Platone

PLATFORM FOR OPERATION
OF DISTRIBUTION NETWORKS

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PLATform for Operation of distribution NEtworks

D8.5 v1.0

Exploitation and marketing plan for the involvement of partners and future customers

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Abstract

The main purpose of this deliverable is to report on the Key Exploitable Results of the project and point out the benefits of Platone to the target group, which consists of the main users DSOs, TSOs, Aggregators and Customers but also of the three stakeholder groups Research, Industry and Regulatory Authorities. The regulatory and legislative framework of Platone is evaluated and recommendations for improvement are given. The KERs of Platone are described in detail and the exploitation strategy is explained. Especially the open-source approach enables a comprehensive exploitation in this context, with the free transfer of findings, software code and tools. Furthermore, the demonstration sites in Italy, Greece and Germany and their lessons learned are evaluated.

Keyword list

Exploitation, Target Group, Regulatory Framework, Key Exploitable Results, Open Framework, Platform, Blockchain, State Estimation, Market, Datasets, Network Tariff, Demonstration Site, Demo

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 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 will also incorporate 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).

The objective of this work is the evaluation of the target group of Platone, the explanation of the corresponding regulatory framework, the documentation of the key exploitable results (KER) and the lessons learnt in the demos. The evaluation of the target group shows that not only the main target group, as DSOs, TSOs, aggregators, customers benefit greatly from the Platone architecture, but also stakeholders like industry, research or regulatory authorities. Especially the assessment of the regulatory and legislative framework is of interest for Regulatory Authorities, revealing that a clearer legislative framework is needed for new actors in the energy sector like aggregators or the application of new technologies like blockchain. When it comes to exploitation, especially the open-source approach allows a broad transfer of knowledge, findings, software code and tools to Research and Industry. At this stage of the project, the consortium can present 14 KERs, of which three provide already publicly available content. The varying Technical Readiness Levels (TRL) levels, with some KERs having a start TRL of 0 and some having end TRL of 8, show that Platone is able to provide not only basic research but also close to the market products and services. At the demos, all the KERs are tested and continuously validated. The analysis of the lessons learned shows, that especially the customer engagement plays a crucial role in preparing and running a successful demo, underlining the philosophy of Platone, that the customer takes a central role in the future energy system. Another common lesson learnt is that partners were successful in using the IEC-62559 standard to conceptualize the demo use cases, helping to detect potential difficulties at the installation of new hardware and requiring standards in the smart grid technology. At this stage of the project, Platone has an exploitation plan with concrete KERs, for which each responsible project partner has a clear exploitation strategy.

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Table of Contents

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 more easily become flexibility market players. 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”.

With its open and diverse architecture covering grid monitoring and control in combination with the integration, management and commercialisation of flexibilities, Platone is able to meet the needs of various target groups. The primary target group are DSOs. Also, TSOs belong to the target group since they benefit from flexibilities to solve grid congestions. A further target group is aggregators, which can use the data of the flexible units within the Platone open framework to pool flexibilities. Since customers need to take part actively in the system to provide the flexibility, they also belong to the target group of Platone.

1.1 Task 8.6 Exploitation of the results

This deliverable is strongly related to task 8.6 Exploitation of the results, led by BAUM. Task 8.6 ensures that all project partners have an aligned understanding of the exploitation targets of the project, which is ensured by a constant feedback loop within the project consortium. Within these feedback loops the key exploitable results are identified as well as exploitation strategies developed. All the findings, results and targets are documented in this deliverable.

1.2 Objectives of the Work Reported in this Deliverable

The objective of this deliverable is to give stakeholders of the Platone project a detailed insight into the regulatory framework and the developed and thoroughly tested Platone architecture as well as the ability to identify the relevant key exploitable results for each of them. In addition, the benefits for the stakeholders should be evident as well as the potential commercialization, if the TRL level of the key exploitable result allows such a conclusion. Finally, the reader should be able to reconstruct, that the Platone architecture was tested individually in demo sites and proved its functionality.

This deliverable covers all the above-mentioned aspects as far as results, analyses and conclusions are available to this state of the project.

1.3 Outline of the Deliverable

Chapter 2 gives an overview of the Platone target groups and describes in which way the target group benefits from the Platone architecture. Chapter 3 explains the legislative and regulatory framework of Platone and its demos and gives recommendations on how the framework could be optimized. Chapter 4 is about the single Platone Key Exploitable Results, offered within the Platone architecture, with a reference to the target group and the corresponding exploitation strategy. Chapter 5 describes the demo sites, the responsible parties and the applied Platone solutions as well as the lessons learnt. The last chapter sums up the conclusions of Chapter 2-5.

1.4 How to Read this Document

This deliverable is a standalone and closed document, which is in no special relation to other deliverables. The direct follow up of this deliverable is D8.10 Exploitation and Marketing Plan for the involvement of partners and future customers (v2) due at the end of the project.

Readers who want to gain a deeper understanding of the Platone Framework architecture are recommended to read D2.1 "Platone Platform requirements and reference architecture" [2]. For gaining a deeper understanding of the regulatory framework D6.8 "Report on the Analysis of the Regulatory and Legislative Framework" [3] and D6.9 "Report on solutions and recommendations for the roll-out of the designed solutions" [4].

2 Assessment of the Platone target groups

The following picture shows the architecture of Platone and its major elements and functionalities. The whole system, comprising all elements developed within Platone is called the Platone Open Framework, which can be freely adapted to the needs of a DSO. The Platone Open Framework has two Blockchain layers. The first one enables the integration of physical infrastructure like flexible assets (PVs, e-vehicles etc.) of customers and measurement equipment on an access platform. Embedded in the IoT and service integration of the physical infrastructure is the device "Light Node" which allows to gather metering data coming from the smart meters of Distributed Energy Resources' (DERs) and receive flexibility activation commands. The second Blockchain layer secures the Platone Market Platform, which serves as a marketplace for flexibility trading for market participants (DSOs, TSOs, aggregators). The Platone DSO Technical Platform allows, with the usage of Phase Measurement Units (PMUs), the installation of new grid monitoring services like state estimation with a data visualization as well as the connection to DSO legacy systems.

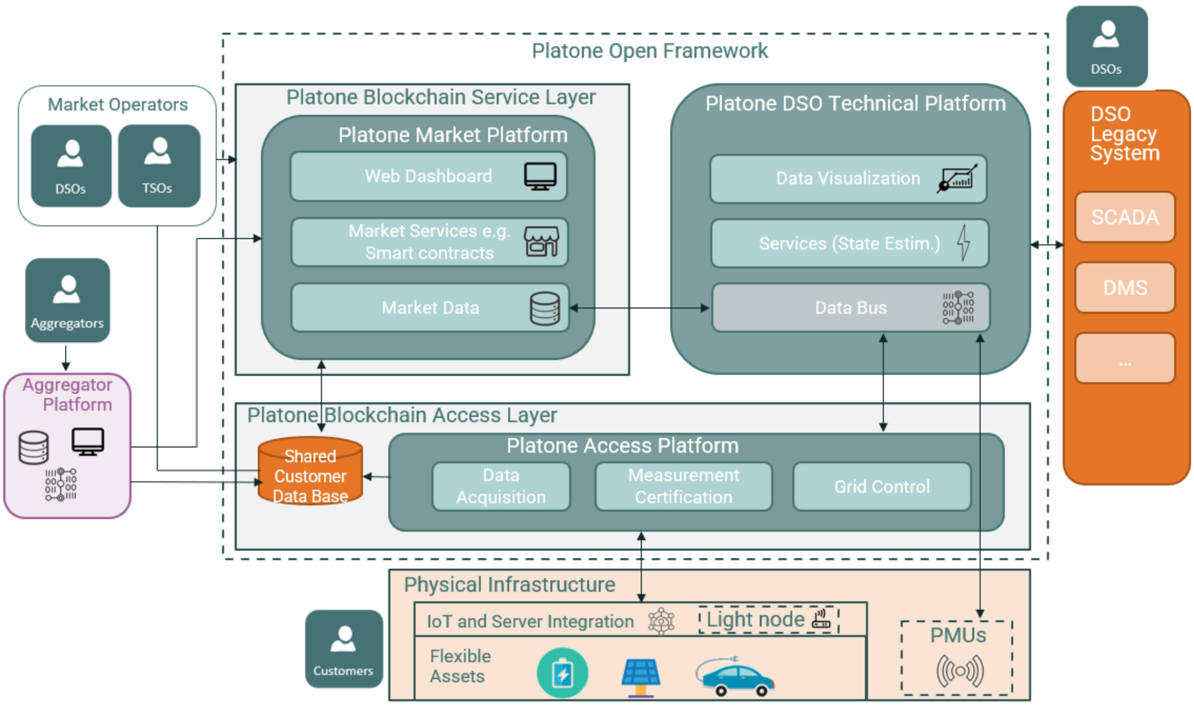


Figure 1: Overview of the Platone architecture with its major elements and functionalities

The goal of Platone is to create a new ecosystem for new market mechanisms for an extensive rollout among DSOs with a large involvement of customers and an active monitoring and management of grids and flexibility markets. With this multi-platform approach of integrating, controlling and commercialisation of flexibilities and offering grid monitoring and control services to DSOs, four main target groups and three stakeholder groups are identified, which are:

Figure 2: Target groups of the Platone Open Framework

The main target group consists of DSOs, TSOs, aggregators and customers, which can be considered as the main users and beneficiaries of the Platone architecture. The stakeholders Research and Industry benefit indirectly from the Platone architecture by the provision of findings, software code or tools. The stakeholder Regulatory Authorities can have benefits by analysing the outcomes of the market schemes adopted in the demos as well as by the recommendations for an optimised regulatory framework.

The following table shows the target groups, their current needs due to the energy transition, and how the Platone architecture addresses those needs.

Table 1: Platone Target Groups

Nr.	**Target group/ Stakeholder**	**Current needs of the target group** *(What are the needs of the target group due to the energy transition)*	**Satisfied need of the target group** *(Why is Platone and its findings/results relevant for the target group?)*
1	DSOs	➢ Tools and knowledge to develop from a plain grid operator to a provider of system services ➢ Cost-efficient and high-quality real-time grid monitoring ➢ Improved grid control to avoid or to react on grid congestions and imbalances ➢ New market design in the form of ○ (regional) market platforms ○ new network tariffs and net billing schemes ➢ New cooperation mechanisms between DSOs and TSOs ➢ Digitization in the form of new communication networks ➢ Adapted regulatory framework	➢ Provision of tools and mechanisms by the Platone's Open Framework Architecture ➢ Platone DSO Technical Platform offers a cost-efficient and easy scalable grid monitoring and control ➢ Small-scale flexibilities for grid balancing or the provision of ancillary is realized by the Platone market platform ➢ Highly secure and traceable way of communication by using Blockchain technology ➢ Recommendations for a new regulatory framework according to the Platone architecture
2	TSOs	➢ More reactive power due to the shut-down of fossil fuel power plants ➢ Flexibilities to solve grid congestions ➢ Constant communication and consultation with the DSO ➢ Organizational and technical framework to take over the role as a market operator	➢ Flexible units can be securely connected and controlled by the Platone Blockchain Access Layer to provide power ➢ Platone market platform creates a safe environment for trading flexible units and a constant communication with DSOs
3	Aggregators	➢ Digitization of the energy system ➢ Platforms to pool and coordinate a huge number of flexible units ➢ Secure and false-proof bidirectional communication technology ➢ Customer engagement for participation	➢ Platone market platform offers, by a Blockchain Service Layer, a secure environment to trade flexibilities ➢ Platone Blockchain Access Layer offers a secure and false-proof bidirectional communication ➢ Platone Shared Customer Database provides the aggregator with all the needed information about the flexibility ➢ Research on customer engagement and organization of workshops

4	Customers	➢ Play an active role in the energy transition ➢ Easy and low-barrier access to offer flexibility ➢ Interest in a financial remuneration of the usage of their flexibility by a third party	➢ Platone Blockchain Access Layer enables the customer to offer the flexibility in an easy and secure way via an aggregator on the Platone Market Platform to DSOs and TSOs ➢ Platone attributes a central role to the customer by conceptualizing multiple engagement workshops
5	Research	➢ Need and request for an open-source and a free-knowledge approach to interchange tools, information and findings across various fields of science and sectors about the energy transition	➢ Offer of various tools and software codes on public repositories e.g. GitHub following an open-source approach
6	Industry	➢ Close cooperation and knowledge transfer between science and industry ➢ Open systems approach e.g. with open interfaces for multiple suppliers with a high scalability	➢ Open-source approach to increase the knowledge transfer to the industry ➢ Platone Open Framework is scalable and open to multiple suppliers and technologies
7	Regulatory Authorities	➢ Adaption of regulation according to new market schemes for ancillary services to encourage participation from DER owners and aggregators ➢ Change regulation to foster new network tariffs reflecting the changing use of the network across various customer groups ➢ Change of regulatory framework to incentivize the reinforcement and digitalization of the grid infrastructure ➢ Adaption of regulatory framework to the new roles and responsibilities of new and existing players in the grid e.g. DSOs and flexibility providers	➢ Proposition of optimizations of the overall regulatory framework for an extended use of flexibilities by DERs ➢ Analysis of the regulatory framework for the usage of new technologies e.g. Blockchain for the grid infrastructure and gives recommendations for changes

The comparison of the current needs of the target groups with the solutions that are created within the Platone project, shows the capability of Platone to fulfil the most urgent and current needs arising due to the energy transition as well as its high value for industry, research and the regulatory authorities.

3 Overview of the Regulatory and Legislative Framework of Platone and its demonstration sites

Chapter 3.1 describes the most relevant themes of Platone that are affected by the legislative framework either on EU or on a national level. First, the theme is brought into context with the Platone project, followed by the regulatory and legislative framework by the EU. The basis for this chapter is deliverable “D6.8 Report on the Analysis of the Regulatory and Legislative Framework” [3], which is recommended for more detailed information. Chapter 3.2 focuses on the demonstration sites of Platone in Italy, Greece and Germany and the national regulatory framework of the corresponding country, followed by the obstacles and gaps of the regulatory framework as well as recommendations for optimization which are most interesting from the perspective of exploitation. More information regarding this chapter can be found in “D6.9 Report on solutions and recommendations for the roll-out of the designed solutions” [4].

3.1 General overview of the regulatory and legislative framework of Platone

For the description of the regulatory and legislative framework of Platone, eight relevant topics were identified, which are illustrated in the following figure. Platone Deliverable 6.8 [3] provides a more in-depth analysis of the eight themes.

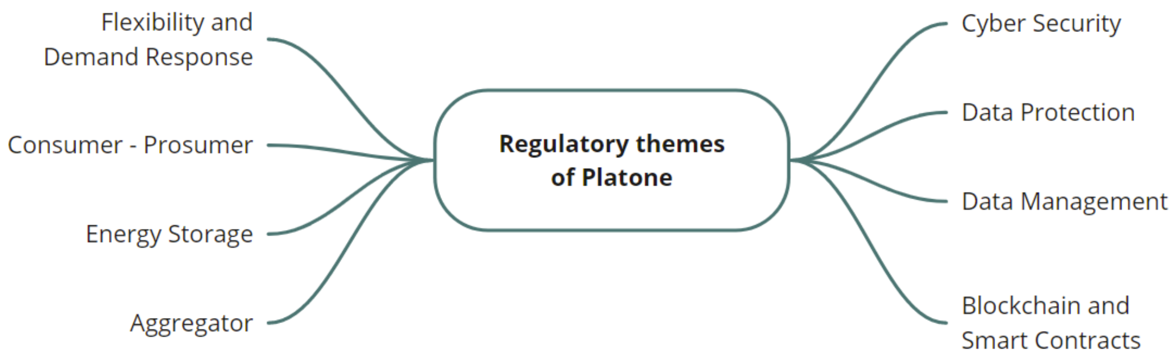


Figure 3: Identified Platone themes for the description of the regulatory and legislative framework

The first identified relevant topic was “Flexibility and Demand Response”. Since Platone aims to evaluate the extensive use of flexibilities on the distribution level by the promotion on a market platform, it is important to examine the correspondent regulatory framework. On the EU level, Demand Response is, among other topics, regulated in the e-Regulation [5] and the e-Directive [6] of the Clean Energy Package [7] (adopted in 2019), which is the fundamental framework for a successful European energy transition. Both, the e-Regulation and e-Directive cover the growing role of DSOs in energy flexibility and demand response as well as a market-based approach to enable DSOs to procure flexibility services to solve grid congestions or to defer grid reinforcements. The directives highlight that DSOs shall act as neutral market facilitators and procure flexibility services in accordance with transparent, non-discriminatory and market-based procedures. Moreover, the cooperation with TSOs in network operation is described. However, rules imposing detailed flexibility requirements, network tariffs, connection agreements and rules for market-based procurement should be defined on a national level by the National Regulatory Authority (NRA) and be consistent with national provisions.

The second relevant regulatory topic is “Consumer-Prosumer”. Platone puts the customer, being consumer or prosumer, in the centre of the energy transition by asking for the flexibility of their assets and encourages all corresponding stakeholders to take part in the energy market. The EU directives of the Clean Energy Package RED II [8] and e-Directive [6] evaluate the role of the consumer and prosumer in this context. In these directives, the EU has for the first time ever established a right for energy consumers (individually or in a community) to both produce and consume their own electricity and obliges its Member States to adapt their national regulations, to enable prosumers to exercise their right. Assuming that required metering points are established, consumers can have more than one electricity supply contract and they are free to buy and trade electricity services independently from their electricity supply contractors.

In Platone “Energy Storage” is used in the low voltage grid to minimize the exchange of electricity by the local network and the supplying medium voltage feeder as well as in the customer level (including communities) for increasing the self-consumption or provide flexibility to the electrical system. The regulatory framework for energy storage systems regarding network integration is only roughly described in the Clean Energy Package, since there is no precise and appropriate definition for energy storage.

The “Aggregator” is a new actor in the electricity systems by aggregating and offering flexibilities of customers to e.g. DSOs for grid balancing in the electrical system. The blockchain-based infrastructure of Platone facilitates aggregators the role to become a market player by the usage of customer data and their flexible assets in a reliable and certificated way. The role of the aggregator is described in the e-Directive of the Clean Energy Package [6] and obliges all member states to ensure that the national regulatory framework encourages the participation of aggregators in the national electricity market. The e-Regulation provides guidelines about the market participation of aggregators, while the Renewable Energy Directive connects renewable self-consumer and energy communities with services that an aggregator can provide.

“Cyber Security” plays a major role in Platone, since new technologies such as blockchain are used and platforms with smart algorithms developed. Cyber security comprises all the safeguards and measurements to defend information systems and their users to unauthorized access, attack and damage. On EU level, cyber security is set by the EU Network and Information Security directive [9], which was developed in 2016. Further measures are described but also still developed on the national level of the EU Member States.

“Data Protection”: in Platone, no personal data is used. Only technical data such as asset descriptions, or measurements are used or stored and this data has no connection to persons. The regulatory framework is given by the General Data Protection Regulation (GDPR) [10] of the EC, valid for all EU member states, and the e-Privacy Regulation, which focuses on the protection of personal data in the electronic communication sector.

In Platone a concept for “Data management” is developed, since Platone aims, among further targets, for an improved grid operation by the usage of flexibilities, which relies on the collection of lots of data. The e-Directive [6] clearly defines data management as the framework of roles and responsibilities of any party in the electricity system related to data collection, processing, delivery, exchange, publishing and access. The e-Regulation of the Clean Energy Package [5], also relevant for Platone, describes that DSOs and TSOs shall exchange all required data regarding the performance of grid assets, the daily operation of their grids and planning of their networks.

The last identified relevant theme is “Blockchain and Smart Contracts” in the energy sector. The usage of Blockchain plays a major role in Platone. Blockchain technology is for example used for the Platone Blockchain Access Layer, which enables the customer to offer its flexibility in a secure way to the DSO. Right now, there is no specific European regulatory framework regarding the application of blockchain technology. There is only a report of the Blockchain Observatory and Forum of the European Union with the title “Legal and Regulatory Framework of Blockchains and Smart contracts” [11], which emphasises the most relevant gaps of the current EU legislation regarding the implementation of Blockchain technology.

3.2 Overview of the regulatory and legislative framework in the demonstration sites with obstacles and recommendations for optimization

The following subchapters deal with the regulatory framework of the three demos of Platone, described according to the eight themes as illustrated in Figure 3: Identified Platone themes for the description of the regulatory and legislative framework. In the last part, the obstacles, resulting from missing or obstructive regulatory framework are listed and recommendations for the optimization are given.

3.2.1 Italy

Short description of demo

The Italian demo will demonstrate a complete local market architecture where an integrated market with new technologies like blockchain or innovative grid equipment are tested and new actors like aggregators, that intermediate between the customers and flexibility market, are enabled. Moreover, the DSOs will become active market participants with the possibility to acquire flexibilities and increase the grid observability.

Regulatory framework relevant for the demo

As stated in chapter 3.1, the regulatory framework for "Flexibility and Demand Response" is described on the EU-level primarily in the e-Regulation [5] and the e-Directive [6] of the Clean Energy Package. On the national level, the national regulatory authority (Italian Regulatory Authority for Energy, Networks and Environment – ARERA) published 2019 the new Italian Despatching Code [12], together with the Consultation Document 322/2019/R/eel [13]. Both documents allow a less restricted flexibility market and are therefore of great relevance for the Italian demo. The guidelines of the documents have two major objectives. The first objective is the identification of the main lines of intervention for the evolution of the dispatching services, due to the increasing emergence of fluctuating and decentralised renewable energy resources. The second objective is the integration of the Italian markets with markets e.g. intraday markets of other European countries, as well as the harmonization and sharing of the services necessary to guarantee the security of the energy system (ancillary services). The theme "Consumer – Prosumer" is described in the EU directives RED II [8] and e-Directive of the Clean Energy Package [6]. The transposition of the directive RED II in national legislation is expected by 30/06/2021. The e-directive will be transferred in national legislation by 31/12/2020, which will predominantly the roles of Citizen Energy Communities and active users. For the national Cyber Security legislation, two resolutions were entered into force by ARERA. Resolution 574/2014/R/EEL [14] implements the integration of the battery storage in the electrical system. Resolution 642/2014/R/EEL [15] defines the functional requirements for storage systems and their proper connection to the grid according to the European legal framework and standards. The role of the "Aggregator" is, with its role and responsibilities according to the Italian legislation, not yet defined. Anyhow, the aggregation of small energy resources is regulated in the Resolution 300/2017/R/EEL [16]. The transposal of the EU directive 2016/1148 [9] dealing with "Cybersecurity" into national law led to Legislative Decree 65/2018 [17]. Furthermore, Italy adopted a National Plan for cyberspace protection and ICT security [18]. The Italian government has recently taken another step towards the implementation of an extensive national cyber-security framework through the adoption of the Law Decree n. 105 [19] of September 21st, 2019. With respect to the General Data Protection Regulation (GDPR) of the EU, the national authority enacted the Legislative Decree no. 101 in 2018 [20]. Within the demo, only technical data (no personal data) is transferred to a third party or project partners. "Data Management" encompasses primarily the handling of energy and personal data, technical data, research data and the dissemination of data. Customer's energy and personal data is protected by the GDPR [10] as well as the national legislation Legislative Decree no. 196 of 2003 [21]. The legislation is only relevant for participants of the flexibility market. Before participation, they are duly informed about the handling of their personal and energy data. They also have the right to access their data any time, which is ensured by the Energy Efficiency Directive 2012/27/EU [22], setting out the rules in relation to metering, as well as the national Legislative Decree no. 102/2014 [23]. In this context, ARERA issued Resolution 87/2016 [24], which defined the functional requirements of Smart Meters that collect technical data as energy consumption. The dissemination of data which is primarily data based on energy consumption of participating customers, is restricted by the Antitrust national laws. In consequence, all sensitive data disseminated within as well as outside the project is anonymized. While

"Blockchain and Smart Contracts" in the energy sector are not clearly regulated by the EC, Italy presses forward with the Law n.12 of 2019 [25] at which both instruments are given a full legal value.

Obstacles and gaps of the regulatory framework and recommendations for optimization

In conclusion, one of the main regulatory gaps in the Italian context, for the local flexibility market is the complete and shared definition of the roles and responsibilities of DSOs, BRPs, BSPs and aggregators. The recommendation goes to ARERA to gather the findings from the National and European demos on this topic and formulate laws and resolutions to close this gap.

3.2.2 Greece

Short description of demo

The field demo in Greece focuses primarily on the customer's flexibility with indirect control methods. The main objectives are to economically optimize the use of DERs to provide ancillary services and market participation to TSOs. Also, an advanced observability, automation and controllability for the DSO is going to be enabled. In this context, variable network tariffs will play a crucial role.

Regulatory framework relevant for the demo

As described in chapter 3.1, the regulatory framework for "Flexibility and Demand Response", in the context of the Greek demo dealing with DSO's procurement of flexibility, aiming at a cost-effective grid operation, is described in the e-Regulation [5] and the e-Directive [6] of the Clean Energy Package. Another guideline framing the provision of flexibility of RES producers through aggregators is the Electricity Balancing Guideline [26]. A national legislative framework is so far not in force. The theme "Consumer – Prosumer" plays in the Greek demo an important role, since consumers as well as prosumers are actively taking part in the electricity market with the aggregator in-between coordinating the retail and control process. This cooperation is regulated by a contract by both parties, which defines the legal terms. This constellation is regulated within the RED II directive of the EC [8] According to national law, DSOs are obliged to provide 80 % of their customers with a telemetering system, facilitating the creation of energy communities. Energy communities themselves are outlined in Greek law 4513/2018 [28], also defining their role in energy markets. "Energy storage" are not considered for the implementation of the Greek demo. Nevertheless, national legislation (national law 4513/2018 [27]) would provide a clear framework for the usage of energy storage systems. "Aggregators" play a key role in the Greek demo, enabling customers to offer their flexibility in day-ahead and intraday-day markets. On EU level, the regulatory framework is given by the e-Directive [6] and the Electricity Balancing Guideline [26]. Also, the Energy Efficiency Directive [22] is relevant, which defines the term aggregator, and was put into national legislation with law 4342 in 2015 [29]. "Cyber Security" plays an important role in the Greek demo with the implementation ICS-SCADA systems, metering infrastructure and data exchange between various stakeholders. In this context, the Council Directive 2008/114/EC [30] on the identification and designation of European Critical Infrastructures points not only out the need of the protection of such infrastructures but also helps to identify the actors, having the responsibility to ensure cybersecurity measures. "Data protection" plays only a minor role in the Greek demo, since only anonymized technical data is used. The handling of smart metering data is regulated by the e-Directive [6]. "Data management" in the Greek demo stands for the collection and elaboration of data by the DSO, which is on the EU level regulated by the EED, but on national level by the Law 4342/2015 [31]. The exchange of data by the actors DSO, TSO and aggregators is regulated by the e-Regulation [5]. "Blockchain and Smart Contracts" in the energy sector is a cross sectional topic for the Greek demo. The technology is used for data certification as well as for security and integrity. So far, there is neither national legislation nor a national strategy for the application of Blockchain, but since more and more applications arise, rules and guidelines are expected to be introduced soon.

Obstacles, gaps and recommendations for the optimization of the regulatory framework

As an overall conclusion, the lack of regulation in terms of Blockchain technology in the energy sector poses an obstacle, even more since many legislative steps are still expected to be taken. Another identified issue is, that in law 4342/2015 the role of the aggregator is not clearly stated, especially when it comes to the representation of RES producers and high efficiency CHP units in the Greek energy market.

3.2.3 Germany

Short description of demo

The German field demo focuses on the implementation of an Energy Management System (EMS) with the application of local balancing mechanisms and centralized grid operation. Also, the arrangement of flexibilities in local networks in connection with the interaction with the high-level networks will be addressed. Furthermore, a temporal uncoupling of low and medium voltage grid will be evaluated by handling the energy supply and export in bulk packages instead of real-time exchange.

Regulatory framework relevant for the demo

The renewable energy act (“Erneuerbare Energien Gesetz” or “EEG”) [32] in §12 EEG states that grid operators are obliged to connect all sources of renewable energy to their network at request and ensure that their network offers enough hosting capacity to accommodate all energy that is produced under the EEG. This includes the obligation to optimize, expand and reinforce the network whenever necessary. The Energy Industry Act (Energiewirtschaftsgesetz) [33] additionally claims in article 11.1 that the DSO as operator of energy supply networks are obliged to operate, maintain and optimize, strengthen and expand a safe, reliable and efficient energy supply network without discrimination, as far as it is economically reasonable. However, the expansion and reinforcement of the grid results in high grid fees for the customer. The application of smart grid technologies has potential to increase the hosting capacity of the existing grid for renewables without expansion or reinforcement.

Therefore, the German demo foresees the integration of private customer households, volunteering to provide their flexible loads. The regulatory framework is given by the directive 2012/27/EU [22], stating that EU Member States shall ensure that incentives hampering the participation in demand response shall be removed, and the Energy Industry Act (§14) [34] by German legislation, which states that network operators are obliged to offer a discount on grid charges for customers who offer flexibilities to the System Operator. An additional technical option to balance the grid is the curtailment of RES, which is regulated by the German Renewable Energy Act (Erneuerbare-Energien-Gesetz – EEG). However, Avacon does not intend to make of this mechanism, since it does not foster the increase of renewable generation. “Energy storage” is in the German demo primarily important for the DSO. The regulatory framework is given by the directive 2019/944/EU [6], stating that DSOs shall not own, develop, manage or operate energy storage facilities. Nevertheless, DSOs are allowed still to operate an energy storage system, when it is a fully integrated network component and the national regulatory authority has given its approval. This regulation just has been implemented into the Energy Industry Act of the German regulation. The DSO in Germany is just allowed to own and make use of storage that are fully integrated network components and whose operation and ownership could not be tendered successfully. According to “Cybersecurity” Germany has issued a variety of different laws, ensuring a high level of cyber security and data protection. For the German demo, only the GDPR and Federal Data Protection Act are relevant. When it comes to “Data protection” and “Data management”, e.g. when dealing with customer data, the GDPR is applied as well is the Federal Data Protection Act. As a supplement, the demo leader and DSO Avacon applies internal guidelines about data protection and company policy privacy. To ensure a regulatory compliant usage of “Blockchain and Smart Contracts”, also the GDPR and the Federal Data Protection Act [35] is supplied. Smart contracts are not in scope of the German demo.

Obstacles, gaps and recommendations for the optimization of the regulatory framework

Overall, the German regulatory framework of the energy sector, mainly consisting of the Renewable Energy Act and Energy Industry Act, has been expanded widely. Nevertheless, the planning and operation of the German demo has revealed obstacles and gaps. First, flexibility mechanisms, e.g. when using equipment like remote devices for control methods, need a clearer regulatory framework. Secondly, the regulatory framework for the usage of batteries by DSOs should be on the one hand facilitated and on the other hand contain incentives for various functionalities e.g. for grid control. Such a change would encourage battery owners to become more active and provide their flexibility to the DSO.

4 Key Exploitable Results of Platone

The following table gives an overview of all KERs and the relevance of the KER for the various target groups, which are TSOs, DSOs, aggregators, customers, researchers and business actors. The mark x in the table shows when the target group can directly utilize the KER for operational or research activities, the mark (x) shows when the target group does not directly utilize the KER but benefits indirectly from the usage or implementation.

Table 2: Overview of all Key Exploitable Results (KER) of Platone, the TRL-levels and the relevance of the KER for the target group

Key Exploitable Result (KER)	TRL start	TRL end	TSO	DSO	Aggre-gators	Custo-mer	Research	Industry
Platone Open Framework	0	7	x	x	x	x	(x)	(x)
DSO Technical Platform, Platone	3	7		x			(x)	(x)
State Estimation Tool	5	7		x		(x)	(x)	
Platone Market Platform	5	8	x	x	x	x		
Network Tariffs model for optimal control of DERs and ancillary services to the TSO	6	7	(x)	x		(x)		
Local Flexibility Market (outstanding)	1	3	x	x	x	x	(x)	(x)
Blockchain Access Layer (1)	5	8	(x)	x	x	(x)	(x)	(x)
Blockchain Access Layer (2)	6	8	(x)	x	x	(x)	(x)	(x)
Phasor Measurement Unit	6	7	x	x			(x)	(x)
Local Flexibility Controller	3	7		x				
Light Node	3	7		(x)	x	x		
Software package for Use Case Description Generation	5	8	(x)	(x)	(x)		x	(x)
Common Information Model (CIM) models	4	4	x	x	(x)		x	x
Open Datasets	0	7	x	x	x		x	x

The target group "Research" comprises institutions and universities. The target group "Industry" includes business actors who could serve as providers for hard- or software or as providers for other services e.g. telecommunication services.

More details about each of the KERs can be found in the following chapters, which include subchapters with detailed description of the KER, its target group and why it is of relevance for the target group as well as one subchapter about the exploitation strategy.

It is important to mention that two different Blockchain Access Layers (BAL) are developed by two different project partners, though fulfilling the same functionalities. The first BAL is used and tested in the German and Greek demo. The second BAL is used and tested in Italy.

4.1 Platone Open Framework

4.1.1 Description

The Platone Open Framework is based on a two-layer blockchain architecture and allows easy integration of both the data coming from the devices installed on the physical infrastructure of distribution grid or from any other external platform.

The Platone Open Framework offers a configurable and customizable architecture that can be exploited by the DSOs for empowering their solutions.

In particular, the Platone Open Framework includes:

- the Platone Blockchain Access Layer (BAL), that provides an interoperable layer for the integration of IoT devices and external Data Server, ensuring data privacy and security mechanisms;
- the Platone DSO Technical Platform (DSOTP), that allows the integration of external platforms as DMS, as well as specific DSO services as State Estimation Tool and Data Visualisation
- the Platone Market Platform, that enables a transparent and shared Flexibility Marketplace, based on blockchain technology, opened to all the Market Participants (TSOs, DSOs and Aggregators)

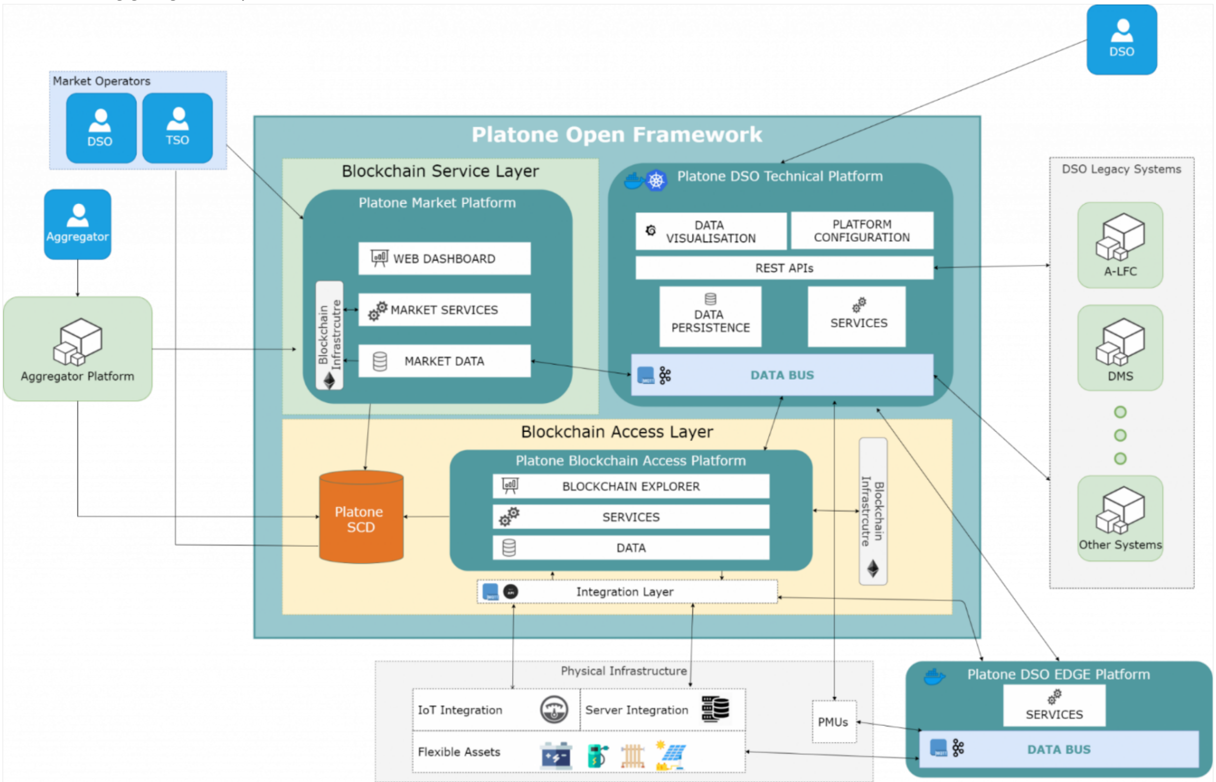


Figure 4: Platone Open Framework Architecture

Engineering is responsible of the implementation and the release of the integrated framework but shares with the other consortium partners, in particular with RWTH, the expertise about the integration and the interoperability mechanisms.

The Platone Open Framework was designed starting from the Platone Open Architecture specifically for the Platone project, thus the starting TRL is 0. The main goal within the project is to demonstrate the usability, flexibility and scalability of the framework during the demonstration pilots and in the scalability and replicability assessment, thus bringing the end TRL to 7.

4.1.2 Target group

The target group of the Platone Open Framework is mainly the DSOs but also other involved stakeholders in the energy transition phase. Platone aims to support the observability of the network and the exploitation of the flexibility for addressing distribution grid flexibility/congestion management, through innovative energy market models involving all the possible actors at many levels (DSOs, TSOs, customers, aggregators).

Of particular interest for the energy stakeholders is the key role played by the blockchain technologies and smart contracts since they are present in both the access layer and the service layer.

The usage of the blockchain technology at these two levels brings several interesting advantages:

- new schemas of coordination among customers are possible such as Peer2Peer trading,
- transparent unmodifiable data management and sharing is preserved and guaranteed.
- multi-party data sharing can be seamlessly extended to data collected in the field for operational purposes and not for market reasons.

4.1.3 Exploitation strategy

The release of the Framework includes, as well as the individual platforms (DSOTP, Market Platform and BAL) integrated with each other, also a series of guidelines on the use of mechanisms and standards for achieving a high interoperability level.

The Platone Open Framework can be used entirely or in part, according to the configuration that best suits ones' needs. A demonstration of this flexibility and openness will be carried out within the project duration in the three different demo sites (Italy, Greece and Germany). In fact, each demo will use different framework configurations, starting from the open one released in WP2, and will install it at its demo site.

The integrated Framework was already demonstrated in RWTH lab and specific workshops were organized with the demo partners and other interested stakeholders (e.g. the University of Alberta) for showing the benefits and advantages that the framework offers, as well as technical details for the integration.

The Platone Open Framework was already disseminated to external stakeholders during conferences using presentations and was described in two scientific publications discussed during CIRED conferences (2020 already presented, 2021 will take place in October).

ENG foresees to present the Platone Open Framework during relevant conferences and workshops.

The long-term exploitation of this asset requires a more in-depth evaluation. It is composed by many platforms, components and interoperability mechanisms, not all developed or owned by ENG.

However, Engineering will provide continuous support for the maintenance and integration of the framework during the project and will evaluate solutions for exploiting the results, to increase the company's expertise beyond the project.

4.2 DSO Technical Platform

4.2.1 Description

The Platone DSO Technical Platform is an open-source platform for the deployment of distribution grid services. The platform and its services are designed as a micro service-based platform architecture that allows the deployment of services such as state estimation or load prediction. Furthermore, the platform aims at an enlarged grid observability by providing a visualization of measured and predicted data. The initial platform architecture as well as the underlying cloud-native software stack were taken up from the previous H2020 project SOGNO. Within Platone, the DSO Technical Platform is further developed by the Institute for Automation of Complex Power Systems (ACS) at RWTH Aachen. Besides the integration of the existing platform architecture into the Platone Open Framework of Platforms (including Platone Market Platform and Blockchain Access Layer), the underlying infrastructure software stack of the platform is extended and updated in order to allow flexible deployment scenarios from cloud to on-premises deployments. In addition, more scalable alternatives to different components have been evaluated and introduced. Furthermore, new services such as state estimation, load prediction, and energy-community balancing that are developed by RWTH and NTUA Universities are integrated into the platform. The platform and its services are tested in the demos of HEDNO (WP4) and Avacon (WP5) in order to ensure a TRL of 7.

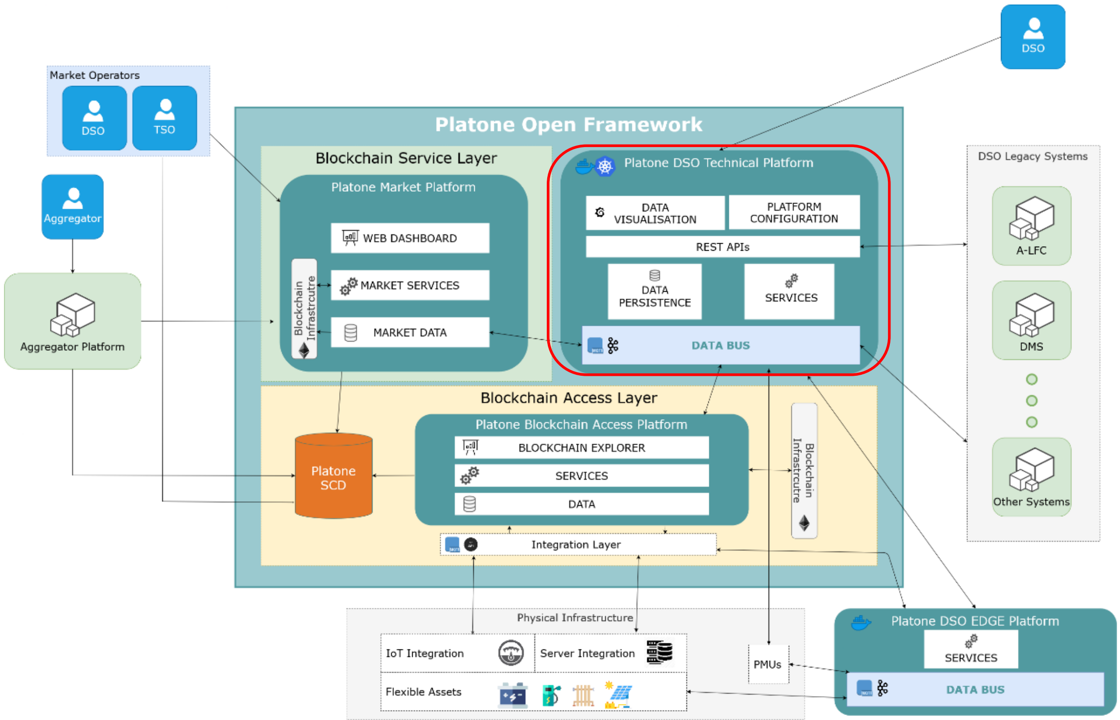


Figure 5: DSO technical platform within the overall Platone framework

4.2.2 Target group

The DSO Technical Platform targets DSOs in need of a software stack to deploy advanced services such as state estimation, fault location isolation and service restoration, microgrid operation, etc. In particular, there is a growing interest in the exploitation of such advanced grid services to improve the observability and operation of the grid. The DSO Technical Platform serves as an open-source environment in which a DSO can install these services without overcoming the burden of defining this operational software stack on its own. The DSO Technical platform also provides different deployment approaches (including private-cloud and on-premises deployments) to provide the system operator with the needed flexibility in fulfilling regulatory requirements. Finally, the open-source nature of the DSO Technical Platform allows custom technical adjustments and fosters the development of additional services by both: industry and academics.

The platform can also be of interest of other business actors that could provide the platform as a service to a DSO. One example in this direction is given by large component manufacturers and providers of software for automation that could use the Platone solution as open integration platform. Thanks to the structure of the 5G network, another example of business actor are telecom companies that could offer automation as a service to a grid operator as already envisioned as business case in SOGNO.

4.2.3 Exploitation strategy

During the course of the project, RWTH is directly in contact with the project partners with respect to the necessary development and deployment phases. A set of workshops and meetings have been held with the project partners including DSOs, NTUA and Engineering to introduce the DSO Technical Platform and its functionalities as well as its measurements integration within the overall Platone architecture.

Besides that, RWTH initiated the launch of SOGNO as a Linux Foundation Energy (LFE) project. LFE fosters neutral, open technical collaboration by hosting open-source projects like SOGNO in the energy sector. In addition to open-source software, the Linux Foundation also enables technical project communities building open standards, open hardware, open data, and open specifications. From the Platone side, RWTH actively contributes updates and extensions that are made on the code base of the DSO Technical Platform to the SOGNO LFE project which, as an actively contributing community, is key to the success of such an open-source initiative.

4.3 State Estimation Tool

4.3.1 Description

The State Estimation (SE) tool is a distribution system state estimator developed within the framework of the Greek demo, which is designed to ensure the observability of the Mesogeia site, that is, the testbed of the Greek demo, and estimates its actual, operating state in real-time conditions. The SE tool is based on the well-established weighted least squares method and exploits actual measurements obtained throughout the Mesogeia site, as well as pseudo-measurements generated via load forecasting and estimation of the power output of renewable energy resources.

The current TRL of the SE tool is 5. A final TRL equal to 7 is targeted.

The responsible party is the National Technical University of Athens (NTUA). HEDNO is the main cooperating partner for the development of the SE tool.

4.3.2 Target group

The SE tool is a functionality which can be exploited by HEDNO in order to satisfy the fundamental need for real-time situational awareness of the Mesogeia pilot site.

Under a broader perspective, DSOs can benefit from the use of a state estimator such as the SE tool, since not only it captures the real-time operation of the grid state, but also it comprises a key enabling function for the operation of advanced distribution applications, such as Volt/VAr control, fault location, network reconfiguration, service restoration and, importantly, the operation of real-time markets via the exploitation of the estimated grid state as basis for determination of locational market prices considering any constraint violations. Additionally, the output of the SE tool can be leveraged in order to conduct offline studies, indicatively DER scheduling, demand response programming, offline contingency analysis, optimal power flow analysis, scheduling of condition-based maintenance, and billing inference.

Evidently, the final beneficiaries of the increased quality of the forenamed applications and services are the end-users, i.e., consumers, prosumers, DER owners etc., since the reliability and quality of power supply will be reinforced, the energy market will operate more efficiently based on accurate images of the actual grid state and the application of flexibility strategies will result in reduction of operational costs and minimization of energy waste.

4.3.3 Exploitation strategy

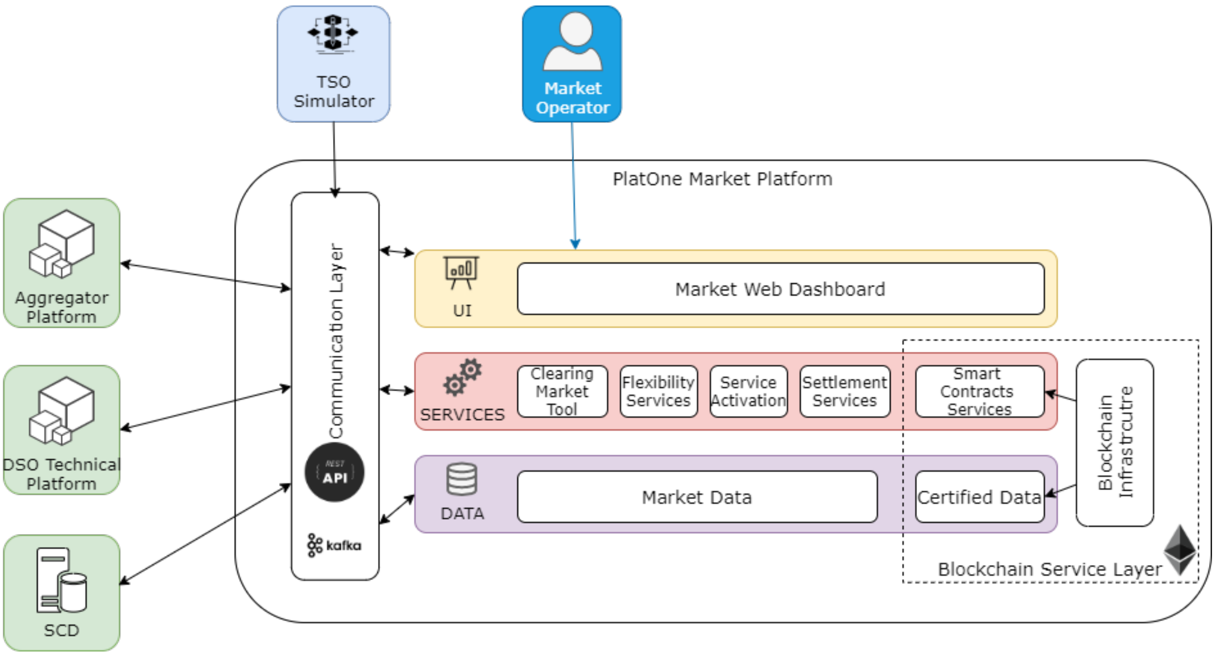
Since HEDNO is one of the partners of Platone, there is already direct interaction and collaboration with NTUA within the framework of development of the SE tool. Considering that at the same time HEDNO is the one and only DSO currently in Greece, there is no actual need for additional dissemination activities. The demonstration of the SE tool and the related outcomes will be part of the expertise HEDNO will gain. The SE tool, developed by NTUA, will remain at HEDNO's premises after the project completion. Further research on the SE tool and possible extensions can be supported by NTUA beyond the project duration. In addition, if any DSO from another country shows interest for the Greek Demo's

SE tool, both HEDNO and NTUA are open to potential exploitation discussion and/or collaborative research.

4.4 Platone Market Platform

4.4.1 Description

The Platone Market platform is one of the core components of the Platone Open Framework (as described in D2.1 [2]). The Market Platform is a blockchain-based platform that enables the management of wide geographical area flexibility requests from TSOs and local flexibility requests from DSOs. The flexibility requests are matched with offers coming from aggregators accordingly to pre-defined rules and dispatching priorities, in order to solve grid issues. All the market operations are registered and certified within the blockchain service layer, ensuring a high level of transparency, security and trustworthiness among all the market players.



The partner responsible for the implementation, integration and deployment of the Platone Market Platform is ENG.

The Platone Market Platform does not start from scratch, since it is based in other blockchain platform developed by ENG in other relevant H2020 projects (e.g. eDream) and the starting TRL is 5. The goal within the Platone Project is reaching a final TRL 8.

4.4.2 Target group

The Platone Market Platform targets all the market participants (DSOs, TSOs, Aggregators, Customers) that aim to create an open market for the flexibility. The Platone Market Platform serves as an open market environment in which market participants can participate to day-ahead and/or real-time market sessions.

The platform covers the role of market operator, a party that provides a service whereby the offers to sell electricity are matched with bids to buy electricity (based on Regulation on the internal market for electricity (EU) 2019/943 [5].

The main characteristic of the Platone Market Platform is providing a fully transparent and secure flexibility market, in which all the market operations (bids, offers, market results and settlement) are certified using blockchain technology. Furthermore, the innovative settlement mechanism, based on blockchain tokenisation, allows a more engaged involvement of the end consumers into the flexibility provisioning.

4.4.3 Exploitation strategy

A demo version of the Platone Market Platform is currently available in the ENG cloud infrastructure. This demo version was already used for a live demo to the partner of the consortium and will be used for recording a video to be presented during the Platone Mid-Term conference to the external stakeholders in September 2021.

The Platone Market Platform is available as open-source and three different versions of the platform will be released within the Platone project. The first version is already available here: https://git.rwth-aachen.de/acs/public/deliverables/platone/platone-market-platform

The platform could be deployed as a stand-alone platform or integrated with other platforms (e.g. the Platone Open Framework). Guidelines for the deployment and the integration are also available as part of the documentation.

In order to be integrated in the Platone Open Framework and in the Platone demos, a specific technical workshop was arranged in WP2, as well as specific presentations of the Platform from technical and non-technical point of views, for presenting the concept to the partners of the consortium (including DSOs, Aggregators and other stakeholders). In addition, ENG foresees to present the Platone Market Platform during conferences in which the application of the blockchain technology in the energy domain is relevant.

More generally, since the Platone Market Platform embodies ENG overall strategy, it could be incorporated into the company innovation process in collaboration with the business unit with the aim to exploit the asset, leveraging in the blockchain technology, to commercialize the new technology as extension of the company offer portfolio.

4.5 Network Tariffs model for optimal control of DERs and ancillary services to the TSO

4.5.1 Description

The network tariff model is a tool that is developed within the Greek demo and aims to assist in flexibility utilisation by DSOs. The tool utilises machine learning and advanced optimisation techniques in order to design tariffs that will motivate beneficial DER behaviour in terms of reducing operational problems.

Some of its key features are: cost reflectivity, incentives for efficient network use, transparency and understandability, applicability, and limited complexity.

The current TRL of the SE tool is 6. A final TRL equal to 7 is targeted.

4.5.2 Target group

This tool is aimed at National Regulatory Authorities (NRAs) and DSOs. It allows for a regulatory framework where DSOs can ensure their required income through tariffs and at the same time reduce their operational costs. It benefits the NRA since it provides a clear framework for defining the income and tariffs that ultimately benefits the end-users, i.e. the customers, which is who the NRA serves. The customers are benefited as a whole by reduced electricity bills achieved by the increased efficiency the tool provides, although individual customers might incur higher bills due to their schedules contributing disproportionally to operational costs.

4.5.3 Exploitation strategy

The interested party will be approached directly. The DSO (HEDNO) is already part of Platone and has direct collaboration on the development and results of tool. The tools demonstration and outcomes will be part of the expertise HEDNO will obtain. The tool, developed by NTUA, will remain at HEDNO's premises after the project and can be researched further.

The NRA can be also approached directly with the outcomes of the Platone demonstration in Greece, where the tool will be tested. The lessons learnt from the demonstration can be part of the ongoing discussion about revising the current regulatory framework on tariffs and DSO income.

4.6 Local Flexibility Market

4.6.1 Description

The Italian demo aims to break down the barriers to the flexibility market and to increase the level of participation of the distribution network customers to flexibility market. This kind of approach fosters an active participation of Distributed Energy Resources connected to the distribution network to support transition toward electric energy and enable System Operators to maintain safe and efficient operation of the whole electrical system. The Platone Italian Demo will pursue this objective by testing the implementation of a Local Flexibility Market where DSO and TSO will place on the market their own request for flexibility (to solve a grid issue) and all customers can offer through the aggregator their flexibility services, participating actively in the market and having an economic benefit thanks to their activities.

This is done through the implementation of the system architecture in which different phases are carried out.

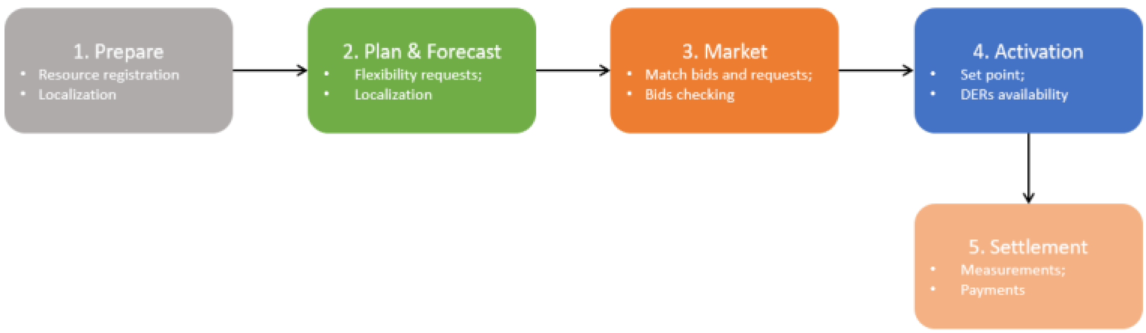


Figure 6: Main phases of Local flexibility Market implementation (Platone Italian Demo)

1. Preparatory phase: this phase includes resources' registration and localization. At the moment of the registration, the Aggregator defines the services that the unit can perform according to the requirements set by the system operator and grid localization, to determine where the resource is able to deliver energy. Once the services and the providers are qualified, the system operators can use the bids of these parties to solve the network issues.

2. Forecasting phase: the system operators plan the grid utilisation forecast (day-ahead and near real time) defining the flexibility requests that can be used for dealing with the issues. Forecasting is undertaken in different timeframes, so the accuracy of the predicted flow of electricity in a certain area improves as the time passes. The forecasts are updated and performed up until real time sessions (using real-time weather data and remote monitoring devices on the grids). It is necessary for system operators to have access to good schedules with relevant locational information, to perform proper forecast for grid management and make efficient and secure decisions.

3. Market Phase: the bids and the requests can be collected and matched for day ahead session and for soft real time sessions. The available bids are efficiently sorted in a merit order list to ensure economic efficiency. Afterwards, the technical evaluation of the bids is done by the DSO checking the local grid limits.

4. Activation Phase: After collecting and evaluating the bids in the market phase, the flexibility bids are activated, sending the set-points to DERs located in the critical area and the congestion or the voltage violation is monitored. The evaluation of the bids will be continued also after activations, so that a granular monitoring of the energy moved is guaranteed. This is done based on real-time measurements.

5. Settlement Phase: The measurements of the activated flexibility should show whether the service is delivered. When a service is delivered by the Aggregator the amount of flexibility must be established, and the flexibility must be paid by the system operator. If the service is not delivered or does not respect the agreed parameters, a penalty is possible. The amount of flexibility delivered is determined by evaluating the data coming from smart meter at the connection point and compared with a baseline. The baseline is the total energy, without the flexibility invoked. The difference between the baseline and the measurements is allocated to the Aggregator.

The system is made of different components with higher TRL, but it can be assumed that the system implemented at the moment started from a TRL 1 and will arrive at a TRL 3.

4.6.2 Target group

Several actors will be involved and will benefit by the implementation of a Local Flexibility Market.

First of all, the TSO and DSO will be able to request flexibility directly to the DERs involved in the market, reducing the cost related to the energy system. The implementation of a Local Flexibility Market can contribute to solve grid issues, improving the safety of the whole energy system.

Users will be an active part of the process offering their own flexibility to the market, contributing to the grid management and obtaining benefits from their activities.

Through the implementation of the Local Flexibility Market, the aggregator will be able to manage a higher number of resources (the ones connected to the distribution grid), than by just relying on his existing system. In this way, the aggregator can enrich its interests and exploit local resources in a more efficient way through new businesses and new earnings.

4.6.3 Exploitation strategy

If the results of the testing phase are satisfactory after the end of the project, then the functionality and processes of the Platone Local Flexibility Market would potentially be implemented and integrated in the existing electricity market. This will make the Energy market more inclusive, efficient and flexible in terms of use of energy resources with the involvement of multiple actors for the different type of roles present in this type of market.

4.7 Blockchain Access Layer (German and Greek demo)

The Blockchain Access Layer (BAL) described in the following subchapters, is implemented and tested in the German and Greek demos.

4.7.1 Description

The Platone BAL is one of the core components of the Platone Open Framework. It is a blockchain-based layer that includes two different components: the Platone Blockchain Access Platform, which allows the integration of the data coming from the physical infrastructure, adding a level of security, transparency and trustworthiness thanks to the blockchain technology and smart contracts, and the Platone Shared Customer Database, which contains all the energy data (e.g., measurements, set points, etc.), providing access to the data to all the stakeholders involved, implementing data security, data privacy and data access policy mechanisms.

The Platone BAL focuses on the integration, modelling, securing and certification of different energy data coming from the physical infrastructure, ensuring data integrity, and avoiding data tampering.

The energy data collected, harmonized, and certified is available for all the energy stakeholders involved as well as external platforms and services (e.g. the Platone DSO Technical Platform), who need to use this data, within the Platone Shared Customer Database.

The Platone Shared Customer Database includes rules and mechanisms for defining a data access policy as well as security mechanisms for ensuring data protection and data privacy.

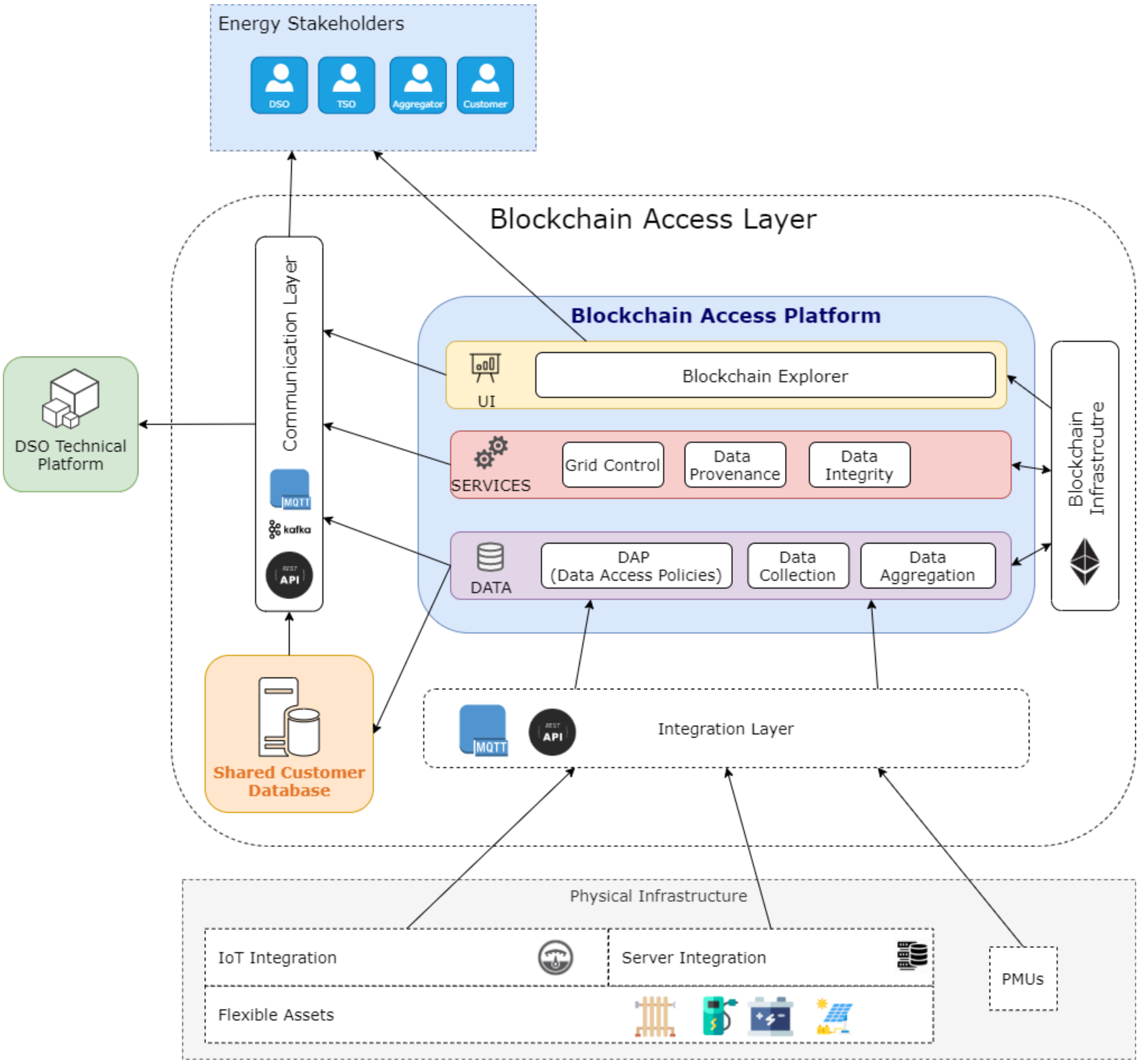


Figure 7: Overview of Blockchain Access Layer

The partner responsible of the implementation, integration and deployment of the Platone BAL is ENG.

The Platone BAL does not start from scratch, since it is based in other blockchain platform developed by ENG in other relevant H2020 project (e.g. eDream) and the starting TRL is 5. The goal within the Platone Project is reaching a final TRL 8.

4.7.2 Target group

The Platone BAL targets all the energy stakeholders (DSOs, TSOs, Aggregators, Customers) that need to have a secure and transparent solution for integrating and sharing any energy data (e.g., measurements, set points, etc.), providing access to the data to all the stakeholders involved, implementing data security, data privacy and data access policies mechanisms.

4.7.3 Exploitation strategy

The Platone Blockchain Access Layer is available as open-source and three different versions of this component will be released within the Platone project. The first version is already available here: https://git.rwth-aachen.de/acs/public/deliverables/platone/platone-blockchain-access-layer

The Platone Blockchain Access Layer could be deployed as a stand-alone component or integrated with other platforms (e.g. within the Platone Open Framework). Guidelines for the deployment and the integration are also available as part of the documentation.

In order to be integrated in the Platone Open Framework and in the Platone demos, a specific technical workshop was arranged in WP2, as well as specific presentations of the Blockchain Access Layer from technical and non-technical point of views, for presenting the concept to the partners of the consortium (in particular to DSOs).

The Platone Blockchain Access Layer was already presented to the partner of the consortium in a live demo as well as using specific detailed presentations during many technical workshops. It was also disseminated to the University of Alberta, with the aim of evaluating its use and replicability and during the FIT Lyon conference at June 2021 to an audience of students and start-ups interested in the application of blockchain technology. A demo version of the Platone Blockchain Access Layer is deployed in the ENG cloud infrastructure for testing purpose or for being presented to external stakeholders.

In addition, ENG foresees to present the Platone Blockchain Access Layer during conferences in which the application of the blockchain technology in the energy domain is relevant (as already done in the FIT Lyon conference).

More generally, since the Platone Blockchain Access Layer embodies ENG overall strategy, it could be incorporated into the company innovation process in collaboration with the business unit with the aim to exploit the asset, leveraging in the blockchain technology, to commercialize the new technology as extension of the company offer portfolio. The exploitation of the Blockchain Access Layer therefore follows the same strategy as pursued for the Platone Market Platform.

4.8 Blockchain Access Layer (Italian demo)

This Blockchain Access Layer (BAL), developed by APIO, is only used in the Italian demo. Since the BAL was already in usage before Platone started, it was decided to further develop the existing BAL instead of implementing a new one. With the BAL already in place, the development is already further advanced regarding commissioning and testing (certification of Smart Meter measurements, management of reception and certification of the set points etc.).

4.8.1 Description

The Blockchain Access Layer (BAL) is an architectural layer that adds a further level of security and trustworthiness to the framework. It certifies data coming from the Light-Node device and runs Smart-Contracts.

It enables a full data integration chain, including data collection, data quality and data provisioning with the Light Node.

The Blockchain Access Layer constitutes the Access Layer with the Light Node and the Shared Customer Database. In fact, it connects the Light Node to the Shared Customer Database ensuring, by means of timestamping features, the immutability of data along the whole path.

The Blockchain Access Layer consists of a five-layer architecture:

- **UI Layer** includes an easy-to-use web dashboard that allows all the stakeholders to explore Blockchain Transactions and DSOs to monitor the Light Node’s status;
- **Services Layer** provides the Shared Customer Database communication, Timestamping services and Smart Contract Services;
- **Data Layer** provides the management of the Blockchain Access Layer and Light Node data and the registration of Timestamping Information of Light Node (Metering and Set-Point).

- **MQTT BROKER** provides communication channel with the connected Light Node;
- **Blockchain Layer** provides the Distributed Ledger Technology (DLT) features, in Blockchain Infrastructure transactions are arranged in blocks, and placed in a P2P network.

The initial TRL stood at 6. At the end of the project, the TRL is expected to reach 8.

4.8.2 Target group

The target groups are the different actors of the flexibility market that Italian Demo is building up (from the user to the DSO). The interaction between Light Node and Blockchain Access Layer makes possible to work with the data coming from the users. It enables a full data integration chain, including data collection, data quality and data provisioning with the Light Node thanks to the timestamping functions, ensuring immutability of data along the whole path. The Blockchain Access Layer and the Light node form the Access Layer, a data exchange infrastructure among flexible DERs, platforms and stakeholders within demo architecture. The Blockchain Access Layer acts as a secure path connecting the Light Nodes to the Shared Customer Database.

4.8.3 Exploitation strategy

During the course of the project, the Italian Demo has implemented the Blockchain Access Layer thanks to the cooperation of the Italian partners. ARETI and APIO have implemented and coordinated the development and deployment phase of this architectural layer integrated in the Access Layer. Its functioning will be perfectly included in the all process that will unlock the flexibility market.

The Blockchain Access Layer is in a testing phase. If the results of the testing phase are satisfactory after the end of the project, then the BAL will be integrated as a system infrastructure. In general, the BAL and the Shared Customer Database should be managed by a specialized operator, for example by DSO or Metering Service Provider (if foreseen by the country).

4.9 Phasor Measurement Unit

4.9.1 Description

Phasor measurement units are devices that measure voltage and current signals in the network calculating synchrophasors, frequency, and rate of change of frequency tagged by a very precise timestamp. Within the Platone Project, two PMUs with the updated software of the Low-Cost Phasor Measurement Unit (PMU) developed by the Institute for Automation of Complex Power Systems, RWTH Aachen University, have been successfully installed at the Avacon demonstration site as of M24 of the project. The PMU provides measurement data required for performing the balancing mechanism within the virtual island and forecasting of the power exchange between LV and MV network at the MV/LV substation. Multiple PMUs will be installed in the network of the Greek DSO HEDNO. The primary goal of this installation is to evaluate the role of PMU as input measurements for state estimation algorithm, subsequently improving observability of the grid and improving accuracy of the state estimation algorithm itself. The updated version of the Low-Cost PMU, both software and hardware, will be installed at HEDNO premises in the upcoming months. The hardware updates contribute to the further reduction of the costs and improvements in the device performance. The LoCo PMU has currently a TRL of 6. Within Platone project, the TRL will be increased to TRL 7 thanks to the demonstration in the operational environment of HEDNO distribution system. That includes operation under extreme weather conditions in the field and operation together with DSO’s distribution network management system, including the state estimation algorithm. Thanks to the TRL increase, Low-Cost PMU becomes more competitive in comparison to other devices in the market.

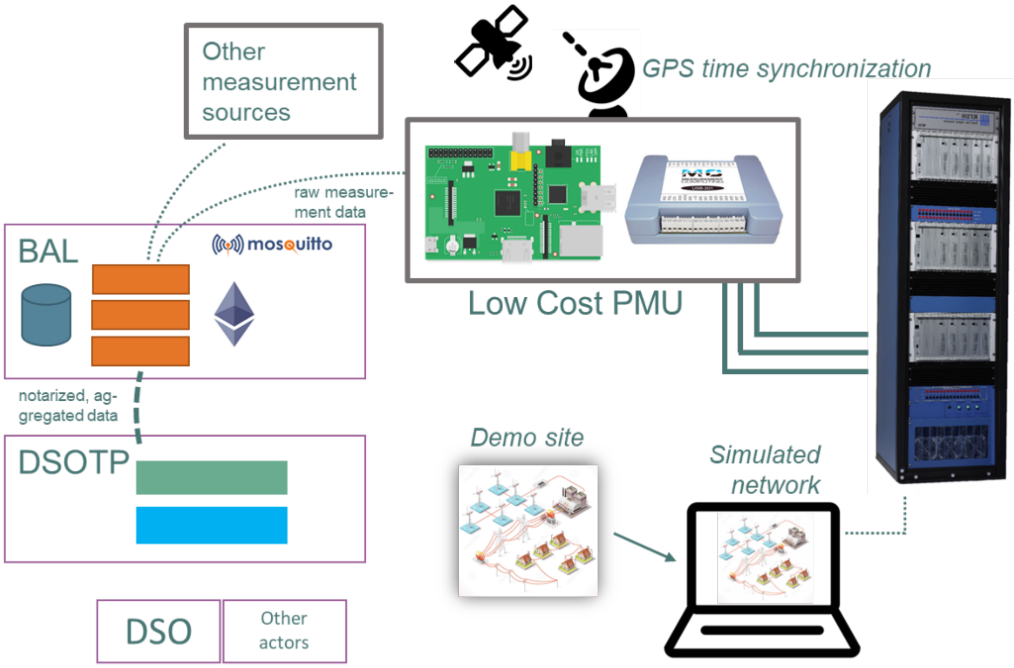


Figure 8 PMU integration within the Platone framework

While RWTH is involved in the development of the new versions of this product, the other partners contribute to the integration and deployment aspects of the technology in their laboratories and in the field. Engineering provides support for the successful integration of the product within the Platone architecture when it comes to security and communication aspects. As described above, Avacon and HEDNO install the PMU devices in their network, hence contributing to the validation of the Platone concepts and use case (which PMU is part of) and increasing TRL level of the device itself.

4.9.2 Target group

The Low-Cost PMU could be deployed by transmission system operators and by distribution system operators, distributed generator owners and other utilities and stakeholders, especially in the distribution network, where the complexity of the network requires higher number of devices than in transmission network.

Given the vast number of nodes and lines in the above-mentioned systems, the LoCo PMU's modular software/hardware architecture allows for cost savings while maintaining the accuracy requirements of the IEEE c37.118 standard. Furthermore, with reference to the overall Platone open framework architecture including the Blockchain Access Layer and the DSO Technical Platform, grid observability can be increased in a secure and efficient manner.

The PMUs satisfies the need of system operators (SO) for improving gird observability and quality of their grid monitoring. SOs have interest in the exploitation of advanced measurement devices such as PMUs in distribution systems in order to develop services and applications utilizing the PMU measurements such as state estimation and distributed state estimation, fault location isolation and service restoration or microgrid operation.

These applications are growing in importance, especially in the distribution network, where due to the vast number of nodes and lines in the above-mentioned systems, the Low-Cost PMU's modular software and hardware architecture allows for a cost savings to DSOs while maintaining the accuracy requirements of the IEEE C37.118 standard. Secondly, jointly with overall Platone open framework architecture including other components such as the Blockchain Access Layer and the DSO Technical Platform, grid observability can be increased in a secure and efficient manner. Furthermore, increased observability and thus quality of monitoring brings new monetary benefit opportunities to the DSOs: (i) directly through reducing costs of operation (e.g.by reducing losses in the network) and (ii) indirectly though possible offering of new services, simultaneously benefiting their business and private customers.

4.9.3 Exploitation strategy

During the course of project, RWTH is directly in contact with the project partners with respect to the necessary development and deployment phases. A set of workshops and meetings have been held with the project partners including DSOs and Engineering to introduce the PMU and its functionalities as well as its measurements integration within the overall Platone architecture. As described above, the Low-Cost PMU has already been installed at the Avacon's demonstration site with the support of RWTH. The successful integration of the Low-Cost PMU measurements within the Platone architecture has been demonstrated to the consortium and the project officer in May 2021. Having gained enough experience and knowledge during the deployment phases in Germany, the deployment of the technology will be supported by RWTH for its successful implementation in the Greek HEDNO demonstration site.

The LoCo PMU is currently at a very mature and advanced stage of development. However, it has never been put to the test in harsh weather conditions. The field testing in Platone will be utilised to complete this final stage, bringing its maturity to market-ready levels. After this activity is completed successfully, further commercialization such as via a new start-up will be considered. RWTH could, for example, use internal German funding for this purpose as the funding EXIST from the Ministry of Economy to begin with the first steps after the project. Exchanges with other commercial players in this field have been already started and two potential customers for the technology have been identified.

The software of the Low-Cost PMU is available at the webpage of Förderer der Energie- und Informationstechnik für zukünftige Netze Aachen e.V. https://fein-aachen.org/projects/ together with several other open-source software developed at the Institute for Automation of Complex Power Systems. The newest and future versions of hardware design and software will be gradually released during the project.

4.10 Avacon Local Flex Controller (ALF-C)

4.10.1 Description

The Avacon Local Flex Controller (ALF-C) is designed as a decentralised energy management system for the deployment of distribution grid services in low voltage networks. It is able to provide different functionalities for different use cases to DSO, TSO, market participants or communities like City Energy Communities (CEC), Local Energy Communities (LEC) or Renewable Energy Community (REC). The system provides basic SCADA/ADMS capabilities and functionalities to monitor and forecast generation and consumption to increase observation of individual LV grid section. It balances the local generation and consumption with direct control of small-scaled flexibilities of any type, such as battery storages and flexible loads, in response to violations of technical grid constraints or even external market signals. Within the application of four different use cases, the system will enable following functionalities:

- monitoring of real time total generation and/or demand,
- forecasting of total generation and demand,
- local balancing of generation and demand.

ALF-C uses different algorithms to

- in UC 1 the ALF-C targets to maximise self-consumption of the energy community.
- in UC 2 – Maintain a non-zero value defined for the power exchange at the grid connection point
- in UC 3 & 4 – enable energy supply and export of generation excess in bulk

The ALF-C will be fully integrated into the Platone Open framework and builds a link between the Energy Community EMS and external parties such as DSO, TSO or market players. The ALF-C will provide an interface to the LEC Energy Management System (EMS) that will enable the synchronization and coordination of flexibility activation with centralised grid management mechanisms of DSOs or TSOs or external flexibility or wholesale-markets. Relevant algorithms, such as balancing, forecasting and optimization, are provided by RWTH Aachen with the Platone DSO Technical Platform.

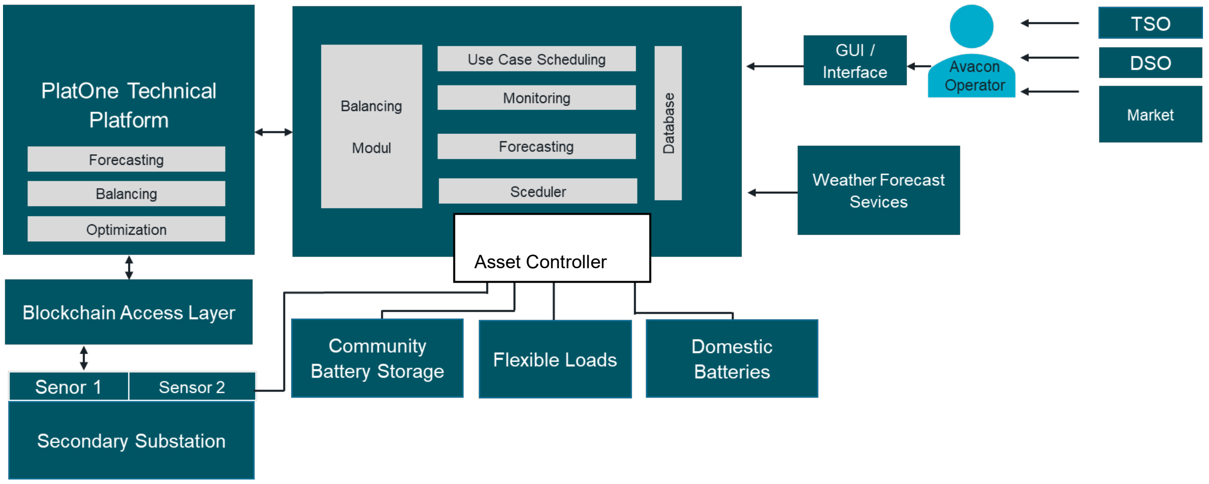


Figure 9: ALF-C within the Platone framework

4.10.2 Target group

The ALF-C is an EMS which aims for two types of target groups.

First, the ALF-C is a system for DSOs that are in need of a software to deploy advanced services to increase observability and automated balancing with direct control of a large number of small-scale flexible assets without direct integration into a centralized grid SCADA/ADMS. The system is able to provide close real-time information about the grid status, available flexibility (Power, Storage Capacity) and forecast of generation consumption and total power demand. The ALF-C serves as a decentral SCADA/ADMS that is able to synchronize with the centralized EMS of DSOs, TSOs or markets in order to coordinate the activation of flexibility. The system is able to operate in a private-cloud, but has potential to be operated on-premises, e.g. locate in a secondary substation as an edge-computing instance. Also, the system is constructed in such a way that the different modules in the ALF-C do not necessarily need to be located in one hardware or software location, creating a flexible system in which additional services or additional modules can be easily integrated.

Second, the system is able to provide services to customer households that target to form a CEC or REC to maximize self-consumption of locally generated energy. The system provides necessary balancing and forecasting capabilities to make maximum use of the limited amount of available flexibility. Furthermore, it is able to synchronize the activation of flexibility with external markets, enabling CEC an REC to participation.

4.10.3 Exploitation strategy

Within the first project months, Avacon is in direct contact with RWTH Aachen, Engineering and manufacturer of flexible assets and grid customers in order to develop, implement and test the solution in the field. Within workshops with the partner and participants, the concept, functionalities, interfaces, data and formats have been scheduled.

Furthermore, Avacon stays in close contact with other ongoing or closed EU projects, e.g. InterFlex, to collect knowledge and experience, gathered during the implementation of comparable solutions. Besides that, Avacon actively disseminates the concept and results in papers, e.g. CIRED, a public event with focus on smart grids, IEEE International Forum on Smart Grid for Smart Cities or e-world.

The ALF-C provides potential functionalities to contribute to a more efficient utilization of the existing distribution and to increase the economical operation. In this context, Avacon is striving to continue the further develop the system, even after Platone, and to implement it in the network, provided that the legal and regulatory framework allows this.

4.11 Light Node

4.11.1 Description

The Light-Node (LN) is an edge device installed on the customer's site, which collects metering data coming from the smart meters installed on Distributed Energy Resources' (DERs) premises. It receives the flexibility activation commands and makes them available to the customer Energy Management System (EMS) (e.g. Storage System, Smart Homes Devices, etc.).

The Light Node is a contact point between Metering (LV/MV Meter) and Customer's Activation Systems (EMS). Moreover, it is an access point to the Blockchain Access Layer through which the Metering and Activation data can be exchanged.

The Light Node, with the Blockchain Access Layer, allows the Italian Demo to:

- Take the *Metering Data* from *Electric Meter*;
- Receive Set-Point that comes from the DSOTP and make this available to Customer's EMS;
- Add Timestamping to Metering and Set-Point data;
- Send Data and Timestamping to the Shared Customer Database;
- Detect Communication and other Anomalies (Light Node Issues, EMS Issues, Blockchain Access Layer Issues).

It consists of two layers and two interfaces:

- ***MQTT Client*** provides connection to the DSO Technical Platform and the Blockchain Access Layer;
- ***Identity Layer*** provides a digital identity (public and a private keys) for the Light Node to signs and sends data packet to Blockchain Access Layer;
- ***EMS Interface*** interacts with several Energy Management Systems (for example Battery Management Systems, Smart Homes Devices, Power Plant Management Systems);
- ***Meter Interface*** interacts with several Meters technologies (for example Low Voltage and Medium Voltage Meters).

The initial TRL stood at 3. At the end of the project, the TRL is expected to reach 7.

4.11.2 Target group

The device, implemented through the project activities, will be relevant for different players. First of all, it will be used by the users. In fact, Light Node once installed at DERs' premises, can receive a setpoint from a DSO Technical Platform and make it available to a customer's activation system (EMS, smart appliance etc.) to activate flexibility. In addition, the Light Node is able to interact with user's systems such as storage and micro photovoltaic, to ensure that users can easily monitor their consumption and provide flexibility services to the grid. Therefore, Light Node enables users to become an active part of the flexibility process.

Moreover, Light Node will be an advantage of the whole process implemented thanks to the project activities. In fact, the Light Node will be the communication tool through which some of the users' data (e.g. metering data) will be received by the whole system architecture.

4.11.3 Exploitation strategy

The Light Node is already installed at the users' place as a hardware installation. It will be available for the whole Platone project duration. The equipment has been implemented thanks to the constant collaboration of ARETI, APIO and an external party (MAC srl). With the Light Node, the user is able to know any time the level of his/her consumption thanks to a free access App that is downloadable on the APIO Store. The equipment was given to the user after the signing of a free for loan contract between ARETI and the user, so the users can decide to buy it for free using it for the functions that will be still active (like data monitoring) or decide to give it back to ARETI at the end of the project. If users are not involved in other projects or the regulatory framework does not let them participate to the flexibility market after the end of the project, then the users will have to give the Light Node back to ARETI.

In fact, it is possible that the user will be involved in further demos in which the use of the Light Node (or its further development) will be requested. Moreover, the Light Node will be useful for the participation of the user in case the flexibility market will be activated.

The Light Node is a device set up behind the meter and it can be a user property or provided by the aggregator.

The Light Node is a device covered by Property Rights, for this reason only some findings will be shared and deployed in further demo.

4.12 Software package for Use Case Description Generation

4.12.1 Description

The purpose of the Smart Grid Use Case Repository tool is to support development of Use Case descriptions, to map existing Use Case descriptions produced by commercial tools into a usable, open format and to provide an open repository for Use Cases. It makes Use Case development cheaper than using commercial tools and enables sharing and re-use of Use Cases. It provides

- A web page where UCs can be entered and edited
- Access to this web page controlled by login procedure
- An IEC-62559 compliant UC template already available for editing
- Support for editing of UCs with markdown files, supporting text and graphics (fixed pictures, .png for example or Visio files).

The tool uses GitHub as the web tool and repository for developing and storing the UCs. The GitHub has two repositories: a project-specific development environment in GitHub where UCs can be worked on, as well as a general-purpose repository for UCs from different projects, called the Smart Grid Use Case Repository [1]. This repository's purpose is to be a place where UCs are freely available to users. The Smart Grid Use Case Repository is automatically generated from the UC development environment by a toolchain using the open-source Hugo[2] and Docsy[3] tools, as shown in **Figure 10**:

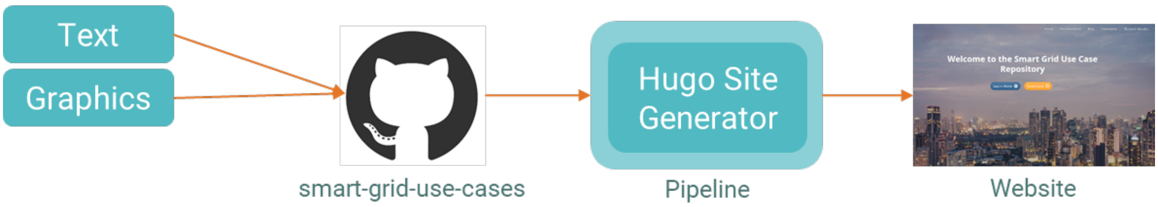


Figure 10: Automatic Generation of Smart Grid Use Cases Repository from smart-grid-use-cases GitHub

Hugo is a static site generator that is used to transform the content of the "github-pages" of the smart-grid-use-cases repo to a website, doing does markdown to HTML conversion. Docsy is a template for Hugo to determine the design of the generated website.

The TRL before Platone was TRL5, and Platone will reach TRL8.

4.12.2 Target group

The target group is developers of new use cases and users of existing use cases. The developers may be in industry or academic researchers. In particular, the tool has been adopted by the Data

[1] https://smart-grid-use-cases.github.io/
[2] https://gohugo.io/
[3] https://www.docsy.dev/

Management working group of BRIDGE for use in future EU projects. The tool addresses the need identified by BRIDGE to create a European repository of all existing and new use cases to facilitate the exchange of knowledge among projects.

Up to now, no open, non-commercial platform for the development and storage of use cases was available. The Smart Grid Use Case Repository will benefit users by being cost-free, while providing a full use case development environment. In addition, users will benefit from being easily able to access and re-use existing use cases, thus avoiding unnecessary re-invention of existing use cases and making it easier to develop new use cases based on existing ones. The tool provides predefined use case templates which follow IEC 62559-2 standard, so that users do not have themselves to develop a template.

The repository has the potential to be a valuable knowledge base for use cases. Also, its use is not limited to Smart Grid Use Cases, it could be applied in other contexts.

4.12.3 Exploitation strategy

The Smart Grid Use Case Repository is already available online and is open-source software. It will continue to be available after the Platone project ends. It has been adopted by the Data Management Work Group of BRIDGE as a standard for H2020 projects and projects involved in BRIDGE. Future development will be driven by BRIDGE, which will also encourage its use in future EU projects. BRIDGE Meetings will also be a dissemination platform, as will events involving BRIDGE project partners. It is already being used in the OneNet project, for example. Dissemination now and in the future will also be done through the Smart Grids Use Case Repository website. As it is open-source software, it will be tried to establish a community of users.

4.13 Common Information Model (CIM)

4.13.1 Description

Within the Platone Project, in collaboration with the DSOs Platone demos, transformations of the electrical grid demos from the PowerFactory data model to the standard IEC CIM model were carried out. The output products are:

- three RDF/XML CIM files (Common Information Model models) representing the three electrical grid demos (Italy, Greece, Germany);
- the methodology and the software to transform an electrical grid from a no standard data model to an international standard like IEC CIM.

The Common Information Model (CIM) is a standard semantic abstract model that represents all the major objects in an electric utility enterprise typically involved in utility operations. This model includes public classes and attributes for these objects, as well as the relationships between them. The standard IEC CIM is described by the International Electrotechnical Commission (IEC) 61970 series.

To obtain the three standard models, one for every electrical grid demo, a methodology to transform an electrical grid description from a custom data format to the IEC CIM model was developed. This methodology exploits a Model Driven Architecture approach using Eclipse Modeling Framework (EMF) where the models are described using the Ecore meta-model and the mappings between models are written in QVTo. The main advantage of this approach is the dynamism of the automatic creation of the input data model and of the QVTo mapping too: it is not necessary to recompile the software every time the data model or the QVTo mapping is modified.

This methodology has been applied to transform three electrical grid demos from the PowerFactory data model to the IEC CIM. Further, it can be extended to other input models and it has been validated in the RSE lab IoT-BigData (TRL 4).

Within the Platone project, the D6.10 result is exploited to show the possibility of using the standard IEC CIM in combination with the Platone DSO Technical Platform (DSOTP) to test existing or future platform tools.

4.13.2 Target group

Using IEC CIM models facilitate the integration of EMS applications developed independently by different vendors, between entire EMS systems developed independently, or between an EMS system and other systems concerned with different aspects of power system operations, such as generation or distribution management systems (DMS). This is accomplished by defining application program interfaces to enable these applications or systems access to public data and exchange information independent of how such information is represented internally. The IEC CIM specifies the semantics for this API and it is one of the reference standards for the SGAM Information Layer [4].

The use of IEC CIM data model facilitates the exchange of power system network data between TSO-DSO. Furthermore, the IEC CIM data model, in combination with the interfaces suggested in the standard IEC 61968 series, improves inter-application integration of a utility enterprise that needs to connect disparate applications that are already built or new (legacy or purchased applications) each supported by dissimilar runtime environments.

Using a grid description as a standard allows a common starting point for network analysis. Researchers, when collaborating with different DSOs, often need to exchange DSOs networks. The DSOs adopt a description of the network based on a data model used by the power system analysis software they use. As a consequence, different tools are needed to perform the analyses, adding complexity in the studies.

For this reason, a translation of the data model into a standard description like IEC CIM allows researchers to carry on a uniform analysis on different networks using the same tools (Figure 11).

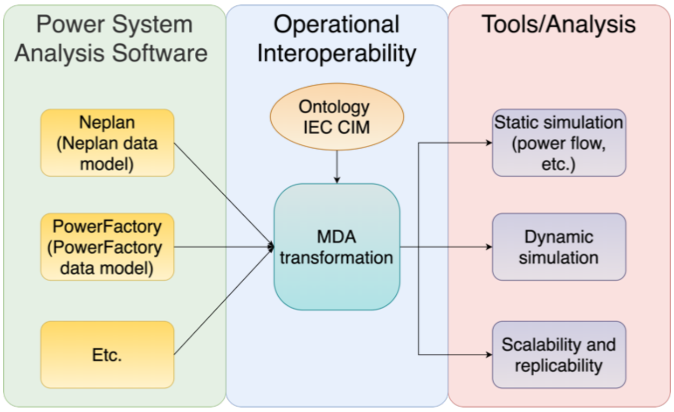


Figure 11: Different models can be mapped into the CIM standards allowing the use of common tools for the analysis

4.13.3 Exploitation strategy

Within the Platone project, the IEC CIM output of the transformation of the three demos has been shared with the project partners involved in scalability and replicability studies. The sensitivity of the data of the demo does not allow a public distribution of the IEC CIM transformed networks.

The methodology and the transformation code are open-source. The transformation methodology will be shared through conference articles.

The code will be available online on GitHub and will be an open-source software. It will continue to be available after the Platone project ends.

Furthermore, the transformation code (PowerFactory to IEC CIM) will be integrated in the Multi-Energy Semantic Platform (MESP) developed by RSE. This platform will have a microservice architecture and will contain services for network analysis such as power flow, network exploration and integration with

[4] https://ec.europa.eu/energy/sites/ener/files/documents/xpert_group1_reference_architecture.pdf

other energy vectors. MESP will be a multi-energy platform based on ontologies (IEC CIM for electrical sector) and will host tools based on MDA to transform grids from non-CIM data models to CIM and vice versa.

4.14 Open Datasets

4.14.1 Description

Platone purposes an innovative approach to data management to increase the level of observability of the electricity grid at distribution level and exploit the flexibilities in electricity production and consumption. Platone puts the electricity end-users at the centre of its solutions, and will test these in three large pilots in Italy, Greece and Germany.

The Platone demo sites will produce datasets deriving from the live demo site infrastructures. The datasets cover:

1. Topology and asset description
2. Measurements
3. Market
4. Prediction and planning.

The datasets follow the FAIR data approach:

- **F**indable data: The datasets will be clearly named and versioned through Digital Object Identifiers (DOI).
- **A**ccessible data: The datasets will be published as open datasets on the Zenodo repository https://zenodo.org/. The datasets will be freely available to all.
- **I**nteroperable data: Use of standards and vocabularies for (meta-) data and datatypes
- **R**e-usable data: The data produced by Platone will be published with full explanations of the meaning of the data and its context in the accompanying metadata documentation. The use of a text format for the data and the provision of full explanatory metadata will facilitate interoperability.

The initial TRL is TRL0 and the target TRL is TRL7.

4.14.2 Target group

Real datasets from grids are generally scarce or publicly unavailable, so that these datasets will provide a valuable resource to industry and researchers. Such data, coming from real grid infrastructures, is expected to be useful for simulations and product development purposes to research institutions, private companies, as well as DSOs and TSOs and aggregators (customers and balance responsible providers - BRPs) who are not Platone partners.

4.14.3 Exploitation strategy

Information about the datasets will be communicated during Platone at events where Platone participates and advertised through Platone’s communication channels. The datasets will be searchable on the Zenodo platform.

The datasets will be freely available as open datasets during and beyond the project on Zenodo.

5 Lessons learned from demo implementations

The following chapters comprise a description about the three demos (Italy, Greece, Germany) as well as an overview of the first outcomes and the lessons learnt.

5.1 Italian demo

In the Italian demo, the activities by the partners aim to break down barriers to the flexibility market, allowing flexible resources connected in medium and low voltage in a large metropolitan area of Rome, to actively participate in the optimized management of the grid in order to solve the TSO and DSO networks issues.

In this way, all the customers connected to the distribution grid can provide flexibility to the TSO and DSO in a common market, where the requests made by System Operators match the offers (that also gather the retail flexibility) presented by the Aggregator.

From the implementation of the demo, several lessons learnt can be noted, such as those shown below:

- **Protecting user confidentiality:** The participation of end-users in the project meant that their personal data had to be secured. A clear perimeter of action regarding the communication of users' consumption data between project partners was outlined, in order to ensure full compliance with privacy regulations (EU Regulation 2016/679 and Legislative Decree no. 196 of 30 June 2003, modified and integrated by Legislative Decree no. 101 of 10 August 2018) and antitrust provisions (Italian Law no. 287, 10 October 1990).
  Specifically, the identified potential risk concerned the need, during the following pilot testing phase, to communicate and exchange among the Italian demo partners information relating to users' consumption data directly linkable to personal data, with consequent impacts on privacy-related aspects.
  This kind of data are already available to the DSO (areti) based on the existing energy transport contract (already in place) with users served by the network managed by areti.
  Moreover, the partnership involved in the Italian Demo also includes Acea Energia (which is an energy trader operating in the free market).
  It was observed that, without identifying a dedicated prevention strategy, this situation could have caused another potential risk of non-compliance with unbundling and antitrust provisions during the pilot testing execution. This risk concerned the possible exchange between areti and Acea Energia of information that could be commercially sensitive, with an involuntary undue advantage in favour to the energy trader.
  To prevent to these potential risks and misunderstanding of effective aims within the project, dedicated discussion tables and focus boards involving the Legal & Compliance and Regulatory Functions of Acea Energia and areti, together with the DPO of Acea S.p.A. were activated.
  This focus led to the definition of an internal governance document which defines the methods and the conduct rules for managing users' personal data exchange during the pilot implementation and during customer-engagement activities. Areti is the only partner appointed to know user's personal data (already in its availability) and to formally contact the users falling under its network management.
  In addition, in order to ensure the sharing of measurement data in the Demo, without disclosing the personal data of the users involved, areti has adopted a pseudonymisation strategy.
  Finally, customers who will freely participate in the pilot testing will be requested by areti to sign a dedicated information document, illustrating project methods and purposes and the use of customers' consumption data specifically for testing the Italian Demo solution, before starting the activities.
- **Readiness in procurement activities:** Throughout the implementation of the activities and the assignation of external activities, one important topic has arisen: the public tender mechanism and its timeline. Current legislation requires a number of mechanisms that can significantly lengthen tender procedures, which can also lead to delays in project activities. For this reason, it was decided to schedule the awarding of contracts in good time in order to avoid any delays and to ensure perfect continuity with the timeline of project activities.
- **User involvement:** The Italian Demo foresees the participation of several users for the implementation of its activities; their involvement represents also one of the KPIs to be

monitored for the success of the project. Since areti is linked to the users by the transport contract, it has little or no immediate relationship. Therefore, in order to ensure that a sufficient number of users is reached, ENEA, the most important Italian research centre operating in the fields of energy and new technologies, and the Energy Community of Centocelle directed by it, composed of citizens already aware of the functioning of the energy market and ready to be involved in the experimentation of the project, were involved. Dedicated workshops, with the support of other WP3 partners, to illustrate objectives and challenges further facilitated user involvement.

5.2 Greek demo

The Greek demo site is located in the area of Mesogeia, in the south-eastern part of the Attica region, close to the capital city of Athens.

The assets included in the demo are as follows:

1. SCADA system in the HV/MV substation of the test site
2. AMR (Automatic Metering Reading system)
3. GIS (Geographic Information System)
4. DSO Data Server
5. Platone Open Framework as versioned for the Greek Demo

The implementation of the Platone solution for the Greek demo includes:

1. The installation of the novel, Low Cost Phasor Measurement Units (LoCo PMUs) in addition to the conventional measurement systems (e.g. SCADA) already in place;
2. The development of the State Estimation Tool, aided by the PMU measurements, to achieve increased grid observability;
3. The algorithm for optimal DER control, with the proposal for the novel variable network tariffs as a means to counter network limit violations and achieve optimal dispatch;
4. The algorithm for ancillary services, where the variable network tariffs are a means to counter frequency violation problems;
5. The DSOTP and BAP, to integrate topology data and measurements from all systems, both conventional data sources and PMUs, as described above.

The demo objectives are the following:

1. To test the Platone architecture and explore its benefits for the Greek DSO (HEDNO).
2. To improve grid operation through advanced grid observability.
3. To achieve optimal dispatching, addressing local congestion and voltage level issues using innovative approaches for flexibility mechanisms at DSO level.
4. To investigate potential provision of ancillary services to the TSO by the users of the distribution network.
5. To assess the penetration limits of DERs for better control and planning of the distribution network.

The detailed description of the Greek demo is presented in the document D4.1: “Report on the definitions of KPIs and UCs” [36].

Lessons Learned

The Greek demo gained significant knowledge via the UCs definition process. The project wide agreed approach to follow the UC Methodology as described in IEC 62559 provided a standardized format for the UCs of the project and at the same time a good comprehension and appreciation of the standard itself and the Smart Grid Architecture Model (SGAM). In addition, experience in defining explicit, measurable, relevant and specific KPIs was acquired.

Investigation of standards has been an important learning process for the Greek demo. By contributing to and reviewing the deliverables of WP6, a solid background for future work was built. D6.1 [37] provided a thorough initial analysis of the standards ecosystem around Platone, offering a deeper understanding of the existing wide spectrum of available standards in the smart grid technology. The input for D6.2 [38] was a significant source of information, not only on the standards and protocols already used per technical area, e.g. SCADA, DMS, AMR, but also on standards that could be theoretically applicable to the UCs defined, e.g. standards regarding demand response from customers/producers who are under a contract with an aggregator. Standards and protocols regarding Blockchain were of great interest considering the novelty and challenges of the technology.

Furthermore, D6.8 [3] presented the results of a detailed study on the main characteristics of the distribution grids in Europe and on the national and European legislative and regulatory framework concerning the innovative solutions developed in Platone. Taking that into account, the Greek demo reviewed and concluded on the laws and specific articles that are applicable to the demo at the current stage of the project, and discussed some regulatory gaps related to the use cases developed. This analysis, included in D6.9 [4], allowed the Greek demo to acquire broad knowledge on the subject. A major point that emerged was the requirement for a more detailed national regulatory framework regarding the role and limitations of the “aggregator”. Also, the legislation gap in both European and national guidelines for the implementation of Blockchain technology in the energy sector became evident.

Regarding regulatory aspects, another valuable learning opportunity was the process of filling-in the questionnaire for D1.3 [39]. It provided the Greek demo with an opportunity to research the national regulations in a multitude of topics, e.g. flexibility services, energy communities, EVs, billing and tariffs, Blockchain and smart contracts. In addition to the above-mentioned deliverable, the completed questionnaire is the result of research that yielded important information on the operation of the Greek energy market and the regulatory aspects that work for and against the implementation of the Platone solution. The ensuing document, currently under review, was also an important learning tool for the Greek demo, as the regulatory aspects are examined for various European countries, apart from the Platone demo partners.

On a more technical scope, the organization of the Platone Engagement Workshop, apart from fulfilling an obligation of the Greek demo activities, was also a source of valuable feedback from stakeholders in the Greek energy market concerning the Greek demo tools. In the breakout sessions, the tools for variable network tariffs and the state estimation were discussed. Regarding the variable network tariffs’ model, the main message was that, apart from developing a robust model, it is very important for the client (consumer/prosumer etc.) to be properly informed, because for example, a potential increase of the network tariff in some areas or times of day would not be well received. This will be an important aspect of implementing the variable tariffs scheme, if and when the regulation governing energy tariffs is modified in the future to allow such variations. Concerning the state estimation tool and the installation of the PMUs that is tied to it, important technical aspects were brought to the attention of the Greek demo members, concerning technical validation of new components and new equipment to be installed in the existing grid as well as the details of the installation itself.

With the information gathered at the workshop as a starting point, considerable know-how was built concerning the standards that HEDNO follows, in order to authorize the installation of new equipment in the grid (e.g. type tests, IP level etc.). Also, research on the standards applicable especially to measurement units and PMUs was conducted, with important information gained. As a result of research on the installation of the LoCo PMUs in the test site grid, the Platone researchers of HEDNO reached out across the organization and built know-how, in order to formulate the correct approach towards the successful completion of such installation. Furthermore, after visiting the Mesogeia HEDNO office (local office responsible for the Greek demo site), a lot of first-hand knowledge was gained, as to the configuration of the MV/LV substations and the challenges facing the grid equipment in an urban/semi-urban environment, such as vandalism, heat, peak load simultaneity etc. This collaboration with the local HEDNO office is now established and will continue throughout the whole process of the installation of the PMUs, including the selection of the most suitable voltage and current sensors for grid signals’ retrieval, which in itself is another opportunity of gaining hands-on experience and expertise.

Improved familiarity has also been built and is still being built regarding the implementation of the DSOTP and BAP. The Greek demo team and the IT department of HEDNO, are in regular effective communication with WP2 partners ENG and RWTH. The deployment of the Platone Open Framework on HEDNO premises includes Virtual Machines and technologies such as Docker, Kubernetes, open-source software and communication protocols, i.e. highly specialized knowledge that is being shared through regular meetings and email communication.

Finally, a less technical but still important lesson learnt by the period of the last 20 months has been the realization that, the physical contact severely limited due to the COVID-19 pandemic, has caused postponement of few tasks. However, the demo activities themselves have not been considerably affected and they are progressing well without significant delays, thanks to good planning, and tools that enable virtual meetings, efficient information sharing, etc.

5.3 German demo

WP5, the German Demonstrator of Platone, led by the German DSO Avacon will develop, implement and test a local balancing mechanism integrated into the Platone architecture framework that enables the advanced usage of small scaled flexible assets located in lower voltage levels of the distribution networks. Avacon aims to implement an energy management system (EMS) named Avacon Local Flex Controller (ALF-C) that allows to monitor and control local small scaled flexibilities. The ALF-C will make use of next level algorithms to predict generation and consumption, balance the local network and determine optimal schedules for the activation of flexibilities. The system provides technical requirements for customers merged in an energy community (EC) to participate on markets and creates required conditions to bring DSOs, TSOs, market participants and aggregators together for a more efficient allocation of DER activation, more efficient grid operation and promotion of the Energy Transition. Furthermore, the ALF-C enables customers and privately-owned flexible assets to be merged in an EC and aggregates them to a single source of flexibility, able to contribute to mechanisms for stabilization and safe operation of the grid.

Within the frame of the field test demo, four different Use Cases will be implemented enabling energy communities to:

- Maximize the consumption of local generation, minimize the demand from the feeding grid and maximize the duration of an islanding period,
- Adhere to a fixed power value at the point of MV/LV connection defined by a third party (e.g. DSO request or in response to a market signal),
- Satisfy the energy deficit left by insufficient local generation within previously defined timeslots (“Bulk supply”) and
- Export the energy surplus generated by excess local generation within previously defined timeslots (“Bulk-export”).

Within the field test Avacon will implement a set of Smart Grid assets:

- A local EMS that will monitor local generation, demand and storage capacities and control available flexibilities in such a way that the consumption of the locally generated energy will be maximized, and the energy demanded from the MV grid will be minimized.
- A Battery Energy Storage System (BESS) and Household Energy Storage that will enable generated energy surplus to be stored and released at times of generation deficit.
- A sensor located at the grid connection that will measure the power exchange of all 3 phases within the MV grid and provide data to the EMS. Additionally, sensors located in private customer households will provide measurements of energy consumption and State of Charge (SOC) or State of Energy (SOE) of storages and provide data to the EMS.
- Weather Forecast that will enable the EMS to predict energy generation and consumption.
- A Blockchain Access Platform (BAP) that will provide encryption functionalities.
- The Platone DSO Technical Platform (DSOTP) that will act as a middleware enabling connection to sensors in the field and providing services (e.g. balancing, forecasting) to the EMS.

Lessons Learned

Within the first 20 project months Avacon has created a concept for the ALF-C and implemented a first fully operable release of the system and has successfully applied UC 1 with first results from measurement and active control. A suitable field test region has been identified that consists of 89 households and agricultural buildings,16 photovoltaic generators with 302 kW installed generation capacity. Into the region, a smart secondary substation with measurement devices and a BESS (300 kW, 777 kWh) has been implemented. A customer recruitment process was successfully implemented and 5 households that were initially planned to be integrated into the project, have been contracted for the active involvement into the local EMS via implementation of a household battery system for measurement and control.

General

- The investigation of protocols used for IT Communication was helpful for the German Demo to lay out the hardware architecture and connections between individual field test components.
- The usage of the IEC-62559 to describe the use cases and the sequence diagrams of the stakeholders involved contributed to a deeper understanding of the use cases to be tested in the field-test demo and revealed knowledge gaps.
- Identifying suitable key performance indicators to measure the success of the field test demo revealed the key connection points where certain measurements are essential for the German field test demo.
- The Demo Harmonization during the first year enabled a better understanding of the other demos, the interfaces and data infrastructure between the demos and the scope about the software solution, used for the German demo, clarifies the degree of development by Avacon and interfaces to other demos.

Implementation and Testing

- The early involvement of municipality and local authorities supported the creation of acceptance and implementation of smart grid technologies into the field test demo.
- The implementation of the DSO-operated large-scaled battery energy storage system prototype into the field required a reinforcement of network equipment (transformer). Analytics have shown that LV networks already today are at its limits and smart gird solutions are needed now in order to make use of its positive effects.
- The evaluation of measurement data of community consumption and generation showed that already today LV-networks generate more energy than they consume.

ECs with a high share of photovoltaic generation create up to 6 times higher fluctuation peaks than consumption peaks, as result of the close location of the plants and the high sensitivity of the generation, even on the smallest clouds.

6 Conclusion

The identification of four main target groups, which are DSOs, TSOs, aggregators, customers as well as three stakeholder groups, which are research, industry and regulatory authorities, show the high diversity of the project. The analysis of the needs of the target groups and stakeholder groups in comparison to the solutions that the Platone architecture offers, shows the capability of Platone to fulfil the most urgent and current needs arising due to the energy transition. The evaluation of the needed regulatory framework revealed, that the regulatory framework lags behind the upcoming and application of new technologies like blockchain and that new actors like aggregators are not fully respected with their roles and business models. In consequence, not only the energy transition itself is slowed down, but also the organisation of the demos within Platone have increased in complexity.

The high number of 14 KERs in total undermine the target of the Platone consortium to utilize results in further research activities or to develop or create and market a product or process. The common exploitation strategy of the consortium of open-source bears already fruit with three KERs (Blockchain Access Layer, Software Package for Use Case Description Generation, Common Information Model) offering already a public utilization, with more in the future to come. The Open Datasets for example will also soon be publicly available. Five KERs have a TRL equal or even below three (e.g. Platone Open Framework, DSOTP etc.), showing that Platone contributes to basic research by evaluating technological concepts or laboratory studies. But with four KERs (Platone Market Platform, BAL (1), BAL (2) etc.) with a targeted final TRL 8, at which systems or models are completely qualified, representing the end of the development, Platone will also deliver close to the market products or services. During the rest of the project duration, feedback loops with the project partners are established to constantly revise the existing KERs but also with the intense to identify new KERs. The approach of open source and free knowledge transfer will be also further pursued as far as confidentiality allows.

The lessons learnt by the demos show, various parallels, allowing similar conclusions and resulting in similar lessons learnt. In all demos, the application of the IEC-62559 led to a deeper understanding of the use cases. Another common lesson learnt can be considered the recognition of the high value of customer involvement and engagement. In this context, in all three demos especially the user confidentiality in the first place, closely connected to data privacy, plays a crucial role in having a trustworthy relationship with the customer as a basis for a further cooperation. Within this cooperation, customers can provide the demo organizers with valuable information about the acceptance, installation and handling of new devices.

7 List of Tables

8 List of Figures

9 List of References

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10 List of Abbreviations

Abbreviation	Term
ADMS	Advanced Distribution Management System
AMR	Advanced Meter Reading
BAL	Blockchain Access Layer
BAP	Blockchain Access Platform
BRP	Balance Responsible Party
BSP	Balance Service Provider
DER	Distributed Energy Resources
DMS	Distribution Management System
DSOTP	DSO Technical Platform
DSO	Distribution System Operator
EED	Energy Efficiency Directive
GDPR	General Data Protection Regulation
HV/MV	High Voltage/Medium Voltage
UC	Use Case
KER	Key Exploitable Result
KPI	Key Performance Indicator
LoCo PMU	Low-Cost Phasor Measurement Unit
MV/LV	Medium Voltage/Low Voltage
NRA	National Regulation Authority
RDF	Resource Description Framework
SCADA	Supervisory Control and Data Acquisition
TRL	Technology Readiness Level
XML	Extensible Markup Language