Platone

PLATFORM FOR OPERATION OF DISTRIBUTION NETWORKS

Platone

PLATform for Operation of distribution NEtworks

D1.2 v1.0

Project KPIs definition and measurement methods

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Abstract

This deliverable describes the work carried out under Task 1.3 “Key Performance Indicators” to define and describe the Key Performance Indicators applicable in Platone project. It provides a description of the applied methodology and evolution of Platone’s KPIs. It presents the Project KPIs, which are indicators common for at least two different demonstrations sites. Five Project KPIs were identified – three corresponding to the technical domain and two to the social domain. In addition, this deliverable also presents KPIs defined specifically for the demonstration sites in Italy, Greece and Germany. For each KPI, a step-by-step calculation process is presented, the needed data is listed and the baseline scenario is defined (if applicable).

Keyword List

Key Performance Indicator – DSOs – grid observability – flexibility – customers - smart grids

Executive Summary

Platone - “PLATform for Operation of distribution Networks” aims to develop an architecture for testing and implementing a data acquisition system based on a two-layer approach (an access layer and a service layer) that will allow greater stakeholder involvement and will enable an efficient and smart grid management.

This deliverable describes the work carried out under Task 1.3 “Key Performance Indicators” to define and describe the Key Performance Indicators (KPIs) applicable in Platone. In addition to Project KPIs, which are KPIs common for at least two different demonstrations sites, it provides a description of KPIs defined specifically for the demonstration sites in Italy, Greece, and Germany. It also describes the calculation methodology, data collection process and baseline scenario for each KPI.

As part of the process to determining KPIs for the Platone project, KPIs concerning electricity system operation that have been used in several other ongoing and completed European projects have been reviewed and discussed. Ultimately, the final list consists of five Project KPIs that have either been directly adopted from relevant European projects, adjusted to Platone (KPIs from another project, but tailored to Platone’s needs) or proposed by demonstration leaders as new KPIs. These KPIs are related to the overall project goals and have been grouped according to domain (three Technical and two Social KPIs were identified).

In addition, a set of KPIs that focus on the technical aspects unique to each demonstration (demo-specific KPIs) were defined – three for the Italian demo, fifteen for the Greek demo and eight for the German demo. In the case of Italy, the focus is on forecast reliability and market aspects. In the case of Greece, the KPIs are primarily related to advanced grid observability and local congestion and voltage level issues. The KPIs defined for the German demo allow evaluation of aspects such as the reduction of energy peaks, increase in self-consumption and maximization of island duration. Each Use Case defined in the demos has at least one corresponding KPI. To ensure the complete description of all the KPIs, a common template was created that gathers basic information about each KPI, its calculation methodology, the data collection process and the baseline conditions.

The defined KPIs and their complete descriptions will allow evaluation of the success of the project and, relating to each of the defined Use Cases, of the individual demos.

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1 Introduction

The project "PLATform for Operation of distribution Networks" – Platone - aims to develop an architecture for testing and implementing a data acquisitions system based on a two-layer approach (an access layer and a service layer) that will allow greater stakeholder involvement and will enable 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), customers, aggregators and other stakeholders like market operators, energy traders or balance responsible parties. In particular, the DSO will invest in a standard, open, non-discriminating, economic dispute settlement blockchain-based infrastructure, to give to both the customers and to the aggregator the possibility to more easily become flexibility market players. This solution will see the DSO evolve into a new form: a market enabler for end users and a smarter observer of the distribution network. By defining this innovative two-layer architecture, Platone removes technical 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 trials (Greek, 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".

The evaluation of the modern solutions proposed under the Platone project requires a quantitative assessment by adopting representative KPIs. These indicators have been defined to serve several purposes. First, they set targets that help achieve the project's objectives and enable the performance of the project in meeting its goals to be assessed. Secondly, they enable measurement of how well the individual UCs are performing and supporting the project's objectives. Thirdly, the KPIs give project participants a focus and motivation to reach the defined targets.

1.1 Task 1.3

The main objective of WP1 – "*DSO Operation Strategies and Harmonization"* – is to foster coordination between the three demonstration sites, ensure harmonization among them and create a possibility for exchanges between demonstration leaders. Task 1.3 *"Key Performance Indicators"* is one of the main tasks of WP1. It defines the Project KPIs, which are indicators common for at least two different demonstrations sites and the demo-specific KPIs. The defined KPIs will enable assessment of Platone's performance in achieving its overall technical objectives.

Task 1.3 started in month 6 (M6) of the project and lasts until the end of the project (M42). It is related to three deliverables:

- D1.2 *"Project KPIs definition and measurement methods"* (M12),
- D1.4 *"Assessment of Project KPIs*" (M36),
- D1.7 "*Update of Project KPIs*" (M48).

KPIs will be used for evaluating the impact of the project in a coherent manner, and to support the scalability and replicability analysis which is to be developed within Tasks 7.1 and 7.2.

1.2 Objectives of the Work Reported in this Deliverable

This deliverable describes the work carried out in Task 1.3 focusing on Key Performance Indicators. It presents the list of project and demo-specific KPIs that will be used to evaluate the results of the solutions implemented in the Platone project. In addition, detailed definitions of the KPIs, their step-by-step calculation methodology, the data collection processes and baseline scenario conditions are included in the Annexes.

The objective of this deliverable is to define the Platone KPIs and their measurement methods that will be used to evaluate project's results. The KPIs will be used and measured by WP3, WP4 and WP5, which implement the demos. In addition, defined KPIs will constitute the base for the scalability and replicability analysis that is to be developed within WP7.

1.3 Outline of the Deliverable

Chapter 2 describes the methodology applied to identify the KPIs. Chapter 3 presents a summary of the KPIs. This comprises the Project KPIs, which are applicable to each demo site, and the demo-specific KPIs. The conclusions of the deliverable are provided in Chapter 4. The template used to gather information about KPIs, detailed descriptions of the Project KPIs and demo-specific KPIs are included in Annexes A-E.

1.4 How to Read this Document

The KPIs described in this deliverable refer to the demos in the Platone project. For a better understanding of the issues covered by each KPI, the reader should be familiar with the details of use cases of each demo. Their descriptions are presented in Deliverable 1.1 "General functional requirements and specifications of joint activities in the demonstrators" (M12) [2].

Further details regarding Italian demonstration can be found in Deliverables 3.3 "Delivery of technology (v1)" (M18) [3]; 3.2 "Report of optimal communication solution between customer database and market players" (M20) [4] and 3.6 "Report on first integration activity in the field" (M20) [5].

Further details regarding Greek demonstration and its Use Cases can be found in Deliverable 4.1 'Report on the definition of KPIs and Use Cases" (M12) [6].

Further details regarding the German demonstration and its Use Cases can be found in Deliverables 5.1 "Solution design and technical specifications" (M6) [7] and 5.2 "Detailed use case description" (M12) [8].

2 Methodology

This chapter aims to describe the methodology applied to identify KPIs for the Platone project. Subchapter 2.1 outlines the methodology applied by the Platone partners to develop KPIs. Subchapter 2.2 is dedicated to the common template that was created for the definition of the indicators.

2.1 Identification of Platone KPIs

In case of Platone project, KPIs has been distinguished into two parts: Project KPIs and demo-specific KPIs. Project KPIs allow common aspects of different demonstrations to be distinguished. They are also additional motivation to transfer the general objectives of the project to the demonstrations. Moreover, they show differences in the approach, data availability and characteristics of different DSOs, even when the same topic is discussed. Demo-specific KPIs, as name suggests, are unique to a given demo.

Platone's demonstrations focus on different DSO operational aspects, which is reflected as well in the project’s KPIs, which support evaluation of the performance of the wide range of solutions proposed by Platone’s demos in reaching the project goals.

The field trial in Italy, operated by areti, aims to carry out a comprehensive implementation of a new local energy flexibility market in a metropolitan area of Rome. It involves flexible resources connected in medium and low voltage in order to solve the TSO and DSO network issues related to voltage and congestion management.

The field trial operated by HEDNO in Greece has specific focus on the observability issue. It investigates whether the novel approach of applying a variable instead of a flat network tariff will appropriately incentivise customers with flexible loads, and lead to an optimal dispatch for the distribution network.

The field trial operated by AVACON, in Germany, focuses on the flexibility implementation in relation to the integration of future energy communities into the DSO grid. It tests innovative strategies for the integration of future energy communities into DSO grid operation strategies to increase hosting capacities of distribution grids and to make them more efficient.

As a first step to define the KPIs, project’s objectives were analysed. The Platone project aims to:

1. Unlock flexibility to address local congestion and voltage stability;
2. Improve grid operation through advanced observability approach;
3. Improve customers engagement and facilitate their fair participation in the market;
4. Support cooperation with the TSO;
5. Ensure reliable and secure power supplies in the context of increasing DER penetration.

Keeping the above-mentioned objectives in mind, KPIs used in several ongoing and completed European projects have been reviewed and discussed by WP1 members. The following nine projects were used for this purpose: UPGRID [9], Grid4EU [10], IDE4L [11], CoordiNet [12], evolvDSO [13], interFLEX [14], interGRIDy [15], EU-SysFlex [16], DREAM [17]. In addition, KPIs from “Measuring the ‘Smartness’ of the Electricity Grid” report [12] were analysed, since their clusters (namely: Metering, Asset management, Quality of Supply & Distribution Generation, Sustainable Communities, Flexibility and Network Balance, Digitalisation) helped to ensure the inclusion of all relevant aspects of smart grids into the discussions.

The KPIs collected from the above-mentioned sources were reviewed by demonstration leaders, who then selected the most interesting and relevant to their Use Cases. This allowed an initial list of KPIs to be created, which could potentially be categorized as Project KPIs (those relating to at least two demonstrations).

As a next step, the list was re-analysed, and its individual elements were changed and adapted to the needs of the Platone project. In the meantime, leaders of the demonstration closely cooperated with each other, giving feedback and interacting in order to make an optimized integration of the proposed KPIs.

After several iterations of the initial list, the consolidated list of the final KPIs were defined and returned to the demonstrators for demo-specific details: threshold of KPIs, data collection procedures, specific calculation methodology, etc.

Ultimately, the final list of Project KPIs consists of directly adopted KPIs from relevant European projects, adapted KPIs (KPIs from another project, but adjusted to the needs of Platone) and new KPIs proposed by demonstrations leaders. The KPIs were linked to the overall objectives of the Platone project to ensure that all aspects are covered by the individual demonstrations.

Focusing on the technical performance of the Use Cases' solutions and effect on the local residents opinion, selected KPIs were grouped according to two domains that serve as a base for achieving a better overview. These domains are:

- Technical domain – these are KPIs measuring technical performance, focussing on topics such as network capacity, peak load reduction, etc.
- Social domain – these are KPIs measuring social impact related to topics such as users' satisfaction, level of participation, etc.

2.2 Definition of Platone KPIs

For the task of definition of KPIs, a common template was created which was used, for both the Project and demo-specific KPIs. The template used for KPI definition is presented in Annex A. The template is organized into four main sections: Basic KPI Information, KPI Calculation Methodology, KPI Data Collection, and KPI Baseline. The details of these sections are presented below.

Basic KPI Information - General KPI Information:

1. **KPI name** - name of KPI, clearly explaining what the indicator intends to measure.
2. **KPI ID** - KPI Identification number.
3. **Project's Objective** – Platone's main objectives KPI is responding to (listed in chapter 2.1).
4. **DEMO where KPI applies** – demonstration site where KPI is used (Italy, Greece or Germany).
5. **Owner** – person or company responsible and accountable for single KPI.
6. **KPI Description** - description of KPI further clarifying what the indicator intends to measure.
7. **KPI Formula** - precise mathematical formula for calculating KPI, and explanation of defined formula.
8. **Unit of measurement** – e.g. percentage basis, MW, MWh, etc.
9. **Target / Thresholds** - target of KPI relative to defined baseline.
10. **Measurement Process** – short explanation how the KPI will be evaluated.
11. **Reporting Period** - indication how often this KPI will be reported (weekly, monthly, yearly, etc.)
12. **Reporting Audience and Access Rights** - to whom will this indicator be reported and access rights (Public / Platone/ Demo / OTHER).

KPI Calculation Methodology – Methodology for calculating KPI, listed step-by-step (demo-specific).

1. **KPI calculation step ID** – calculation step identification number.
2. **Step** – description of step taken during calculation of KPI.
3. **Responsible** – person or company responsible for specific step in KPI calculation methodology.

KPI Data Collection – Data required to be collected for calculating KPI (demo-specific).

1. **Data** – name of data to be collected.
2. **Data ID** – Identification number of data requiring collection, that is later used in formulas for calculating KPI.
3. **Methodology for data collection** – description of the method by which data is collected.
4. **Source/Tools/Instruments for Data collection** - Instruments / Tools used to collect data.
5. **Location of Data collection** – indicator of the place where data is collected.
6. **Frequency of data collection** - Indicate how often, when and for how long data is collected.
7. **Data collection responsible** - person or company responsible for collecting data.

KPI Baseline – Baseline for calculating KPI (demo-specific).

1. **Source of Baseline Condition** – literature values / company historical values / values measured at the start of project.
2. **Details of Baseline** – detailed description of the chosen baseline.
3. **Responsible for baseline** – person or company responsible for definition of baseline.

3 Platone's KPIs

Following the methodology described in chapter 2, five Project KPIs have been identified and are presented in subchapter 3.1. The detailed descriptions of these KPIs are presented in Annex B.

Moreover, in the next subchapters (3.2-3.4), seven KPIs are described for the Italian demo (four Project KPIs and three demo-specific presented in Annex C), sixteen KPIs for the Greek demo (one Project KPI and fifteen demo-specific presented in Annex D), and thirteen KPIs for the German demo (five Project KPIs and eight demo-specific presented in Annex E),

As mentioned in chapter 2, KPIs were grouped according to the Platone's objectives. One KPI can correspond to more than one objective. As presented in the table below (Table 1), the defined KPIs provide a coverage of all objectives and ensure that all the main aspects of the project will be evaluated.

Project's Objective	KPI ID
Unlocking flexibility to address local congestion and voltage stability;	KPI_PR_03, KPI_PR_04, KPI_PR_05, KPI_IT_01, KPI_GR_07, KPI_GR_08, KPI_GR_09, KPI_GR_10, KPI_GR_11, KPI_DE_01, KPI_DE_02, KPI_DE_03, KPI_DE_04, KPI_DE_05, KPI_DE_06, KPI_DE_07, KPI_DE_08
Improving grid operation through advanced observability approach	KPI_GR_01, KPI_GR_02, KPI_GR_03, KPI_GR_04, KPI_GR_05, KPI_GR_06, KPI_GR_13, KPI_GR_14, KPI_GR_15
Improving customers engagement and facilitating their fair participation in the market	KPI_PR_01, KPI_PR_02, KPI_PR_03, KPI_IT_01, KPI_GR_12, KPI_DE_01, KPI_DE_02, KPI_DE_03, KPI_DE_04, KPI_DE_05, KPI_DE_06
Supporting cooperation with the TSO	KPI_IT_01, KPI_GR_12, KPI_DE_05, KPI_DE_06
Ensuring reliable and secure power supplies in the context of increasing DER penetration.	KPI_PR_05, KPI_IT_02, KPI_IT_03, KPI_GR_07, KPI_GR_08, KPI_GR_09, KPI_GR_10, KPI_GR_11, KPI_GR_12, KPI_DE_07, KPI_DE_08

Table 1.List of Platone's objectives and corresponding to them KPIs

3.1 Project KPIs

Table below (Table 2) shows the identified Project KPIs. In addition, the domain of the KPIs and mapping to demonstration sites are presented.

No.	KPI ID	KPI Name	KPI Domain	Demo		
				IT	GR	DE
1	KPI_PR_01	Participants' recruitment	Social	X		X
2	KPI_PR_02	Active participation	Social	X		X

3	KPI_PR_03	Flexibility Availability	Technical	X		X
4	KPI_PR_04	Flexibility Effectiveness	Technical	X		X
5	KPI_PR_05	Distribution Network Hosting Capacity	Technical		X	X

Table 2. List of Project KPIs

3.2 KPIs of Italian Demonstration

The Italian demo is coordinated by areti, the DSO of the capital, Rome. This demo focuses on TSO and DSO network issues related to voltage and congestion management and for that purpose it aims to carry out a comprehensive implementation of a new local energy flexibility market in a large metropolitan area of Rome, involving flexible resources connected in medium and low voltage. To achieve that, the Italian demo is implementing an innovative multi-layer system architecture composed of multiple platforms based on the application of blockchain technologies and new grid equipment, to promote an efficient, democratic and non-discriminatory market model for the exploitation of local flexibility with the involvement of all relevant actors (TSO, DSO, Aggregator, end-users etc.).

Two Use Cases are designed under the scope of this demonstration side:

1. UC-IT-1: Voltage Management
2. UC-IT-2: Congestion Management

Table 3 presents the list of KPIs designed for the Italian demo, its domain and specific corresponding Use Cases. Their complete description is available in Annexes B and C. As the Italian demo aims to test all components of the Platone platform, the KPIs are related to all focus areas: flexibility, observability, customer engagement, market.

No.	KPI ID	KPI Name	KPI Domain	Use Case
1	KPI_PR_01	Participants' recruitment	Social	UC-IT-1, UC-IT-2
2	KPI_PR_02	Active participation	Social	UC-IT-1, UC-IT-2
3	KPI_PR_03	Flexibility Availability	Technical	UC-IT-1, UC-IT-2
4	KPI_PR_04	Flexibility Effectiveness	Technical	UC-IT-1, UC-IT-2
5	KPI_IT_01	Market Liquidity	Technical	UC-IT-1, UC-IT-2
6	KPI_IT_02	Forecast reliability – customer profile	Technical	UC-IT-1, UC-IT-2
7	KPI_IT_03	Forecast reliability – grid profile	Technical	UC-IT-1, UC-IT-2

Table 3. List of KPIs in Italian Demo.

3.3 KPIs of Greek Demonstration

The Greek demo is led by the Greek DSO HEDNO and is situated in Mesogia in the Attica region, which encompasses a mix of rural, urban and sub-urban areas servicing Athens as well as the islands Kea, Andros and Tinos. This demo aims to test the Platone architecture and to investigate whether the novel approach of applying a variable instead of a flat network tariff will appropriately incentivise customers with flexible loads, and lead to an optimal dispatch for the distribution network. The demo will also develop state estimation techniques for grid forecasting and real-time grid monitoring purposes to both enhance distribution network operation and allow the exploration of diverse dispatch scenarios. PMUs installed in selected nodes of the demo site will further improve the observability of the associated network.

Five Use Cases are designed under the scope of this demonstration side:

1. UC-GR-1: Functions of the State Estimation tool
2. UC-GR-2: PMU data integration into SE tool
3. UC-GR-3: Distribution Network limit violation mitigation
4. UC-GR-4: Frequency support by the distribution network
5. UC-GR-5: PMU integration and Data Visualization for Flexibility Services Management

Table 4 presents the list of KPIs designed for the Greek demo, its domain and specific corresponding Use Cases. Their complete description is available in Annexes B and D. The KPIs focus on technical aspects that will help to assess the grid operation improvement through advanced grid observability, optimal dispatching, addressing local congestion and voltage level issues, and enable investigation of the potential provision of ancillary services to the TSO by the users of the distribution network.

No.	KPI ID	KPI Name	KPI Domain	Use Case
1	KPI_PR_05	Distribution Network Hosting Capacity	Technical	UC-GR-3
2	KPI_GR_01	Relative root mean square error (RRMSE)	Technical	UC-GR-1, UC-GR-2
3	KPI_GR_02	Relative percentage error (RPE)	Technical	UC-GR-1, UC-GR-2
4	KPI_GR_03	Accuracy metric for complex phasor voltage estimation (MaccV)	Technical	UC-GR-1, UC-GR-2
5	KPI_GR_04	Convergence metric in terms of objective function	Technical	UC-GR-1, UC-GR-2
6	KPI_GR_05	Convergence metric in terms of estimated voltage magnitude	Technical	UC-GR-1, UC-GR-2
7	KPI_GR_06	Convergence metric in terms of estimated voltage angle	Technical	UC-GR-1, UC-GR-2
8	KPI_GR_07	Generation curtailment	Technical	UC-GR-3
9	KPI_GR_08	Demand curtailment	Technical	UC-GR-3
10	KPI_GR_09	Generation curtailment occurrences	Technical	UC-GR-3
11	KPI_GR_10	Demand curtailment occurrences	Technical	UC-GR-3
12	KPI_GR_11	Network limit violation occurrences	Technical	UC-GR-3
13	KPI_GR_12	Frequency support not provided	Technical	UC-GR-4
14	KPI_GR_13	Field installation and data integration of PMUs	Technical	UC-GR-5
15	KPI_GR_14	Data visualization	Technical	UC-GR-5
16	KPI_GR_15	Visualized tools and services	Technical	UC-GR-5

Table 4. List of KPIs in Greek demo.

3.4 KPIs of German Demonstration

The German demo is led by the German DSO AVACON and situated in a rural area denominated by a low residential and commercial consumption and a high penetration of distributed energy resources (DER). The strategic aim of the demo is to develop and test innovative strategies for the integration of future energy communities into DSO grid operation strategies, thereby increasing the hosting capacities of distribution grids and making them more efficient.

Four Use Cases are designed under the scope of this demonstration side:

1. UC-DE-1: Island Mode
2. UC-DE-2: Third Party Flex Request
3. UC-DE-3: Energy Delivery
4. UC-DE-4: Energy Export in Discrete Packages

Table 5 presents the list of KPIs designed for the German demo, its domain and specific corresponding Use Cases.

Their complete description is available in Annexes B and E. The KPIs focus on both technical and social aspects, enabling to investigate customer's involvement and improved operations of the grid.

No.	KPI ID	KPI Name	KPI Domain	Use Case
1	KPI_PR_01	Participants' recruitment	Social	UC-DE-3, UC-DE-4
2	KPI_PR_02	Active participation	Social	UC-DE-3, UC-DE-4
3	KPI_PR_03	Flexibility Availability	Technical	UC-DE-2
4	KPI_PR_04	Flexibility Effectiveness	Technical	UC-DE-2
5	KPI_PR_05	Distribution Network Hosting Capacity	Technical	UC-DE-3, UC-DE-4
6	KPI_DE_01	Reduction of energy demand provided by MV-grid	Technical	UC-DE-1
7	KPI_DE_02	Reduction of power recuperation peaks	Technical	UC-DE-1
8	KPI_DE_03	Increase of self-consumption	Technical	UC-DE-1
9	KPI_DE_04	Maximization of Islanding Duration	Technical	UC-DE-1
10	KPI_DE_05	Responsiveness	Technical	UC-DE-2
11	KPI_DE_06	Accuracy of the achievement of a given setpoint	Technical	UC-DE-2
12	KPI_DE_07	Success of package-based energy provision	Technical	UC-DE-3, UC-DE-4
13	KPI_DE_08	Accuracy in forecasting deficits	Technical	UC-DE-3, UC-DE-4

Table 5. List of KPIs in German demo.

4 Conclusions

This deliverable describes the methodology applied for KPI definition in the Platone project and a detailed description of the identified KPIs. Five Project KPIs (KPIs corresponding to at least two demonstration sites) have been identified. Three of these and can be classified as technical and two as social. In addition, twenty-six demo-specific KPIs has been defined – three corresponding to Italian demo, fifteen to the Greek demo and eight to the German demo. All the KPIs have been described with the use of the common template that, in addition to basic information about each KPI, includes detailed information about the KPIs' calculation methodology, the data collection process and details of KPIs' baseline.

Despite typical uncertainties regarding demonstration details, it is important to implement a clear KPI framework already at the first stage of the project, which is what this task aims at. Platone KPIs have been very carefully deliberated and their targets have been set by the subject-matter experts in the demonstrations. These targets are realistic but still motivate continuous improvement. At the same time, it should be remembered that Use Cases naturally evolve after closer interaction with test trials - therefore it is difficult to plan KPIs at an early stage with a single effort. This was already foreseen by the project partners who plan to continuously review this aspect of the work.

Project KPIs, i.e. those relating to at least 2 demonstrations, allow distinguishing common aspects of different demonstrations. Still, comparing the demos based on the value of this indicator should be carried out with extreme caution. The individual conditions of each demonstrator significantly affect the outcomes, and also the targets set by the leaders of the demonstration, a diversity which ultimately benefits the quality of the project solutions.

Covering all the Platone's objectives and Use Cases, the defined KPIs constitute the base for evaluation of the project in general and also the performance of the individual demos. Detailed methodology for KPI calculation and data collection process will support the scalability and replicability analysis conducted in WP7. Moreover, the realistic but progressive targets of the KPIs will provide project partners focus and motivation to work intensively on their achievement and, consequently, will help to improve the overall performance of the project. The values of KPIs measured in the field will be reported twice during the project in two restricted deliverables: D1.4 [18] and D1.7 [19].

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7 List of Abbreviations

Abbreviation	Term
ALF-C	Avacon Local Flex Controller
DER	Distributed Energy Resources
DSO	Distribution System Operator
KPI	Key Performance Indicator
POD	Point of Delivery
R&D	Research and Development
RES	Renewable Energy Sources
TSO	Transmission System Operator
UC	Use Case
WP	Work Package

Annex A Template for Gathering KPIs Information

This annex presents a common template that was used for the definition of both Project and demo-specific KPIs. The template is organized into four main sections: Basic KPI Information, KPI Calculation Methodology, KPI Data Collection, and KPI Baseline.

BASIC KPI INFORMATION			
KPI Name		**KPI ID**	
Project's Objective			
DEMO where KPI applies	☐IT ☐GR ☐DE		
Owner			
KPI Description			
KPI Formula			
Unit of measurement			
Target / Thresholds			
Reporting Period			
Measurement Process			
Reporting Audience and Access Rights	☐Public ☐Platone ☐Demo ☐Other		

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**

KPI DATA COLLECTION						
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/ Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Data collection responsible**

KPI BASELINE			
Source of Baseline Condition	Literature values ☐	Company historical values ☐	Values measured at start of project ☐
Details of Baseline			
Responsible (Name, Company) for Baseline			

Annex B Project KPIs

This annex presents five Project KPIs (i.e. KPIs common for at least two different demonstrations sites).

B.1 Participants' Recruitment

BASIC KPI INFORMATION			
KPI Name	Participants' Recruitment	**KPI ID**	KPI_PR_01
Project's Objective	To improve customers' engagement and facilitate their fair participation to market		
DEMO where KPI applies	☒IT ☐GR ☒DE		
Owner	Italian demo: areti/ACEA Energia German demo: Avacon		
KPI Description	This indicator calculates the percentage of customers accepted their participation in the demo in relation with the total amount of customers contacted to participate in the demo. This indicator can be used to evaluate customer engagement.		
KPI Formula	$$R = \frac{N_{accept}}{N_{total}} \cdot 100$$ Where: N_{accept}: number of customers that accepted to participate in the demo. N_{total}: number of customers contacted to participate in the demo.		
Unit of measurement	%		
Target / Thresholds	Italian demo: 10% Considering that the Italian Demo tests an innovative solution involving active customers' cooperation in grid operation, it is guessed that participation is fulfil by few "early adopters". The maximum number of customers involved depends on number of Light Nodes available. German demo: 20 % Experience from other research projects made it clear that the general interest in participation is relatively low, as in most cases little or no incentives exist. The average response rate is around 7%. Since additional incentives can be given within the framework of Platone, such as free measuring systems, discounted battery storage, the response rate is expected to be higher at around 20%.		
Measurement Process	Italian demo: The number of customers agreeing to participate to the project and the number of customers involved in engagement are gathered during each customer engagement process. The KPI is calculated whenever a customer engagement process is complete. German demo: The number of households contacted to participate in the demo (N_{total}) will be determined by end of 2020 when letter of invitations will be sent to households. The final number of households interested in participation (N_{accept}) will be determined in		

	M30. The determination will be based on number of written signed confirmations that has been sent via letter to the project office.
Reporting Period	Italian demo: yearly German demo: once per project (M30 with Deliverable 5.5)
Reporting Audience and Access Rights	☐Public ☒Platone ☐Demo ☐Other

KPI CALCULATION METHODOLOGY		
Italian demo		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
KPI_PR_01_IT_1	Detecting the list of customers located in the demo's areas, through the Operational Systems (in detail the Customer Relation Management will be used)	areti
KPI_PR_01_IT_2	Evaluating the number of customers contacted (several solutions can be used: calls, letters, meetings) to participate in the demo	areti
KPI_PR_01_IT_3	Evaluating the number of customers that accepted to participate in the demo	areti
KPI_PR_01_IT_4	KPI calculation	areti
German demo		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
KPI_PR_01_AVA_1	Determination of Baseline N_{total}	AVACON
KPI_PR_01_AVA_2	Determination of N_{accept}	AVACON
KPI_PR_01_AVA_3	KPI calculation	AVACON

KPI DATA COLLECTION						
Italian demo						
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Data collection responsible**
Number of customers contacted to participate in the demo	N_{total}	List of customers contacted to participate in the demo	Datasheet of customer extracted from Operational System	Shared Customer Database	Once (update on even), up to end of project	areti

Number of customers that accepted to participate in the demo	$N_{accepted}$	List of customers that accepted to participate in the demo	Datasheet of customer involved in the demo	Shared Customer Database	Once (update on even), up to end of project	areti
German demo						
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Data collection responsible**
Number of customers participating	N_{total}	Record	Project invitation sent to the customers	AVACON customer management system	Once per project	AVACON
Number of customers accepting participation in project	N_{accept}	Record	Received positives replies for project participation from customers	AVACON customer management system	Once per project	AVACON

KPI BASELINE			
Italian demo			
Source of Baseline Condition	LITERATURE VALUES ☐	COMPANY HISTORICAL VALUES ☐	VALUES MEASURED AT START OF PROJECT ☐
Details of Baseline	N.A.		
Responsible (Name, Company) for Baseline	N.A.		
German demo			
Source of Baseline Condition	LITERATURE VALUES ☐	COMPANY HISTORICAL VALUES ☐	VALUES MEASURED AT START OF PROJECT ☒ Info: Start of Use Case Phase
Details of Baseline	N_{total} equals the total number of households invited to participate in the demo. The number will be determined by March of 2021 when letter of invitation have been sent to households.		
Responsible (Name, Company) for Baseline	AVACON		

B.2 Active Participants

BASIC KPI INFORMATION			
KPI Name	Active Participants	**KPI ID**	KPI_PR_02
Project's Objective	To improve customers' engagement and facilitate their fair participation to market		
DEMO where KPI applies	☒IT ☐GR ☒DE		
Owner	Italian demo: areti/ACEA Energia German demo: Avacon		
KPI Description	This indicator measures the percentage of customers actively participating in the Platone demo with respect to the total customers that accepted the participation. This indicator can be used to evaluate customer engagement and their participation to provide flexibility services.		
KPI Formula	$R = \frac{N_{active}}{N_{accept}} \cdot 100$ Where: N_{accept}: number of customers that accepted to participate in the demo N_{active}: number of customers actively participating in the demo* * definition of active customers will be determined by demo leaders		
Unit of measurement	%		
Target / Thresholds	Italian demo: 100% German demo: 70% The successful integration of a household depends on numerous technical requirements. For example, there must be sufficient space for the installation of measurement and control equipment or battery storages. Furthers a communication link must exist. These requirements are not met in all households, which is why some households that have accepted participation cannot be actively included into the field test trial.		
Measurement Process	Italian demo: The number of customers actively providing flexibilities services are extracted from reports provided by Market Platform. The number of customers accepted to participate to the project are gathered during each customer engagement process. A further analysis of the Market Platform report will allow extracting more details, for example the number of active customers divided for connected power or voltage level. German demo: N_{accept} equals the number of customers that accepted to participate in the demo. The final number of households interested in participation will be determined in M30. The determination will be based on number of written signed confirmations that has been sent via letter to the project office. N_{active} equals the number of households owning a sensor or battery storage that is		

	connected and interacting with the Energy Management System of Avacon (ALF-C). The number will be determined by July of 2021.
Reporting Period	Italian demo: yearly German demo: once per project (M30 with Deliverable 5.5)
Reporting Audience and Access Rights	☐Public ☒Platone ☐Demo ☐Other

KPI CALCULATION METHODOLOGY		
Italian demo		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
KPI_PR_02_IT_1	Evaluate number of customers that accepted to participate in the demo	areti
KPI_PR_02_IT_2	Evaluate number of customers actively participating in the demo	areti
KPI_PR_02_IT_3	KPI calculation	areti
German demo		
KPI_PR_02_AVA_1	Determination of number of customers accepting project participation (Baseline - N_{accept})	AVACON
KPI_PR_02_AVA_2	Determination of number of customers active integrated in the project (N_{active})	AVACON
KPI_PR_02_AVA_3	KPI calculation	AVACON

KPI DATA COLLECTION						
Italian demo						
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Data collection responsible**
Number of customers contacted to participate in the demo	N_{total}	List of customers that accepted to participate in the demo	Datasheet of customer involved in the demo	Shared Customer Database	Once (update on even), up to end of project	areti
Number of customers providing offers activelly	N_{active}	Analysis of offers list issued in Market Platform	Market Platform	-	Daily, Up to end of projects	areti

German demo						
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Data collection responsible**
Number of customers participating	N_{active}	Record	Successfully connected to EMS	AVA customer management system	Once per Project	AVACON
Number of customers accepting participation in project	N_{accept}	Record	Received positives replies for project participation from customers	AVA customer management system	Once per Project	AVACON

KPI BASELINE			
Italian demo			
Source of Baseline Condition	LITERATURE VALUES ☐	COMPANY HISTORICAL VALUES ☐	VALUES MEASURED AT START OF PROJECT ☐
Details of Baseline	N.A.		
Responsible (Name, Company) for Baseline	N.A.		
German demo			
Source of Baseline Condition	LITERATURE VALUES ☐	COMPANY HISTORICAL VALUES ☐	VALUES MEASURED AT START OF PROJECT ☒ Info: Start of Use Case Phase
Details of Baseline	N_{accept} equals the total number of letters of positive confirmation of households send via letter to Avacon. The number will be determined by March of 2021 when letter of invitations have been sent to customer households.		
Responsible (Name, Company) for Baseline	AVACON		

B.3 Flexibility Availability

BASIC KPI INFORMATION			
KPI Name	Flexibility Availability	**KPI ID**	KPI_PR_03
Project's Objective	To unlock flexibility to address local congestion and voltage stability issues. To improve customers' engagement and facilitate their fair participation to market.		
DEMO where KPI applies	☒IT ☐GR ☒DE		
Owner	Italian demo: areti / Engineering German demo: Avacon		
KPI Description	This KPI aims to measure the potential amount of flexibility that is available to the grid by flexible resources.		
KPI Formula	Italian demo: $$Flexibility\ Availability\ Up = \frac{1}{T}\sum_{t=1}^{T}\frac{\sum_{i=1}^{N}\lvert Available\_Flexibility\_Up_{i,t}\rvert}{\sum_{i=1}^{N}\lvert Baseline_{i,t}\rvert}\cdot 100$$ $$Flexibility\ Availability\ Down = -\frac{1}{T}\sum_{t=1}^{T}\frac{\sum_{i=1}^{N}\lvert Available\_Flexibility\_Down_{i,t}\rvert}{\sum_{i=1}^{N}\lvert Baseline_{i,t}\rvert}\cdot 100$$ Where: *Available_Flexibility_Up*$_{i,t}$: amount (kW, kVAr, etc.) of flexibility to increase generation/ decrease demand made available from *i*-th flexible resource in the period *t* *Available_Flexibility_Down*$_{i,t}$: amount (kW, kVAr, etc.) of flexibility to decrease generation/ increase demand made available from *i*-th flexible resource in the period *t* *Baseline*$_{i,t}$: baseline of flexible resource in the period *t* *N*: set of flexible resources that made flexibility available *T*: examined period For each flexibility services (congestion solving, voltage regulation), the separate value of this KPI will be calculated. German demo: $$Flexibility\ Availability = \sum_{t=1}^{T}\frac{\sum_{i=1}^{N}\lvert Duration\ of\ available\ Flexibility_{i,t}\rvert}{\sum_{i=1}^{N}\lvert Baseline_{i,t}\rvert}\cdot 100$$ $$Duration\ of\ available\ Flexibility_{i,t} = \mathrm{dt}_{\mathrm{available\ i,t}}$$ Where: *Duration_of_available_Flexibility*$_{i,t}$: the total duration of time in which *i*-th flexible resource in the period *T* is corresponding to controlling signals and provides		

	measurement values. Regardless of what the amount of flexibility is provided by the resource and how it relates to the initially requested of amount of flexibility, just the fact counts that the asset is reacting qualifies it as being available. $Baseline_{i,t}$: the total duration of time in which *i*-th flexible resource in the period *T* is requested to provide measurement data and is controlled *N*: set of flexible resources providing measurement signals or reacting on controlling commands *T*: examined period
Unit of measurement	%
Target / Thresholds	Italian demo: 20% Taking into account that the Italian Demo tests an innovative solution involving active customers' cooperation in grid operation, it is guessed that amount of available flexibility approximately of 20% could be reasonable offered by customers. German demo: 80% It is expected that, during the field test phase, individual systems will not be fully available for measurement and control purposes due to communication problems (weak LTE, signal, deactivation of the asset by the customer, etc.).
Measurement Process	Italian demo: Available flexibilities are data included in the offers. These data are then extracted from report provided by Market Platform. The *Baselines* are data stored in Shared Customer Database and gathered by Market Platform. The platform, at the end of day, provides a report and automatically calculates the KPI. A further analysis of the Market Platform report will allow to extract more details for example quantity of available flexibility divided by customer categories, connected power or voltage level. German demo: Available flexibility equals each resource and measurement device that is communicating with the EMS providing measurement data and able to receive controlling signals. The duration of time dt for which a resource provides measurement signal with the period T will be summed. This equals $dt_{available;I,t}$. $Baseline_{i,t}$ equals the duration of time dt a resource was actively involved in the UC application and requested to provide measurement values and/or react controlling signals.
Reporting Period	Italian demo: yearly German demo: once per project (M30 with Deliverable 5.5)
Reporting Audience and Access Rights	☐Public ☒Platone ☐Demo ☐Other

KPI CALCULATION METHODOLOGY		
Italian demo		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
KPI_PR_03_IT_1	Extract flexible resources' offers from Market Platform	areti
KPI_PR_03_IT_2	Extract baselines of resources offering flexibilities services from Market Platform	areti
KPI_PR_03_IT_3	KPI calculation	areti
German demo		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
KPI_PR_03_AVA_1	Determination of Baseline $\lvert Duration\ of\ available\ Flexibility_{i,t} \rvert$ = B_D_1	AVACON
KPI_PR_03_AVA_2	Determination of $\lvert Duration\ of\ available\ Flexibility_{i,t} \rvert$ = F_A_1	AVACON
KPI_PR_03_AVA_3	KPI calculation	AVACON

KPI DATA COLLECTION						
Italian demo						
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Data collection responsible**
Amount of flexibility offered in the Market Platform	*Available_Flexibility_Up*$_{i,t}$ *Available_Flexibility_Down*$_{i,t}$	Values included in offers issued by Aggregator in Market Platform	Market Platform	-	Daily, Up to end of project	areti
Baselines of resources offering flexibilities services	*Baseline*$_{i,t}$	Values inserted in Shared Customer Database by BRP and gathered by Market Platform	Share Customer Database	-	Daily, Up to end of project	areti
German demo						
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Data collection responsible**

Duration of time a resource where requested to be actively involved	B_D_1	Record	Setpoint/ Setpoint schedule send from EMS to resources	EMS (ALF-C)	Once during Use Case demonstration	AVACON
Duration of time a resource were corre-sponding	F_A_1	Record	Sensors located in customer households	EMS (ALF-C)	Once during Use Case demonstration	AVACON

KPI BASELINE			
Italian demo			
Source of Baseline Condition	LITERATURE VALUES ☐	COMPANY HISTORICAL VALUES ☐	VALUES MEASURED AT START OF PROJECT ☐
Details of Baseline	Baseline is estimated by forecasted tool (for more details refer to D3.3 [3]). For every customer involved in the flexibility market, the BRP (simulated in the demo by Aggregator) calculates the baseline for the day after and uploads it to the Shared Customer Database.		
Responsible (Name, Company) for Baseline	Acea Energia		
German demo			
Source of Baseline Condition	LITERATURE VALUES ☐	COMPANY HISTORICAL VALUES ☐	VALUES MEASURED AT START OF PROJECT ☒ Info: Start of Use Case Phase
Details of Baseline	$Baseline_{i,t}$ equals the duration of time dt when asset$_i$ was actively involved in the UC application and requested to provide measurement values and/or react controlling signals.		
Responsible (Name, Company) for Baseline	AVACON		

B.4 Flexibility Effectiveness

<table>
<tr><th colspan="4">BASIC KPI INFORMATION</th></tr>
<tr><td>KPI Name</td><td>Flexibility Effectiveness</td><td>KPI ID</td><td>KPI_PR_04</td></tr>
<tr><td>Project's Objective</td><td colspan="3">To unlock flexibility to address local congestion and voltage stability issues.</td></tr>
<tr><td>DEMO where KPI applies</td><td colspan="3">☒IT ☐GR ☒DE</td></tr>
<tr><td>Owner</td><td colspan="3">Italian demo: areti
German demo: Avacon</td></tr>
<tr><td>KPI Description</td><td colspan="3">This KPI targets the measurement of the effectiveness of flexibility provision. The KPI measures the sum of successfully provided flexibility in relation to the requested demand for flexibility.</td></tr>
<tr><td>KPI Formula</td><td colspan="3">Italian demo:
$$Flexibility\ Effectiveness = \frac{1}{T}\sum_{t=1}^{T}\frac{1}{N}\sum_{i=1}^{N}\frac{|Quantity\_provided_{i,t}|}{|Setpoint_{i,t}|}\cdot 100$$
where:
Quantity_provided$_{i,t}$: amount of quantity (kW, kVAr, etc.) exchange with the grid by i-th flexible resource in the period t
Setpoint$_{i,t}$: amount (kW, kVAr, etc.) of i-th request of flexibility in the period t
N: set of flexible resources that made flexibility available
T: examined period
For each flexibility services (congestion solving, voltage regulation), the separate value of this KPI will be calculated.

German demo:
$$Flexibility\ Effectiveness = \sum_{t=1}^{T}\frac{\sum_{i=1}^{N}|Flexibility_provided_{i,t}|}{\sum_{j=1}^{R}|Flexibility_requested_{j,t}|}\cdot 100$$
$$Flexibility_{i,t} = \sum_{i=1}^{N} P_{i,t} = \sum_{i=1}^{N} U_{i,t} * I_{i,t}$$
where:
Flexibility_requested$_{t}$: active power of j-th request of flexibility in the period t. Details are documented in setpoint schedules from an EMS
Flexibility_provided$_{i,t}$: active power provided from i-th flexible resource in the period t
N: set of flexible resources that made flexibility available
R: number of user requests for flexibility
T: the period of investigation for which measurements will take place considered for evaluation (2h, 6h, 12h, 24h, 48h, 96h)
U: Voltage [V] measured at grid connection point
I: Current [A] measured at grid connection point</td></tr>
</table>

Unit of measurement	%
Target / Thresholds	Italian demo:70% This percentage is used by Italian TSO to penalize the DERs involved in the pilot project, descripted in the regulation 300/2017/R/ee (reported in the D 6.2). In detail, in the relevant period (daily) the energy provided by all resources is verified with respect to their setpoint. If the ratio is over ± 30% out of the reference value, TSO apply the penalty. German demo:50% Due to the capacity limits of the storage facilities located in the field test area and possible unavailability due to breaks in the communication connection, it is expected that only part of the requested flexibility will be actually implemented.
Measurement Process	Italian demo: Quantity_provided are measured by smart meters, gathered by Light-Nodes and stored in the Shared Customer Database. Setpoints are stored in Shared Customer Database. A further analysis of the collected data will allow more details to be extracted, for example customers' reliability. German demo: The baseline $Flexibility\_requested_{j,t}$ is defined by a user sending handing a setpoint or setpoint schedule over to the EMS, where it is documented. The measurement values for determination $Flexibility\_provided_{i,t}$ are provided by sensors (PMU or other) located at the busbar of the MV/LV grid connection point. Data will be sent to EMS (ALF-C) where they will be stored for evaluation.
Reporting Period	Italian demo: yearly German demo: once per project (M30 with Deliverable 5.5)
Reporting Audience and Access Rights	☐Public ☒Platone ☐Demo ☐Other

KPI CALCULATION METHODOLOGY		
Italian demo		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
KPI_PR_04_IT_1	Extract amount measured quantities from Shared Customer Database	areti
KPI_PR_04_IT_2	Extract of Setpoints from Shared Customer Database	areti
KPI_PR_04_IT_3	KPI calculation	areti
German demo		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
KPI_PR_04_AVA_1	Collection of baseline data from setpoint schedule stored on EMS of the period dt.	AVACON
KPI_PR_04_AVA_2	Determination of baseline by applying the formula to the values given in the setpoint schedule $\sum_{j=1}^{R} \lvert Flexibility\_requested_{j,t} \rvert$	AVACON
KPI_PR_04_AVA_3	Determination of $Flexibility_{i,t}$ for each set of measurement values by applying the formula $\sum_{i=1}^{N} P_{i,t} = \sum_{i=1}^{N} U_{i,t} * I_{i,t}$	AVACON
KPI_PR_04_AVA_4	Determination of active power provided from *i*-th flexible Resource in the period d*t* $\sum_{i=1}^{N} \lvert Flexibility\_provided_{i,t} \rvert$	AVACON
KPI_PR_04_AVA_5	KPI calculation	AVACON

KPI DATA COLLECTION						
Italian demo						
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Data collection responsible**
amount of quantity (kW, kVAr, etc.) exchange with the grid	$Quantity\_provided_{i,t}$:	POD's electrical data measured by Smart-Meters, gathered by Light-Node and sent to Shared Customer Database	Shared Customer Database	-	Daily, Up to end of project	areti
Setpoint	$Setpoint_{i,t}$	Values defined during Market phase and stored in Shared Customer Database	Shared Customer Database	-	Daily, Up to end of project	areti
German demo						
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Data collection responsible**
Flexibility requested in time period dt	F_{req}_1	Record	Setpoint schedule stored on EMS	EMS (ALF-C)	Once per UC demonstration	AVACON
Number of customers accepting participation in project	F_{prov}_1	Record	Values measured by sensors (PMU or other) send to EMS	EMS (ALF-C)	Once per UC demonstration	AVACON

KPI BASELINE			
Italian demo			
Source of Baseline Condition	LITERATURE VALUES ☐	COMPANY HISTORICAL VALUES ☐	VALUES MEASURED AT START OF PROJECT ☐
Details of Baseline	N.A.		
Responsible (Name, Company) for Baseline	N.A.		
German demo			
Source of Baseline Condition	LITERATURE VALUES ☐	COMPANY HISTORICAL VALUES ☐	VALUES MEASURED AT START OF PROJECT ☒ Info: Start of Use Case Phase
Details of Baseline	The baseline is determined once per UC demonstration phase. The data are provided with the setpoint schedule that is created by a user and handed over to the EMS for execution of UC.		
Responsible (Name, Company) for Baseline	AVACON		

B.5 Distribution Network Hosting Capacity

<table>
<tr><th colspan="4">BASIC KPI INFORMATION</th></tr>
<tr><td>KPI Name</td><td>Distribution Network Hosting Capacity</td><td>KPI ID</td><td>KPI_PR_05</td></tr>
<tr><td>Project's Objective</td><td colspan="3">To ensure reliable and secure power supplies in the context of increasing DER penetration.
To unlock flexibility to address local congestion and voltage stability issues.</td></tr>
<tr><td>DEMO where KPI applies</td><td colspan="3">☐IT ☒GR ☒DE</td></tr>
<tr><td>Owner</td><td colspan="3">Greek demo: HEDNO
German demo: Avacon</td></tr>
<tr><td>KPI Description</td><td colspan="3">This indicator measures the potential increase of hosting capacity for distributed energy resources with the solutions proposed by Platone compared to the baseline scenario where DSO has no flexibility tools and services. The indicator gives a statement about the additional DERs that can be installed in the network due to innovative grid services without the need for conventional reinforcements (i.e. new grid lines).</td></tr>
<tr><td>KPI Formula</td><td colspan="3">$$HC = \frac{HC_{R\&I} - HC_{BaU}}{HC_{BaU}} * 100$$
Where:
HC_{BaU}: Hosting Capacity of Business as Usual scenario (kW).
$HC_{R\&I}$: Hosting Capacity of Research & Innovation scenario (kW).

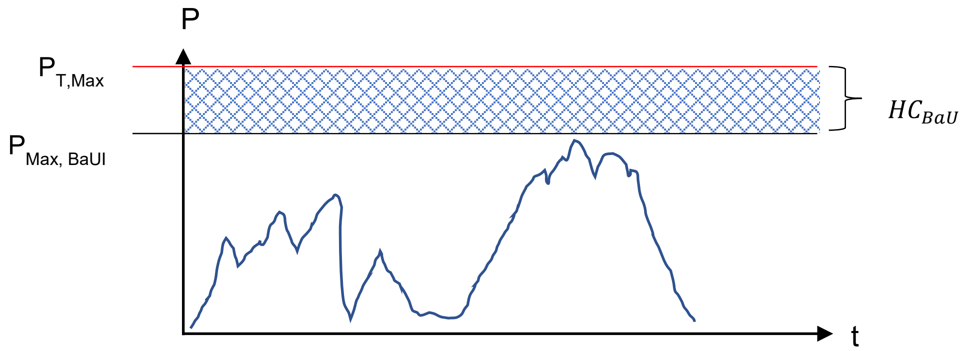
Demo leaders will select the most suitable indicator to calculate HC_{BaU} and $HC_{R\&I}$ depending on their information availability.

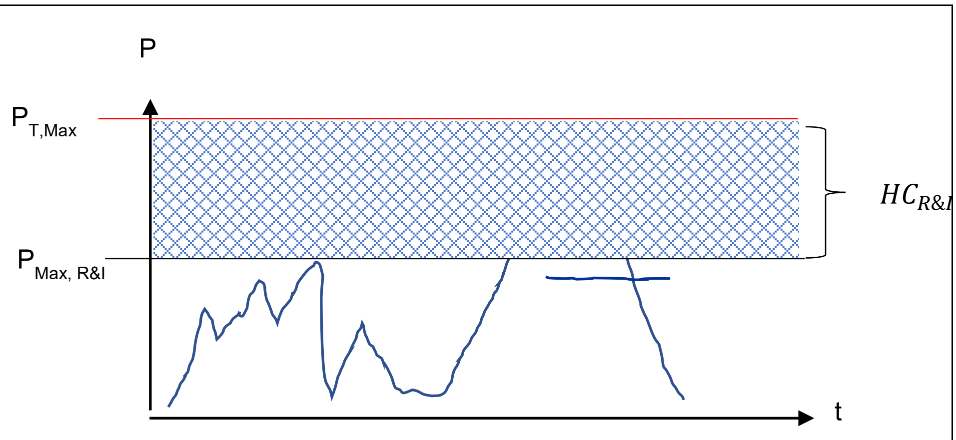
Greek demo:

HC_{BaU} and $HC_{R\&I}$ is the maximum capacity that does not cause excessive network violations and consequently excessive network operational costs in each of the scenarios.

German demo:

$HC_{R\&I}$ = $P_{T,Max}$ - $|P|_{Max,R\&I}$ (T)
HC_{BaU} = $P_{T,Max}$ - $|P|_{Max, BaU}$ (T)
Where:
$P_{Max,Transformer}$: Rated capacity of the MV/LV Transformer
$P_{Max,R\&I}$ (dt): Maximum measured value of active power exchanged at MV/LV Transformer during Research & Innovation scenario (UC is applied)
$P_{Max, BaU}$ (dt): Maximum measured value of active power exchanged at MV/LV Transformer during Business as Usual scenario (UC is not applied)
T: the period of investigation of Research & Innovation scenario at which measurements will take place and is considered for (12h, 24h, 48h, 96h).</td></tr>
<tr><td>Unit of measurement</td><td colspan="3">%</td></tr>
</table>

Target / Thresholds	Greek demo: 10 % Achieving any increase is considered as a success (as the proposed method has no implementation costs);10% increase in hosting capacity is a reasonable goal as it is enough to relieve pressure for additional DER installations in this part of Mesogeia German demo: 40 %
Measurement Process	Greek demo: Two cases are tested, one with the use of the Algorithm for optimal DER control and one without. An acceptable curtailment volume threshold is used to characterise if the network capacity limit is reached or not. This means that a low amount of curtailment is allowed, but when it exceeds a certain threshold, the DSO considers this to be unacceptable, and hence the network capacity limit is exceeded, too. Hosting capacity is increased incrementally for both cases until the network capacity limit is reached in each case. We measure at which hosting capacity the network capacity limit is reached for both cases. The aforementioned curtailment volume is obtained using the methods described in KPI_GR_07, 08, 09, 10. German demo: 1.) Determination of Baseline The baseline HC_{BaU} is determined by measuring U, I, Phase and timestamp measured at the busbar of the MV/LV grid connection point in the period T, followed by the calculation of total value of highest active power ($\|P\|_{Max, BaU}$) in the period T and then calculating the difference between P_{Max} the rated capacity of the transformer $P_{Max,Transformer}$. HC_{BaU} = $P_{Max,Transformer}$ - $\|P\|_{Max, BaU}$ (T).  2.) Determination of $HC_{R\&I}$ $HC_{R\&I}$ is determined by measuring U, I, Phase and timestamp measured at the busbar of the MV/LV grid connection point in the period T, followed by the calculation of highest active power ($\|P\|_{Max, R\&I}$) in the period T and then calculating the difference between $\|P\|_{Max, R\&I}$ the rated capacity of the transformer $P_{T,Max}$.

	
Reporting Period	Greek demo: once per project (M48) German demo: once per project (M43 with Deliverable 5.6)
Reporting Audience and Access Rights	Greek demo: ☐Public ☐Platone ☒Demo ☐Other German demo: ☐Public ☒Platone ☐Demo ☐Other

KPI CALCULATION METHODOLOGY		
Greek demo		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
KPI_PR_05_GR_1	For the examined period (time horizon of days) the DSO operates the network in a Flat Network Tariff scenario mode and measures the hosting capacity HC_{BaU} in kW of the test site network as the capacity that does not cause excessive network violations and consequently excessive network operational costs.	HEDNO/NTUA
KPI_PR_05_GR_2	The Algorithm for optimal DER control calculates on day (d-1) a per-hour network tariff value for day (d) in a Day-Ahead context over a period (time horizon of days) to be communicated to the Aggregators by the DSO.	NTUA
KPI_PR_05_GR_3	For the examined period (time horizon of days) the DSO operates the network in a Variable Network Tariff scenario mode as per the tariffs calculated by the Algorithm for optimal DER control and measures the hosting capacity $HC_{R\&I}$ in kW of the test site network as the capacity that does not cause excessive network violations and consequently	HEDNO/NTUA

	excessive network operational costs.	
KPI_PR_05_GR_4	KPI calculation	HEDNO/NTUA
German demo		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
KPI_PR_05_AVA_1	Measurement of U, I, Phase and timestamp for the duration dt and determination rated capacity of transformer.	AVACON
KPI_PR_05_AVA_2	Determination of baseline HC_{BaU} via calculation of difference between $\|P\|_{Max,\ BaU}$ and $P_{T,Max.}$	AVACON
KPI_PR_05_ AVA _3	Measurement of U, I, Phase and timestamp for the duration and rated capacity of transformer.	AVACON
KPI_PR_05_ AVA _4	Determination of baseline $HC_{R\&I}$ via calculation of difference between $\|P\|_{Max,\ R\&I}$ and $P_{T,Max.}$	AVACON
KPI_PR_05_ AVA _5	Calculation of KPI	AVACON

KPI DATA COLLECTION						
Greek demo						
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Data collection responsible**
Active/reactive power injections from distributed generation units	P_{DG} Q_{DG}	Record from the field	Sensors (smart meters)	**Measurement:** At generation unit (e.g.) **Data Storage:** DSO Data Server	15 min	HEDNO
Aggregated consumer demand at MV/LV transformer level	P_L Q_L	Obtained via computational procedure based on actual field data	Application of load estimation or forecasting methods to AMR data	**Measurement:** Smart Meters via AMR system **Data Storage:** DSO Data Server	15 min	HEDNO
Curtailment	E_g, E_d	Projection of required curtailment	Standard optimal	DSO data server	Examined period (time	HEDNO

		that would occur under an examined scenario	power flow calculation		horizon of days)	
German demo						
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Data collection responsible**
Maximum power value (Business as Usual scenario)	$\|P\|_{Max,\ BaU}$	Record	Sensor (PMU or other) measuring at busbar of MV/LV grid connection point	EMS (ALF-C)	Once per UC demonstration	AVACON
Maximum power value (Research & Innovation scenario)	$\|P\|_{Max,\ R\&I}$	Record	Sensor (PMU or other) measuring at busbar of MV/LV grid connection point	EMS (ALF-C)	Once per UC demonstration	AVACON

KPI BASELINE			
Greek demo			
Source of Baseline Condition	LITERATURE VALUES ☐	COMPANY HISTORICAL VALUES ☐	VALUES MEASURED AT START OF PROJECT ☒
Details of Baseline	The baseline value (Step 1) is calculated by running the test scenario with a business as usual approach, i.e. employing the variable network tariffs.		
Responsible (Name, Company) for Baseline	HEDNO		
German demo			
Source of Baseline Condition	LITERATURE VALUES ☐	COMPANY HISTORICAL VALUES ☐	VALUES MEASURED AT START OF PROJECT ☒ Info: Start of Use Case Phase
Details of Baseline	The baseline HC_{BaU} is determined by measuring U, I, Phase and timestamp measured at the busbar of the MV/LV grid connection point in the period T, followed by the calculation of total value of highest active power ($\|P\|_{Max,\ BaU}$) in the period T and then calculating the difference between P_{Max} the rated capacity of the transformer $P_{Max,Transformer}$.		
Responsible (Name, Company) for Baseline	AVACON		

Annex C Italian Demo-specific KPIs

This annex presents three KPIs specific for Italian demo. The remaining four Project KPIs used in this demo are available in Annex A.

C.1 Market Liquidity

BASIC KPI INFORMATION			
KPI Name	Market Liquidity	**KPI ID**	KPI_IT_01
Project's Objective	To unlock flexibility to address local congestion and voltage stability issues. To improve customers' engagement and facilitate their fair participation to market. To support cooperation with the TSO.		
DEMO where KPI applies	☒IT ☐GR ☐DE		
Owner	areti / Engineering		
KPI Description	This KPI is targeting to measure the market liquidity. The ratio of the sum of flexibility offered to the requested demand for flexibility is measured.		
KPI Formula	$$Market\ Liquidity\ Up = \frac{1}{T}\sum_{t=1}^{T}\frac{\sum_{i=1}^{N}\lvert Flexibility\_offered\_up_{i,t}\rvert}{\sum_{j=1}^{R}\lvert Flexibility\_requested\_up_{j,t}\rvert}\cdot 100$$ $$Market\ Liquidity\ Down = \frac{1}{T}\sum_{t=1}^{T}\frac{\sum_{i=1}^{N}\lvert Flexibility\_offered\_down_{i,t}\rvert}{\sum_{j=1}^{R}\lvert Flexibility\_requested\_down_{j,t}\rvert}\cdot 100$$ where: $Flexibility\_offered\_up_{i,t}$: amount (kW, kVAr, etc.) of flexibility to increase generation/decrease demand offered from *i*-th flexible resource in the period *t* $Flexibility\_offered\_down_{i,t}$: amount (kW, kVAr, etc.) of flexibility to decrease generation/increase demand offered from *i*-th flexible resource in the period *t* $Flexibility\_requested\_up_{j,t}$: amount (kW, kVAr, etc.) of *j*-th request of flexibility to increase generation/decrease demand in the period *t* $Flexibility\_requested\_down_{j,t}$: amount (kW, kVAr, etc.) of *j*-th request of flexibility to decrease generation/increase demand in the period *t* N: set of flexible resources that made flexibility available R: number of SOs flexibility requests T: examined period For each flexibility service (congestion solving, voltage regulation), a separate value of this KPI will be calculated		
Unit of measurement	%		
Target / Thresholds	>150% To guarantee market liquidity this value should be as great as possible. A preliminary indicative value is assumed 150%.		

	Note that liquidity of market should take into account also the quantity of offers vs the quantity of requests. This topic will be analysed in D3.3 [3].
Measurement Process	Offers and Requests are collected daily by Market Platform. The platform, at the end of day, provides a report and automatically calculates the KPI. A further analysis in the Deliverables 3.3 [3], 3.4 [20] and 3.5 [21] will allow to extract more details for example number of resources that provide offers divided by connected power or voltage level.
Reporting Period	yearly
Reporting Audience and Access Rights	☐Public ☒Platone ☐Demo ☐Other

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
KPI_IT_01_1	Extract amount of requested flexibility from Market Platform	areti
KPI_IT_01_ 2	Extract amount of flexibility offered from Market Platform	areti
KPI_IT_01_ 3	KPI calculation	areti

KPI DATA COLLECTION						
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Data collection responsible**
Amount of flexibility requested	$Flexibility\_requested\_up_{j,t}$ $Flexibility\_requested\_down_{j,t}$	Values included in requests issued by SOs in Market Platform	Market Platform	-	Daily, Up to end of projects	areti
Amount of flexibility offered by resources	$Flexibility\_offered\_up_{i,t}$ $Flexibility\_offered\_down_{i,t}$	Values included in offers issued by Aggregator in Market Platform	Market Platform	-	Daily, Up to end of projects	areti

KPI BASELINE			
Source of Baseline Condition	LITERATURE VALUES ☐	COMPANY HISTORICAL VALUES ☐	VALUES MEASURED AT START OF PROJECT ☐
Details of Baseline	N.A.		
Responsible (Name, Company) for Baseline	N.A.		

C.2 Forecast reliability – Customer Profile

BASIC KPI INFORMATION			
KPI Name	Forecast reliability – Customer Profile	**KPI ID**	KPI_IT_02
Project's Objective	To ensure reliable and secure power supplies in the context of increasing DER penetration.		
DEMO where KPI applies	☒IT ☐GR ☐DE		
Owner	areti / Siemens		
KPI Description	This KPI evaluates the reliability of the tool performing forecasting of power flows exchange by each Resource with the grid. The indicator is calculated for forecasted time range (next 24h or next 4h).		
KPI Formula	$$FC_{Next24h}(\,or\ FC_{Next4h}) = \frac{1}{T}\sum_{t=1}^{T}\frac{1}{N_t}\sum_{i=1}^{N_t}\left\|\frac{RL\_profile_{i,t} - FC\_profile_{i,t}}{RL\_profile_{i,t}}\right\| \cdot 100$$ where: $RL\_profile_{i,t}$: real profile [kW or kVAr] of *i*-th customer in the period *t*; $FC\_profile_{i,t}$: forecasted profile [kW or kVAr] of *i*-th customer for the period *t*; N_t : number of customers in the period *t*; T : examined period		
Unit of measurement	%		
Target / Thresholds	25% It is guessed that 25% is a realistic value. This KPI is strongly linked to the data availability and granularity.		
Measure-ment Process	*RL_profile* data is measured by smart meters and stored in the Shared Customer Database. *FC_profile* data is calculated by and stored in DSO Technical Platform.		
Reporting Period	yearly		
Reporting Audience and Access Rights	☐Public ☒Platone ☐Demo ☐Other		

KPI CALCULATION METHODOLOGY		
Italian demo		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
KPI_IT_02_1	Execute Forecasting Tool	areti

KPI_IT_02_ 2	Extract Smart-Meter's measures stored in Shared Customer Database relevant to the forecasted period.	areti
KPI_IT_02_ 3	KPI calculation	areti

KPI DATA COLLECTION						
Italian demo						
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Data collection responsible**
Forecasted Power Demand and Generation for next 24h/4h	$FC\_profile_{i,t}$	Generated by forecasting tool	DSO Technical Platform	-	Yearly, Up to end of project	areti
Ex post Power Demand and Generation	$RL\ profile_{i,t}$	POD's electrical data measured by Smart-Meters and stored in DSO Operational Systems	Smart-Meters, DSO Operational Systems	-	Yearly, Up to end of project	areti

KPI BASELINE			
Italian demo			
Source of Baseline Condition	LITERATURE VALUES ☐	COMPANY HISTORICAL VALUES ☐	VALUES MEASURED AT START OF PROJECT ☐
Details of Baseline	N.A.		
Responsible (Name, Company) for Baseline	N.A.		

C.3 Forecast reliability – Grid Profile

BASIC KPI INFORMATION			
KPI Name	Forecast reliability – Grid Profile	**KPI ID**	KPI_IT_03
Project's Objective	To ensure reliable and secure power supplies in the context of increasing DER penetration.		
DEMO where KPI applies	☒IT ☐GR ☐DE		
Owner	areti / Siemens		
KPI Description	This KPI evaluates the reliability of the tool performing forecasting of power flow in significant assets of the grid. The indicator is calculated for forecasted time range (next 24h or next 4h).		
KPI Formula	$Power\_Flow\_FC\_Next24h\ (or\ Power\_Flow\_FC\_Next4h) =$ $$= \frac{1}{T}\sum_{t=1}^{T}\frac{1}{N_t}\sum_{i=1}^{N_t}\left\lvert\frac{RL\_Power\_Flow_{i,t} - FC\_Power\_Flow_{i,t}}{RL\_Power\_Flow_{i,t}}\right\rvert \cdot 100$$ where: $RL\_Power\_Flow_{i,t}$: real power flow [kW or kVA] of *i*-th asset in the period *t* $FC\_Power\_Flow_{i,t}$: power flow forecasted [kW or kVA] of *i*-th asset for the period *t* N_t: number of assets of same category (e.g. Primary Substation nodes, Secondary Substation nodes etc.) in the period *t* T: examined period		
Unit of measurement	%		
Target / Thresholds	30% It is guessed that 30% is a realistic value that could be fulfilled. This KPI is strongly linked to the data availability, reliability of network topology and accuracy of electrical model.		
Measurement Process	*RL_Power_Flow* are measured by DSO's sensors and stored in the Operational Systems. *FC_Power_Flow* are calculated by and stored in DSO Technical Platform. The DSO Technical Platform will calculate the KPI.		
Reporting Period	yearly		
Reporting Audience and Access Rights	☐Public ☒Platone ☐Demo ☐Other		

KPI CALCULATION METHODOLOGY		
Italian demo		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
KPI_IT_03_1	Execute Forecasting Tool	areti
KPI_IT_03_ 2	Extract asset measures from SCADA relevant to the forecasted period	areti
KPI_IT_03_ 3	KPI calculation	areti

KPI DATA COLLECTION						
Italian demo						
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Data collection responsible**
Forecasted Power Flows for next 24h/4h	*FC_Power_Flow*$_{i,t}$	Generated by forecasting tool	DSO Technical Platform	-	Yearly, Up to end of project	areti
Ex post Power Flows	*RL_Power_Flow*$_{i,t}$	Assets' electrical data measured by Field Sensors, gathered by SCADA	Field sensors, Operational Systems (SCADA)	-	Yearly, Up to end of project	areti

KPI BASELINE			
Italian demo			
Source of Baseline Condition	LITERATURE VALUES ☐	COMPANY HISTORICAL VALUES ☐	VALUES MEASURED AT START OF PROJECT ☐
Details of Baseline	N.A.		
Responsible (Name, Company) for Baseline	N.A.		

Annex D Greek Demo-specific KPIs

This annex presents fifteen KPIs specific for Greek demo. The remaining one Project KPI used in this demo is available in Annex A.

D.1 Relative root mean square error (RRMSE)

BASIC KPI INFORMATION			
KPI Name	Relative root mean square error (RRMSE)	**KPI ID**	KPI_GR_01
Strategic Objective	To improve grid operation through an advanced observability approach.		
DEMO where KPI applies	☐IT ☒GR ☐DE		
Owner	HEDNO		
KPI Description	RRMSE is a unitless metric for the evaluation of state estimation accuracy in terms of bus voltage magnitudes. It captures the average 2-norm relative error in estimating bus voltage magnitudes.		
KPI Formula	$$RRMSE = \sqrt{{}^{1}/_{\mathrm{n}} \sum_{i=1}^{n} (\frac{V_i^{true} - V_i^{est}}{V_i^{true}})^2} * 100$$ Where: n: number of network buses, V_i^{est}: estimated voltage magnitude of i-th bus, V_i^{true} : true voltage magnitude of i-th bus		
Unit of measurement	%		
Target / Thresholds	<1% The KPI indicates how close to the reality the estimated grid state was in terms of bus voltage magnitudes. The average 2-norm relative error between the actual and the estimated magnitudes should be as low as possible and certainly below 1%. By meeting this target value, the average performance of the state estimation will be precise enough to support real-time decision making and operation planning.		
Measurement Process	Available measurements (referring to power flows and voltage magnitudes at the top of distribution feeders, power injections from distributed generation units, load pseudo-measurements for aggregated consumer demand at MV/LV transformer level or/and synchronized measurements of voltage/current phasors obtained from PMUs) from the Distribution Network are used as an input for the grid state estimation. The State Estimation tool processes the data and computes the voltage magnitudes of all buses of the test grid. Actual bus voltage magnitudes from the Distribution Network are compared against the calculated ones and the average 2-norm relative error between the two is calculated to evaluate the accuracy of the state estimation algorithm.		
Reporting Period	Once per project (M48)		
Reporting Audience and Access Rights	☐Public ☐Platone ☒ Demo ☐Other		

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
KPI_GR_01_1	The State Estimation tool processes the input available measurements.	NTUA
KPI_GR_01_2	The State Estimation tool computes the estimated voltage magnitudes of all buses of the test grid.	NTUA
KPI_GR_01_3	All available measurements of actual bus voltage magnitudes from the Distribution Network are collected. The rest, non-measured bus voltage magnitudes are obtained via power flow execution. All values, actually measured or calculated, are merged to build the set of actual voltage magnitudes.	NTUA
KPI_GR_01_4	KPI calculation	NTUA

KPI DATA COLLECTION						
Data	**Data ID**	**Methodology for data collection**	**Source/Tools /Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Data collection responsible**
Active/ Reactive Power flow	P_{fl} Q_{fl}	Record from the field	Sensors (SCADA)	Measurement: At the top of the distribution feeder(s) originating from HV/MV substation Data Storage: DSO Data Server	15 min	HEDNO
Voltage magnitudes of busbars at HV/MV substation	V_i	Record from the field	Sensors (SCADA)	Measurement: Busbar(s) at HV/MV substation Data Storage: DSO Data Server	15 min	HEDNO
Active/reactive power injections from distributed generation units	P_{DG} Q_{DG}	Record from the field	Sensors (smart meters)	Measurement: At generation unit (e.g. PV) Data Storage: DSO Data Server	15 min	HEDNO

Synchro-nized measure-ments of voltage /current phasors at buses where PMUs are installed	V_{PMU_i}, I	Record from the field	Sensors (PMUs)	Measurement: PMUs Data Storage: DSOTP	5 min	HEDNO
Load pseudo-measurements for aggregated consumer demand at MV/LV transformer level	P_L Q_L	Obtained via computational procedure based on actual field data.	Application of load estimation or forecasting methods to AMR data	Measurement: Smart Meters via AMR system Data Storage: DSO Data Server	15 min	HEDNO

KPI BASELINE			
Source of Baseline Condition	LITERATURE VALUES ☐	COMPANY HISTORICAL VALUES ☐	VALUES MEASURED AT START OF PROJECT ☒
Details of Baseline	In the Business as Usual scenario, there is no State Estimation tool that the one developed within Platone will be compared with. However, the actual grid state as formed based on field measurements and power flow studies, constitutes an appropriate, indicative baseline for the KPI. The KPI shows how close to the reality the estimated grid state was in terms of bus voltage magnitudes.		
Responsible (Name, Company) for Baseline	HEDNO		

D.2 Relative percentage error (RPE)

BASIC KPI INFORMATION			
KPI Name	Relative percentage error (RPE)	**KPI ID**	KPI_GR_02
Strategic Objective	To improve grid operation through advanced observability approach.		
DEMO where KPI applies	☐IT ☒GR ☐DE		
Owner	HEDNO		
KPI Description	RPE is a unitless metric for the evaluation of state estimation accuracy in terms of bus voltage magnitudes. It captures the relative error in estimating voltage magnitude per individual bus.		
KPI Formula	$$RPE_i = \frac{V_i^{true} - V_i^{est}}{V_i^{true}} * 100$$ Where: V_i^{est}: estimated voltage magnitude of i-th bus V_i^{true} : true voltage magnitude of i-th bus		
Unit of measurement	%		
Target / Thresholds	<1% The KPI_GR_02 again indicates how close to the reality the estimated grid state was in terms of bus voltage magnitudes. It is different compared to the KPI_GR_01 in its per-individual-bus approach. The relative percentage error between the actual and the estimated voltage magnitude for each individual bus should be as low as possible and certainly below 1%. By satisfying this precision threshold, the State Estimation tool will be accurate enough in order to support the quality standards according to the Hellenic regulatory framework (Hellenic Electricity Distribution Network Code), where it is stated that the average voltage at any MV bus should not exceed ±5% of the nominal voltage, e.g. 20 kV. In this way, the worst-case estimation error of 1% will be kept considerably lower than the maximum permissible voltage fluctuation, thus, possible voltage violation will be reliably detected.		
Measurement Process	Available measurements (referring to power flows and voltage magnitudes at the top of distribution feeders, power injections from distributed generation units, load pseudo-measurements for aggregated consumer demand at MV/LV transformer level or/and synchronized measurements of voltage/current phasors obtained from PMUs) from the Distribution Network are used as an input for the grid State Estimation. The State Estimation tool processes the data and computes the voltage magnitudes of all buses of the test grid. Actual bus voltage magnitudes from the Distribution Network are compared against the calculated ones and the relative percentage error between the two per individual bus is calculated to evaluate the accuracy of the state estimation algorithm.		
Reporting Period	Once per project (M48)		
Reporting Audience and Access Rights	☐Public ☐Platone ☒ Demo ☐Other		

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
KPI_GR_02_1	The State Estimation tool processes the input available measurements.	NTUA
KPI_GR_02_2	The State Estimation tool computes the estimated voltage magnitudes of all buses of the test grid.	NTUA
KPI_GR_02_3	All available measurements of actual bus voltage magnitudes from the Distribution Network are collected. The rest, non-measured bus voltage magnitudes are obtained via power flow execution. All values, actually measured or calculated, are merged to build the set of actual voltage magnitudes.	NTUA
KPI_GR_02_4	KPI calculation	NTUA

KPI DATA COLLECTION						
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Data collection responsible**
Active /Reactive Power flow	P_{fl} Q_{fl}	Record from the field	Sensors (SCADA)	Measurement: At the top of the distribution feeder(s) originating from HV/MV substation Data Storage: DSO Data Server	15 min	HEDNO
Voltage magnitudes of busbars at HV/MV substation	V_i	Record from the field	Sensors (SCADA)	Measurement: Busbar(s) at HV/MV substation Data Storage: DSO Data Server	15 min	HEDNO
Active /reactive power injections from distributed generation units	P_{DG} Q_{DG}	Record from the field	Sensors (smart meters)	Measurement: At generation unit (e.g. PV) Data Storage: DSO Data Server	15 min	HEDNO
Synchron-ized measure-ments of	V_{PMU_i}	Record from the field	Sensors (PMUs)	Measurement: PMUs Data Storage: DSOTP	5 min	HEDNO

voltage/ current phasors at buses where PMUs are installed						
Load pseudo-measurements for aggregated consumer demand at MV/LV transformer level	P_L Q_L	Obtained via computational procedure based on actual field data.	Application of load estimation or forecasting methods to AMR data	Measurement: Smart Meters via AMR system Data Storage: DSO Data Server	15 min	HEDNO

KPI BASELINE			
Source of Baseline Condition	LITERATURE VALUES ☐	COMPANY HISTORICAL VALUES ☐	VALUES MEASURED AT START OF PROJECT ☒
Details of Baseline	In the Business as Usual scenario, there is no State Estimation tool that the one developed within Platone will be compared with. However, the actual grid state as formed based on field measurements and power flow studies, constitutes an appropriate, indicative baseline for the KPI. The KPI shows again how close to the reality the estimated grid state was in terms of bus voltage magnitudes. It is different compared to the KPI_GR_01 in its per-individual-bus approach.		
Responsible (Name, Company) for Baseline	HEDNO		

D.3 Accuracy metric for complex phasor voltage estimation (MaccV)

BASIC KPI INFORMATION			
KPI Name	Accuracy metric for complex phasor voltage estimation (MaccV)	**KPI ID**	KPI_GR_03
Strategic Objective	To improve grid operation through advanced observability approach.		
DEMO where KPI applies	☐IT ☒GR ☐DE		
Owner	HEDNO		
KPI Description	MaccV is a metric for the evaluation of state estimation accuracy in terms of complex phasor voltages. It captures the effect of both bus voltage magnitude and angle errors by combining them in a common 2-norm formula.		
KPI Formula	$$Macc_V = \sqrt{\sum_{i=1}^{n} \left\| \tilde{V}_i^{true} - \tilde{V}_i^{est} \right\|^2}$$ Where: n: number of network buses, $\tilde{V}_i^{true}$: true complex phasor voltage of i-th bus $\tilde{V}_i^{est}$: estimated complex phasor voltage of i-th bus		
Unit of measurement	pu		
Target / Thresholds	<0.2 The KPI indicates how close to the reality the grid state estimation was in terms of bus voltage phasors, i.e., both bus voltage magnitudes and angles. For a network comprising 350 buses, the error between the actual and the estimated complex phasor voltages as expressed by the KPI's formula should be as low as possible and certainly below 0.2, assuming that the worst-case estimation error of 1% occurs for all estimated bus voltages.		
Measurement Process	Available measurements (referring to power flows and voltage magnitudes at the top of distribution feeders, power injections from distributed generation units, load pseudo-measurements for aggregated consumer demand at MV/LV transformer level or/and synchronized measurements of voltage/current phasors obtained from PMUs) from the Distribution Network are used as an input for the grid state estimation. The State Estimation tool processes the data and computes the complex phasor voltage (magnitude and angle) of all buses of the test grid. Actual complex phasor voltages from the Distribution Network are compared against the calculated ones and the error between the two is calculated to evaluate the accuracy of the state estimation algorithm.		
Reporting Period	Once per project (M48)		
Reporting Audience and Access Rights	☐Public ☐Platone ☒ Demo ☐Other		

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
KPI_GR_03_1	The State Estimation tool processes the input available measurements.	NTUA
KPI_GR_03_2	The State Estimation tool computes the estimated complex phasor voltage (magnitude and angle) of all buses of the test grid.	NTUA
KPI_GR_03_3	All available measurements of actual bus voltage magnitudes from the Distribution Network are collected. The rest, non-measured bus voltage magnitudes are obtained via power flow execution. All available measurements of Active and Reactive Power flows from the Distribution Network are collected. All values, actually measured or calculated, are merged to build the set of actual complex phasor voltages.	NTUA
KPI_GR_03_4	KPI calculation	NTUA

KPI DATA COLLECTION						
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Data collection responsible**
Active /Reactive Power flow	P_{fl} Q_{fl}	Record from the field	Sensors (SCADA)	Measurement: At the top of the distribution feeder(s) originating from HV/MV substation Data Storage: DSO Data Server	15 min	HEDNO
Voltage magnitudes of busbars at HV/MV substation	V_i	Record from the field	Sensors (SCADA)	Measurement: Busbar(s) at HV/MV substation Data Storage: DSO Data Server	15 min	HEDNO
Active /reactive power injections from distributed	P_{DG} Q_{DG}	Record from the field	Sensors (smart meters)	Measurement: At generation unit (e.g. PV) Data Storage: DSO Data Server	15 min	HEDNO

generation units						
Synchron-ized measure-ments of voltage /current phasors at buses where PMUs are installed	V_{PMU_i}	Record from the field	Sensors (PMUs)	Measurement: PMUs Data Storage: DSOTP	5 min	HEDNO
Load pseudo-measurements for aggregated consumer demand at MV/LV transformer level	P_L Q_L	Obtained via computational procedure based on actual field data.	Application of load estimation or forecasting methods to AMR data	Measurement: Smart Meters via AMR system Data Storage: DSO Data Server	15 min	HEDNO

KPI BASELINE			
Source of Baseline Condition	LITERATURE VALUES ☐	COMPANY HISTORICAL VALUES ☐	VALUES MEASURED AT START OF PROJECT ☒
Details of Baseline	In the Business as Usual scenario, there is no State Estimation tool that the one developed within Platone will be compared with. However, the actual grid state as formed based on field measurements and power flow studies, constitutes an appropriate, indicative baseline for the KPI. The KPI shows how close to the reality the grid state estimation was in terms of bus voltage phasors, i.e., both bus voltage magnitudes and angles.		
Responsible (Name, Company) for Baseline	HEDNO		

D.4 Convergence metric in terms of objective function

BASIC KPI INFORMATION			
KPI Name	Convergence metric in terms of objective function	**KPI ID**	KPI_GR_04
Strategic Objective	To improve grid operation through advanced observability approach.		
DEMO where KPI applies	☐IT ☒GR ☐DE		
Owner	HEDNO		
KPI Description	$Mconv_{obj}$ is a metric for the evaluation of the ability of the state estimation algorithm to converge to a solution. It quantifies the relative change in objective function ($Mconv_{obj}$) which occurs at the final iteration.		
KPI Formula	$$Mconv_{obj} = \left\| 1 - \frac{J^{kterm}}{J^{kterm-1}} \right\|$$ Where: J: value of objective function, $kterm$: the ascending number of the terminal iteration of the state estimation algorithm		
Unit of measurement	unitless		
Target / Thresholds	<<1 Since the KPI assesses the ability of the state estimation algorithm to converge to a solution, the target value for the relative change in the objective function which occurs at the final iteration, is any value below '1'. The closer to zero the value is the better.		
Measurement Process	Available measurements (referring to power flows and voltage magnitudes at the top of distribution feeders, power injections from distributed generation units, load pseudo-measurements for aggregated consumer demand at MV/LV transformer level or/and synchronized measurements of voltage/current phasors obtained from PMUs) from the Distribution Network are used as an input for the grid state estimation. The State Estimation tool processes the data and computes the complex phasor voltage (magnitude and angle) of all buses of the test grid. The relative change in objective function which occurs at the final iteration of the state estimation process is calculated.		
Reporting Period	Once per project (M48)		
Reporting Audience and Access Rights	☐Public ☐Platone ☒ Demo ☐Other		

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
KPI_GR_04_1	The State Estimation tool processes the input available measurements.	NTUA
KPI_GR_04_2	The State Estimation tool computes the estimated complex phasor voltage (magnitude and angle) of all buses of the test grid.	NTUA
KPI_GR_04_3	The value of the objective function for each iteration of the computing process is calculated.	NTUA
KPI_GR_04_4	KPI calculation	NTUA

KPI DATA COLLECTION						
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Data collection responsible**
Active /Reactive Power flow	P_{fl} Q_{fl}	Record from the field	Sensors (SCADA)	Measurement: At the top of the distribution feeder(s) originating from HV/MV substation Data Storage: DSO Data Server	15 min	HEDNO
Voltage magnitudes of busbars at HV/MV substation	V_i	Record from the field	Sensors (SCADA)	Measurement: Busbar(s) at HV/MV substation Data Storage: DSO Data Server	15 min	HEDNO
Active /reactive power injections from distributed generation units	P_{DG} Q_{DG}	Record from the field	Sensors (smart meters)	Measurement: At generation unit (e.g. PV) Data Storage: DSO Data Server	15 min	HEDNO
Synchron-ized measure-ments of voltage /current phasors at buses	V_{PMU_i}, I	Record from the field	Sensors (PMUs)	Measurement: PMUs Data Storage: DSOTP	5 min	HEDNO

where PMUs are installed						
Load pseudo-measurements for aggregated consumer demand at MV/LV transformer level	P_L Q_L	Obtained via computational procedure based on actual field data.	Application of load estimation or forecasting methods to AMR data	Measurement: Smart Meters via AMR system Data Storage: DSO Data Server	15 min	HEDNO

KPI BASELINE			
Source of Baseline Condition	LITERATURE VALUES ☐	COMPANY HISTORICAL VALUES ☐	VALUES MEASURED AT START OF PROJECT ☒
Details of Baseline	In the Business as Usual scenario, there is no State Estimation tool that the one developed within Platone will be compared with. Since the KPI assesses the ability of the state estimation algorithm to converge to a solution, '1' can be considered as the baseline value for the relative change in the objective function which occurs at the final iteration.		
Responsible (Name, Company) for Baseline	HEDNO		

D.5 Convergence metric in terms of estimated voltage magnitude

BASIC KPI INFORMATION			
KPI Name	Convergence metric in terms of estimated voltage magnitude	**KPI ID**	KPI_GR_05
Strategic Objective	To improve grid operation through advanced observability approach.		
DEMO where KPI applies	☐IT ☒GR ☐DE		
Owner	HEDNO		
KPI Description	$Mconv_V$ is a metric for the evaluation of the ability of state estimation algorithm to converge to a solution. It quantifies the maximum relative change in estimated voltage magnitudes which occur at the final iteration.		
KPI Formula	$$Mconv_V = \max_i \left| 1 - \frac{V_i^{kterm}}{V_i^{kterm-1}} \right|$$ Where: V_i: voltage magnitude of i-th bus, $kterm$: the ascending number of the terminal iteration of the state estimation algorithm		
Unit of measurement	unitless		
Target / Thresholds	<<1 Since the KPI assesses the ability of the state estimation algorithm to converge to a solution in regards with voltage magnitudes, the target value for the relative change in estimated voltage magnitudes which occurs at the final iteration, is any value below '1'. The closer to zero the value is the better.		
Measurement Process	Available measurements (referring to power flows and voltage magnitudes at the top of distribution feeders, power injections from distributed generation units, load pseudo-measurements for aggregated consumer demand at MV/LV transformer level or/and synchronized measurements of voltage/current phasors obtained from PMUs) from the Distribution Network are used as an input for the grid state estimation. The State Estimation tool processes the data and computes the complex phasor voltage (magnitude and angle) of all buses of the test grid. The relative change in voltage magnitude which occurs at the final iteration of the state estimation process is calculated per individual bus and the maximum relative change among all buses is reported for this KPI in a worst-case scenario approach.		
Reporting Period	Once per project (M48)		
Reporting Audience and Access Rights	☐Public ☐Platone ☒ Demo ☐Other		

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
KPI_GR_05_1	The State Estimation tool processes the input available measurements.	NTUA
KPI_GR_05_2	The State Estimation tool computes the estimated voltage magnitude of all buses of the test grid.	NTUA
KPI_GR_05_3	The values of the buses' voltage magnitudes for each iteration of the computing process are calculated.	NTUA
KPI_GR_05_4	KPI calculation	NTUA

KPI DATA COLLECTION						
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Data collection responsible**
Active/ Reactive Power flow	P_{fl} Q_{fl}	Record from the field	Sensors (SCADA)	Measurement: At the top of the distribution feeder(s) originating from HV/MV substation Data Storage: DSO Data Server	15 min	HEDNO
Voltage magnitudes of busbars at HV/MV substation	V_i	Record from the field	Sensors (SCADA)	Measurement: Busbar(s) at HV/MV substation Data Storage: DSO Data Server	15 min	HEDNO
Active /reactive power injections from distributed generation units	P_{DG} Q_{DG}	Record from the field	Sensors (smart meters)	Measurement: At generation unit (e.g. PV) Data Storage: DSO Data Server	15 min	HEDNO
Synchron-ized measure-ments of voltage /current phasors at buses	V_{PMU_i}	Record from the field	Sensors (PMUs)	Measurement: PMUs Data Storage: DSOTP	5 min	HEDNO

where PMUs are installed						
Load pseudo-measurements for aggregated consumer demand at MV/LV transformer level	P_L Q_L	Obtained via computational procedure based on actual field data.	Application of load estimation or forecasting methods to AMR data	Measurement: Smart Meters via AMR system Data Storage: DSO Data Server	15 min	HEDNO

KPI BASELINE			
Source of Baseline Condition	LITERATURE VALUES ☐	COMPANY HISTORICAL VALUES ☐	VALUES MEASURED AT START OF PROJECT ☒
Details of Baseline	In the Business as Usual scenario, there is no State Estimation tool that the one developed within Platone will be compared with. Since the KPI assesses the ability of the state estimation algorithm to converge to a solution in regards with voltage magnitudes, '1' can be considered as the baseline value for the relative change in estimated voltage magnitudes which occurs at the final iteration.		
Responsible (Name, Company) for Baseline	HEDNO		

D.6 Convergence metric in terms of estimated voltage angle

BASIC KPI INFORMATION			
KPI Name	Convergence metric in terms of estimated voltage angle	**KPI ID**	KPI_GR_06
Strategic Objective	To improve grid operation through advanced observability approach.		
DEMO where KPI applies	☐IT ☒GR ☐DE		
Owner	HEDNO		
KPI Description	$Mconv_{\delta}$ is a metric for the evaluation of the ability of state estimation algorithm to converge to a solution. It quantifies the maximum change in estimated voltage angles which occur at the final iteration.		
KPI Formula	$$Mconv_{\delta} = \max_{i}\left\|\theta_i^{kterm} - \theta_i^{kterm-1}\right\|$$ Where: θ_i: voltage angle of i -th bus, kterm: the ascending number of the terminal iteration of the state estimation algorithm		
Unit of measurement	unitless		
Target / Thresholds	<<1 Since the KPI assesses the ability of the state estimation algorithm to converge to a solution in regards with voltage angles, the target value for the relative change in estimated voltage angles which occurs at the final iteration, is any value below ‘1’. The closer to zero the value is the better.		
Measurement Process	Available measurements (referring to power flows and voltage magnitudes at the top of distribution feeders, power injections from distributed generation units, load pseudo-measurements for aggregated consumer demand at MV/LV transformer level or/and synchronized measurements of voltage/current phasors obtained from PMUs) from the Distribution Network are used as an input for the grid state estimation. The State Estimation tool processes the data and computes the complex phasor voltage (magnitude and angle) of all buses of the test grid. The relative change in voltage angle which occurs at the final iteration of the state estimation process is calculated per individual bus and the maximum relative change among all buses is reported for this KPI in a worst-case scenario approach.		
Reporting Period	Once per project (M48)		
Reporting Audience and Access Rights	☐Public ☐Platone ☒ Demo ☐Other		

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
KPI_GR_06_1	The State Estimation tool processes the input available measurements.	NTUA
KPI_GR_06_2	The State Estimation tool computes the estimated voltage magnitude of all buses of the test grid.	NTUA
KPI_GR_06_3	The values of the buses' voltage angles for each iteration of the computing process are calculated.	NTUA
KPI_GR_06_4	KPI calculation	NTUA

KPI DATA COLLECTION						
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Data collection responsible**
Active/ Reactive Power flow	P_{fl} Q_{fl}	Record from the field	Sensors (SCADA)	Measurement: At the top of the distribution feeder(s) originating from HV/MV substation Data Storage: DSO Data Server	15 min	HEDNO
Voltage magnitudes of busbars at HV/MV substation	V_i	Record from the field	Sensors (SCADA)	Measurement: Busbar(s) at HV/MV substation Data Storage: DSO Data Server	15 min	HEDNO
Activev/reactive power injections from distributed generation units	P_{DG} Q_{DG}	Record from the field	Sensors (smart meters)	Measurement: At generation unit (e.g. PV) Data Storage: DSO Data Server	15 min	HEDNO
Synchron-ized measure-ments of voltage /current phasors at buses where	V_{PMU_i}	Record from the field	Sensors (PMUs)	Measurement: PMUs Data Storage: DSOTP	5 min	HEDNO

PMUs are installed						
Load pseudo-measurements for aggregated consumer demand at MV/LV transformer level	P_L Q_L	Obtained via computational procedure based on actual field data.	Application of load estimation or forecasting methods to AMR data	Measurement: Smart Meters via AMR system Data Storage: DSO Data Server	15 min	HEDNO

KPI BASELINE			
Source of Baseline Condition	LITERATURE VALUES ☐	COMPANY HISTORICAL VALUES ☐	VALUES MEASURED AT START OF PROJECT ☒
Details of Baseline	In the Business as Usual scenario, there is no State Estimation tool that the one developed within Platone will be compared with. Since the KPI assesses the ability of the state estimation algorithm to converge to a solution in regards with voltage angles, '1' can be considered as the baseline value for the relative change in estimated voltage angles which occurs at the final iteration.		
Responsible (Name, Company) for Baseline	HEDNO		

D.7 Generation curtailment

BASIC KPI INFORMATION			
KPI Name	Generation curtailment	**KPI ID**	KPI_GR_07
Strategic Objective	To ensure reliable and secure power supplies in the context of increasing DER penetration. To unlock flexibility to address local congestion and voltage level issues.		
DEMO where KPI applies	☐IT ☒GR ☐DE		
Owner	HEDNO		
KPI Description	The indicator compares the amount of energy from Renewable Energy Sources (RES) that is not injected to the grid (even though it is available) due to operational limits of the grid, between the Variable Network Tariff scenario and the Business as Usual scenario.		
KPI Formula	$$\Delta C_{RES} = \frac{\sum_{t\in T}\sum_{i\in I} E_{g\,i,t}^{BaU} - \sum_{t\in T}\sum_{i\in I} E_{g\,i,t}^{R\&I}}{\sum_{t\in T}\sum_{i\in I} E_{g\,i,t}^{BaU}} * 100$$ Where: $E_{g\,i,t}^{BaU}$: energy curtailment of the i-th RES facility at period t in the Business as Usual - Flat Network Tariff scenario (kWh) $E_{g\,i,t}^{R\&I}$: energy curtailment of the i-th RES facility at period t in the Variable Network Tariff scenario (kWh) I: set of RES facilities under consideration T: set of time intervals of the period under consideration (excluding periods of scheduled maintenance and outages)		
Unit of measurement	%		
Target / Thresholds	Reduction by 20% The use of variable network tariff instead of flat network tariff by the DSO will incentivise certain behaviours from the DERs' owners, which will lead to an optimal dispatch with the least possible RES generation curtailed. A variable network tariff could potentially resolve all cases, which would theoretically mean that no RES generation curtailment would be needed at all, if it were a true locational marginal price. However, since the network tariff is subject to regulatory constraints and there are technical constraints regarding the efficient network use, the reduction of RES generation curtailment is expected to be 20%.		
Measurement Process	Available measurements (referring to power flows and voltage magnitudes at the top of distribution feeders, power injections from distributed generation units, load pseudo-measurements for aggregated consumer demand at MV/LV transformer level or/and synchronized measurements of voltage/current phasors obtained from PMUs) from the Distribution Network are used as an input for the grid state estimation. The State Estimation tool processes the data and provides an accurate grid state estimation. The Algorithm for optimal DER control calculates on day (d-1) a per-hour network tariff value for day (d) in a Day-Ahead context to be communicated to the Aggregators by the DSO. The Aggregators schedule their resources at optimal cost, accordingly. On day (d) the DSO operates the network and measures the RES generation curtailment that was required for the safe and stable operation of the distribution network. The amount of RES generation curtailed		

	in kWh is compared with the Business as Usual - Flat Network Tariff scenario on the same test data. The period (T) examined can be one day, one month or one year depending on the reporting requirements.
Reporting Period	Once per project (M48)
Reporting Audience and Access Rights	☐Public ☐Platone ☒ Demo ☐Other

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
KPI_GR_07_1	For a period T, which usually is an entire day (d) the DSO operates the network in a Business as Usual - Flat Network Tariff scenario mode and measures the required generation curtailment $\sum_{i \in I} {E_g}_{i,t}^{BaU}$ to maintain the network within limits.	HEDNO/NTUA
KPI_GR_07_2	The Algorithm for optimal DER control calculates on day (d-1) a per-hour network tariff value for day (d) in a Day-Ahead context to be communicated to the Aggregators by the DSO.	NTUA
KPI_GR_07_3	For a period (T), which usually is an entire day (d), the DSO operates the network in a Variable Network Tariff scenario mode as per the tariffs calculated by the Algorithm for optimal DER control and measures the required generation curtailment $\sum_{i \in I} {E_g}_{i,t}^{R\&I}$.	HEDNO/NTUA
KPI_GR_07_4	KPI calculation for the period (T), which usually is an entire day (d)	HEDNO/NTUA

KPI DATA COLLECTION						
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Data collection responsible**
Active/ reactive power injections from distributed generation units	P_{DG} Q_{DG}	Record from the field	Sensors (smart meters)	Measurement: At generation unit (e.g. PV) Data Storage: DSO Data Server	15 min	HEDNO
Aggregated consumer demand at	P_L Q_L	Obtained via computatio	Application of load estimation or	Measurement:	15 min	HEDNO

MV/LV transformer level		nal procedure based on actual field data	forecasting methods to AMR data	Smart Meters via AMR system Data Storage: DSO Data Server		
Generation Curtailment	E_g	Projection of required generation curtailment that would occur under an examined scenario	Standard optimal power flow calculation	DSO data server	Examined period (time horizon of days)	HEDNO

KPI BASELINE			
Source of Baseline Condition	LITERATURE VALUES ☐	COMPANY HISTORICAL VALUES ☐	VALUES MEASURED AT START OF PROJECT ☒
Details of Baseline	The baseline value (Step 1) is calculated by running the test scenario with a business as usual approach, i.e. without employing the variable network tariffs.		
Responsible (Name, Company) for Baseline	HEDNO		

D.8 Demand curtailment

BASIC KPI INFORMATION			
KPI Name	Demand curtailment	**KPI ID**	KPI_GR_08
Strategic Objective	To ensure reliable and secure power supplies in the context of increasing DER penetration. To unlock flexibility to address local congestion and voltage level issues.		
DEMO where KPI applies	☐IT ☒GR ☐DE		
Owner	HEDNO		
KPI Description	The indicator compares the amount of energy consumption that needs to be curtailed due to operational limits of the grid, between the Variable Network Tariff and the Business as Usual scenario.		
KPI Formula	$$\Delta C_{DEMAND} = \frac{\sum_{t\in T}\sum_{i\in I} E_{d_{i,t}}^{BaU} - \sum_{t\in T}\sum_{i\in I} E_{d_{i,t}}^{R\&I}}{\sum_{t\in T}\sum_{i\in I} E_{d_{i,t}}^{BaU}} * 100$$ Where: $E_{d_{i,t}}^{BaU}$: demand curtailment of the i-th flexible customer facility at period t in the Business as Usual –Flat Network Tariff scenario (kWh) $E_{d_{i,t}}^{R\&I}$: demand curtailment of the i-th flexible customer facility at period t in the Variable Network Tariff scenario (kWh) I: set of flexible customers under consideration T: set of time intervals of the period under consideration		
Unit of measurement	%		
Target / Thresholds	Reduction by 20% The use of variable network tariff instead of flat network tariff by the DSO will incentivise certain behaviours from the DERs' owners, which will lead to an optimal dispatch with the least possible demand curtailed. A variable network tariff could potentially resolve all cases, which would theoretically mean that no demand curtailment would be needed at all, if it were a true locational marginal price. However, since the network tariff is subject to regulatory constraints and there are technical constraints regarding the efficient network use, the reduction of demand curtailment is expected to be 20%.		
Measurement Process	Available measurements (referring to power flows and voltage magnitudes at the top of distribution feeders, power injections from distributed generation units, load pseudo-measurements for aggregated consumer demand at MV/LV transformer level or/and synchronized measurements of voltage/current phasors obtained from PMUs) from the Distribution Network are used as an input for the grid state estimation. The State Estimation tool processes the data and provides an accurate grid state estimation. The Algorithm for optimal DER control calculates on day (d-1) a per-hour network tariff value for day (d) in a Day-Ahead context to be communicated to the Aggregators by the DSO. The Aggregators schedule their resources at optimal cost, accordingly. On day (d) the DSO operates the network and measures the demand curtailment that was required for the safe and stable operation of the distribution network. The amount of demand curtailed in kWh is compared with the Business as Usual - Flat Network Tariff scenario on the same		

	test data. The period (T) examined can be one day, one month or one year depending on the reporting requirements.
Reporting Period	Once per project (M48)
Reporting Audience and Access Rights	☐Public ☐Platone ☒ Demo ☐Other

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
KPI_GR_08_1	For a period (T), which usually is an entire day (d), the DSO operates the network in a Business as Usual - Flat Network Tariff scenario mode and measures the required demand curtailment $\sum_{i\in I} E_{d_{i,t}}^{BaU}$ to maintain the network within limits.	HEDNO/NTUA
KPI_GR_08_2	The Algorithm for optimal DER control calculates on day (d-1) a per-hour network tariff value for day (d) in a Day-Ahead context to be communicated to the Aggregators by the DSO.	NTUA
KPI_GR_08_3	For a period (T), which usually is an entire day (d), the DSO operates the network in a Variable Network Tariff scenario mode as per the tariffs calculated by the Algorithm for optimal DER control and measures the required demand curtailment $\sum_{i\in I} E_{d_{i,t}}^{R\&I}$.	HEDNO/NTUA
KPI_GR_08_4	KPI calculation for the period (T), which usually is an entire day (d)	HEDNO/NTUA

KPI DATA COLLECTION						
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/ Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Data collection responsible**
Active /reactive power injections from distributed generation units	P_{DG} Q_{DG}	Record from the field	Sensors (smart meters)	Measurement: At generation unit (e.g. PV) Data Storage: DSO Data Server	15 min	HEDNO

Aggregated consumer demand at MV/LV transformer level	P_L Q_L	Obtained via computational procedure based on actual field data	Application of load estimation or forecasting methods to AMR data	Measurement: Smart Meters via AMR system Data Storage: DSO Data Server	15 min	HEDNO
Demand Curtailment	E_d	Projection of required demand curtailment that would occur under an examined scenario	Standard optimal power flow calculation	DSO data server	Examined period (time horizon of days)	HEDNO

KPI BASELINE			
Source of Baseline Condition	LITERATURE VALUES ☐	COMPANY HISTORICAL VALUES ☐	VALUES MEASURED AT START OF PROJECT ☒
Details of Baseline	The baseline value (Step 1) is calculated by running the test scenario with a business as usual approach, i.e. without employing the variable network tariffs.		
Responsible (Name, Company) for Baseline	HEDNO		

D.9 Generation curtailment occurrences

BASIC KPI INFORMATION			
KPI Name	Generation curtailment occurrences	**KPI ID**	KPI_GR_09
Strategic Objective	To ensure reliable and secure power supplies in the context of increasing DER penetration. To unlock flexibility to address local congestion and voltage level issues.		
DEMO where KPI applies	☐IT ☒GR ☐DE		
Owner	HEDNO		
KPI Description	The metric compares the number of occurrences of generation curtailment for the mitigation of network limit violations between the Variable Network Tariff scenario and the Business as Usual scenario.		
KPI Formula	$$\Delta Nc_{RES} = \frac{Nc_{RES}^{BaU} - Nc_{RES}^{R\&I}}{Nc_{RES}^{BaU}} * 100$$ Where: $Nc_{RES} = \sum_{t \in T} k_t$, number of occurrences of RES generation curtailment k_t: binary variable indicating if generation curtailment occurred anywhere at period t T: set of time intervals of period under consideration Nc_{RES}^{BaU}: Number of occurrences of RES generation curtailment in the Business as Usual - Flat Network Tariff scenario. $Nc_{RES}^{R\&I}$: Number of occurrences of RES generation curtailment in Variable Network Tariff scenario.		
Unit of measurement	%		
Target / Thresholds	Reduction by 20% The use of variable network tariff instead of flat network tariff by the DSO will incentivise certain behaviours from the DERs' owners, which will lead to an optimal dispatch with the least possible RES generation curtailment occurrences. A variable network tariff could potentially resolve all cases, which would theoretically mean that no RES generation curtailment would be needed at all. However, since the network tariff is subject to regulatory constraints and there are technical constraints regarding the efficient network use, the reduction of RES generation curtailment occurrences is expected to be 20%.		
Measurement Process	Available measurements (referring to power flows and voltage magnitudes at the top of distribution feeders, power injections from distributed generation units, load pseudo-measurements for aggregated consumer demand at MV/LV transformer level or/and synchronized measurements of voltage/current phasors obtained from PMUs) from the Distribution Network are used as an input for the grid state estimation. The State Estimation tool processes the data and provides an accurate grid state estimation. The Algorithm for optimal DER control calculates on day (d-1) a per-hour network tariff value for day (d) in a Day-Ahead context to be communicated to the Aggregators by the DSO. The Aggregators schedule their resources at optimal cost, accordingly. On day (d) the DSO operates the network and measures the number of cases that curtailed RES generation for the safe and stable operation of the distribution network. The number of occurrences when RES generation was curtailed is compared with the Business as Usual - Flat Network		

	Tariff scenario on the same test data. The period (T) examined can be one day, one month or one year depending on the reporting requirements.
Reporting Period	Once per project (M48)
Reporting Audience and Access Rights	☐Public ☐Platone ☒ Demo ☐Other

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
KPI_GR_09_1	For a period (T), which usually is an entire day (d), the DSO operates the network in a Flat Network Tariff scenario mode and measures the required generation curtailment occurrences Nc_{RES}^{BaU} to maintain the network within limits.	HEDNO/NTUA
KPI_GR_09_2	The Algorithm for optimal DER control calculates on day (d-1) a per-hour network tariff value for day (d) in a Day-Ahead context to be communicated to the Aggregators by the DSO.	NTUA
KPI_GR_09_3	For a period (T), which usually is an entire day (d), the DSO operates the network in a Variable Network Tariff scenario mode as per the tariffs calculated by the Algorithm for optimal DER control and measures the required generation curtailment occurrences $Nc_{RES}^{R\&I}$.	HEDNO/NTUA
KPI_GR_09_4	KPI calculation for the period (T), which usually is an entire day (d)	HEDNO/NTUA

KPI DATA COLLECTION						
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Data collection responsible**
Active /reactive power injections from distributed generation units	P_{DG} Q_{DG}	Record from the field	Sensors (smart meters)	Measurement: At generation unit (e.g. PV) Data Storage: DSO Data Server	15 min	HEDNO
Aggregated consumer demand at MV/LV transformer level	P_L Q_L	Obtained via computational procedure based on actual field data	Application of load estimation or forecasting methods to AMR data	Measurement: Smart Meters via AMR system Data Storage: DSO Data Server	15 min	HEDNO
Generation Curtailment occur-rences	Nc_{RES}	Projection of required generation curtailment occurrences.	Standard optimal power flow calculation	DSO data server	Examined period (time horizon of days)	HEDNO

KPI BASELINE			
Source of Baseline Condition	LITERATURE VALUES ☐	COMPANY HISTORICAL VALUES ☐	VALUES MEASURED AT START OF PROJECT ☒
Details of Baseline	The baseline value (Step 1) is calculated by running the test scenario with a business as usual approach, i.e. without employing the variable network tariffs.		
Responsible (Name, Company) for Baseline	HEDNO		

D.10 Demand curtailment occurrences

BASIC KPI INFORMATION			
KPI Name	Demand curtailment occurrences	**KPI ID**	KPI_GR_10
Strategic Objective	To ensure reliable and secure power supplies in the context of increasing DER penetration. To unlock flexibility to address local congestion and voltage level issues.		
DEMO where KPI applies	☐IT ☒GR ☐DE		
Owner	HEDNO		
KPI Description	The metric compares the number of occurrences of demand curtailment for the mitigation of network limit violations between the Variable Network Tariff scenario and the Business as Usual scenario.		
KPI Formula	$$\Delta Nc_{DEMAND} = \frac{Nc_{DEMAND}^{BaU} - Nc_{DEMAND}^{R\&I}}{Nc_{DEMAND}^{BaU}} * 100$$ Where: $Nc_{DEMAND} = \sum_{t \in T} m_t$, number of occurrences of demand curtailment m_t: binary variable indicating if demand curtailment occurred anywhere at period t T: set of time intervals of period under consideration Nc_{DEMAND}^{BaU}: Number of occurrences of demand curtailment in the Business as Usual - Flat Network Tariff scenario. $Nc_{DEMAND}^{R\&I}$: Number of occurrences of demand curtailment in the Variable Network Tariff scenario.		
Unit of measurement	%		
Target / Thresholds	Reduction by 20% The use of variable network tariff instead of flat network tariff by the DSO will incentivise certain behaviours from the DERs' owners, which will lead to an optimal dispatch with the least possible demand curtailment occurrences. A variable network tariff could potentially resolve all cases, which would theoretically mean that no demand curtailment would be needed at all. However, since the network tariff is subject to regulatory constraints and there are technical constraints regarding the efficient network use, the reduction of demand curtailment occurrences is expected to be 20%.		
Measurement Process	Available measurements (referring to power flows and voltage magnitudes at the top of distribution feeders, power injections from distributed generation units, load pseudo-measurements for aggregated consumer demand at MV/LV transformer level or/and synchronized measurements of voltage/current phasors obtained from PMUs) from the Distribution Network are used as an input for the grid state estimation. The State Estimation tool processes the data and provides an accurate grid state estimation. The Algorithm for optimal DER control calculates on day (d-1) a per-hour network tariff value for day (d) in a Day-Ahead context to be communicated to the Aggregators by the DSO. The Aggregators schedule their resources at optimal cost, accordingly. On day (d) the DSO operates the network		

	and measures the number of cases that curtailed demand for the safe and stable operation of the distribution network. The number of occurrences when demand was curtailed is compared with the Business as Usual - Flat Network Tariff scenario on the same test data. The period (T) examined can be one day, one month or one year depending on the reporting requirements.
Reporting Period	Once per project (M48)
Reporting Audience and Access Rights	☐Public ☐Platone ☒ Demo ☐Other

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
KPI_GR_10_1	For a period (T), which usually is an entire day (d), the DSO operates the network in a Flat Network Tariff scenario mode and measures the required demand curtailment occurrences Nc_{DEMAND}^{BaU} to maintain the network within limits.	HEDNO/NTUA
KPI_GR_10_2	The Algorithm for optimal DER control calculates on day (d-1) a per-hour network tariff value for day (d) in a Day-Ahead context to be communicated to the Aggregators by the DSO.	NTUA
KPI_GR_10_3	For a period (T), which usually is an entire day (d), the DSO operates the network in a Variable Network Tariff scenario mode as per the tariffs calculated by the Algorithm for optimal DER control and measures the required demand curtailment occurrences $Nc_{DEMAND}^{R\&I}$.	HEDNO/NTUA
KPI_GR_10_4	KPI calculation	HEDNO/NTUA

KPI DATA COLLECTION						
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Data collection responsible**
Active /reactive power injections from distributed generation units	P_{DG} Q_{DG}	Record from the field	Sensors (smart meters)	Measurement: At generation unit (e.g. PV) Data Storage: DSO Data Server	15 min	HEDNO
Aggregated consumer demand at MV/LV transformer level	P_L Q_L	Obtained via computational procedure based on actual field data	Application of load estimation or forecasting methods to AMR data	Measurement: Smart Meters via AMR system Data Storage: DSO Data Server	15 min	HEDNO
Demand Curtailment occurr-ences	Nc_{DEM}	Projection of required demand curtailment occurrences.	Standard optimal power flow calculation	DSO data server	Examined period (time horizon of days)	HEDNO

KPI BASELINE			
Source of Baseline Condition	LITERATURE VALUES ☐	COMPANY HISTORICAL VALUES ☐	VALUES MEASURED AT START OF PROJECT ☒
Details of Baseline	The baseline value (Step 1) is calculated by running the test scenario with a business as usual approach, i.e. without employing the variable network tariffs.		
Responsible (Name, Company) for Baseline	HEDNO		

D.11 Network limit violation occurrences

BASIC KPI INFORMATION			
KPI Name	Network limit violation occurrences	**KPI ID**	KPI_GR_11
Strategic Objective	To ensure reliable and secure power supplies in the context of increasing DER penetration. To unlock flexibility to address local congestion and voltage level issues.		
DEMO where KPI applies	☐IT ☒GR ☐DE		
Owner	HEDNO		
KPI Description	This indicator evaluates the difference between the number of network limit violation occurrences under a 24-hour timeframe in the Variable Network Tariff scenario and the equivalent one in the Business as Usual scenario.		
KPI Formula	$$NV = \frac{N^{BaU}_{total_{violations}} - N^{R\&I}_{total_{violations}}}{N^{BaU}_{total_{violations}}} * 100$$ Where: $N^{BaU}_{total_{violations}} = Nc^{BaU}_{RES} \cup Nc^{BaU}_{demand}$: Total number of network limit violation occurrences in the Business as Usual - Flat Network Tariff scenario. $N^{R\&I}_{total_{violations}} = Nc^{R\&I}_{RES} \cup Nc^{R\&I}_{demand}$: Total number of network limit violation occurrences in the Variable Network Tariff scenario. Nc_{RES}: number of occurrences of RES generation curtailment Nc_{demand}: number of occurrences of demand curtailment		
Unit of measurement	%		
Target / Thresholds	Reduction by 20% The use of variable network tariff instead of flat network tariff by the DSO will incentivise certain behaviours from the DERs' owners, which will lead to an optimal dispatch with the least possible network limit violations. Since the network tariff is subject to regulatory constraints and there are technical constraints regarding the secure and efficient network use, the reduction of network limit violations is expected to be 20%.		
Measurement Process	Available measurements (referring to power flows and voltage magnitudes at the top of distribution feeders, power injections from distributed generation units, load pseudo-measurements for aggregated consumer demand at MV/LV transformer level or/and synchronized measurements of voltage/current phasors obtained from PMUs) from the Distribution Network are used as an input for the grid state estimation. The State Estimation tool processes the data and provides an accurate grid state estimation. The Algorithm for optimal DER control calculates on day (d-1) a per-hour network tariff value for day (d) in a Day-Ahead context to be communicated to the Aggregators by the DSO. The Aggregators schedule their resources at optimal cost, accordingly. On day (d) the DSO operates the network and measures the number of cases that there has been a network limit violation. A limit violation occurrence is equivalent to a generation and/or demand curtailment occurrence as every time a limit violation is bound to happen, curtailment is decided to prevent it. The number of occurrences of network limit violations on a day is compared with the Business as Usual - Flat Network Tariff scenario on the same test data.		

Reporting Period	Once per project (M48)
Reporting Audience and Access Rights	☐Public ☐Platone ☒ Demo ☐Other

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
KPI_GR_11_1	On day (d) the DSO operates the network in a Flat Network Tariff scenario mode and records the required generation and demand curtailment occurrences $(Nc_{RES}^{BaU}, Nc_{demand}^{BaU})$ required to maintain the network within limits.	HEDNO/NTUA
KPI_GR_11_2	The curtailment occurrences under the Business as Usual scenario are summed (union operation)	HEDNO/NTUA
KPI_GR_11_3	The Algorithm for optimal DER control calculates on day (d-1) a per-hour network tariff value for day (d) in a Day-Ahead context to be communicated to the Aggregators by the DSO.	NTUA
KPI_GR_11_4	On day (d) the DSO operates the network in a Variable Network Tariff scenario mode as per the tariffs calculated by the Algorithm for optimal DER control and records the required generation and demand curtailment occurrences $(Nc_{RES}^{R\&I}, Nc_{demand}^{R\&I})$.	HEDNO/NTUA

KPI DATA COLLECTION						
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Data collection responsible**
Active /reactive power injections from distributed generation units	P_{DG} Q_{DG}	Record from the field	Sensors (smart meters)	Measurement: At generation unit (e.g. PV) Data Storage: DSO Data Server	15 min	HEDNO
Aggregated consumer demand at MV/LV transformer level	P_L Q_L	Obtained via computational procedure based on actual field data	Application of load estimation or forecasting methods to AMR data	Measurement: Smart Meters via AMR system Data Storage: DSO Data Server	15 min	HEDNO
Curtailment	Nc_{dema} Nc_{RES}	Projection of required demand and/or generation curtailment occurrences under a 24-hour timeframe	Standard optimal power flow calculation	DSO data server	On a daily basis	HEDNO

KPI BASELINE			
Source of Baseline Condition	LITERATURE VALUES ☐	COMPANY HISTORICAL VALUES ☐	VALUES MEASURED AT START OF PROJECT ☒
Details of Baseline	The baseline value (Step 1) is calculated by running the test scenario with a business as usual approach, i.e. without employing the variable network tariffs.		
Responsible (Name, Company) for Baseline	HEDNO		

D.12 Frequency support not provided

BASIC KPI INFORMATION			
KPI Name	Frequency support not provided	**KPI ID**	KPI_GR_12
Strategic Objective	To ensure reliable and secure power supplies in the context of increasing DER penetration. To support cooperation with the TSO. To improve customers' engagement and facilitate their fair participation to market.		
DEMO where KPI applies	☐IT ☒GR ☐DE		
Owner	HEDNO		
KPI Description	This indicator evaluates the difference between the power deficit between the TSO's request for the frequency support and customers' response, due to operational limits of the grid in the Variable Network Tariff scenario and the Business as Usual scenario.		
KPI Formula	$$\Delta P_{FSNP} = \frac{P_{FSNP}^{BaU} - P_{FSNP}^{R\&I}}{P_{FSNP}^{BaU}} * 100$$ Where: $FSNP$: Frequency Support Not Provided P_{FSNP}^{BaU}: Power deficit between the TSO's request for frequency support and customers' response in the Business as Usual – Flat Network Tariff scenario (kW) $P_{FSNP}^{R\&I}$: Power deficit between the TSO's request for frequency support and customers' response in the Variable Network Tariff scenario (kW)		
Unit of measurement	%		
Target / Thresholds	Reduction by 20% The use of variable network tariff instead of flat network tariff by the DSO will incentivise certain behaviours from the DERs' owners (users of the distribution network), so that they can provide frequency support to the TSO. Given that the network tariff is subject to regulatory constraints and there are technical constraints regarding the secure and efficient network operation, the frequency support that the DERs' owners did not manage to provide is expected to be reduced by 20%.		
Measurement Process	In a continuous manner, available measurements (referring to power flows and voltage magnitudes at the top of distribution feeders, power injections from distributed generation units, load pseudo-measurements for aggregated consumer demand at MV/LV transformer level or/and synchronized measurements of voltage/current phasors obtained from PMUs) from the Distribution Network are used as an input for the grid state estimation. The State Estimation tool processes the data and provides the Algorithm for ancillary services with an accurate grid state estimation. When a frequency response activation arrives by the TSO, the DSO is imposing a short-duration network tariff, which the Algorithm for ancillary services computes to represent the state of the network to the Aggregators and incentivise certain behaviours to satisfy the TSO's request. The Aggregators take into account the network usage costs, which are applicable in a short balancing period and not in an entire day and decide their response accordingly. The amount of frequency support eventually not provided to the TSO in kW for a certain frequency support request is compared with the Business as Usual - Flat Network Tariff scenario by the use of historical data.		

Reporting Period	Once per project (M48)
Reporting Audience and Access Rights	☐Public ☐Platone ☒ Demo ☐Other

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
KPI_GR_12_1	On time interval (t) the DSO operates the network in a Business as Usual - Flat Network Tariff scenario mode and measures the power that was not provided to the TSO after a frequency support request.	HEDNO/NTUA
KPI_GR_12_2	The Algorithm for ancillary services calculates ahead of time interval (t) a network tariff value for (t) to be communicated to the Aggregators by the DSO.	NTUA
KPI_GR_12_3	On time interval (t) the DSO operates the network in a Variable Network Tariff scenario mode as per the tariffs calculated by the Algorithm for ancillary services and measures the power that was not provided to the TSO after a frequency support request.	HEDNO/NTUA
KPI_GR_12_4	KPI calculation	HEDNO/NTUA

KPI DATA COLLECTION						
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/ Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Data collection responsible**
Active /reactive power injections from distributed generation units	P_{DG} Q_{DG}	Record from the field	Sensors (smart meters)	Measurement: At generation unit (e.g. PV) Data Storage: DSO Data Server	15 min	HEDNO
Aggregated consumer demand at MV/LV transformer level	P_L Q_L	Obtained via computational procedure based on actual field data	Application of load estimation or forecasting methods to AMR data	Measurement: Smart Meters via AMR system Data Storage: DSO Data Server	15 min	HEDNO
Power not delivered	P_{FSNP}	Projection of power not delivered that would occur under an examined scenario	Standard optimal power flow calculation	DSO data server	Examined period (time interval (t))	HEDNO

KPI BASELINE			
Source of Baseline Condition	LITERATURE VALUES ☐	COMPANY HISTORICAL VALUES ☐	VALUES MEASURED AT START OF PROJECT ☒
Details of Baseline	The baseline value (Step 1) is calculated by running the test scenario with a business as usual approach, i.e. without employing the variable network tariffs.		
Responsible (Name, Company) for Baseline	HEDNO		

D.13 PMUs‘ field installation and integration

BASIC KPI INFORMATION			
KPI Name	PMUs’ field installation and integration	**KPI ID**	KPI_GR_13
Strategic Objective	To improve grid operation through advanced observability approach.		
DEMO where KPI applies	☐IT ☒GR ☐DE		
Owner	HEDNO		
KPI Description	Indicates the number of PMUs actually installed in the field and integrated in the DSO Technical Platform.		
KPI Formula	$$PMU_{sum} = n$$ Where: n: number of PMU installed		
Unit of measurement	unitless		
Target / Thresholds	30 The target value for the number of PMUs installed in selected nodes is proportional to the size of the test site, and it is set considering the impact on enhancing state estimation algorithm the PMUs are supposed to have.		
Measurement Process	PMUs will be installed and commissioned in selected nodes of the test grid. PMUs’ measurement data will be integrated in the DSO Technical Platform. As long as a PMU is physically installed and its measurement data is read by the DSO Technical Platform, it will be counted as a successful PMU field installation and integration for the purposes of this KPI.		
Reporting Period	Once per project (M48)		
Reporting Audience and Access Rights	☐Public ☐Platone ☒ Demo ☐Other		

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
KPI_GR_13_1	Number of PMUs installed and commissioned on the field.	HEDNO
KPI_GR_13_2	Verification of PMU data integration in the DSOTP	HEDNO
KPI_GR_13_3	KPI calculation	HEDNO

KPI DATA COLLECTION						
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Data collection responsible**
Number of PMUs	n	Verify the correct installation and commissioning of PMUs and data integration in DSOTP	Field inspection/DSOTP UI	Field/DSOTP	Once	HEDNO

KPI BASELINE			
Source of Baseline Condition	LITERATURE VALUES ☐	COMPANY HISTORICAL VALUES ☐	VALUES MEASURED AT START OF PROJECT ☒
Details of Baseline	The baseline scenario represents the beginning of the project when no PMUs are installed in the field or integrated in the DSOTP.		
Responsible (Name, Company) for Baseline	HEDNO		

D.14 Data visualisation

BASIC KPI INFORMATION			
KPI Name	Data visualisation	**KPI ID**	KPI_GR_14
Strategic Objective	To improve grid operation through advanced observability approach.		
DEMO where KPI applies	☐IT ☒GR ☐DE		
Owner	HEDNO		
KPI Description	This KPI indicates the number of data sources (e.g. AMR, GIS, SCADA-DMS, DSO data server) that will be visualised in the open DSO Technical Platform.		
KPI Formula	$DS_{vis} = m$ Where: m : the data sources used for the testing of the Greek demo Use Cases within Platone		
Unit of measurement	unitless		
Target / Thresholds	4 The data from 4 different data sources will be required for testing the tools and services the Greek demo develops within Platone.		
Measurement Process	The data from a HEDNO data source (e.g. AMR, GIS, SCADA-DMS, DSO data server) is visualised in the DSO Technical Platform to be counted as a successful data visualisation for the purposes of this KPI.		
Reporting Period	Once per project (M48)		
Reporting Audience and Access Rights	☐Public ☐Platone ☒ Demo ☐Other		

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
KPI_GR_14_1	AMR data visualisation	HEDNO
KPI_GR_14_2	GIS data visualisation	HEDNO
KPI_GR_14_3	SCADA/DMS data visualisation	HEDNO
KPI_GR_14_4	DSO data server data visualisation	HEDNO
KPI_GR_14_5	KPI calculation	HEDNO

KPI DATA COLLECTION						
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Data collection responsible**
Number of Data sources	m	Verify that data from AMR, GIS, SCADA/DMS and DSO data server are visualised on the DSOTP	DSOTP UI	DSOTP	Once	HEDNO

KPI BASELINE			
Source of Baseline Condition	LITERATURE VALUES ☐	COMPANY HISTORICAL VALUES ☐	VALUES MEASURED AT START OF PROJECT ☒
Details of Baseline	The baseline scenario represents the beginning of the project when the data from the available data sources are not yet visualised on the DSOTP.		
Responsible (Name, Company) for Baseline	HEDNO		

D.15 Visualised tools and services

BASIC KPI INFORMATION			
KPI Name	Visualised tools and services	**KPI ID**	KPI_GR_15
Strategic Objective	To improve grid operation through advanced observability approach.		
DEMO where KPI applies	☐IT ☒GR ☐DE		
Owner	HEDNO		
KPI Description	This KPI indicates the number of tools and services visualised, outputs of which, allow the DSO to operate the distribution network more efficiently by the use of the DSO Technical Platform.		
KPI Formula	$$T_{vis} = k$$ Where: k: the tools (algorithms) developed within Platone		
Unit of measurement	unitless		
Target / Thresholds	3 There will be three tools and services developed by the Greek demo within Platone		
Measurement Process	As long as the outputs of the tools and services developed by the Greek demo within Platone are visualised in the DSO Technical Platform, the related tool will be counted as a successfully visualised tool for the purposes of the KPI. The tool will be then considered as a new add-on for the DSO's day to day operation.		
Reporting Period	Once per project (M48)		
Reporting Audience and Access Rights	☐Public ☐Platone ☒ Demo ☐Other		

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
KPI_GR_15_1	Visualisation of SE tool output	HEDNO
KPI_GR_15_2	Visualisation of DER control algorithm output	HEDNO
KPI_GR_15_3	Visualisation of ancillary services algorithm output	HEDNO
KPI_GR_15_4	KPI calculation	HEDNO

KPI DATA COLLECTION						
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Data collection responsible**
Output of tools and services	k	Verify that outputs from SE tool, DER control and ancillary services algorithms are visualized on the DSOTP	DSOTP UI	DSOTP	Once	HEDNO

KPI BASELINE			
Source of Baseline Condition	LITERATURE VALUES ☐	COMPANY HISTORICAL VALUES ☐	VALUES MEASURED AT START OF PROJECT ☒
Details of Baseline	The baseline scenario represents the beginning of the project when the outputs of Platone tools and services are not yet visualised on the DSOTP.		
Responsible (Name, Company) for Baseline	HEDNO		

Annex E German Demo-specific KPIs

This annex presents eight KPIs specific for German demo. The remaining five Project KPIs used in this demo are available in Annex A.

E.1 Reduction of Energy Demand Exchange along the MV feeder

BASIC KPI INFORMATION			
KPI Name	Reduction of Energy Demand Exchange along the MV feeder	**KPI ID**	KPI_DE_01
Project's Objective	To improve customers' engagement and facilitate their fair participation to market. To unlock flexibility to address local congestion and voltage stability issues.		
DEMO where KPI applies	☐IT ☐GR ☒DE		
Owner	Avacon		
KPI Description	UC 1 is targeting to maximize consumption of locally generated energy and minimize consumption of energy provided by the feeding MV grid. This KPI evaluates the ability of the developed solution to reduce and avoid the energy consumption from the feeding grid by measuring the deviation of energy consumption in times of UC 1 application and times UC 1 is not applied.		
KPI Formula	RED - Reduction of energy demand $RED = \frac{\sum_{t=1}^{T}\lvert Energy\ Exchange\ no\ Islanding\rvert_{i;t} - \sum_{t=1}^{T}\lvert Energy\ Exchange\ Islandi\rvert}{\sum_{t=1}^{T}\lvert Energy\ Exchange\ Islanding\rvert_{i;t}} * 100$ $\sum_{t=1}^{T}\lvert Energy\ Exchange\ no\ Islanding\rvert_{i;t} = \sum_{t=1}^{T} U * I * (t_{t-1} - t_t)$ Where: $\lvert Energy\ Exchange\ no\ Islanding\rvert$: the absolute value of energy (kWh) that has been exchanges along the MV/LV grid connection point during the time period of investigation T while UC1 is **not** applied. The value of energy exchange is positive or negative direction will be added as absolute values. U : Voltage [V] measured at grid connection point I : Current [A] measured at grid connection point $(t_{t-1} - t_t)$: Duration of time between two subsequent timestamps of measurement. $\lvert Energy\ Exchange\ Islanding\rvert$: the absolute value of energy (kWh) that has been exchanged along the MV/LV grid connection point during the time period of investigation T while UC1 is applied. The value of energy exchange is positive or negative direction will be added as absolute values. T : the period of investigation for which measurements will take place considered for evaluation (2h, 6h, 12h, 24h, 48h, 96h).		

	Constraint: For a comparison, the same environmental conditions must exist.
Unit of measurement	%
Target / Thresholds	60 % The reduction of energy demand from the MV grid is expected to be 70%. The target value is only valid for a period of time at which sufficient flexibility is available (flexible load and free and available storage capacity). Assuming an average energy consumption of household during the measurement and an average PV generation (no cloud cover), it is to be expected that the value of 60% can be maintained for up to 48 hours in winter months. In the summer months, however, it is expected that the target value can be maintained for a maximum of 3 hours in periods of full solar irradiation due to the limited storage capacity of approx. 650 kWh and the high installed PV generation capacity of 300 kW. It is expected that, due to latencies delays in the measure-switch-measure cycle, a real-time synchronization of generation and consumption will not be achieved and thus minor power exchanges will take place via the grid connection point during UC application. It is expected that this will lead to energy exchanges that in total equal 40% of the energy that will be exchanged, while UC1 is not applied.
Measurement Process	The KPI will be evaluated for different season of the year (winter, spring, summer, autumn) and different durations of investigations *T* (*T* - 2h, 6h, 12h, 24h, 48h, 96h). In order to calculate the KPI 2 measurements a different time but comparable environment (weather conditions) have to be applied. One the measurement of baseline $\lvert Energy\ Exchange\ no\ Islanding \rvert$ will take place before each investigation (*T* - 2h, 6h, 12h, 24h, 48h, 96h) after a measurement to determine $\lvert Energy\ Exchange\ Islanding \rvert$ for the duration T while UC 1 will be applied. 1.) <u>Determination of baseline</u> $E_{NO\text{-}UC}$_01: The measurement values for determination of $\lvert E \rvert_{Exchange,\ no\ Islanding}(dt)$ will be collected from the sensor located at the grid connection point in the secondary substation measuring the load exchange between MV and LV network of the field test grid. The values U, I, timestamp will be provided every 1 Seconds up to 15 Minutes and used for the determination of E = U * I * t. Positive and negative values will be added as absolute values |E|. 2.) <u>Determination of</u> E_{UC}_01: A second measurement has to be applied for the determination of the amount of energy that is exchanged along the grid connection for the time period of investigation T while UC 1 is applied, $\lvert Energy\ Exchange\ Islanding \rvert$. The environmental condition, such as temperature, solar radiation, cloudiness should be similar in order to create comparable scenario. Therefore, measurements will be done at the same time, at the same point of measurement but at a different day with comparable weather conditions. After the data of measurements have been collected, the KPI has to be calculated according to the KPI_DE_01 formula.
Reporting Period	Once per project (M24 with the D5.4)

Reporting Audience and Access Rights	☐Public ☒Platone ☐Demo ☐Other

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
KPI_DE_01_1	Measurement of U, I for baseline determination	AVACON
KPI_DE_01_2	Determination of baseline with the formula $\sum_{t=1}^{T} \lvert Energy\ Exchange\ no\ Islanding \rvert_{i;t}$ that describes the Energy exchanged when UC 1 is not applied.	AVACON
KPI_DE_01_3	Measurement of U, I while UC 1 applied	AVACON
KPI_DE_01_4	Determination of $\sum_{t=1}^{T} \lvert Energy\ Exchange\ Islanding \rvert_{i;t}$ that describes the Energy exchanged when UC 1 is applied	AVACON
KPI_DE_01_5	KPI calculation	AVACON

KPI DATA COLLECTION						
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Data collection responsible**
Energy exchanged no UC application	E_{NO-UC}_01	Record	Sensors (PMU, PLMulti-II or other)	Measurement: Busbar of each phase of MV/LV grid connection point Data Storage: EMS (ALF-C)	6 measurements per season (winter, spring, summer, autumn) with a measurement duration *T* of 2, 6, 12, 24, 48, 96 hours.	AVACON
Energy exchanged with UC 1 application	E_{UC}_01	Record	Sensors (PMU, PLMulti-II or other)	Measurement: Busbar of each phase of MV/LV grid connection point Data Storage: EMS (ALF-C)	6 measurements per season (winter, spring, summer, autumn) with a	AVACON

					measurement duration T of 2, 6, 12, 24, 48, 96 hours.	

KPI BASELINE			
Source of Baseline Condition	LITERATURE VALUES ☐	COMPANY HISTORICAL VALUES ☐	VALUES MEASURED AT START OF PROJECT ☒ Info: Measurement at start of Use Case Phase
Details of Baseline	The measurement values for determination of $\lvert E \rvert_{Exchange,\ no\ Islanding}(dt)$ will be collected from the sensor located at the grid connection point in the secondary substation measuring the load exchange between MV and LV network of the field test grid. The values U, I, timestamp will be provided every 1 Seconds up to 15 Minutes and used for the determination of E = U * I * △t. Positive and negative values will be added as absolute values |E|. U * I will be multiplied with the time interval between the time stamps of individual measured value. E.g. in case a measurement takes place every 60 seconds, P will be multiplied by 0,0166 in order to determine the energy exchange for 60 seconds in kWh. The baseline will determined for each period of investigation and evaluated for different season of the year (winter, spring, summer, autumn) and different durations of investigations T (T - 2h, 6h, 12h, 24h, 48h, 96h).		
Responsible (Name, Company) for Baseline	AVACON		

E.2 Reduction of power recuperation peaks

BASIC KPI INFORMATION			
KPI Name	Reduction of power recuperation peaks	**KPI ID**	KPI_DE_02
Project's Objective	To improve customers' engagement and facilitate their fair participation to market. To unlock flexibility to address local congestion and voltage stability issues.		
DEMO where KPI applies	☐IT ☐GR ☒DE		
Owner	Avacon		
KPI Description	Use Case 1 targets the reduction of power peaks along the MV/LV grid connection point. A coordinated control of a local BESS, household energy storages and flexible loads enables the avoidance of power peak at grid connection point. This KPI evaluates the ability to reduce power peaks of an EC caused by fluctuating generation or demand within a defined period of time dt.		
KPI Formula	$Peak\ Reduction = \frac{\lvert P\rvert_{Max,\ no\ Islanding}(T) - \lvert P\rvert_{Max,\ with\ Islanding}(T)}{\lvert P\rvert_{Max,\ no\ Islanding}(dt)} * 100$ Where: $\lvert P\rvert_{Max,\ no\ Islanding}(T)$: the absolute maximum value of active power (kW) measured at the MV/LV feeder within the period of investigation *T* while UC1 is not applied. $\lvert P\rvert_{Max,\ with\ Islanding}(T)$: the absolute maximum value of power exchange (kW) along the MV/LV feeder within the period of investigation *T*, while UC1 is applied. T : the period of investigation for which measurements will take place to be considered for evaluation (2h, 6h, 12h, 24h, 48h, 96h).		
Unit of measurement	%		
Target / Thresholds	40 % The maximum peak load measured at the grid connection point is expected to be 60 % lower than the peak load measured without the UC 1 application. The BESS, from a theoretical point of view, provides enough load capacity for the compensation of generation or load peaks along the grid connection points. But, due to expected latencies in the communication and data process of the infrastructure of the EMS and the resulting delays in the measure-switch-measure cycle, a real-time synchronization will not be possible. High fluctuating power feed from PV generators still may result in high load fluctuation. Therefore, a KPI value of 0 to 20 %, meaning a reduction of power peaks between 80 % to 100 % is expected to be not reachable.		
Measurement Process	The KPI will be evaluated for different season of the year (winter, spring, summer, autumn) and different durations of *T* (*T* - 2h, 6h, 12h, 24h, 48h, 96h). In order to calculate the KPI 2 measurements a different time but comparable environment (weather conditions) have to be applied. One the measurement of baseline $\lvert P\rvert_{Max,\ no\ Islanding}(T)$ for the time period of investigation T and one measurement of the duration dt while UC 1 is applied for determination of $\lvert P\rvert_{Max,\ with\ Islanding}(T)$.		

	1.) <u>The measurement to determine the baseline $P_{Max\ NoUC}$</u> The baseline $\|P\|_{Max,\ \ no\ Islanding}(T)$ for this KPI is defined as the maximum value of active power that has been measured by a sensor located at the connection point in the secondary substation in the period *dt.* The sensor provides voltage (U) and current (I) measurement data and a time stamp. For each set of data the active power will be calculated by applying the formula P = U * I. The maximum value in the period dt will be used for the KPI calculation. 2.) <u>Measurement of $P_{MAX\ UC}$ while UC 1 is applied</u> A second measurement has to be carried out at the same point of measurement during the application of UC 1 to determine the maximum value of power $\|P\|_{Max,\ \ with\ Islanding}(T)$ measured at the grid connection point in the same for the time period of investigation T. The environmental condition, such as temperature, solar radiation, cloudiness should be similar in order to create comparable scenario. Therefore, measurements will be done at the same time, at the same point of measurement but at a different day with comparable weather conditions. After the data of measurements have been collected, the KPI has to be calculated according to the KPI_DE_02 formula.
Reporting Period	Once per project (M24 with the D5.4)
Reporting Audience and Access Rights	☐Public ☒Platone ☐Demo ☐Other

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
KPI_DE_02_1	Measurement for baseline determination (U, I, t)	AVACON
KPI_DE_02_2	Measurement for baseline determination $\|P\|_{Max,\ \ no\ Islanding}(T) = U * I\ (T)$ I	AVACON
KPI_DE_02_3	Measurement while UC 1 application	AVACON
KPI_DE_02_4	Determination of $\|P\|_{Max,\ \ with\ Islanding}(dt)$	AVACON
KPI_DE_02_5	KPI calculation	AVACON

KPI DATA COLLECTION						
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Data collection responsible**
Maximum Power exchange while UC 1 is not applied	$P_{Max\ NoUC}$	Record	Sensors (PMU, PLMulti-II or other)	Measurement: Busbar of each phase of MV/LV grid connection point Data Storage: EMS (ALF-C)	6 measurements per season (winter, spring, summer, autumn) with a measurement duration *T* of 2, 6, 12, 24, 48, 96 hours.	AVACON
Maximum value of power exchange while UC 1 is applied	$P_{MAX\ UC}$	Record	Sensors (PMU, PLMulti-II or other)	Measurement: Busbar of each phase of MV/LV grid connection point Data Storage: EMS (ALF-C)	6 measurements per season (winter, spring, summer, autumn) with a measurement duration *T* of 2, 6, 12, 24, 48, 96 hours.	

KPI BASELINE			
Source of Baseline Condition	LITERATURE VALUES ☐	COMPANY HISTORICAL VALUES ☐	VALUES MEASURED AT START OF PROJECT ☐
Details of Baseline	Values of U, I, Phase and timestamp measured while the EMS is not activated and no UC is applied. The measurement values for determination of $\|P\|_{Max,\ no\ Islanding}(dt)$ will be collected from the sensor located at the grid connection point in the secondary substation measuring the load exchange between MV and LV network of the field test grid. The values U, I, timestamp will be provided every 1 Seconds up to 15 Minutes and used for the determination of P = U * I. Positive and negative values will be added. The highest value measured within the time period of investigation T will be considered as baseline for the KPI calculation. The baseline will determined for each period of investigation and evaluated for different season of the year (winter, spring, summer, autumn) and different durations of investigations *T* (*T* - 2h, 6h, 12h, 24h, 48h, 96h).		
Responsible (Name, Company) for Baseline	AVACON		

E.3 Increase in self-consumption

BASIC KPI INFORMATION			
KPI Name	Increase in self-consumption	**KPI ID**	KPI_DE_03
Project's Objective	To improve customers' engagement and facilitate their fair participation to market. To unlock flexibility to address local congestion and voltage stability issues.		
DEMO where KPI applies	☐IT ☐GR ☒DE		
Owner	Avacon		
KPI Description	UC 1 is targeting the reduction of power exchanges along the MV/LV grid connection point. The balancing algorithm shall maximize the consumption of locally generated energy by storing generated surplus in local battery storages (BESS and household energy storages) and make use of stored generation surplus in times of higher demand. This KPI measures the increase of self -consumption in times of UC 1 is applied by comparing the energy export in the period dt with the application of UC 1 and in for the time period of investigation T without the application of UC 1.		
KPI Formula	Increase of self-consumption $IoSC = \frac{\sum_{t=1}^{T_0} \|Energy\ Export\ no\ Islanding\|_{i;t} - \sum_{t=1}^{T} \|Energy\ Export\ Islanding\|_{i;t}}{\sum_{t=1}^{T} \|Energy\ Export\ Islanding\|_{i;t}} * 100$ $Energy = \sum_{t=1}^{T} U * I * (t_{t-1} - t_t)$ Where: $\|Energy\ Export\ no\ Islanding\|$: the cumulative value of energy exported out of the energy community LV network into MV network in the time of investigation T_0 when UC1 is not applied. The resulting value is defined as the baseline. $\|Energy\ Export\ Islanding\|$: the absolute value of energy in kWh exported out of the energy community into MV network in the period of investigation T while UC1 is applied. U : Voltage [V] measured at grid connection point I : Current [A] measured at grid connection point $(t_{t-1} - t_t)$: Duration of time between two subsequent timestamps of measurement T : the period of investigation for which measurements will take place considered for evaluation (2h, 6h, 12h, 24h, 48h, 96h).		
Unit of measure-ment	%		

Target / Thresholds	80%. Assuming that sufficient storage capacity is available for the storage of generation surplus, the self-consumption during UC 1 application should reach be almost 100% compared to a situation UC is not applied. Due to delays in the measure-switching-measure cycle of the EMS IT-infrastructure, a real time synchronization of generation and storage charging will not be possible. It is therefore expected that a certain amount of energy will be unintentionally exported out of the local grid leading to a reduction of self-consumption from 100 % to 80 %.
Measure-ment Process	The KPI will be evaluated for different seasons of the year (winter, spring, summer, autumn) and different durations T (2h, 6h, 12h, 24h, 48h, 96h) of application of the UC 1. For the calculation of the KPI two measurements have to be done: 1.) Determination E_{EXP_1} - One measurement to determine the baseline at which the UC 1 is not applied. The baseline $E_{\,Export,\ no\,Islanding}(T)$ for this KPI is defined as the cumulated energy that has been exported out of the community along the grid connection point from the EC LV network into the MV network during for the time period of investigation T. Relevant measurement are implemented by sensors located in the secondary substation sending measurements values to the EMS for documentation and evaluation. 2.) Determination E_{EXP_2} - A second measurement has to be done when UC 1 is applied to determine the amount of energy that is exported along the grid connection point $E_{Export,\ Islanding}(T)$ within the same period *T.* The environmental condition, such as temperature, solar radiation, cloudiness should be similar in order to create comparable scenario. Therefore, measurements will be done at the same time, at the same point of measurement but at a different day with comparable weather conditions. After the data of measurements have been collected, the KPI has to be calculated according to the KPI_DE_03 formula.
Reporting Period	Once per project (M24)
Reporting Audience and Access Rights	☐Public ☒Platone ☐Demo ☐Other

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
KPI_DE_03_1	Measurement for baseline determination	AVACON
KPI_DE_03_2	Baseline determination $E_{\,Export,\ no\,Islanding}(dt)$	AVACON
KPI_DE_03_3	Measurement while UC 1 application	AVACON
KPI_DE_03_4	Determination of $E_{Export,\ during\,Islanding}(dt)$	AVACON
KPI_DE_03_5	KPI calculation	AVACON

KPI DATA COLLECTION						
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Data collection responsible**
E Exported out of the grid, while UC 1 is no applied	E_{EXP}_1	Record	Sensors (PMU, PLMulti-II or other)	Measurement: Busbar of each phase of MV/LV grid connection point Data Storage: EMS (ALF-C)	6 measurements per season (winter, spring, summer, autumn) with a measurement duration *T* of 2, 6, 12, 24, 48, 96 hours.	AVACON
E Exported out of the grid, while UC 1 is applied	E_{EXP_2}	Record	Sensors (PMU, PLMulti-II or other)	Measurement: Busbar of each phase of MV/LV grid connection point Data Storage: EMS (ALF-C)	6 measurements per season (winter, spring, summer, autumn) with a measurement duration *T* of 2, 6, 12, 24, 48, 96 hours.	AVACON

KPI BASELINE			
Source of Baseline Condition	LITERATURE VALUES ☐	COMPANY HISTORICAL VALUES ☐	VALUES MEASURED AT START OF PROJECT ☒ Info: Measurement at start of Use Case Phase
Details of Baseline	The measurement values for determination of $E_{Export,\ no\ Islanding}(dt)$ will be collected from the sensor located at the grid connection point in the secondary substation measuring the energy export from LV network of the field test grid into the MV network. The values U, I, timestamp will be provided every 1 Seconds up to 15 Minutes and used for the determination of E_{Export} by applying the formula $\sum_{t=1}^{T} \lvert U * I * \triangle t_t \rvert$. U * I will be multiplied with the time interval between the time stamps of individual measured value. E.g. in case a measurement takes place every 60 seconds, P_{Export} will be multiplied by 0,0166 in order to determine the energy exchange for 60 seconds in kWh. Power flows into the grid (MV to LV) will not be considered. The total amount of energy exported in time period of investigation T will be summed up.		
Responsible (Name, Company) for Baseline	AVACON		

E.4 Maximization of Islanding Duration

BASIC KPI INFORMATION			
KPI Name	Maximization of Islanding Duration	**KPI ID**	KPI_DE_04
Project's Objective	To improve customers' engagement and facilitate their fair participation to market. To unlock flexibility to address local congestion and voltage stability issues.		
DEMO where KPI applies	☐IT ☐GR ☒DE		
Owner	Avacon		
KPI Description	Use Case 1 is targeting to maximize the total duration or number of times in which the load exchange along the grid connection point is zero or close to zero. This KPI measures the success of maximizing the duration of time at which a load exchange along grid connection point is avoided.		
KPI Formula	$\text{Maximization of Islanding Duration} = \text{MoID}$ $\text{MoID} = \frac{\sum_{t=1}^{T} t_{Islanding;\, P_{Breaker} \approx 0}}{\sum_{t=1}^{T} t_{No\ Islanding;\, P_{Breaker} \approx 0}} * 100$ Where: $\sum_{t=1}^{T} t_{Islanding;\, P_{Breaker} \approx 0}$: the sum of duration of times within the period *T* at which the power exchange along the grid connection point (grid breaker) is close to zero (P = ~ 10 kW). $\sum_{t=1}^{T} t_{No\ Islanding;\, P_{Breaker} \approx 0}$: During the UC 1 application it is the sum of duration of time within the period *T* in which the power exchange along the grid connection point is kept about zero (within ± 10 kW). T : the period of investigation for which measurements will take place considered for evaluation (2h, 6h, 12h, 24h, 48h, 96h). Constraint: For a comparison, the same environmental conditions must exist. The measurement takes place at the LV/MV grid connection point.		
Unit of measurement	%		
Target / Thresholds	The KPI target is to increase the duration of islanding by 19.2 hour (≈1,152 minutes) that equals 19,200.00 % per day compared to a scenario at which UC 1 is not applied. The average duration of time at which the power exchange along the grid connection point is in the range of ± 10 kW is expected to be maximum 6 Minutes within 24 hours of an average day. Household load demand during night hours as well as PV generation during the day hours will lead to load flows higher than 10 kW in positive or negative direction at the grid connection point. With the application of UC 1 it is expected that in 80 % (=1440 minutes) of the time of the day the load flow along the grid connection point will be kept between ± 10 kW.		
Measurement Process	The KPI will be evaluated for different season of the year (winter, spring, summer, autumn) and different durations of investigations *T* (*T* - 2h, 6h, 12h, 24h, 48h, 96h). For the calculation of the KPI "MoID" two separate measurements are necessary. 1.) Determination of baseline t_{Island} 1:		

	In the first step, the baseline $\sum_{t=1}^{T} t_{No\ Islanding;\ P_{Breaker}\approx 0}$ has to be determined. During baseline determination, UC 1 is not applied. The baseline is the sum of durations of time within the time of investigation T at which the active power exchange (P) along the grid connection point (grid breaker) is less than +- 10 kW. 2.) Determination of $t_{Island\_}2$: A second measurement has to be carried out at the same point of measurement during the UC 1 application. $\sum_{t=1}^{T} t_{Islanding;\ P_{Breaker}\approx 0}$ is the sum of duration of times within a period *T* at which the active power exchange (P) along the grid connection point (grid breaker) is close to zero (less +- 10 kW). The environmental condition, such as temperature, solar radiation, cloudiness should be similar in order to create comparable scenario. Therefore, measurements will be done at the same time, at the same point of measurement but at a different day with comparable weather conditions. After the data of measurements have been collected, the KPI has to be calculated according to the KPI_DE_04 formula.
Reporting Period	Once per project (M24 with the D5.4)
Reporting Audience and Access Rights	☐Public ☒Platone ☐Demo ☐Other

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
KPI_DE_04_1	Measurement for baseline determination	AVACON
KPI_DE_04_2	Calculation of P(t) for the period of investigation T	AVACON
KPI_DE_04_3	Baseline determination $$\sum_{t=1}^{T} t_{No\ Islanding;\ P_{Breaker}\approx 0}$$	AVACON
KPI_DE_04_4	Measurement while UC 1 application	AVACON
KPI_DE_04_5	Determination of $\sum_{t=1}^{T} t_{Islanding;\ P_{Breaker}\approx 0}$	AVACON
KPI_DE_04_6	KPI calculation	AVACON

KPI DATA COLLECTION						
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Data collection responsible**
Sum of duration of	$t_{Island\_}1$	Record, Calculation	Sensors (PMU,	Measurement:	6 measureme	AVACON

time at which the power exchange is approx. 0 while UC is not applied			PLMulti-II or other)	Busbar of each phase of MV/LV grid connection point Data Storage: EMS (ALF-C)	nts per season (winter, spring, summer, autumn) with a measurement duration *T* of 2, 6, 12, 24, 48, 96 hours.	
Sum of duration of time at which the power exchange is approx. 0 while UC is applied	t_{Island_2}	Record, Calculation	Sensors (PMU, PLMulti-II or other)	Measurement: Busbar of each phase of MV/LV grid connection point Data Storage: EMS (ALF-C)	6 measurements per season (winter, spring, summer, autumn) with a measurement duration *T* of 2, 6, 12, 24, 48, 96 hours.	AVACON

KPI BASELINE			
Source of Baseline Condition	LITERATURE VALUES ☐	COMPANY HISTORICAL VALUES ☐	VALUES MEASURED AT START OF PROJECT ☒ Info: Measurement at start of Use Case Phase
Details of Baseline	The baseline will be calculated in a 3 step approach. First measurements values for the time period of investigation T will be collected from sensor located at the busbar of the MV/LV grid connection point in the secondary substation measuring the values U, I, timestamp in 1 Seconds up to 15 Minutes intervals. In the second step P(t) will be calculated by applying the formula P = U * I for the measurement period T. In the third step all durations of time intervals within the considered measuring period T at which |P| <= 10 kW will be summed according to the formula $\sum t_{\ no\ Islanding}\ (P_{Breaker} \approx 0)$. As result the baseline has been determined. The baseline will determined for each period of investigation and evaluated for different season of the year (winter, spring, summer, autumn) and different durations of investigations *T* (*T* - 2h, 6h, 12h, 24h, 48h, 96h).		
Responsible (Name, Company) for Baseline	AVACON		

E.5 Responsiveness

BASIC KPI INFORMATION			
KPI Name	Responsiveness	**KPI ID**	KPI_DE_05
Project's Objective	To improve customers' engagement and facilitate their fair participation to market. To unlock flexibility to address local congestion and voltage stability issues. To support cooperation with the TSO.		
DEMO where KPI applies	☐IT ☐GR ☒DE		
Owner	Avacon		
KPI Description	This KPI focuses on the assessment of response times of requests request for flexibility and latencies of the IT infrastructure. The promptness of the implementation of a triggered setpoint ($P'_{Breaker}$) into a measurable value ($P_{Breaker}$) is an important indicator of the value of flexibility provided by local network or energy communities. Background: A user sets a setpoint that defines the load exchange at the grid connection point of the field test community. The setpoint will be forwarded to the EMS, which will determine setpoint for individual DER to increase or decrease local consumption in order to reach the requested value of load exchange at the grid connection point ($P'_{Breaker}$). The KPI evaluates the duration of time from setting the setpoint $P'_{Breaker}$ until the successful fulfilment, at which $P_{Breaker} = P'_{Breaker}$. A sensor located in the secondary substation monitors the load exchange along the grid connection point and provides the value of $P_{Breaker}$.		
KPI Formula	$$\text{Responsiveness} = t_{(P'_{Breaker} = P_{Breaker})} - t_{Setpoint\ trigger}$$ Where: $t_{(P'_{Breaker} = P_{Breaker})}$: Timestamp at which the target setpoint is measurably reached after the setpoint has been triggered. $t_{Setpoint\ trigger}$: Timestamp at which the target setpoint is triggered. $P_{Breaker}$: Active power of load exchange along the MV/LV grid connection point. $P'_{Breaker}$: Setpoint value describing the target value of active power of load exchange along the MV/LV.		
Unit of measurement	T [seconds]		
Target / Thresholds	maximum 5 minutes With the ability to provide a predefined value of power within 5 minutes, an important criterion is fulfilled for the participation on tertiary and secondary balancing power markets. The ability to provide a predefined value of power also add additional value to the flexibility of EC for the use of congestion management measure of the DSO.		
Measurement Process	$t_{Setpoint\ trigger}$ – The timestamp at which UC 2 is triggered will be noted right away and documented in protocols. $t_{(P'_{Breaker} = P_{Breaker})}$ – The timestamp will be noted in the first moment, when the measured load exchange at the grid connection point ($P_{Breaker}$) equals the triggered		

	target setpoint ($P'_{Breaker}$) set to the EMS. The measurement data will be provided by the sensors located in the secondary substation.
Reporting Period	Once per project (M30 - with the D5.5)
Reporting Audience and Access Rights	☐Public ☒Platone ☐Demo ☐Other

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
KPI_DE_05_1	Determination of baseline $t_{Setpoint\ trigger}$	AVACON
KPI_DE_05_2	Determination of point of earliest point of time at which $t_{(P'_{Breaker} = P_{Breaker})}$	AVACON
KPI_DE_05_3	Calculation of the KPI	AVACON

KPI DATA COLLECTION						
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Data collection responsible**
Timestamp at which setpoint is triggered	$t_{Setpoint\ trigger}$_1	Record	Sensors (PMU, PLMulti-II or other)	Data Storage: EMS (ALF-C)	Once during UC demonstration	AVACON
Earliest Timestamp at which $P'_{Breaker}$ equals $P_{Breaker}$	$t_{P'=P}$_2	Record, Calculation	Sensors (PMU, PLMulti-II or other)	Measurement: Busbar of each phase of MV/LV grid connection point Data Storage: EMS (ALF-C)	Once during UC demonstration	AVACON

KPI BASELINE			
Source of Baseline Condition	LITERATURE VALUES ☐	COMPANY HISTORICAL VALUES ☐	VALUES MEASURED AT START OF PROJECT ☒ Measurement at start of UC phase
Details of Baseline	Source of Baseline Condition: Recorded point of time at which the setpoint or setpoint schedule has been send by the user via user interface to EMS. The baseline will be determined for each period of investigation and evaluated for different season of the year (winter, spring, summer, autumn) and different durations of investigations *T* (*T* - 2h, 6h, 12h, 24h, 48h, 96h).		
Responsible (Name, Company) for Baseline	AVACON		

E.6 Accuracy of the achievement of a given setpoint

BASIC KPI INFORMATION			
KPI Name	Accuracy of the achievement of a given setpoint	**KPI ID**	KPI_DE_06
Project's Objective	To improve customers' engagement and facilitate their fair participation to market. To unlock flexibility to address local congestion and voltage stability issues. To support cooperation with the TSO.		
DEMO where KPI applies	☐IT ☐GR ☒DE		
Owner	Avacon		
KPI Description	The accuracy of reaching and maintaining a defined setpoint is a quality feature of flexibility that can be provided by local networks and communities. The ability to achieve and maintain a setpoint exactly helps to avoid power fluctuations in medium voltage network. This KPI is intended to evaluate the precision of balancing consumption with generation of a hole energy community in order to achieve an given active power setpoint defining the load exchange at the grid connection point. During the application of UC 2, the KPI shall measure the relation between the reached (measured) active power exchange ($P_{Breaker}$) along the grid connection point and the target value ($P'_{Breaker}$).		
KPI Formula	$$\text{Accuracy of Setpoint reaching} = \frac{\bar{P}_{Breaker}(dt)}{P'_{Breaker}(dt)} * 100$$ $$\bar{P}_{Breaker}(T) = \lvert\bar{P}_{Breaker}\rvert = \frac{1}{n}\sum_{i=1}^{m} \emptyset \widehat{P_{15Min\ i}}$$ Where: $\bar{P}_{Breaker}(T)$: Average measured peak load exchange along grid connection point during the time period of investigation T while UC 2 is applied. $P'_{Breaker}(T)$: Triggered Setpoint for load exchange along the grid connection point in the time period of investigation T while UC 2 is applied. T : the period of investigation for which measurements will take place considered for evaluation (2h, 6h, 12h, 24h, 48h, 96h). $\hat{P}_{Breaker;15Min}$: maximum value of P of a 15 minute interval, $\bar{P}_{Breaker}$: arithmetic mean of 15 minutes values of maximum active power, $P'_{Breaker}(T)$: Is defined in the setpoint/setpoint set by a user for the period of investigation T.		
Unit of measurement	%		
Target / Thresholds	80%. Due to delays in the measure-switching-measure cycle of the EMS IT-infrastructure, a real time synchronization of generation and storage charging will not be possible. It is therefore expected that the average deviation between target active power and reached active power flow will be 20 %.		
Measurement Process	$\emptyset\ \widetilde{P_{Breaker}}(T)$ – For the measurement period T the maximum peak load value $\hat{P}_{Breaker;15Min}$ will be determined for every 15 minutes $P_{Breaker}$. The arithmetic		

	mean of all 15 minutes peak load values will be then calculated by applying the formula $\lvert\bar{P}\rvert = \frac{1}{n}\sum_{i=1}^{m} \emptyset\widehat{\hat{P}_{Breaker;15Min}}_i$. The values $P_{Breaker}$ are measured by a sensor located in the secondary substation measuring U and I at the grid connection point to determine the active power exchange between the MV grid and LV network of the EC. T: Will be set 2, 6 and 12 hours. Therefore 3 measurements will have to be applied $P'_{Breaker}(dt)$: Is defined in the setpoint/setpoint set by a user.
Reporting Period	Once per project (M30 - with the D5.5)
Reporting Audience and Access Rights	☐Public ☒Platone ☐Demo ☐Other

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
KPI_DE_06_1	Determination of baseline that equals the setpoint $P'_{Breaker}(T)$ that has been set by user for the duration T.	AVACON
KPI_DE_06_2	Collection of measurements of U, I of the period T.	AVACON
KPI_DE_06_3	Calculation of active power value (P) by applying P = U * I for each measurement data set.	AVACON
KPI_DE_05_4	Determination of 15 minutes maximum value of power $\hat{P}_{Breaker;15Min}$.	AVACON
KPI_DE_06_5	Calculation of arithmetic mean of ØP by applying $\lvert\overline{P_{Breaker}}\rvert = \frac{1}{n}\sum_{i=1}^{m} \emptyset\widehat{P}_{i_{Breaker;15Min}}$ for the considered duration of investigation T.	AVACON
KPI_DE_06_6	Calculation of KPI	AVACON

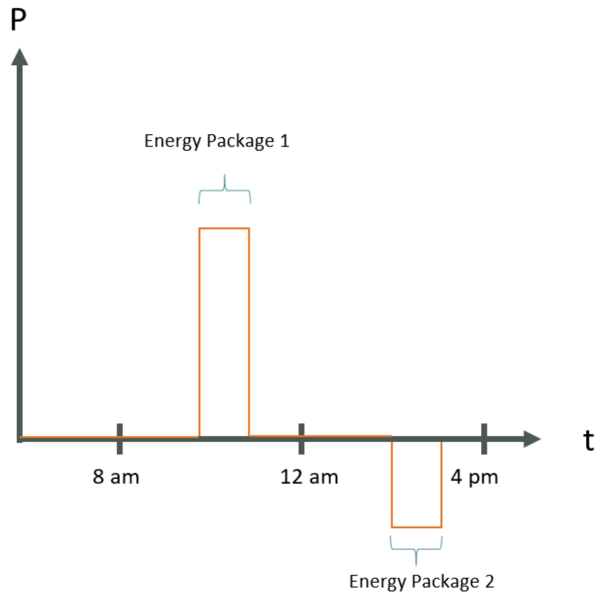
KPI DATA COLLECTION						
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Data collection responsible**
Arithmetic mean of active power exchange along grid connection	$\overline{P}_{Breaker}$	Record, Calculation	Sensors (PMU, PLMulti-II or other)	Measurement: Busbar of each phase of MV/LV grid connection point Data Storage:	6 measurements per season (winter, spring, summer,	AVACON

point for period dt				EMS (ALF-C)	autumn) with a measurement duration *dt* of 2, 6, 12, 24, 48, 96 hours.	
Triggered setpoint of active power exchange along grid connection point for period dt	$P'_{Breaker}$ (dt)	Record	Sensors (PMU, PLMulti-II or other)	Data Storage: EMS (ALF-C)	6 measurements per season (winter, spring, summer, autumn) with a measurement duration *dt* of 2, 6, 12, 24, 48, 96 hours.	AVACON

KPI BASELINE			
Source of Baseline Condition	LITERATURE VALUES ☐	COMPANY HISTORICAL VALUES ☐	VALUES MEASURED AT START OF PROJECT ☒ Info: Measurement at start of Use Case Phase
Details of Baseline	The measurement values for determination of baseline will be collected from the sensor located at the grid connection point in the secondary substation measuring the load exchange between MV and LV network of the field test grid. The values U, I, timestamp will be provided every 1 Seconds up to 15 Minutes and used for the determinations. The baseline will determined for each period of investigation and evaluated for different season of the year (winter, spring, summer, autumn) and different durations of investigations *T* (*T* - 2h, 6h, 12h, 24h, 48h, 96h).		
Responsible (Name, Company) for Baseline	AVACON		

E.7 Success of package based energy supply/export

BASIC KPI INFORMATION			
KPI Name	Success of package based energy supply/export	**KPI ID**	KPI_DE_07
Project's Objective	To unlock flexibility to address local congestion and voltage stability issues. To ensure reliable and secure power supplies in the context of increasing DER penetration.		
DEMO where KPI applies	☐IT ☐GR ☒DE		
Owner	Avacon		
KPI Description	During the application of UC 3, the success of delivery of energy packages shall be documented. This KPI evaluates the success of delivery of energy packages to an EC/ the success of export energy packages of energy an EC. The KPI is determined by comparing the total number of energy packages provided successfully and the number of packages initially triggered for delivery.		
KPI Formula	$\text{Success of energy supply; export in bulks} = \frac{Total\ number\ of\ successful\ deliveries\ (\mathrm{T})}{Total\ number\ triggered\ deliveries(T)} * 100$ Where: $Total\ number\ of\ successful\ deliveries\ (T)$: The total number of energy packages delivered in the time of investigation T. $Total\ number\ triggered\ deliveries(T)$: The total number of energy packages triggered by a user via a setpoint schedule in the time of investigation T. T : the period of investigation for which measurements will take place considered for evaluation (2h, 6h, 12h, 24h, 48h, 96h). Constraint: For a comparison, the same environmental conditions must exist.		
Unit of measurement	%		
Target / Thresholds	70%.		
Measurement Process	<u>Baseline:</u> $Total\ number\ triggered\ deliveries(T)$ defines the baseline that is set by a user. The user is defining a setpoint schedule P (t+1) that is defining different power values and their duration, including the starting time t_{Start} and the time of end t_{End}, for the load exchange along the MV/LV feeder. For most of the time, P will be set to "0". In this case, the community has to be operated by the EMS in an islanding mode and any load exchange along the MV/LV feeder should be avoided. In case P is a positive value, e.g. of 10 kW, that hast to be maintain from 10 am to 11 am, then 10 kWh shall be imported into the community during the period of time of investigation. Each period of the setpoint schedule at which P is ≠ 0 is defined as a single energy package. $Total\ number\ triggered\ deliveries(dt)$ is equal to the number of energy packages defined in the setpoint schedule. A visualized example of a setpoint schedule with 2 energy packages is shown in figure below.		

	 <u>Measurement:</u> The delivery of an energy package is defined successful when following criteria are fulfilled: 1.) The energy package is provided between t_{Start} and t_{End} as defined in the baseline set by a user in a setpoint schedule. 2.) The amount of energy exchanged between t_{Start} and t_{End} equals the amount of energy ± 20% defined in the baseline. For the calculation, measurement values from sensors located at the grid connection point measuring U, I, P and taking a time stamp will be used. The KPI will be determined for different measurement periods of dt 2, 6, 12, 24, 48 and 96 hours.
Reporting Period	Once per year (M43 with the D5.5)
Reporting Audience and Access Rights	☐Public ☒Platone ☐Demo ☐Other

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
KPI_DE_07_1	Determination of baseline_ Baseline is defined as the total number of energy deliveries set in a setpoint schedule triggered by a user. The setpoint schedules defines a t_{Start} and t_{End} of each delivery and the amount of energy to be delivered within t_{Start} and t_{End}.	AVACON
KPI_DE_07_2	Determination of t_{Start} and t_{End} of each energy delivery set in setpoint schedule within time period	AVACON

	of consideration T that has been send from user to EMS.	
KPI_DE_07_3	Determination of energy exchanged along grid connection point in the time period t_{End}_t_{Start} of each energy delivery of setpoint schedule by applying the formula E = P * (t_{End}_t_{Start})	AVACON
KPI_DE_07_4	Collection of measurement data of U, I of the period dt.	AVACON
KPI_DE_07_5	Calculation of active power value (P) by applying P = U * I for each measurement data set.	AVACON
KPI_DE_07_6	Determination of exchanged energy for each minute by applying the formula E = P * Δt (Δt = 1 second).	AVACON
KPI_DE_07_7	Check whether measured energy exchange within t_{Start} and t_{End} equals E defined in setpoint schedule	AVACON
KPI_DE_07_8	Check, whether $E_{measured}$ between t_{Start} and t_{End} equals +-20 % of $E_{Setpoint\ schedule}$	AVACON
KPI_DE_07_9	Summation of successful deliveries (=$Total\ number\ of\ successful\ deliveries\ (dt)$)	AVACON
KPI_DE_07_10	Calculation of KPI	AVACON

KPI DATA COLLECTION						
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Data collection responsible**
Number of successful deliveries within dt	E_{SU}_1	Record, Calculation	Sensors (PMU, PLMulti-II or other)	Measurement: Busbar of each phase of MV/LV grid connection point Data Storage: EMS (ALF-C)	6 measurements per season (winter, spring, summer, autumn) with a measurement duration *dt* of 2, 6, 12, 24, 48, 96 hours.	AVACON
Number of triggered deliveries within dt	E_{SU}_2	Record	Sensors (PMU, PLMulti-II or other)	Data Storage: EMS (ALF-C)	6 measurements per season (winter, spring, summer, autumn) with a measurement duration *dt* of 2, 6, 12, 24, 48, 96 hours.	AVACON

KPI BASELINE			
Source of Baseline Condition	LITERATURE VALUES ☐	COMPANY HISTORICAL VALUES ☐	VALUES MEASURED AT START OF PROJECT ☐
Details of Baseline	Source of Baseline Condition: Setpoint schedule set by user handed to EMS The baseline is defined as the total number of energy deliveries set in a setpoint schedule triggered by a user. The setpoint schedules defines a t_{Start} and t_{End} of each delivery and the amount of energy to be delivered within t_{Start} and t_{End} for the considered period dt.		
Responsible (Name, Company) for Baseline	AVACON		

E.8 Forecast of total Energy Demand

BASIC KPI INFORMATION			
KPI Name	Forecast of total Energy Demand	**KPI ID**	KPI_DE_08
Project's Objective	To unlock flexibility to address local congestion and voltage stability issues. To ensure reliable and secure power supplies in the context of increasing DER penetration.		
DEMO where KPI applies	☐IT ☐GR ☒DE		
Owner	Avacon		
KPI Description	The forecast of generation and load for an EC is a fundamental function for the EMS to increase the quality of strategy of activation of DER. It enables the EMS to balance generation and demand with a higher quality in order to maintain a given setpoint defining the load exchange along the LV/MV grid connection point and enables to forecast generation deficits or generation surplus within a an given period of time. The KPI aims to evaluate the accuracy of the algorithm to forecast the total net energy demand as a result of local generation and demand by comparing the amount of energy imported into the local network of the EC or exported out of the local network of the EC with the forecasted amount of energy to be actual exchanged within a given period of time.		
KPI Formula	Forecast of Energy Exchange = FEE $$FEE = \frac{\sum_{t=1}^{T} \lvert Energy\ Exchange\ Measured \rvert_{i;t}}{\sum_{t=1}^{T} \lvert Energy\ Exchange\ Forecasted \rvert_{i;t}} * 100$$ $$\sum_{t=1}^{T} \lvert Energy\ Exchange\ Forecasted \rvert_{i;t} = E_{forecasted\ demand}\ (T) - E_{forecasted\ generation}(T)$$ $\sum_{t=1}^{T} \lvert Energy\ Exchange\ Measured \rvert_{i;t} = \sum_{t=1}^{T} \lvert U \rvert * \lvert I \rvert * (t_{t-1} - t_t)$ Where: $\sum_{t=1}^{T} \lvert Energy\ Exchange\ Measured \rvert_{i;t}$: the total amount of energy that has been exchanged along the grid connection point for the period of investigation T. $\sum_{t=1}^{T} \lvert Energy\ Exchange\ Forecasted \rvert_{i;t}$: Total amount energy forecasted to be exchanged along the grid connection point for the period of investigation T. U : Voltage [V] measured at grid connection point I : Current [A] measured at grid connection point $(t_{t-1} - t_t)$: Duration of time between two subsequent timestamps of measurement T : period of investigation for which measurements will take place considered for evaluation (2h, 6h, 12h, 24h, 48h, 96h).		

	Constraint: For a comparison, the same environmental conditions must exist.
Unit of measurement	%
Target / Thresholds	80%.
Measurement Process	The KPI will be evaluated for different season of the year (winter, spring, summer, autumn) and different durations (2h, 6h, 12h, 24h). For the calculation of the KPI "FEC", a baseline will be determined. For evaluation, measurement values will be collected from sensor located in the secondary substation. 1.) Determination of baseline E_{EF}_1: The baseline equals the forecasted net energy demand of the EC, which results from the sum of the forecast energy consumption and the forecast energy generation. The baseline will be determined for the period of time dt under consideration. $$\sum_{t=1}^{T} \lvert Energy\ Exchange\ Forecasted \rvert_{i;t} = E_{forecasted\ demand} d(t) - E_{forecasted\ generation} d(t)$$ $E_{forecasted\ demand} d(t)$ and $E_{forecasted\ generation} d(t)$ are determined by forecasting algorithm. Data are documented for evaluation by the EMS. 2.) Determination of E_{EM}_1 : A sensor located the secondary substation provides voltage (U) and current (I) measurement values with a time stamp. All 3 phases of the grid connection point will be metered. For each measurement the active power will be determined by applying the formula P = U * I. The Energy will be calculated by applying E = P * △t. The value P will be multiplied with the time interval between the time stamps of individual measured value. E.g. in case a measurement takes place every 60 seconds, P will be multiplied by 0,017. All values that have accrued in the period T will be summed to determine$\sum_{t=1}^{T} \lvert Energy\ Exchange\ Measured \rvert_{i;t}$. After the data of measurements have been collected, the KPI has to be calculated according to the KPI_DE_08 formula.
Reporting Period	Once per year (M43 with the D5.5)
Reporting Audience and Access Rights	☐Public ☒Platone ☐Demo ☐Other

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
KPI_DE_08_1	Determination of baseline_ Baseline equals $E_{forecasted\ demand} d(t) -$	AVACON

	$E_{forecasted\ generation}d(t)$ for the period dt	
KPI_DE_08_2	Measurement of U, I while UC 3 or 4 is applied	AVACON
KPI_DE_08_3	Determination of $\sum_{t=1}^{T} \|U\| * \|I\| * (t_{t-1} - t_t)$	AVACON
KPI_DE_08_4	Determination of $\sum_{t=1}^{T} \|Energy\ Exchange\ Measured\|_{i;t}$	AVACON
KPI_DE_08_5	Determination of KPI	AVACON

KPI DATA COLLECTION						
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Data collection responsible**
Measured amount of energy exchanged along grid connection point	E_{EF}_1	Record, Calculation	Sensors (PMU, PLMulti-II or other)	Measurement: Busbar of each phase of MV/LV grid connection point Data Storage: EMS (ALF-C)	6 measurements per season (winter, spring, summer, autumn) with a measurement duration *dt* of 2, 6, 12, 24, 48, 96 hours.	AVACON
Amount of forecasted energy to be exchanged along grid connection point	E_{EM}_1	Record	Sensors (PMU, PLMulti-II or other)	Data Storage: EMS (ALF-C)	6 measurements per season (winter, spring, summer, autumn) with a measurement duration *dt* of 2, 6, 12, 24, 48, 96 hours.	AVACON

KPI BASELINE			
Source of Baseline Condition	LITERATURE VALUES ☐	COMPANY HISTORICAL VALUES ☐	VALUES MEASURED AT START OF PROJECT ☒ Info: Measurement at start of Use Case Phase
Details of Baseline	$E_{Measured\ Energy\ Exchange}\ (T) = E_{forecasted\ demand}(T) - E_{forecasted\ generation}(T)$ The forecasts are determined by EMS algorithms. The determination is based on asset key figures, weather forecasts and historic data. Forecasts of $E_{forecasted\ demand}(T)$, $E_{forecasted\ generation}(T)$ and $E_{Measured\ Energy\ Exchange}\ (T)$ are stored on the data base of EMS (ALF-C)		
Responsible (Name, Company) for Baseline	AVACON		