operation of distribution NEtworks

D3.5 v1.0

Delivering of Technology (v3)

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Abstract

The Italian Demo aims to enable network users to participate in the optimized grid management through the flexibility mechanism. Thanks to the coordination of areti and the cooperation of all the partners involved in the WP3, the Italian Demo is developing an innovative system, enabling distributed resources connected in medium and low voltage grids to provide grid services through a market model approach, guaranteeing the inclusion of all the electrical sector stakeholders.

This document reports about the third version of the technologies implemented within the Italian Demo activities. The document illustrates the updates made, the descriptions of new functionalities implemented on the platforms and the technical updates on the trial areas.

Keyword list

Scalability; Day Ahead; Real Time; Chain2Full; Flexibility; Light Node

Executive Summary

"Innovation for the customers, innovation for the grid" is the vision of project Platone - Platform for Operation of distribution Networks. Within the H2020 programme "A single, smart European electricity grid", Platone addresses the topic "Flexibility and retail market options for the distribution grid". Modern power grids are moving away from centralised, infrastructure-heavy transmission system operators (TSOs) towards distribution system operators (DSOs) that are flexible and more capable of managing diverse renewable energy sources. DSOs require new ways of managing the increased number of producers, end users and more volatile power distribution systems of the future.

Platone is using blockchain technology to build the Platone Open Framework to meet the needs of modern DSO power systems, including data management. The Platone Open Framework aims to create an open, flexible and secure system that enables distribution grid flexibility/congestion management mechanisms, through innovative energy market models involving all the possible actors at many levels (DSOs, TSOs, customers, aggregators). It is an open-source framework based on blockchain technology that enables a secure and shared data management system, allows standard and flexible integration of external solutions (e.g. legacy solutions), and is open to the integration of external services through standardized open application program interfaces (APIs). It is built with existing regulations in mind and will allow small power producers to be easily certified so that they can sell excess energy back to the grid. The Platone Open Framework has also incorporated an open-market system to link with traditional TSOs. The Platone Open Framework will be tested in three European demos and within the Canadian Distributed Energy Management Initiative (DEMI).

During the last period of the project, Italian Demo partners worked on tuning the Italian Demo System Architecture. The project architecture has been consolidated in the previous period, therefore the developments described in this report concern the optimisation of the implemented functionalities, the platform scalability tests and the updates on KPIs calculation.

The main activities, bug fixes and functionalities tested in this period are:

Market Platform	• Datasets export in csv.
Aggregator Platform	• Expansion of the Real-time flows on the Day-ahead; • Introduction of a higher number of Balance Service Provider (BSP) on the Platform; • Bugfix on the sending of all Point of Delivery (PoDs) labelled as "ready for the market" towards the Market Platform
Flessibili App	• Bugfix on the wallet layout interface
Shared Customer Database	• Updates on Baseline calculation;
Blockchain Access Layer & Light Node	• Light Node and Blockchain Access Layer updates and bugfix; • Extension of Chain2Full to all users involved in the Demo;

Moreover, the document provides an explanation and evaluation of the Platform scalability analysis conducted within the overall architecture involving all the technical platforms, updates on the flexibility resources involved in the demo testing and illustrates the Italian Demo KPIs status.

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1 Introduction

The project “PLATform for Operation of distribution Networks – Platone” aims to develop an architecture for testing and implementing a data acquisition system based on a two-layer Blockchain approach: an “Access Layer” to connect customers to the Distribution System Operator (DSO) and a “Service Layer” to link customers and DSO to the Flexibility Market environment (Market Place, Aggregators, …). The two layers are linked by a Shared Customer Database, containing all the data certified by Blockchain and made available to all the relevant stakeholders of the two layers. This Platone Open Framework architecture allows a greater stakeholder involvement and enables an efficient and smart network management. The tools used for this purpose will be based on platforms able to receive data from different sources, such as weather forecasting systems or distributed smart devices spread all over the urban area. These platforms, by talking to each other and exchanging data, will allow collecting and elaborating information useful for DSOs, transmission system operators (TSOs), Market, customers and aggregators. In particular, the DSOs will invest in a standard, open, non-discriminatory, blockchain-based, economic dispute settlement infrastructure, to give to both the customers and to the aggregator the possibility to become flexibility market players more easily. This solution will allow the DSO to acquire a new role as a market enabler for end users and a smarter observer of the distribution network. By defining this innovative two-layer architecture, Platone strongly contributes to aims to removing technical and economic barriers to the achievement of a carbon-free society by 2050 [1], creating the ecosystem for new market mechanisms for a rapid roll out among DSOs and for a large involvement of customers in the active management of grids and in the flexibility markets. The Platone platform will be tested in three European demos (Greece, Germany and Italy) and within the Distributed Energy Management Initiative (DEMI) in Canada. The Platone consortium aims to go for a commercial exploitation of the results after the project is finished. Within the H2020 programme “A single, smart European electricity grid” Platone addresses the topic “Flexibility and retail market options for the distribution grid”.

1.1 Associated Tasks

The System Architecture of the Italian Demo is in constant development and improvement. For the release of the third version of the System Architecture, five tasks have been identified, three internal tasks related to WP3, and two external tasks related to WP1 and WP2.

Task 3.2 “Development of a standard blockchain-based infrastructure, implementing a Common Access Interface between all the market players” is one of the project tasks composing WP3 – Italian Demo. Task 3.2 is coordinated by areti and performed by areti in cooperation with Apio, Siemens, Engineering and Acea Energia. It includes the following sub-activities:

- HW/SW (Hardware and Software) development of blockchain technologies to include customers in the system, led by Apio;
- Definition of communication protocols, identification of the communication channel and development of the apparatus for meter data exchange, led by Apio;
- Development of Shared Customer Database platform led by areti.

Task 3.3 “Implementation of a technical platform for grid state estimation and flexibility requests validation” is another project task composing WP3 – Italian Demo. It is coordinated by Siemens and performed by Siemens in cooperation with areti. It includes the following sub-activities:

- Hardware and software developments related to the real-time state estimation of the grid, led by Siemens;
- Definition of telecommunication infrastructure, led by Siemens;
- Development, testing and implementation of the state estimation tool, led by Siemens.

Thanks to all the data gathered from the hardware/software implemented on the field, the weather forecasts, historical data, and network topology knowledge the technical platform performs the state estimation and indicates any forecasted network operating constraints violation.

Task 3.4 “Solutions to enable Aggregators to provide flexibility: Aggregator platform and customer involvement” is coordinated by areti and performed by areti in cooperation with Siemens, Engineering,

Acea Energia and B.A.U.M. It includes activities aimed to test a local flexibility market in which end-users can be considered as market actors, thanks also to the role of the Aggregator.

The sub-activities composing the Task 3.4 are reported below:

- Aggregator Platform development and integration, led by Siemens;
- Solutions to enable local flexibility market, led by areti;
- Customer engagement techniques led by Acea Energia in cooperation with B.A.U.M.

The sub-task mentioned ensures an integration at every level of the Aggregator Platform and the acquisition of relevant data from the architecture regarding the flexibility analysis.

1.2 Objectives of the Work Reported in this Deliverable

The objective of the work reported in D3.5 is to present and describe the updates developed within the third release of technology. After the release of the D3.3 and D3.4 that led to the finalization of the structure of the Platone system architecture, this document will present the third version of the technology. The final year of implementation has been characterized mainly by activities of debugging, stabilization, and harmonization, and by the implementation of analysis like scalability analysis. The deliverable will then report on the main geographical and Italian Demo KPIs updates.

WP3 Italian Demo fully implements the Platone Reference Architecture in all its components and functionalities, both from a technological point of view and from a market structure point of view. The Italian Demo also performed non-functional activities like scalability analysis to test the potentiality of the system.

1.3 Outline of the Deliverable

The introductory chapter explains the Platone reference context, and the specific project task linked to the present deliverable, also providing indications about the objectives and characteristics of the document. Chapter 2 Overview summarizes the structure of the Platone system architecture and the updates regarding the data flows among the platforms. Chapter 3 Updates and Implementations, analyses the achievements and developments within the third release of technology, both on the technical, geographical (demo) side and through some non-functional activities perfomed within the Demo (Platform scalability analyses). Chapter 4 KPIs analyses the ongoing status and updates of WP3 Project KPIs. Chapter 5 Conclusions closes the document with the conclusions part, it is followed by the list of tables, the list of figures, the list of references, the list of abbreviations and the list of technical terms.

1.4 How to Read this Document

The document provides relevant information and updates based on the third release of technology of the Italian Demo. Furthermore, significant links and insights on the evolution of the technology during the project can be made through these Platone Deliverables.

- D3.3 [2] “Delivering of technology V1”, released by areti on month 21 (May 2021) as a public report about the detailed work on the release of the first version of the System Architecture. Within D3.3 areti describes the Italian Demo architecture, by providing a first overview and then describing all the components of the System Architecture, by highlighting their roles in the process;
- D3.4 [3] “Delivering of technology V2”, released by areti on month 38 (October 2023) as a public report about the detailed work on the release of the second version of the System architecture. Within D3.3 areti describes the second version of the System Architecture. Within D3.4 areti describes the Italian Demo Platforms updates that led to the final structural development of the Italian Demo architecture.
- D3.6 [5] “Report on first integration activity in the field”, released by SIEMENS on month 23 (July 2021) as a public report about the detailed work on relevant integration activities and data setup that followed the first “Delivery of technology”. Within D3.6, SIEMENS describes the integration activities that follow the “Delivering of technology (v1)” considering the general adopted

approach, focusing on the single Italian Demo platforms and on the overall necessary integration architecture. Furthermore, the Deliverable contains the description of the economical/technical scenario setup to test the overall Platone Italian Demo process;

- D3.8 [5] “Report on second integration activity in the field”, released by SIEMENS on month 40 (December 2023) as a public report about the detailed work on relevant integration activities and data setup that followed the second “Delivery of technology”. Within D3.8, SIEMENS describes the integration activities that follow the “Delivering of technology (v2)”, this Deliverable shows the technical and economic scenario defined with Low Voltage (LV) real network data that was used to validate the evolved overall Italian Demo Platone process. The complete up and running system allowed to test the new internal algorithms leading again to some significant results in terms of User Flexibility services exploitation
- D2.2 [6] “Platone platform requirements and reference architecture (v2)” released by Engineering on month 30 (February 2022) as a public report detailed on the Platone Open Framework. Within D2.2, Engineering describes the Platone Open Framework, a relevant element for all Platone Demos including the Italian one
- D2.5 [7] “Platone Market Platform v3” released by Engineering on month 46 (June 2023) as a public report detailed on the Platone Open Framework. Within D2.5, Engineering describes the third prototype of Platone Market Platform focused on the consolidation of the functionalities already implemented (with minor fixes) and some supporting features that including: the possibility to extract any kind of dataset in many standard formats and the preparation for the environment for the scalability test, performed jointly by WP2 and WP3 in the context of the Italian demo.

2 Overview

The Italian Demo has developed a full implementation of the common Platone Architecture introduced in D2.1 using data coming directly from the distribution grid and equipment in field. D2.2 provided an overview of the upgrade undergone during the second phase of the project to the Platone Architecture. Concerning the Italian Demo, the System Architecture released during the project activities is shown below in Figure 1

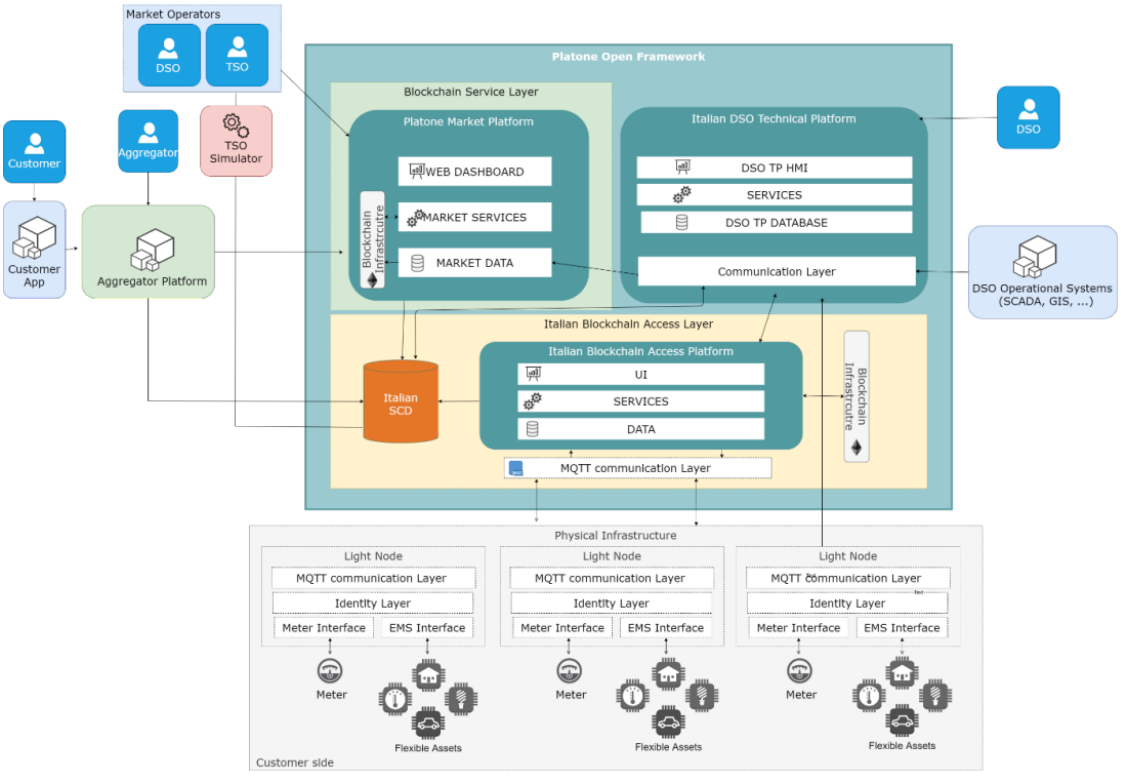

Figure 1 Italian Demo Architecture

The architecture described in detail in the D3.3 [2], is composed of five different platforms enabling the Local Flexibility Market. These platforms are:

- The **Market Platform** is one of the core components of the Platone Open Framework and is developed within the WP2 activities. It is a blockchain technology-based platform in which the global flexibility needs coming from the TSOs and the local flexibility requests coming from the DSOs are stored. The requests are matched with the offers received by the aggregators that sell the flexibility of the resources enclosed in their portfolio according to ancillary services defined by system operators, in order to solve the grid issues occurred. These market operations are fully registered and certified thanks to the blockchain service layer;
- The **Aggregator Platform** is the platform in charge of managing the flexibility resources and runs the required algorithms to optimize market strategy and flexibility offers;
- The **Blockchain Access Layer** is an architectural layer that acts as a level of security and trustworthiness of the framework. It is able to certify all the data coming from the Light Node (device used to gather data from the main meter) and runs the Smart-Contracts;
- The **Shared Customer Database (SCD)** collects all the data and information in a single archive and makes them available, after an appropriate authorization, to the stakeholders involved in the Local Flexibility Market. This database is able to arrange, store and collect the measurements, the flexibility orders and the other data related to the DERs, providing this

information to the other Platone platforms to implement the functionalities for the market (and all other stakeholders involved in the activities according to the authorization rules);

- The **DSO Technical Platform (DSO TP)**, in compliance with the market session timeframes, is the platform able to perform:
  - the power flows,
  - the sending of the flexibility requests to the Market Platform;
  - the technical validation check of the economic market outcomes;
  - the broadcast of the set-points to the flexible resources.

  Thanks to the continuous interaction with the DSO monitoring and control system, it receives all the inputs required to detect grid issues and to solve them with the flexibility provided by DERs.

The architecture depicted in Figure 1 has already been described in the previous version of the technology reported in D3.3.

In Figure 2, the data exchange among platforms developed within the Italian Demo System Architecture has been depicted.

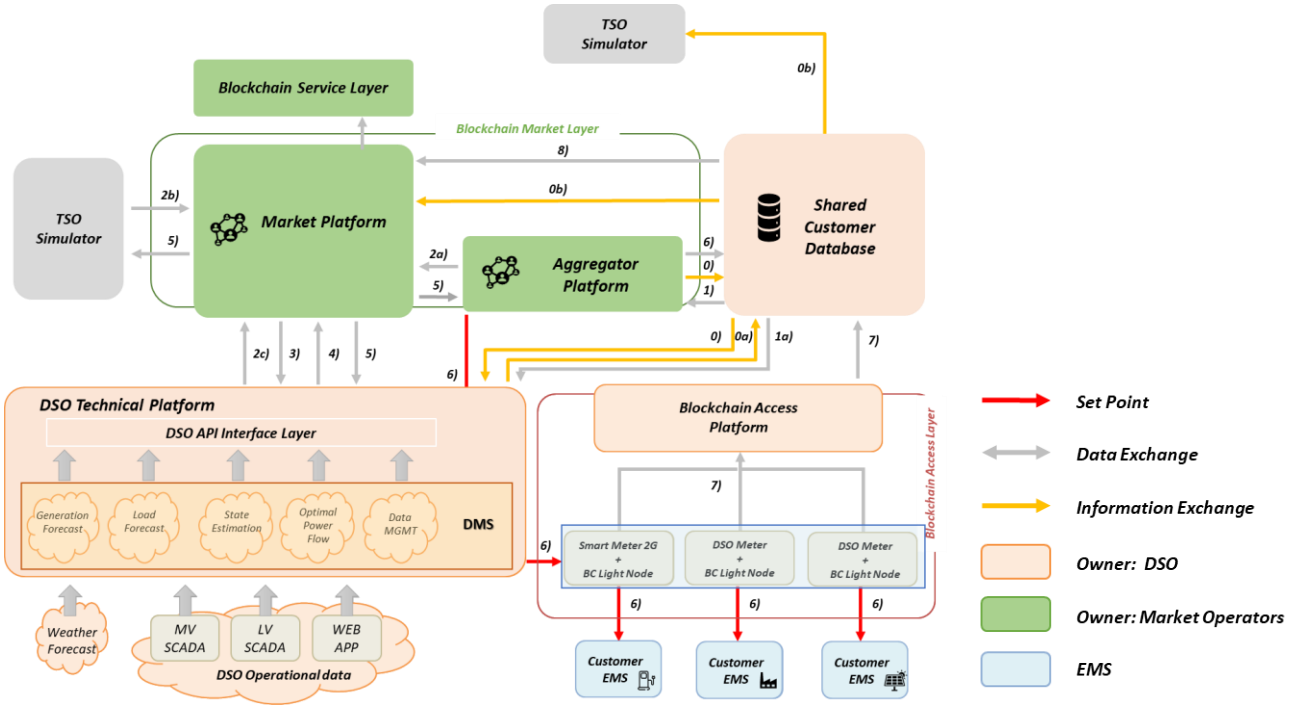

Figure 2 Italian Demo Data Flows

The following Table 1 describes the data flows reported in Figure 2 and the corresponding updates with respect to the previous second release of the technology:

Table 1 Communication and Data Flow specifications (final version)

Flow	Sender	Receiver	Description final version
0	Aggregator Platform	Shared Customer Database	Flexible PoD registration: Aggregator Platform sends all the data to register the resource in the SCD
0	Shared Customer Database	DSO Technical Platform	Flexible PoD registration: SCD turns the data to DSO TP to localize the resource on the distribution grid
0a	DSO Technical Platform	Shared Customer Database	Flexible PoD - PoM association: DSO TP detects the PoM (Point of Measurement) code linked to the resource
0b	Shared Customer Database	Market Platform (TSO Simulator service)	Flexible PoD data: The SCD sends the data of the flexibility resources to TSO Simulator
1	Shared Customer Database	Aggregator Platform	Flexible PoD data: The SCD sends, in streaming manner, to Aggeragator Platform the quartorary measurements
1a	Shared Customer Database	DSO Technical Platform	Flexible PoD data: The SCD sends, on demand, the measurement data to DSO TP with the implementation of the on-demand call
2a	Aggregator Platform	Market Platform	New flexibility offers: Aggregator Platform sends the flexibility offers to MP
2b	TSO Simulator	Market Platform	New flexibility requests: TSO sim sends the flexibility requests to MP
2c	DSO Technical Platform	Market Platform	New flexibility requests: DSO sends the flexibility requests to Market Platform with the implementation of the LV flexibility requests with separate flow with respect to Medium Voltage (MV) requests
3	Market Platform	DSO Technical Platform	Market outcomes for technical validation: Market Platform sends to DSO TP the more economics offers for the technical validation. Unique flow to gather the outcomes for LV and MV resources
4	DSO Technical Platform	Market Platform	Validated market outcomes: DSO TP sends the offers in compliance with the grid limits. Unique flow to gather the outcomes for LV and MV resources
5	Market Platform	Aggregator Platform Market Platform (TSO Simulator service) DSO Technical Platform	Market results: Market Platform sends the market outcomes to the stakeholders. Unique flow to gather the outcomes for LV and MV resources
6	Aggregator Platform	Shared Customer Database	Set-point: Aggreagator Platform sends the set-point to SCD

Flow	Sender	Receiver	Description final version
6	Aggregator Platform	DSO Technical Platform	Set-point: Aggregator Platform sends the set-point to DSO TP
6	DSO Technical Platform	Light Node	Set-point: DSO TP sends the set-point to Light Node
6	Light Node	Customer Activation Systems (e.g. Energy Management System EMS)	Set-point: Light Node makes available the set-point to Customer activation System
7	Light Node	Blockchain Access Layer (Blockchain Platform)	Measurement data & Set-point: Light Node sends the data to Blockchain Access Layer
7	Blockchain Access Layer (Blockchain Platform)	Shared Customer Database	Measurement data & Set-point: Blockchain Access Layer sends the data to SCD
8	Shared Customer Database	Market Platform	Measurement data & Set-point: SCD sends data to Market Platform for the settlement phase (on demand)

3 Updates and Implementation

3.1 Technical Updates

During the second release of technology of the Italian Demo, the design, implementation, and development of the system architecture was finalized by developing a Local Flexibility Market able to unlock the flexibility in the distribution grid and enable users to be part of a process in which they would be crucial to solve eventual issues detected in the grid. Once this objective was achieved, the partners focused on the few final implementations, the necessary bug fixing to improve the overall process, and also on making the system more reliable and responsive both for the market operators (SOs and Aggregators) as well as for the customers.

The activities realised during the second phase of the project have led to the third delivery of the technology that involves the following updates:

Table 2 Platforms' updates and bugfix

Market Platform	• Datasets export in csv.
Aggregator Platform	• Expansion of the Real-time flows on the Day-ahead; • Introduction of a higher number of Balance Service Providers (BSP) on the Platform; • Bugfix on the sending of all PoDs labelled as "ready for the market" towards the Market Platform
Flessibili App	• Bugfix on the wallet layout interface
Shared Customer Database	• Updates on Baseline calculation;
Blockchain Access Layer & Light Node	• Light Node and Blockchain Access Layer updates and bugfix; • Extension of Chain2Full to all users involved in the Demo;

DSO Technical Platform: The latest version of the DSO TP was completed with all the features required in the project for this reason no further features were included in this phase and most of the work was directed towards the implementations of the scalability analysis described in Chapter 3.2.1.

The descriptions of the developments and the activities are presented below.

3.1.1 Market Platform

The second version of the Market Platform included all the expected functionalities to be implemented and evaluated in the Italian demo. For this reason, during the final period of the project the activities were mainly focused on the consolidation of the architectural stack, including some minor fixes, as well as some non-functional activities:

- Scalability evaluation of the platform in a stand-alone and distributed architecture environment (Chapter 3.2);
- Updates of calculation of the KPI_IT_02 (Chapter 4);
- Dataset export.

Scalability Evaluation

The scalability evaluation was conducted in collaboration between WP2 and WP3 in order to test the entire Platone Open Framework from a scalability perspective and it will be further explored in chapter 3.2.

Dataset export

An additional feature was introduced in the Market Platform final version, this being the possibility to export all the data stored in the Market Platform database in a specific dataset as csv (Comma-Separated Value) format.

The following datasets are available:

- DSO requests;
- TSO request;
- Aggregators bids;
- Market outcomes;
- Settlements.

3.1.2 Aggregator Platform

Elaboration of Real-Time offers

During the development phase for the second release of technology, the Aggregator Platform activities have been mainly related to the elaboration of flexibility offers for the Real-time sessions, defining the offers for Real-time sessions with the update data from the fields and send them to the Market Platform before each Real-time Market Session. With the third release of technology, the Aggregator Platform worked on the expansion of the Real-time flows on the Day-ahead. This addition improved the automatic management of the Real-time offers, increasing the liquidity of the market and guaranteeing more flexibility in the customers involvement. Further improvements in the aggregator platform are related to the introduction of a higher number of BSP on the Platform, and by fixing the error related to the sending of all the PoDs, labelled as “ready for the market” to the Market Platform, the normal flows of data that were previously overcrowded, were restored.

3.1.3 Flessibili App

The Flessibili App implements an electronic wallet section, where users can check their tokens acquired at the end of the settlement phase. During the final period of the project the layout in the wallet section was fixed to ensure proper behaviour in most devices.

Figure 3 Flessibili App wallet interface

3.1.4 Shared Customer Database

Updates on baseline calculations

The partners have worked for the implementation of a Standardized Baseline. The exploiting methodology is depicted in the scientific paper [8], and it is defined as:

- a baseline ex-ante (customer behavior regardless of their participation in the Flexibility Market) equal to the average consumption/generation of 5 corresponding hours in the days with the highest daily consumption/generation;
- a baseline ex-post (how customer behavior changes after their participation in the Flexibility Market) adjusted upward and downward by the difference between the last two hours' actual consumption and baseline. Ex-post baseline would be used to validate the settlement calculation verifying that the handlings have been used to achieve the target set by the Local Flexibility Market.

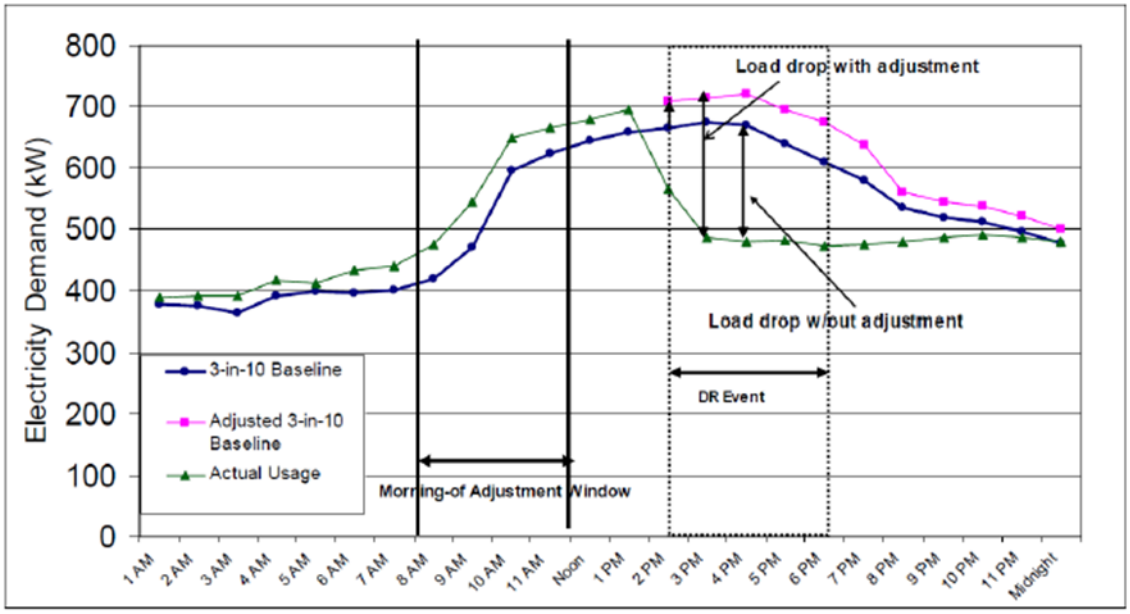

Figure 4 Comparison of the Standardized Baselines [8]

The Shared Customer Database performed the updates on the Baseline ex-ante which has been implemented both with the simulated data received from the Aggregator Platform and with real data collected by the shared customer database. The Baseline ex-post has been implemented only with the simulated data received from the Aggregator Platform. In Figure 5 we can observe the difference between the measurement of real active power and the two baseline ex-ante. The real active power refers to the actual power consumed by an electrical load, and it represents in this case the rate at which energy is being used in an electrical circuit. The comparison with the baseline refers to the value against which the actual energy consumption or power usage, compared with the real power is measured. The alteration observable in Figure 5 diagram (upper blue lines and salmon lines) are between the measurements of the real active power and the baseline, they are the variation between the actual power consumption and the expected reference value obtained in the baseline. If the measured real active power is higher than the baseline, it indicates that the device is consuming more power than expected or the energy efficiency has decreased. Conversely, if the measured real active power is lower than the baseline, it suggests that the device load is consuming less power than expected or the energy efficiency has improved. The upper side of this figure shows the result obtained using the data coming from the aggregator platform while the lower one shoes the results obtained using the data collected by the shared customer database. This kind of monitoring analysis measures the effectiveness and the difference between real active power and the baseline, in order to identify deviations, energy

inefficiencies, or changes in power consumption patterns, allowing for corrective actions, energy optimization and for performance improvements.

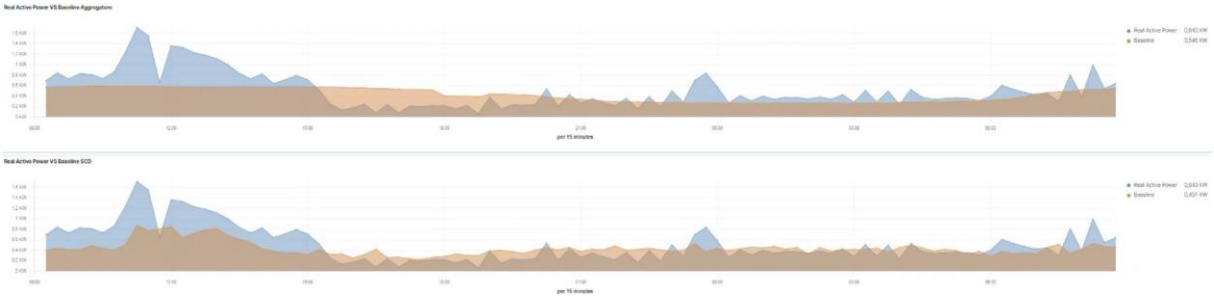

Figure 5 Comparison of baseline ex-ante on real active power

3.1.5 Light Node & Blockchain Access Layer

Light Node: Bug fixing and Chain2Full Implementation

During the second release of technology, a new version of the Light Node data format, named Chain2Full, was implemented and tested on the areti's lab smart meters and on the Light Node firmware to acquire new datasets. With the third release of technology, the Chain2Full has been extended to all the Light Nodes deployed within the field trial of the Italian Demo. Chain2Full extends the datasets adding the quarterly data of energy active absorbed/injected, instant active power absorbed/injected, the reactive energy measurements (only for 3Phase main meter) and other measurement data. The implementation of this feature within the smart meters and the installed users' devices participating in the Demo increases the awareness of the users and their capacity to actively monitor the energy consumption and production.

In Table 3 are described the differences between these two datasets (the * indicates the features only for 3Ph meters).

Table 3 Differences between datasets Chain2 and Chain2Full

DATA	Chain2	Chain2Full
Measurement date	X	X
Measurement time	X	X
Quarter-hour sample of active energy absorbed	X	X
Quarter-hour sample of active energy injected		X
Quarter-hour sample of inductive reactive energy when active energy absorbed*		X
Quarter-hour sample of capacitive reactive energy when active energy absorbed*		X
Quarter-hour sample of inductive reactive energy when active energy injected*		X
Quarter-hour sample of capacitive reactive energy when active energy injected*		X
Quarter-hour average of active power exchange	X	X

Furthermore, a set of features and bug fixing activities has been implemented to improve and ensure the proper functioning of the Light Nodes and the Blockchain Access Layer within the Italian Demo architecture:

Light Node:

- Bugfix: It was ensured that the Unit of Measurement (UoM) of the activation set to the Energy Management System (EMS) in response to a setpoint is correct;
- Bugfix: The logging activities of the Light Node software have been improved;

- New Feature: A local API has been added to send setpoints to the EMS and to retrieve setpoints received from DSO TP

Blockchain Access Layer:

- Bugfix: The error handling in the Shared Customer Database integration related to the data transport on Kafka has been removed;
- New Feature: An extension was provided that provides future support for other public Ethereum-based blockchains for the tokenization activities;

3.2 Platform Scalability Analysis

The Italian Demo was selected among the three Platone Demos to perform platform scalability analysis in partnership with WP2 in February 2023, as it was the first Demo to complete the implementations on the system architecture and ready to perform comprehensive tests on the various platforms. The scalability analysis performed in the Italian Demo were developed to test two kinds of evaluations:

- **Scalability at Platform Level:** The Platform scalability level monitoring checks the state of every single platform during the execution of specific business processes. In particular, it is important to monitor how a single platform is able to scale in terms of computational load when the number of users involved in the test environment increases.
- **Scalability at Inter-Platform Level:** The inter-platform scalability analysis checks the state of the overall system and its workflow and processes through a set of performance metrics, monitoring how the different platforms interact with each other for implementing specific business processes without compromising the performance of the entire system.

The methodology that was chosen to perform the scalability tests was to perform the tests on the platforms for three consecutive weeks. Starting the first week on the 3rd of May and moving towards the third one which was completed on the 24th, every week the number of PoDs in the system have been exponentially increased.

To test the above-mentioned scalability requirements, two sets of KPIs were defined:

Scalability at Platform Level KPIs:

- CPU Load Average (%);
- CPU Load Max (%);
- RAM Usage Average (MB);
- RAM Usage Max (MB);
- Uptime (%).

Scalability at Inter-Platform Level KPIs:

- Running Time;
- Latency of Networking.

Boundary conditions: The scalability tests over the three weeks, previously planned, were successfully executed in the month of May 2023. In the first week, the tests were performed on 10 PoDs, i.e. the actual number of users involved in the Italian Demo experimentations. During the second week, the number of PoDs has been increased by ten times testing 100 PoDs. During the third and last week, the number of PoDs has been increased to the number of users simulated in a possible real-case environment with approximately the 30% of Distributed Energy Resources (DERs) expected in the Italian demonstration geographical area, testing 1500 PoDs. The data related to the three weeks of testing were correctly extracted and will be presented in the Deliverable 2.16 [9] scheduled for the end of August.

3.2.1 Platform updates for scalability tests

To correctly perform and monitor the various stages of the scalability analysis, the Platforms of the Italian Demo underwent different stages of updates and bugfixes that are reported below:

Aggregator Platform:

The aggregator platform mainly worked on the monitoring of the possible spike in Random Access Memory (RAM) and Central Processing Unit (CPU) related to the exponential increase of PoDs in the system.

Market Platform:

From a technical perspective, the Market Platform included two new modules for the monitoring of the scalability KPIs:

- A monitoring framework, based on Promethues.io [10], for collecting all the information at the Platform level.

- A logging system, based on Winston Logger [11], for collecting all the information at the Inter-Platform level.

Shared Customer Database:

For the Shared Customer Database, the main requirements for monitoring the processing of the PoDs activation were the collection of the CPU load, network latency and memory usage in real-time. These evaluations have been done using the dashboard implemented in Grafana.

The Dashboard has considered the Amazon Web Service (AWS) machines used to process the requests in real-time. Once the activation of the various PoDs has been sent, the data were collected to verify the performance based on the above-mentioned KPIs.

Thanks to the data collected, the outputs reported in Figure 6, Figure 7, Figure 8 and Figure 9 were produced with the conclusion of the scalability tests:

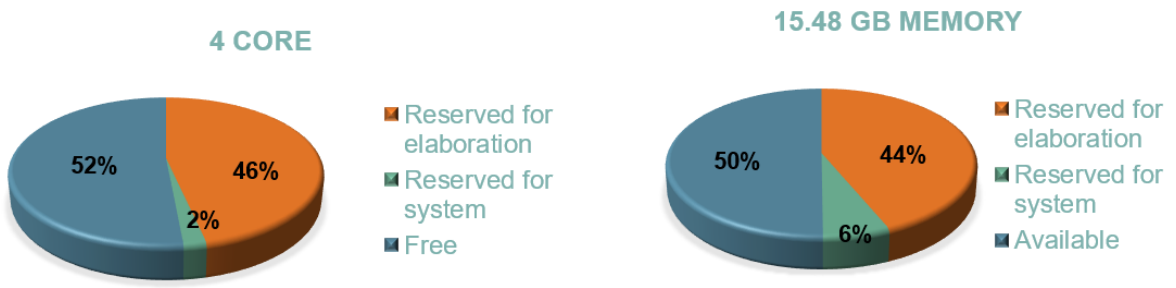

Figure 6 Current AWS machines allocation for SCD

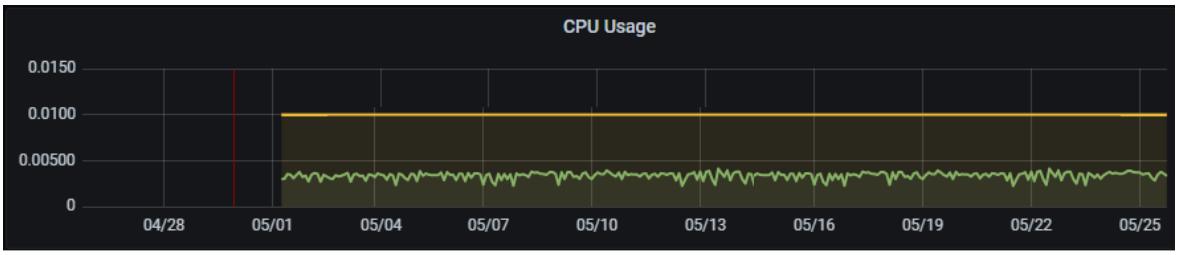

Figure 7 CPU Load Average

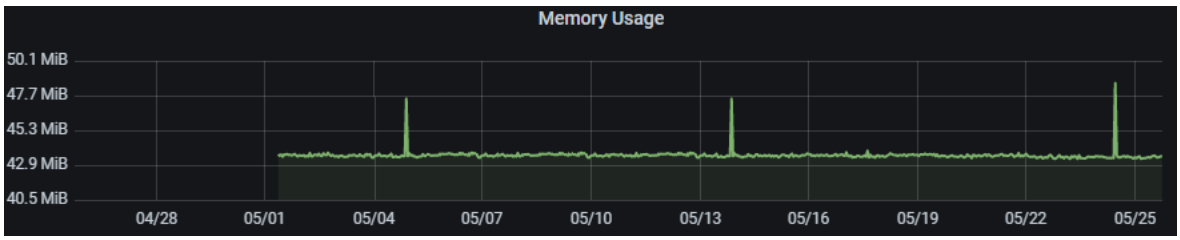

Figure 8 RAM Load Average

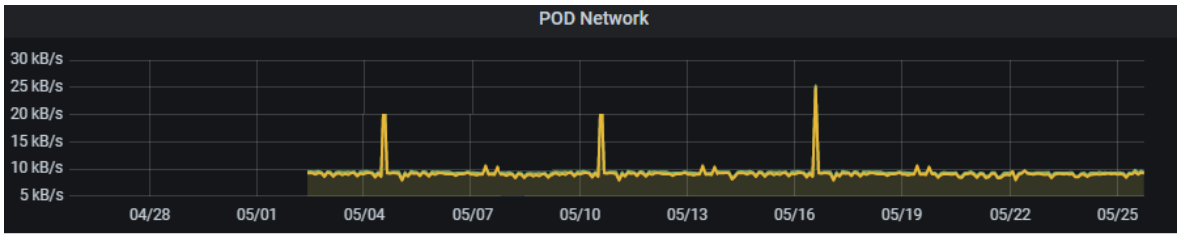

Figure 9 Network Latency

DSO Technical Platform:

the DSO TP has been prepared for the collection of the logs relaed to the resource consumption during the execution of all the flows in which it is involved:

- Flow 1a (SCD – DSO TP): Flexible PoD data (on demand calls)
- Flow 2c (DSO TP – MP): DSO Flexibility requests
- Flow 3 (MP – DSO TP): Market outcomes for technical validation
- Flow 4 (DSO TP – MP): Validated market outcomes
- Flow 5 (MP – AP/DSO TP/TSO Simulator): Market results
- Flow 6 (AP – SCD/DSO TP): Setpoint
- Flow 6b (DSO TP – Light Node): Setpoint (to the field)

To collect this information, the logging systems of the DSO TP were configured accordingly:

- Elastic [12] Logstash (part of the ELK framework);
- Prometheus [10] (an open-source monitoring solution for metrics and alerting);

Platform-level consumption data were collected over a 3-week period, in each week the number of users was progressively increased:

- 10 PoDs for the first week;
- 100 PoDs for the second week;
- 1500 PoDs for the third week;

Block Chain Access Layer:

The Block Chain Access Layer worked on the upgrade of logging activities to face the exponential increase of data due to the scalability analysis performed.

3.3 Updates on the involved flexibility resources

Within the Italian Demo, the DSO TP uses the data coming from the field devices installed in the secondary substations, located in the area of the project. The architecture built up during the first period is interfacing with areti's assets like the LV switches, Remote Terminal Unit (RTU) and Router that the DSO has already installed in the field.

Since the release of the first technology, the Italian Demo has also seen the involvement of the first users participating to the trial phase. Indeed, during the second period of the project, after the conclusion of the installation phase of technological equipment at the users' location, the 11 different residential users started to take active part in the trial and in the experimentation activities in order to test the Local Flexibility Market developed for the Platone Italian Demo. More in detail and after the first release of the technology till the third release of it, all the processes depicted in the Italian Demo have been tested, including the sending of the setpoints and the related delivery of the flexible services. Focusing on these two last processes, dedicated tests have been arranged to evaluate distributed resources efficiency in providing the requested services, or in other words, their ability to respect the sent setpoints.
After gathering the availabilities of flexible customers to offer flexibility services to the grid by the installed storages and to perform the tests, the DSO TP has been forced to identify some congestions (by temporarily decreasing the capability of the grid) in the part of the grid where the same flexible users are connected. In such a contingency case, the DSO TP has identified the need to send flexibility requests to the Market Platform; similarly, the TSO Simulator sent some flexibility requests, and the Aggregator Platform translated the availability of the flexibility customer in flexibility offers. The results of the market sessions were the matching of some flexibility offers with some DSO and TSO requests, leading to the calculation of the setpoints to be sent to the related distributed flexibility resources.

Once the time for the flexibility service delivery occurs, the setpoint received by each Light Node is forwarded to the related BEMS that manages the charging or discharging of the storage in a coordinated manner with the other loads and generators in order to provide at PoD the requested flexibility services.

Figure 10, Figure 11 and Figure 12 show the delivery of flexibility registered by the Light Nodes of the distributed resources to which setpoints were sent. The delivery of flexibility (requested from time 18:30 to 19:00 delivery of flexibility registered by the Light Nodes of the distributed resources to which was sent setpoints. The delivery of flexibility (requested form time 18:30 to 19:00) happens in form of power exchange with the grid at the PoD

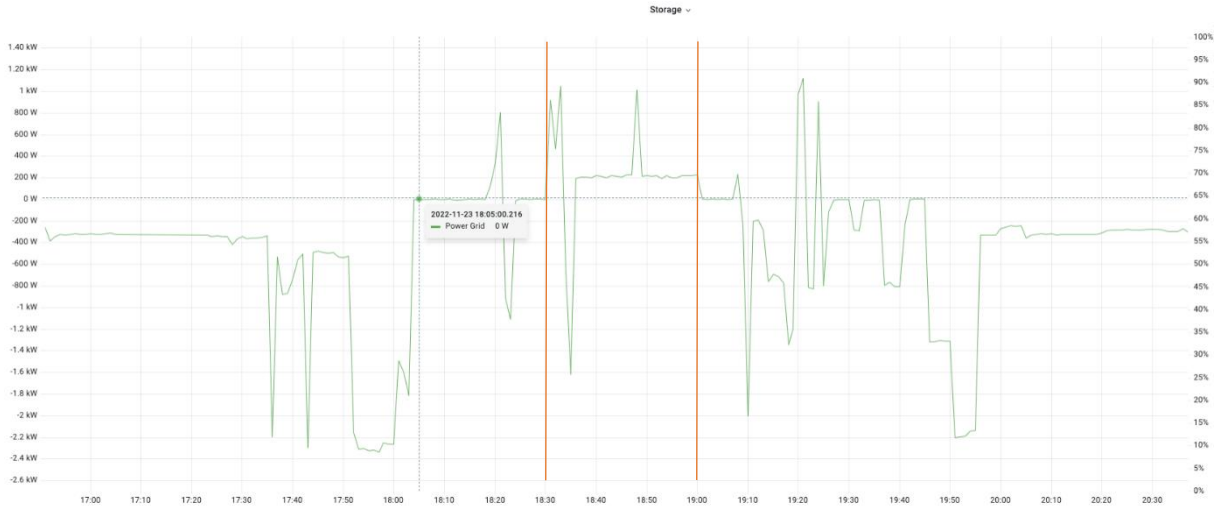

Figure 10 Light Node 14 requests for 300W

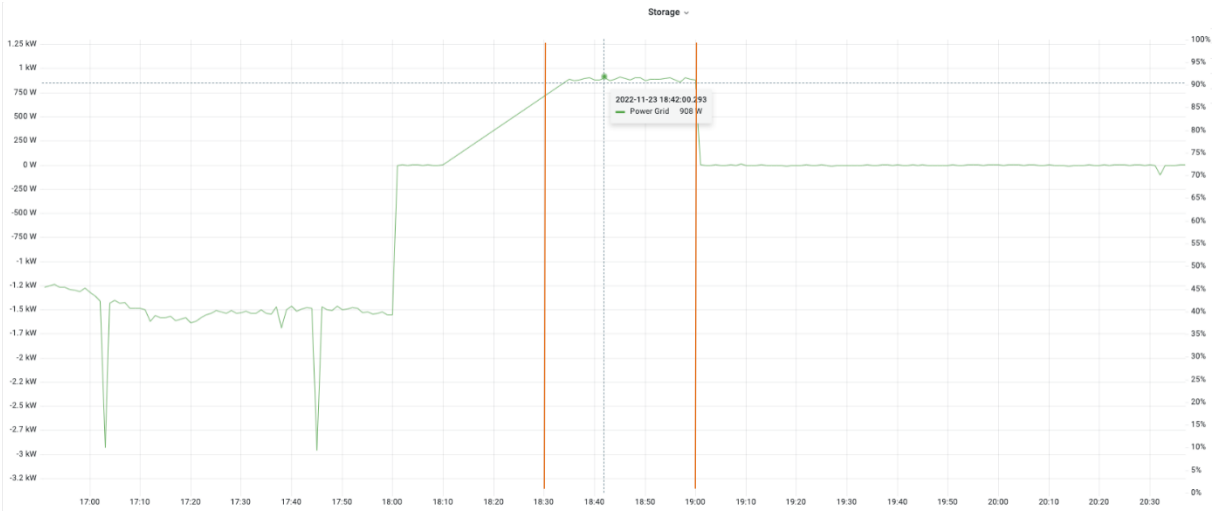

Figure 11 Light Node 16 requests for 1kW

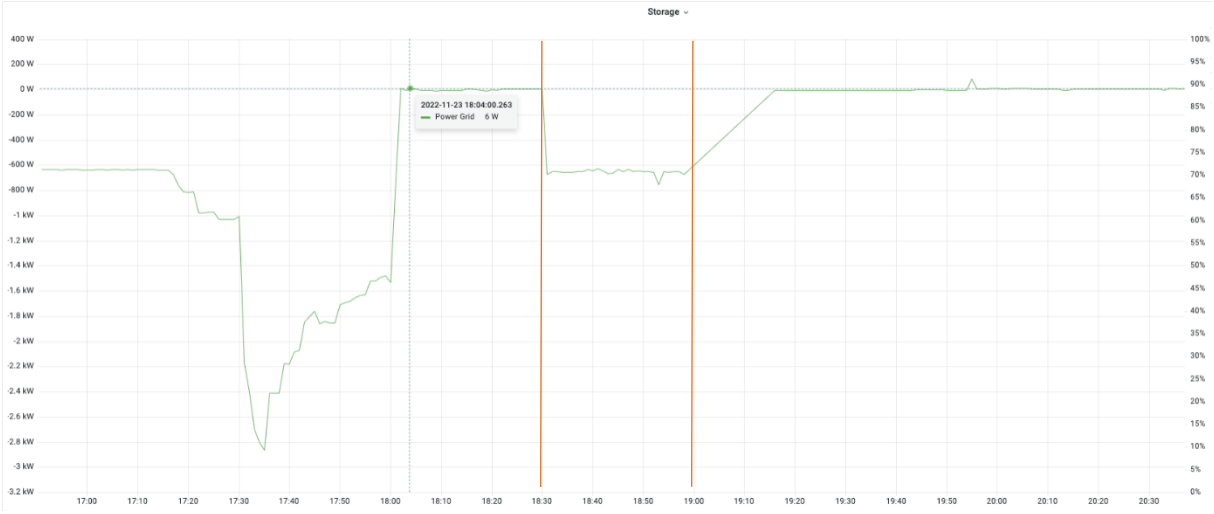

Figure 12 Light Node 17 requests for 600W

The results are very interesting. From Figure 10, Figure 11 and Figure 12, it is possible to note that all the flexibility resources were able to provide the flexibility service with an error of 100W. This is most probably due to why the tolerance of the control loop of the BEMS which are approximately 100W. This is a significant result because gives us information about the minimum amount of service that a single distributed resource can provide to the grid: indeed, if the distributed resource will be requested to provide an amount of service less or equal to 100W its control loop will not be able to follow the received setpoint because lower than its sensitivity threshold.

In order to have a better understanding about the involvement of customers for the field trials, Figure 13 shows Platone Italian Demo users' location and future plans for the application of the proposed solutions for the Smart Park in the Ostiense District. More in details, areti installed the Light Nodes in the area of the Ostiense district, specifically in the smart Electric Vehicle (EV) parking. This installation consents the monitoring and, in the future, the management of the charging infrastructure to test the flexibility provided by the EV charging stations, to solve local congestion.

Figure 13: Platone Italian Demo users' location

Indeed, areti is also implementing other applications to test the approach developed into the Platone Italian Demo; more in detail areti installed the Light Nodes in the area of the Ostiense district, specifically in the smart EV parking. This installation consents the monitoring and, in the future, the management of the charging infrastructure to test the flexibility provided by the EV charging stations, in order to solve local grid congestion.

As reported in the D3.4, for the comfort of the readers, in Figure 14 is shown the architecture of the areti's smart park.

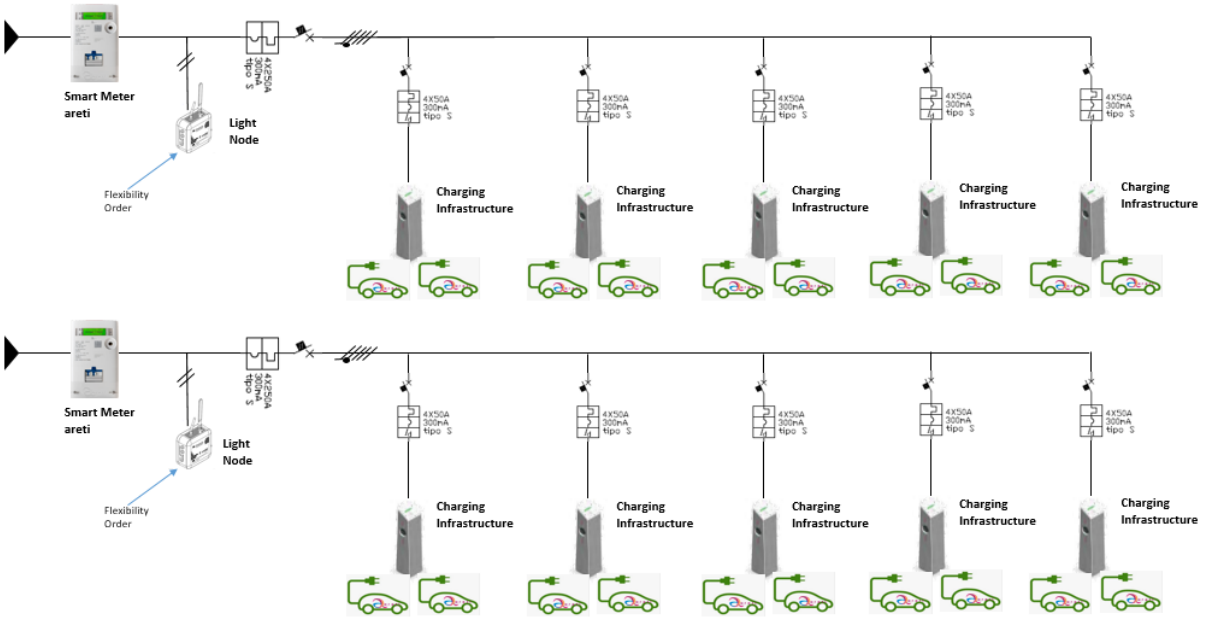

Figure 14 Areti's smart park

Regarding the involvement of self-consumption community foreseen in the previous stage and reported in D3.4, the construction of the apartment complexes has not been yet finalized. Therefore, there are delays in the installation of the PV generators and the related storages units due to the required authorization permits that are still missing. As a matter of fact, the public offices involved in this activity are overloaded by several requests concerning the incentivization activities promoted by the Italian government such as "Incentivi 110%" concerning energy efficient policy and other initiatives within the so called "Piano Nazionale di Ripresa e Resilienza (PNRR) supported also by EU funding.

4 Updates on KPIs

In the last year of the project, the KPIs calculation has been finalized and some of the KPIs PR_03, PR_04, IT_01 and IT_02 are automatically calculated. All the formulas used for the calculation of the KPIs can be found in D1.2 [13] and then assessed and reformulated with the D1.4 (confidential deliverable).

Concerning the Social KPI_PR_02 (Active Participation), the partners agreed to use customer's information gathered by means of the Flessibili App.

Table 4 Updated Platone KPIs

No.	KPI ID	KPI Name	KPI Domain	Calculation Algorithms Available
1	KPI_PR_01	Participants' recruitment	Social	Yes
2	KPI_PR_02	Active participation	Social	Yes
3	KPI_PR_03	Flexibility availability	Technical	Yes
4	KPI_PR_04	Flexibility effectiveness	Technical	Yes
5	KPI_IT_01	Market liquidity	Technical	Yes
6	KPI_IT_02	Forecast reliability – customer profile	Technical	Yes
7	KPI_IT_03	Forecast reliability – grid profile	Technical	Yes

In Table 4, highlighted KPIs indicate the updates during the last phase of the project.

WP3 partners have performed periodic monitoring and activation of the platform to keep the KPIs results time-aligned until the end of the project.

The major updates regarding the KPIs's extraction and graphic designed were done on the following KPIs:

KPI_PR_03: The KPI PR03 "Flexibility Availability" measures the maximum value of flexibility availability divided by the values of the baseline for the respective quarters' hours in both descending and ascending orders of the flexibility availability. The KPI is calculated daily with the data of the previous day. Figure 15 represents the two cases of increasing and decreasing the flexibility availability and can be viewed both as an aggregate and per PoD. Moreover, it can be viewed as per session (4 hours), or for the whole day.

Figure 15 KPI PR03 Flexibility Availability

KPI_PR_04: The KPI PR04 "Flexibility Effectiveness" measures the relationship between the measurements of the real power received by the Light Node compared to the set point sent. This KPI has been extracted and represented graphically in Figure 16.

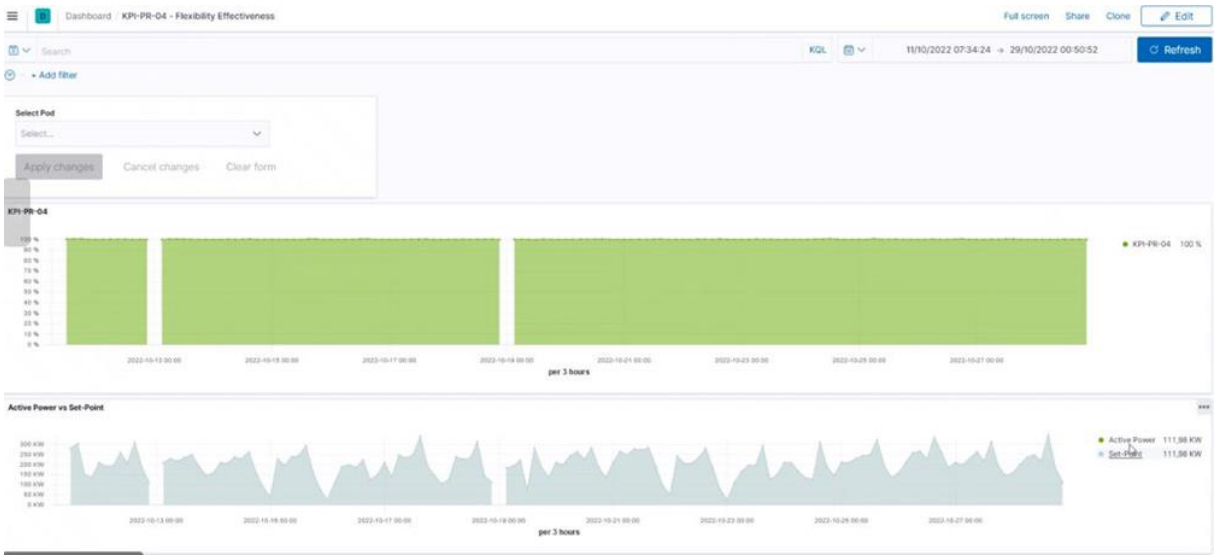

Figure 16 KPI PR04 Flexibility Effectiveness

KPI_IT_01: The KPI IT 01 “Market liquidity”. The Market Platform was in charge of collecting data for evaluating two specific KPIs: *market liquidity up and market liquidity down.* For the calculation of these KPIs, a specific module has been implemented and a new REST API has been made available and further described in D2.5 [7].

KPI_IT_02: The KPI IT 02 "Forecast reliability - Customer Profile". In the first diagram of Figure 17 reported in the upper side, the KPI values are observed while in the lower diagram, the active power and the baseline values are represented. The KPI has been updated by eliminating the PoD that distorted its measurements leading to a more uniform trend of the Baseline and active power.

Figure 17 KPI IT02 Forecast reliability - Customer Profile

5 Conclusion

With the activities and bugfixes carried out in the final period of the project, WP3 partners improved the functionalities of the complete version of the system architecture of the Italian Demo.

This final version represents the complete Local Flexibility Market approach developed for the Italian Demo. The successful platform scalability analysis performed in the final period of the projects evidence of the possible expansion and further implementation of the solutions developed in the Italian Demo. The solution implemented within the Platone Italian Demo have been proposed to the National Regulation Authority (ARERA) as the pilot for the local flexibility market in Italy and it's going to be adopted in the Rome area by the RomeFlex project. The approach and the platforms developed within the Platone project are being proposed again within this regulatory framework in order to enable the DSO to acquire local flexibility services and make possible implementation of a complete end-to-end TSO/DSO coordination. An important role is played by the Shared Customer Database that is going to be referred to as Flexibility Register, which will act as a unique storage of the flexibility resources data, including their flexibility capabilities, baseline, nameplate and contractual data, certified measurements and setpoints that are shared among the platforms. With the use of the Shared Customer Database, such data are shared among all the stakeholders and the platforms involved in the market leading to the enhanced the observability of the grid and related flexibility resources connected to it. In this regard, a significant role is done by the Light-Node that thanks to its developed functionality is able to exploit the features of the Smart-Meter 2G such as the data and measurements provided by the chain2 communication and elevate time granularity up to real-time. This eliminates the need of installing other sub-meter(s) at the customer premises.

Moreover, thanks to the significant knowledge gained by the project partners through the project activities on the field trials, it is now easier to understand the major issues and needs. It is for this reason that the solution developed in the Platone project will be applied to different environments in order to reuse the significant knowledge gained through the implementation of the Italian demo. Different projects have already started (such as Flow and BeFlexible, Horizon Europe projects) in which the Platone Italian Demo solutions will be replicated.

6 List of Tables

7 List of Figures

8 List of References

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[7] Platone Deliverable 2.5 “Platone Market Platform v3” Soon Available at: https://www.platone-h2020.eu/Resources/Deliverables

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[9] Platone Deliverable D2.16 “Platone Integrated Framework Prototype (v3)” Soon available online at: https://www.platone-h2020.eu/Resources/Deliverables

[10] Prometheus link available at: https://prometheus.io

[11] Winston logger available at: https://github.com/winstonjs/winston

[12] Elastic Stack: https://www.elastic.co

[13] Platone Deliverable D1.2 “Project KPIs definition and measurement methods” [Online] Available: https://www.platone-h2020.eu/Resources/Deliverables

9 List of Abbreviations

Abbreviation	Term
AWS	Amazon Web Services
BEMS	Building Energy Management System
BSP	Balance Service Provider
CPU	Central Processing Unit
CSV	Comma-Separeted Value
DER	Distributed Energy Resources
DSO	Distribution System Operator
DSO TP	DSO Technical Platform
EMS	Energy Management System
EV	Electric Vehicle
LV	Low Voltage
KPI	Key Performance Indicator
MV	Medium Voltage
PoD	Point of Delivery
PoM	Point of Measurements
RAM	Random Access Memory
RTU	Remote Terminal Unit
TSO	Transmission System Operator
UoM	Unit of Measurement