IANOS
SUSTAINABLE SOLUTIONS
for islands' decarbonisation

D2.3 Report on Islands requirements engineering and Use Cases definitions

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Executive Summary

This document presents Deliverable D2.3, the second update of IANOS' *Report on Islands requirements engineering and Use Cases definitions* developed under task T2.1 - *Islands requirements engineering and use case definitions* of Work Package 2 - *Requirements Engineering & Decarbonization Roadmapping*.

This deliverable presents a detailed definition of the 9 Technical Use Cases of IANOS project along with the identification of the requirements for each technological solution that will be demonstrated in the pilot sites of Ameland and Terceira.

The methodology followed to define the Use Cases was the IEC 62559-2 standard, which templates were used to describe in detail the Key Performance Indicators (KPIs) associated, the pre-requisites and assumptions considered, the actors involved, the relations and information exchanged between them, the scenarios that might occur and the functional, regulatory and safety requirements. Additionally, the Smart Grid Architecture Model (SGAM) was also used to facilitate the description of the different layers of interoperability of the Use Cases.

The first part of the deliverable describes demonstrator sites, where current energy systems are characterized in detail. This part also comprises of product specifications and installation requirements for each hardware solution that will be installed in Terceira and Ameland islands. Moreover, it is presented a characterization of the current energy system of the Fellow Islands (Lampedusa, Bora-Bora and Nisyros) where some of the use cases will be replicated.

Finally, the second part of the deliverable presents the 9 Technical Uses Cases which are defined in detail according to the standard IEC 62559 *Use case methodology*. At the moment of writing, some of the technologies regarding the demonstrator in Ameland are suffering alterations, which may impact the Use Case definition. If need so, a new version of this deliverable will be written, updating the Use Cases and technology descriptions accordingly.

The results of this deliverable, mainly the definition of the Use Cases, will be used in other tasks of the IANOS project, such as T2.4, T2.5, T4.1, T4.3, T4.4, T5.1, T5.2, T5.3, T.5.4, T6.1, T6.2, T6.3 and T6.4.

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Abbreviations and Acronyms

API	Application Programming Interface
AS	Ancillary Services
BESS	Battery Energy Storage System
BMS	Building Management Systems
CHP	Combined Heat and Power
CO2	Carbon Dioxide
DC	Direct Current
DER	Distributed Energy Resources
DHW	Domestic Hot Water
DLT	Distributed Ledger Technology
DSM	Demand-Side Management
DR	Demand Response
DSO	Distribution System Operator
ESS	Energy Storage System
EV	Electric Vehicle
FC	Fuel Cell
FEID	Fog-Enabled Intelligent Device
FFR	Fast Frequency Response
FRR	Frequency Restoration Reserve
aFRR, mFRR	Automatic/Manual FRR
GDPR	General Data Protection Regulation
GOPACS	Grid Operation Platforms for Congestion Solutions
HEMS	Home Energy Management System
HVAC	Heating, Ventilating and Air Conditioning
H2	Hydrogen
ICT	Information and Communication Technologies
IEC	International Electrotechnical Commission
IED	Intelligent Electronic Device
IEPT	IANOS Energy Planning and Transition Suite
IoT	Internet of Things
iVPP	Intelligent Virtual Power Plant
KPI	Key Performance Indicators
LEC	Local Energy Communities
LH	Lighthouse
LV	Low Voltage
MV	Medium voltage
NG	Natural Gas
OCPP	Open Charge Point Protocol
PCM	Phase-Change Material

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PSI	Project Success Indicator
PV	Photovoltaic
PUCs	Primary Use Cases
P2P	Peer-to-peer
RES	Renewable Energy Sources
RTU	Remote Terminal Unit
SCADA	Supervisory Control and Data Acquisition
SG-CG	Smart Grid Coordination Group
SGAM	Smart Grids Architecture Model
SoC	State of Charge
SUC	Specialized Use Case
TCP/IP	Transmission Control Protocol/Internet Protocol
TSO	Transmission System Operator
TT	Transition Track
UC	Use Case
UI	User Interface
UML	Unified Modelling Language
VRDT	Voltage Regulating Distribution Transformers
V2G	Vehicle-to-Grid
iVPP	Intelligent Virtual Power Plant
WP	Work Package
WT	Wind Turbine

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1. Introduction

1.1 Purpose and Scope of the Deliverable

IANOS project aims to decarbonize the energy systems of the Lighthouse Islands (Ameland and Terceira) and explore the possibility of replication in the Fellow Islands (Bora-Bora, Lampedusa, Nisyros). For this purpose, the project will demonstrate, under real-life operational conditions, a group of both technological and non-technological solutions adapted to harsh islandic conditions that are described in 9 Use Cases.

The Deliverable 2.3 - *Report on Islands requirements engineering and UCs definitions* developed under task T2.1 - *Islands requirements engineering and use case definitions* presents a characterization and identification of the Lighthouse Islands' requirements for each hardware solution that will be deployed in the demonstrator sites. Accordingly, this deliverable comprises a characterization of the current energy system of the islands (both Lighthouse and Fellow Islands) and a description of the product and technical specifications as well as installation requirements of the hardware solutions that will be demonstrated.

Moreover, the Deliverable 2.3 also presents a detailed definition of the 9 Use Cases of IANOS project where information is presented concerning various scopes such as the possible scenarios along with the information exchanged between the different actors of the Use Cases and the list of requirements.

1.2 Structure of the Deliverable

Deliverable D2.3 is structured as follows:

- Chapter 2: Use Cases Methodology is presented, comprising of the overview of the Use Cases in respect to the transition tracks and demonstrator sites of the project, the standards used for the definition of the Use Cases and the participation of the partners in each Use Case.
- Chapter 3: Terceira Demonstrator is characterized. This chapter contains a general characterization of Terceira, followed by a characterization of the current energy system of the island. Additionally, this chapter comprises of the specifications and installation requirements for all the solutions that will be

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implemented in Terceira followed by the list of stakeholders where the solutions will be installed.

- Chapter 4: Ameland Demonstrator is characterized. This chapter contains a general characterization of Ameland, followed by a characterization of the current energy system of the island. Additionally, this chapter comprises of the specifications and installation requirements for the solutions that are currently planned to be implemented in Ameland, followed by the list of stakeholders where the solutions will be installed.
- Chapter 5: Fellow Islands characterization is presented where a general characterization of the island and the assessment of the current energy system are described for each Fellow Island.
- Chapter 6: Use Cases Definition is presented and is divided according to the 3 Transition Tracks of the project.
- Chapter 7: Conclusions and Next Steps are summarized.

1.3 Relation to other deliverables

Task 2.1 is strongly related to several tasks of IANOS project since it defines in detail the Use Cases implemented in the Lighthouse Islands and identifies the requirements to demonstrate all the solutions in the pilot sites. Therefore, the results and conclusions from this task will be used in the subsequent tasks, mainly in the ones related with Requirements Engineering & Decarbonization Roadmapping (WP2), IANOS Multi-Layer VPP Operational Framework (WP4) and Deployment, Use Cases Realization and Monitoring at LH (WP5, WP6).

In order to define the specifications and descriptions of the hardware technological solutions that will be demonstrated in the pilot sites, some inputs from Task 1.2 were needed.

Furthermore, Task 2.1 provides inputs regarding information and communication protocols of hardware solutions and the list of stakeholders to Task 2.3 and receives the KPIs to address to each one of the Use Cases, as well as Project Success Indicators (PSI) to evaluate the project success as a whole. Additionally, Task 2.1 provides inputs to Task 2.4 and Task 2.5 mainly related with the requirements identified. This task is also connected to Tasks 4.1, 4.3 and 4.4, since the development of the ICT components of

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the iVPP platform will need the requirements and the detailed definition of the Use Cases. Finally, Task 2.1 will provide inputs for Tasks 5.1, 5.2, 5.3, 5.4, 6.1, 6.2, 6.3 and 6.4 since these tasks will comprise of Use Cases realization and deployment, as well as, inputs for Task 7.1 to perform the technical impact assessment as it is illustrated in Figure 1.

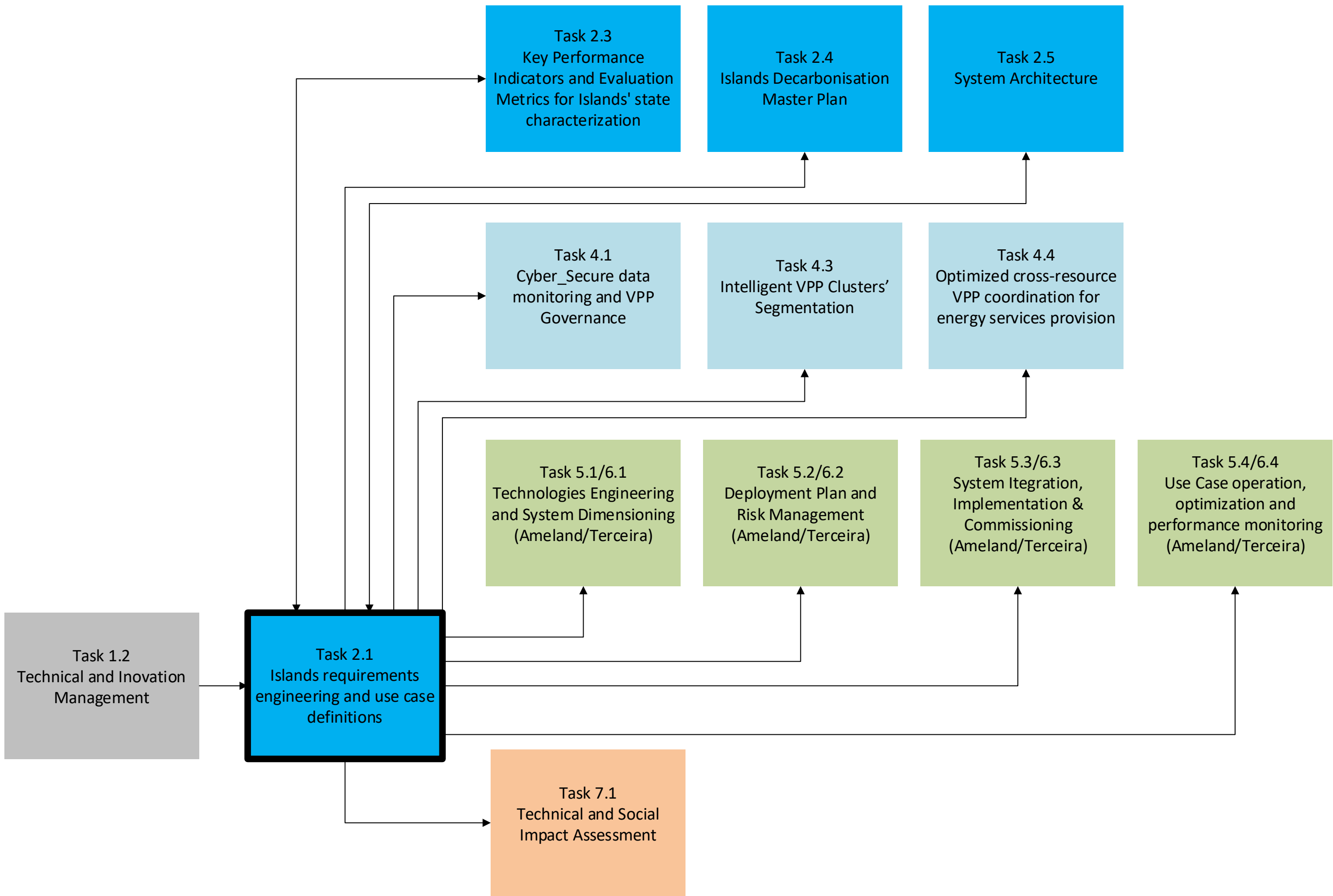

Figure 1: Task 2.1 and the relation with other tasks

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2 Use Cases Methodology

2.1 Use Cases Overview

Use Cases allow to identify, clarify and organize system requirements since they are made up of a set of possible sequences of interactions between different actors in a particular environment and related to a particular goal. The Use Cases that will be demonstrated in IANOS project are technical Use Cases which describe the functionality level of the system and therefore specify functions or services that the system provides to the user. Furthermore, these Use Cases intend to be generic about the technological implementation in order to ensure replicability.

Except Use Case 9, all Use Cases are connected with the intelligent Virtual Power Plant (iVPP) and basically describe the interaction between the different actors (iVPP platform included) in order to meet its aim.

The 9 Use Cases, that will be demonstrated in Terceira and Ameland pilots and replicated in the Fellow Islands, are clustered into 3 Energy Transition Tracks (TT) according to the challenges addressed and exploitation opportunities. The Energy Transition Tracks are the following:

-TT#1 - Energy efficiency and grid support for extremely high-RES penetration – which comprises of UC1, UC2, UC3 and UC4. This TT utilizes the iVPP logic to reduce energy curtailment and enabling a high-RES penetration in the energy system.

-TT#2 - Decarbonization through electrification and support from non-emitting fuels – which comprises of UC5, UC6, UC7 and UC8. This TT demonstrates the potential of electrification as a means to decarbonize relevant sectors along with non-emitting fuels utilization for cross-resource integration and circular economy.

-TT#3: Empowered Local Energy Communities – that includes only UC9 and aims to engage and involve citizens into the decarbonization transition of the islands.

Furthermore, the Use Cases of IANOS project will be demonstrated (D) in at least one of the Lighthouse Islands during the course of the project and replicated (R) in the Fellow Islands.

Table 1 presents an updated overview of the Use Cases of IANOS project regarding the Transition Track associated and their demonstrator and replication sites.

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Table 1: Use Cases overview

Use Case Number	Use Case Name	Ameland	Terceira	Bora-Bora	Lampedusa	Nisyros
#TT1: Energy efficiency and grid support for extremely high RES penetration						
UC1	Community demand-side driven self-consumption maximization	D	D	-	-	R
UC2	Community supply-side optimal dispatch and intra-day services provision	D	D	-	R	-
UC3	Island-wide, any-scale storage utilization for fast response ancillary services	D	D	R	R	-
UC4	Demand Side Management and Smart Grid methods to support Power quality and congestion management services	D	D	-	R	R
#TT2: Decarbonization through electrification and support from non-emitting fuels						
UC5	Decarbonization of transport and the role of electric mobility in stabilizing the energy system	D	D	R	R	R
UC6	Decarbonizing large industrial continuous loads through electrification and locally induced generation	D	-	-	-	R
UC7	Circular economy, utilization of waste streams and gas grid decarbonization	D	-	R	R	R
UC8	Decarbonization of heating network	D	-	R	-	R
#TT3: Empowered Local Energy Communities						
UC9	Active Citizen and LEC Engagement into Decarbonization Transition	D	D	R	R	R

D: Demonstration / R: Replication

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2.2 Standards used

In order to guarantee harmonisation and replicability of the use cases, standardized methodologies were used such as the Smart Grid Architecture Model (SGAM) and the IEC 62559-2 standard.

2.2.1 SGAM

The Smart Grid Architecture Model (SGAM) is a unified standard for smart grid use-cases and architecture design defined by the CEN-CENELEC-ETSI Smart Grid Coordination Group (SG-CG) [1]. This model enables the provision of a global and clear view of smart grid projects by mapping the different actors and devices considering 3 dimensions. The first dimension describes the domains which range from generation through transmission and distribution to end-consumers. The second dimension corresponds to the zones of operation from the processes through field, station and operation to enterprise and market zones. Finally, the third dimension describes the interoperability layers that range from the component layer to the business layer.

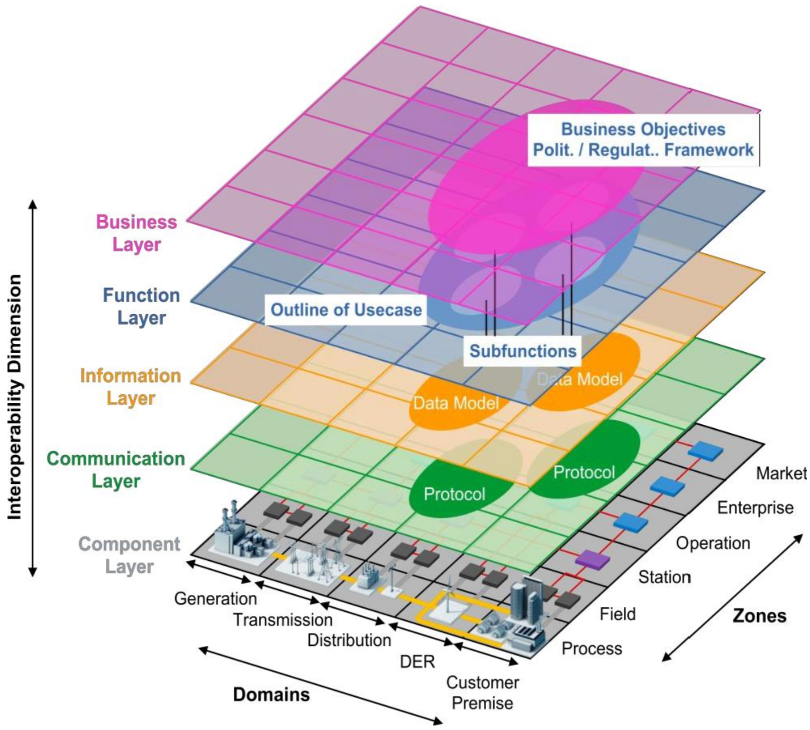

Figure 2: Smart Grid Architecture Model (SGAM) dimensions: Domains, Zones and Interoperability Layers

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As it is shown in Figure 2, according to the SGAM, there are 5 interoperability layers:

- The Business Layer which represents the business view of the smart grid model. The business layer can be used to map different stakeholders within the zones and domains and also to map their roles and responsibilities.
- The Function Layer which comprises of functions and services independent from actors and physical implementations in applications, systems and components. These functions reveal the functionalities of the Use Case.
- The Information Layer which contains the information exchanged between the actors involved in the Use Case. This layer comprises of information objects and the underlying canonical data models.
- The Communication Layer which describes protocols and mechanisms for the interoperable exchange of information between components.
- The Component Layer represents the physical distribution of all the components (e.g. system actors, applications, power system equipment, smart meters, etc.).

For each interoperability layer, there is a 2-Dimensional plane characterized by Domains and Zones.

Domains cover the complete electrical energy conversion chain:

- The Generation includes generation of electrical energy in bulk quantities (fossil, nuclear, hydropower plants, offshore wind farms, large-scale solar power plants), normally connected to the transmission system.
- The Transmission includes all the infrastructure responsible for transporting electricity over long distances.
- The Distribution represents the infrastructure responsible for distributing electricity to the customers.
- The Distributed Energy Resources (DER) include any distributed technologies of small-scale power generation (from 3 kW to 10.000 kW) directly connected to the distribution grid.
- The Customer Premises host consumers but also prosumers which apart from consuming electricity are also able to generate electricity through solar PV panels, micro turbines, electric vehicles storage, etc.. The premises can be

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industrial, commercial and home facilities such as airports, shopping centres and homes.

Finally, Zones represent the hierarchical levels of power system management:

- The Process includes all the physical, chemical or spatial transformations of energy and the equipment directly involved such as generators, transformers, cables, sensors, etc.
- The Field includes all the equipment to protect, control and monitor the power system such as protection relays, intelligent electronic devices, etc.
- The Station which represents the aggregation of field zones such as local SCADA systems, data concentration, etc.
- The Operation which hosts power system control operation in the respective domain such as distribution management system, energy management system, etc.
- The Enterprise which includes commercial and organizational processes, services and infrastructures for enterprises such as asset management, logistics, work force management, customer relation management, etc.
- The Market which reflects the market operations possible along the energy conversion path such as energy trading or retail market.

In Chapter 6 - *Use Cases Definition*, each Use Case is defined according to the IEC 62559-2 standard and in Section 1.4 (Narrative of the Use Case – Complete Description) of this template a characterization of the SGAM layers that are applicable to the Use Case is presented. For each interoperability layer, actors are mapped into Domains and Zones. All Use Cases, except UC 9, have the Function and Information Layer characterized. Only UC1, UC4 and UC5 present the Communication Layer due to the absence of information regarding communication and information protocols from its actors. Moreover, since IANOS' Use Cases are technical Use Cases, the Business and Component Layers are not characterized.

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2.2.2 IEC 62559-2

The Use Cases are described according to the IEC 62559-2 standards, thereby the standard IEC 62559 *Use case methodology* (Annex I) is the template used for the description of the 9 Use Cases of IANOS project.

This template contains 7 Sections:

- Section 1: Description of the Use Case

  1.1 Name of the Use Case: Use Case identification, transition track and name.

  1.2 Version Management: History of updates, contributions and comments from project partners to the use case definition.

  1.3 Scope and Objectives of Use Case: Boundaries and the listed objectives.

  1.4 Narrative of Use Case: Short and complete description of the use case. The complete description describes what occurs when, why, with what expectation, and under which conditions. In this section, the characterization of SGAM layers that are applicable to the Use Case is included. Additionally, this section presents a table that describes the information and communication protocols for the hardware technological solutions that will be implemented within the scope of the Use Case along with the respective demonstrator sites where they will be demonstrated.

  1.5 Key Performance Indicators (KPIs): KPIs from the D2.9 - *IANOS KPIs and evaluation metrics*. Due to the technical nature of the Use Cases, only some of the KPIs were chosen and explained here (e.g. KPIs in economic domain were not considered in this deliverable). The KPI identification number corresponds to the number defined in D2.9 and the KPIs are linked to the objectives defined in section 1.3. Throughout the task 2.1 progress, several KPIs were adapted and redefined to better adapt to each Use Case reality. This was done in coordination with the Consortium partners and Task 2.3. In addition to the KPIs, also the PSIs in deliverable D2.9 should be taken into consideration when measuring UC and Project success.

  1.6 Use Case Conditions: Assumptions and Prerequisites for each use case.

  1.7 Further Information for classification / mapping

  Relation to other use cases: IANOS' Use Cases are strongly related with each other, mainly the ones that belong to the same Transition Track.

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Level of depth: All Use Cases, except UC9 which is a high-level use case, are specialized use cases since they use specific technological solutions/implementations.

Prioritisation: All Use Cases have a high priority since all have the same level of importance for the project.

Generic, regional or national relation: All Use Cases are generic because they will be demonstrated in more than one country.

Nature of the use case: All Use Cases have a technical nature, except UC9 which has a social nature.

Further Keyword for classification: List of keywords related to the Use Case.

1.8 **General Remarks:** Any other important details related to the Use Case that were not referred in other sections.

- Section 2: **Diagrams**

  UML Use Case diagrams where objectives and actors are presented; activity diagrams where different tasks of the use case are described; and sequence diagrams where the information exchanged between actors is presented.

- Section 3: **Technical Details**

  3.1 **Actors:** List of actors involved in the use case.

  3.2 **References**: Any documents or standards that are important for the Use Case.

- Section 4: **Step by step analysis of use case**

  4.1 **Overview of scenarios:** A scenario describes a situation that might occur in the Use Case. A short description, the responsible actor, the triggering event, the pre-conditions and post-conditions are presented.

  4.2 **Steps – Scenarios:** For each scenario the succession of events is described. The information flows presented in the sequence diagrams correspond to the steps of the scenario.

- Section 5: **Information Exchanged**

  Describes the information exchanged between actors in specific scenarios.

- Section 6: **Requirements**

  Describes the necessary requirements (functional, data privacy, cybersecurity, etc.) for the implementation of the Use Cases.

- Section 7: **Common Terms and Definitions:** Glossary of terms.

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2.3 Participation and responsibilities

Each Use Case includes the contribution of different partners of the project:

- Technological Providers (T): Partners who provide technological hardware solutions to be demonstrated in the Lighthouse Islands.
- Local Partners (L): Partners located in the LH (e.g. municipalities).
- Lighthouse island system's integrators (LH): Partners that cope with LH integration and operation and performance monitoring. Additionally, partners that are involved in the development of the iVPP platform.
- People Engagement Partners (P): Partners which are responsible for citizens or stakeholder's engagement in LH islands.
- Replication Activities Partners (R): Partners that will support Fellow Islands in the replication of the Use Cases.

Table 2 presents the participants for each Use Case as well as the characterization of the type of contribution to the Use Case according to the groups of partners described above:

Table 2: Partners' participations on the Use Cases

Partners	UC1	UC2	UC3	UC4	UC5	UC6	UC7	UC8	UC9
EDP NEW	LH T	LH	LH	LH	LH				LH
Uninova	T P			T P					P
Efacec Energia				T					
EDA	L LH	L LH	L LH	L LH	L LH				
Efacec Electic Mobility					T LH				
Governo Regional dos Açores	L	L	L	L	L				L
Virtual Power Solutions	LH T	LH T	LH T	LH T	LH T				
Teraloop			T						
Sunamp	T								
BeOn	T								
Municipality of Ameland	L	L	L	L	L	L	L	L	L
New Energy Coalition							P		P

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TNO	LH	LH	LH	LH	LH	LH	LH	LH	
Alliander	L	L	L	L	L	L	L	L	
Amelander Energie Coöperatie	P			P					P
SuWoTec	T			T					
Hanze University									P
Neroa	LH	LH	LH	LH	LH	LH	LH	LH	
Repowered B.V.	LH	LH	LH	LH	LH	LH	LH	LH	
SeaQurrent Holding B.V.						T			
GasTerra B.V.							T		
Municipality of Lampedusa and Linosa			L	L	L		L		L
CNR-IIA			R	R	R		R		R
Commune de Bora-Bora		L	L		L		L	L	L
Akuo Energy		R	R		R		R	R	R
Municipality of Nisyros	L			L	L	L	L	L	L
CERTH	LH T	LH	LH	LH	LH	LH	LH	LH	
ETRA	LH	LH	LH	LH	LH	LH	LH	LH	LH
Engineering-Ingegneria Informatica SpA	LH								
RINA			R	R	R		R		R
EREF									P
UBITECH ENERGY	LH	LH	LH	LH	LH	LH	LH	LH	

T: Hardware Technology Provider L: Local Partners LH: Lighthouses' System Integration

P: People Engagement Partners R: Replication Activities Partners

Each Use Case will be assigned to a Use Case Owner which will be responsible for the implementation of the Use Case. Use Case owners assure that the objectives of the Use Case defined in this deliverable are met, assure KPIs' results are obtained and also monitor UC development. Table 3 presents the Use Case owners for each Use Case in the 2 Lighthouse Islands.

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Table 3: Use Case Owners

	Use Case Owners	
Use Case	Terceira	Ameland
UC1	EDP NEW/EDA	NEROA
UC2	EDP NEW/EDA	REPOWERED
UC3	EDP NEW/EDA	REPOWERED
UC4	EDP NEW/EDA	ALLIANDER
UC5	EDP NEW/EDA	AMELAND
UC6	-	AMELAND
UC7	-	AMELAND
UC8	-	AEC
UC9	RGA	AEC

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3 Terceira Demonstrator

3.1 General characterization

Terceira is the third largest island in the Azores archipelago, with an area of 402.2 km². Terceira is a volcanic island located in the middle of the north Atlantic Ocean 1,600 km West of Portugal and its population is 55,300 inhabitants. Its economy is mostly based on the raising of livestock, production of dairy-based products and, recently, tourism. Between 2010-2018 the tourism in Terceira has grown 230%, reaching in 2018 137,920 tourists. Angra do Heroísmo, the historical capital of the archipelago and part of Terceira, is classified as an UNESCO World Heritage Site. Terceira has a subtropical climate with mild annual oscillations. Given its volcanic origin, geothermal surfaces allow the use of geothermal resources for power generation.

Figure 3: Terceira's location

3.2 Site assessment and existing infrastructure

Terceira's current energy system state is described addressing the current energy supply and demand as well as a detailed description of the electricity grid of the island.

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3.2.1 Supply and Demand

In 2020, 184.6 GWh of electricity were generated in Terceira, where approximately 38% were from renewable energy sources as it is shown in Figure 4. The fuel oil is still the dominant energy source in the island.

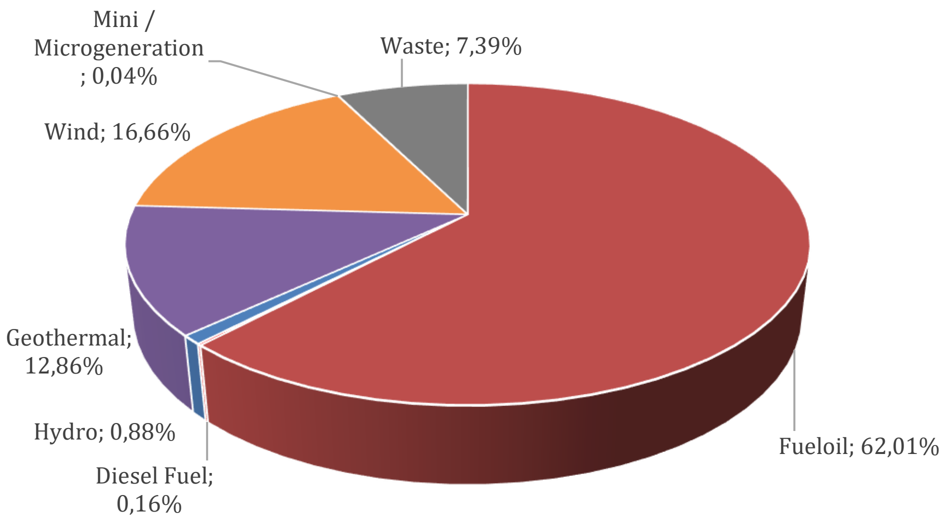

Figure 4: Energy mix in Terceira in 2020

Regarding the electricity consumption in 2020, 170.7 GWh were consumed in the island: 101.1 GWh from Low Voltage and 69.6 GWh from Medium Voltage. According to Figure 5, the Residential Sector is the one who represents the most significant consumption.

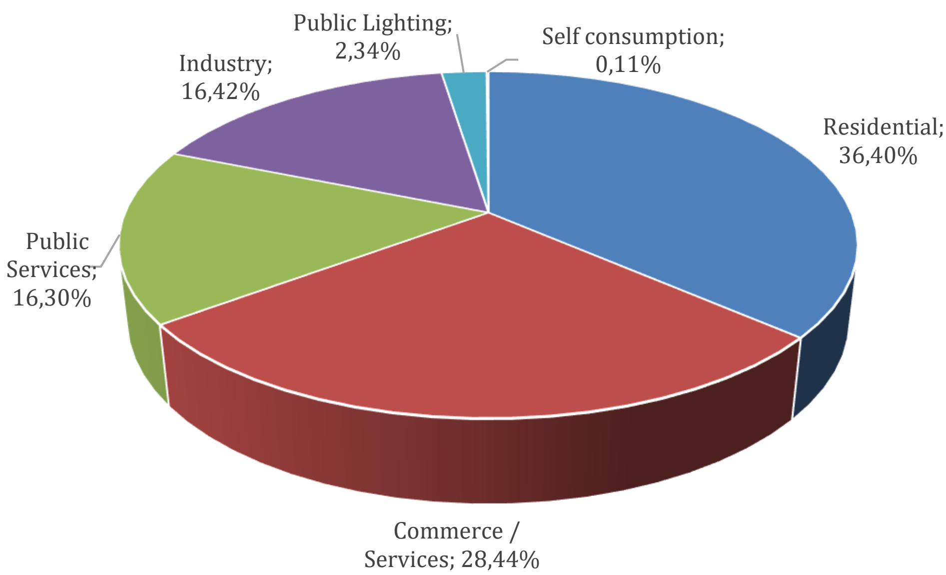

Figure 5: Electricity consumption in Terceira in 2020

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As illustrated in Figure 6, the annual peak demand in 2020 was in 29 December at 7:30 PM, while the annual off-peak demand was in 7 May at 04:45 PM.

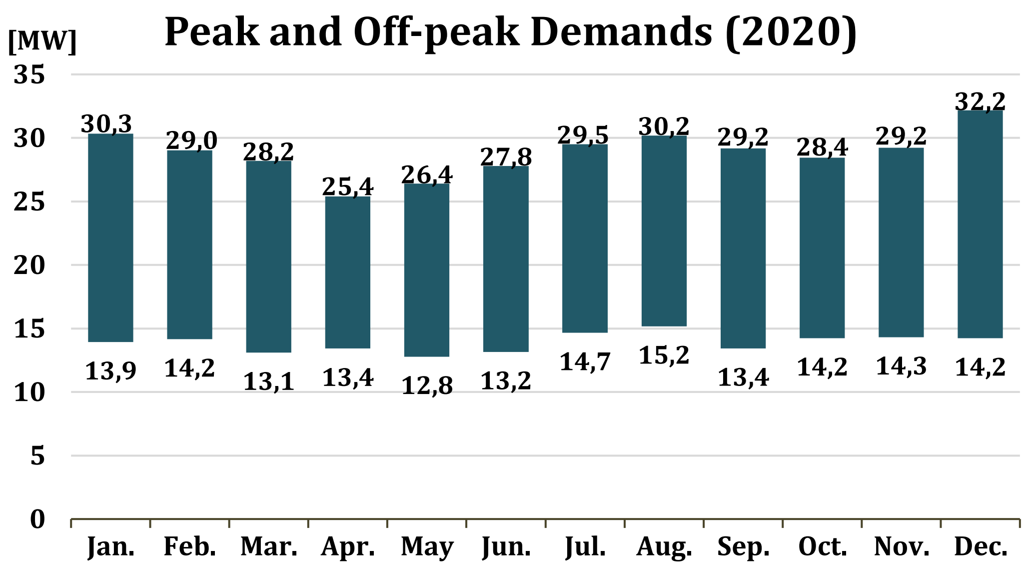

Figure 6: Peak and Off-Peak Demands in Terceira, in 2020

The typical load demand curve obviously varies according to the seasons of the year as it can be observed in Figure 7. Accordingly, the highest rise in consumption happens in the morning, certainly driven by the beginning of activity from commercial and residential sectors. The peak consumption depends on the season: while in Winter and Autumn is around 08:00 PM, in Spring and Summer is in the morning at 10:00 AM and 12.00 AM, respectively.

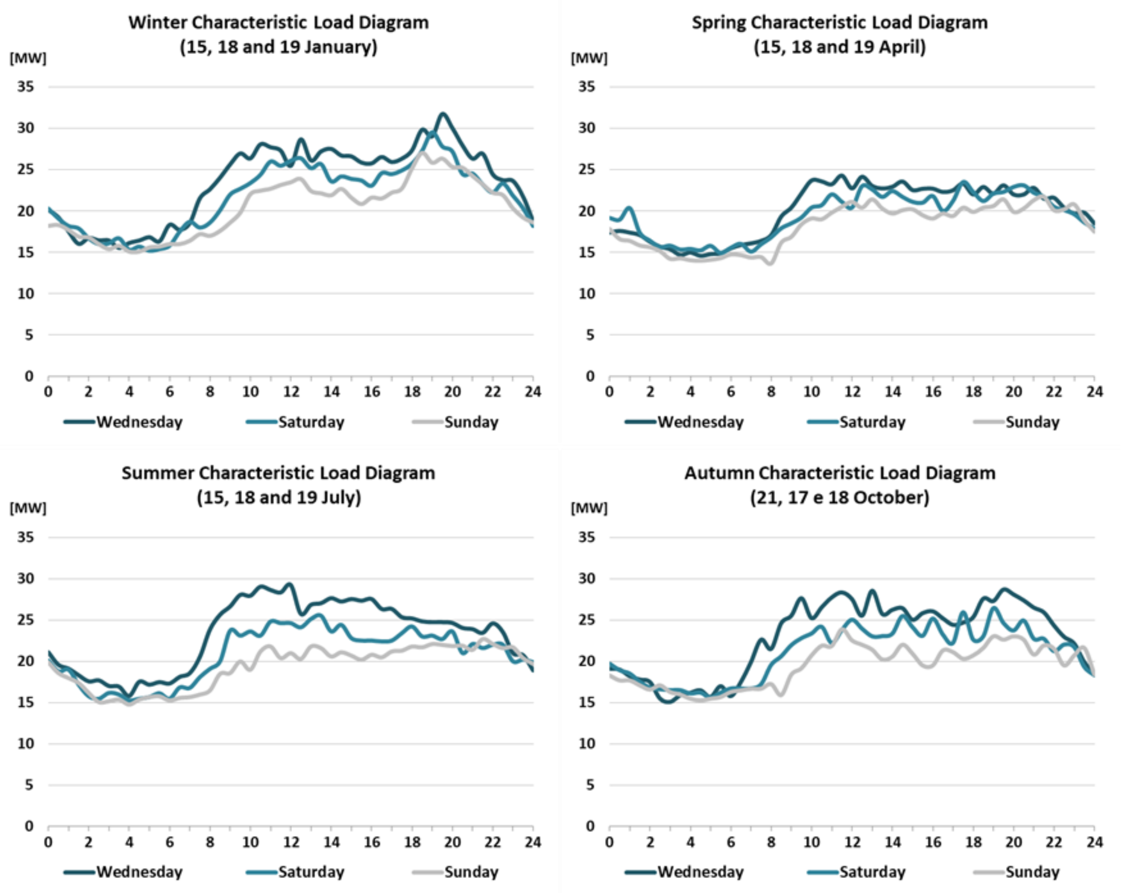

Figure 7: Load Demand Curves for different seasons in Terceira, in 2020

3.2.2 Electricity Grid

The electric system of Terceira is composed of 8 power plants and 6 substations. It has a MV transmission line at 30 kV, MV distribution lines at 15 kV and LV distribution lines at 0.4 kV as displayed in Figure 8. The distribution grid has a total of 1,490 km of network length: 1,092 km aerial cables and 398 km underground cables. 358 km correspond to 15 kV lines, 0.74 km correspond to 30 kV while 1,131 km are LV lines. On the other hand, the transmission grid has only 79 km of length: 67 km aerial and 12 km underground cables.

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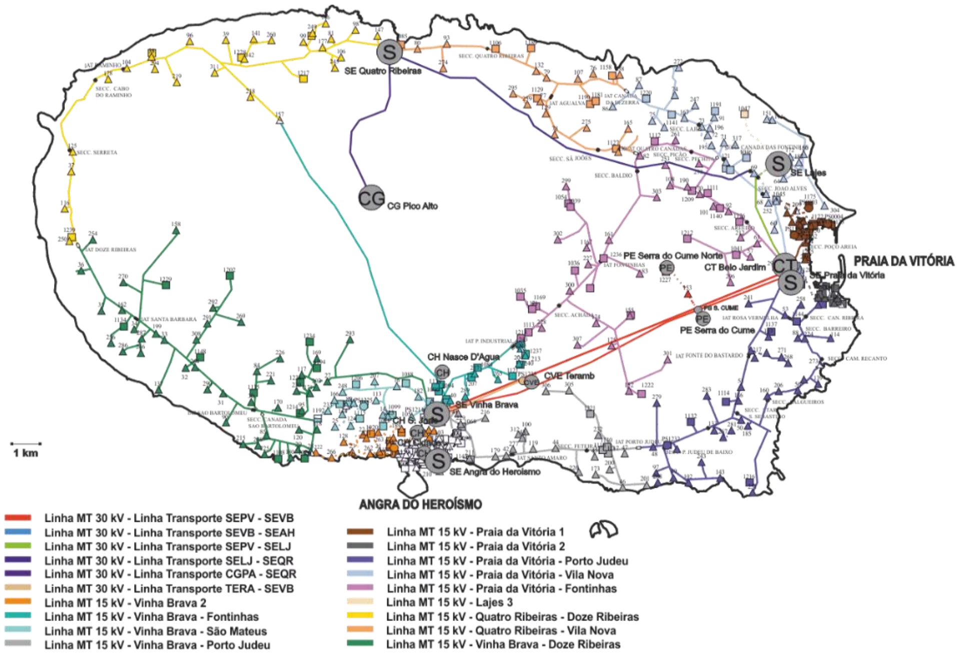

Figure 8: Terceira's electricity grid

Table 4 presents the 8 power plants of Terceira. The island has 79.5 MW of capacity installed with a diverse portfolio of power plants: thermal, hydro, wind, waste and geothermal. Hydropower plants are the oldest with more than 60 years operation and the geothermal power plant the newest, which is in operation only since 2017. The plant which generates more electricity is undoubtedly Belo Jardim power plant, followed by the geothermal plant Pico Alto and wind park Serra do Cume.

Table 4: Terceira's power plants

Name	In operation since (*)	Type of production	Generator Groups			Electricity Production [MWh]
			Voltage level [kV]	Units	Installed Capacity [kW]	
Belo Jardim	1983	Diesel Fuel	6.6	3	9,116	255.2
		Fueloil	6	6	49,000	120,029.8
Cidade	1955	Hydro	0.4	1	264	376.7
Nasce d'Água	1955	Hydro	0.4	1	720	852.1
São João de Deus	1955	Hydro	0.4	1	448	400.2
Serra do Cume	2008	Wind	0.4	10	9,000	23,192.5

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Serra do Cume Norte	2012	Wind	0.4	4	3,600	7,555.8
TERAMB	2016	Waste	6	1	2,720	13,651.1
Pico Alto	2017	Geothermal	11	1	4,675	23,741.7
			-	28	79,543	190,055.2

* Date referring to the start of operation of the system and not including subsequent refurbishments or expansions.

The electricity grid is composed of 6 substations: 1 for the Belo Jardim power plant and 5 in the MV transmission line at 30 kV. Table 5 presents information regarding the 6 substations of Terceira.

Table 5: Terceira's substations

Name	Abbreviation	In operation since (*)	Transformation Ratio	Installed Capacity [MVA]
Belo Jardim	SEBJ	1983	30/15 kV	10.00
Praia da Vitória	SEPV	2016	30/15 kV	20.00
Vinha Brava	SEVB	1990	30/15 kV	20.00
Angra do Heroísmo	SEAH	2003	30/15 kV	10.00
Quatro Ribeiras	SEQR	2010	30/15 kV	10.00
Lajes	SELJ	2004	30/6,9 kV	12.50
			30/15 kV	1.00
			Total	83.50

* Date of to the start of operation of the system, not including subsequent refurbishments or expansions.

Concerning energy losses, analysing the year 2020, Table 6 illustrates that there were around 13.9 GWh of energy losses corresponding to 7.52% of grid losses. Isolated systems, like Terceira Island, are subject to frequency and voltage fluctuations caused by power deviations of independent generation (wind, waste and geothermal generation) and load demand. The autonomous and decentralized frequency and voltage control system is achieved by each diesel generator connected to the grid in Belo Jardim Power Station, with conventional droop control methods implemented on individual speed and voltage regulators and based on droop characteristic.

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Table 6: Energy Losses in Terceira's power system, in 2020

Energy [kWh]	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Total
Production	46,137,524	42,770,054	47,801,179	47,900,405	184,609,162
Consumption	43,022,677	39,993,438	44,081,395	43,622,254	170,719,763
Grid Losses	3,114,847	2,776,616	3,719,783	4,278,152	13,889,399
	6.75%	6.49%	7.78%	8.93%	7.52%

3.3 Equipment and system specification

In Terceira, several hardware solutions will be installed in certain stakeholders. In this subchapter, a description of the technical and product specifications and the installation requirements of the hardware solutions are presented.

3.3.1 *PV panels with microinverter*

Solar PV panels and microinverter plug & play kit to be installed in customer premises in Terceira, to be used towards community demand-side driven self-consumption. These solar kits are modular and allow for ease of installation.

Product Specifications

Table 7 Technical Characteristics of PV panels with microinverters

Technical Specifications	
Nominal power for each installation	1,500W (5x300W)
Dimensions	10m^2 (around 2m^2 per panel)
Maximum voltage	49V DC, 230V AC

Installation Requirements

Requires 10m^2 for the installation.

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3.3.2 *Electrochemical batteries*

Sixteen distributed electrochemical batteries will be installed in customer premises in Terceira. These batteries will be standard batteries, with no innovation feature associated. Therefore, it is not necessary to identify the specifications and installation requirements.

3.3.3 *Heat Batteries*

Twenty-four heat batteries developed by SUNAMP (UniQ eHW 3 +iPV) will enable the production of domestic hot water heating by using grid electricity and surplus PV energy. These batteries allow the maximization of thermal power by immersing a powerful heat exchanger into the Phase Change Material used as storage medium.

Product Specifications

Table 8: Technical specifications of SUNAMP'S Heat Batteries

Technical Specifications	UniQ eHW 3 +iPV
Width x Height x Depth (mm)	575 x 440 x 365
Gross Weight (kg)	74
Net Weight (kg)	70
Volume (m3)	0.092
Heat storage capacity (kWh)	3.5
Water Content (L)	2.3
Equivalent Hot Water Cylinder Size (L)	71
V40, Volume of Hot water available at 40°C (L)	85
Standby heat loss rate (kWh / 24h (W))	0.48 / (20)
Energy efficiency rating class	C
Recommended maximum HW flow rate (L/Min)	6
Minimum mains supply pressure at inlet of Heat Battery (Bar)	1.5
Maximum working pressure (MPa / (Bar))	1.0 (10)
Hot water outlet temperature at design flow rate (°C)	45-55
Connected load at ~ 230 V, 50Hz (W)	2,800
Power supply / Standby consumption (W)	1 PH ~ 230 V / 7
Electrical efficiency (ηelecwh) (%)	81.4

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Annual electricity consumption (AEC) (kWh/annum)	542
Tapping cycle	S

Installation Requirements

- The Heat Battery is suitable for indoor use only;
- Due to the weight of the Heat Battery, it must be ensured that the floor is level, sound and capable of supporting its weight;
- There must be a space of 150mm around the Heat Battery (i.e. to view LED lights), and space of 450mm above it (i.e. to remove the lid if necessary).

3.3.4 Electric Water heaters

The solution developed by UNINOVA allows the non-intrusive characterization and use of energy flexibility provided by existing electric water heaters. The solution will be tested and implemented in new electric water heaters to be installed at the consumers' households.

UNINOVA's solution comprises of a set of sensors coupled and installed in individual water heaters, to collect operation information. Collected information is then passed through a microcontroller and communicated wirelessly to UNINOVA's servers and through them to the iVPP. The iVPP will provide high level instructions on the grid's flexibility requirements; these instructions will be translated to specific actions on the cloud, at UNINOVA's servers, and communicated wirelessly to the on-site microcontroller which will in turn control individual water heaters.

In more detail, the system is composed of:

- A set of sensors to acquire temperature and power data, which are installed on electric water heaters with minimum impact on consumers' comfort;
- A microcontroller with Wi-Fi communication capabilities to collect and send data, while also receiving the control signals that define the state of the heating element (on or off);

- An actuator that enables the supply of power to the heating element;
- A remote-control system where the energy flexibility characterization and control strategy are computed, which also ensures communication with the iVPP.

There will be five electric water heaters deployed in Terceira in the context of IANOS, which will be newly installed in the consumers' premises. The water heaters will include sets of non-intrusive sensors, which are the innovative solution of IANOS, and a more intrusive set of sensors to enable the measurement of water heater temperature in order to validate the development of the non-intrusive solution.

Product specifications

Table 9 Technical Specifications of Smart Electric Water Heaters to be installed in Terceira

Technical Specifications	
Water Heater Power	1.5kW (230V)
Water Heater Max capacity	150L
Available space needed at electric socket	30x30x30 cm
Available space needed at the hot water outlet	20x20x20 cm

Installation Requirements

In order to install the components for the non-intrusive characterization and use of energy flexibility provided by Electric Water Heaters, as referred in the previous point, a cubic space with dimensions 30X30X30 (in cm) is needed at the water heater electric socket. Additionally, a cubic space with dimensions 20X20X20 (in cm) is needed at the water heater's hot water output. These cubic spaces must be accessible at all times.

3.3.5 V2G chargers

Two V2G chargers developed by EFACEC MOBILITY will be installed in Terceira. V2G chargers are smart chargers that besides providing energy to

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electric vehicles also have the capability of providing control algorithms for ancillary services and grid support.

Product specifications

Table 10 Technical specifications of the V2G Chargers to be installed in Terceira

Technical Specifications	
Rated Power	10 kVA
Grid Connection	Triphasic + neutral, 400V +- 10% / 50Hz

Installation Requirements

The V2G chargers are wall mounted equipment. The dimensions (WxHxD) of the wall box are 740x646x415 (mm, excluding the cable connection) and its weight is 60 kg. A free space around the equipment should be considered for user access and to manipulate the charging cable. Moreover, the equipment can reach IP54. The place of installation may need additional protection/filtering conditions, if necessary. Additionally, there should not be a direct exposure to sunlight and the equipment should be protected against vehicle collisions.

3.3.6 Flywheel

The Flywheel developed by Teraloop will allow the provision of fast frequency regulation support and power quality, meeting the demands of unpredictable charge/discharge conditions and presenting an inertial load for the iVPP.

Product specifications

Table 11: Technical specifications of TERALOOP's flywheel

Technical Specifications	Flywheel
Max Power Rating (kW)	100
Max Energy Rating (kWh)	3
Max Energy Storage (kJ)	10,800

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Efficiency (%)	95
Flywheel Type	Hubless Rotor, Magnetic Bearings, Vacuum
Operating Rotational Speed (RPM)	6,000-18,000
Flywheel Runtime (sec) [Load]	3,600 [3kW], 512 [25kW], 216 [50kW], 162 [75kW], 108 [100kW]
Flywheel Recharge Time (sec@100kW)	130
Self Discharge (h)	1
DC Link Voltage (VDC)	400-750
Duty cycling (min)	4 (minimum full cycle, discharge and recharge time combined)
Operating temperature (°C)	-25 to 40
Cabinet Dimensions (mm)	2 x 1,000 (width), 800 (depth), 2,000 (height)
Ingress protection (IEC 60509:1989)	IP61 (flywheel with vacuum cover), IP48 (cabinets)
Grid Operating Voltage (VLL)	380/400/415 VAC 3-phase, 4-wire plus ground
Frequency (Hz)	50/60
Power Factor	0.99 at rated load and nominal voltage
Phases	3
Surge Withstand	Meets IEEE 587/ANSI C62.41
Weight (kg)	750 (flywheel only), 1,200 (20kW AC), 2,200 (100kW AC)
Audible Noise (dBA)	<75 (at 1 meter)
Operating Temperature (°C)	0 to 40 (cabinet)
Storage Temperature (°C)	-25 to 70 (flywheel)
Humidity (%)	5 to 95 (non-condensing)
Emissions and Immunity	EN 62040-2
Connectivity	System to grid or flywheel to DC link

The combined estimated electricity consumption of the ventilation, air conditioning and ancillary services is a maximum of continuous 4kWh.

Installation Requirements

- Concrete bed/floor and M24 bolts, anchored to the concrete foundation, that must be able to sustain 1,500 kg/m^2.
- Dry environment with good ventilation.
- Flywheel space requirement: 2x2x2 m (including vacuum and cooling system).
- Power electronics space requirement: 2x1x2 m.
- Flywheel and power electronics to be installed in the same facility.

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- Main requirement: 400Vac, 3x250A main fuse for 100 kW machine.
- Additional 230Vac, 3x16A and 16A sockets required for the auxiliary systems.

3.3.7 Smart Energy Router

The Smart Energy Router developed by UNINOVA is a power electronics device that manages the energy transfer from/to different sources (distribution grid, RES-based distributed generators), loads and electricity storage systems. The Energy Router collects data from various energy assets, like PVs (generation profile) and batteries (charge state) and will receive higher level instructions from the iVPP to control individual assets accordingly. Thus, it acts as an intermediary between the iVPP and the individual assets at building level.

In IANOS project, the Smart Energy Router will be located at building level (behind-the-meter). There will be 2 smart energy routers deployed in Terceira in the context of IANOS, both installed in residencies outside of the Terra Chã neighbourhood, in households with PV self-consumption and electric appliances such as heat pumps and air conditioned.

Product specifications

Table 12: Technical Specifications of UNINOVA'S Smart Energy Router

Technical Data	Energy Router 5.0
Input PV System (DC)	
Max. PV array power	5,000 Wp
Input voltage range	300 V to 800 V
MPP voltage range	350 V to 750 V
Rated input voltage	550 V
Max. input current (input A / input B)	7.5 A / 7.5 A
Max. DC short-circuit current (input A / input B)	12.5 A / 12.5 A
Number of independent MPP inputs	2

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Input/output Grid (AC)	
Rated power (at 230 V, 50 Hz)	5,000 W
Max. apparent AC power	5,000 VA
Power factor range	0.7 lag to 0.7 lead
Nominal AC voltage	3-NPE 400 V / 230 V
Rated grid frequency / rated grid voltage	50 Hz / 230 V
Max. input/output current	3 x 7.5 A
Max. input/output overcurrent protection	12 A
Total harmonic distortion	5 %
Phases	3
General data	
Dimensions (W x H x D)	300 mm x 500 mm x 200 mm
Operating temperature	0 °C to 60 °C
Topology / cooling method	Transformerless / convection
Maximum Switching frequency	50 kHz

Installation Requirements

- Two Smart Energy Routers will be installed at residential buildings with three phase power supply.
- All equipment will be installed behind-the-meter.
- PV generation must be available on-site and Smart Energy Routers will substitute the existing power inverters.
- An indoor cubic space with dimensions 1x1x1 (in meters) is required for the installation. This space should be available to IANOS personnel but not to the buildings' users.
- Local Wi-Fi connection is required.

3.3.8 Hybrid Transformer

The hybrid transformer developed by EFACEC ENERGIA incorporates two technologies, electrical and electronic, operating simultaneously. These

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combined technologies will allow the stepless, phase by phase, voltage regulations at the LV side with power factor control and monitoring.

Product specifications

Table 13T Technical Characteristics of the hybrid transformer

Technical Specifications	
Rated Power	400 kVA
Rated Voltage	15,000 V +- 2x 2.5%/420V/242V +-12%

Installation Requirements

- 2.3 m^3 (1.5x1.7x0.9) of space is required for the transformer itself and 2 m^3 for the regulator block.
- Cellular signal for communication between the hybrid transformer and EFACEC platform.
- Industrial low voltage supply for auxiliary systems (e.g. 400Vac 3~).

3.3.9 FEID-PLUS

The FEID-Plus developed by CERTH is a fog-enabled computing device equipped with special functions to control I/O, phase width modulation and analog signals. It employs enough processing capacity for distributed computing application such as information capturing and storing, algorithms execution and control over the installation. Additionally, it has the capacity to interface with several field elements, such as controllable building loads, storage and EV charging stations through appropriate protocols. There will be 20 FEID-PLUS installed in residential buildings of Terra Chã.

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Product specifications:

Table 14 Technical specifications of the FEID-Plus

Technical Specifications	
Power Management	Dual step-down current- mode DC-DC Converter (PAM2306) 5V to 3.3V and 1.8V
Processing	Raspberry Pi Compute Module 3+ (CM3+) with a BCM2837B0 processor 1Gbyte LPDDR2 RAM and eMMC Flash
Operating Characteristics	
Power consumption @ 5VDC	
Boot	0.25A
Idle	0.45A/network connection
Full	1.2A
Max Voltage	5.5V
Max Current	1.5A
Dimensions	
PCB	87x68x35 mm
Enclosure	96 x 72 x 50 (mm, 4 DIN positions
1x Pluggable terminal blocks 2P	5 mm
1x Pluggable terminal blocks 6P	5 mm
1x Pluggable terminal blocks 7P	3.5 mm
1x 5V 2.4A power supply (1 DIN position)	90 x 17.5 x 54 (mm)
PSU	
Max supply Voltage	264VAC / 370VDC
Max power supply	12W

Installation requirements:

- Indoor installation, since the FEID-PLUS does not have the necessary protection from weather and therefore it is not suitable for outdoor areas.
- Power supply 5 VDC.
- Ethernet (connection to the local network for the configuration of the device).

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3.3.10 HEMS

The HEMS developed by CLEANWATTS will allow the remote monitoring, management and control of the technological solutions that will be installed within the customer premises. The system is composed of the hardware (Smart Meters, Sensors and Actuators), the Data Management (Communication, Data Processing and other modules) and the User Interfaces.

Product specifications:

The CLEANWATTS HEMS platform has the capacity to remotely control the loads with the characteristics referred on the following table. Much more devices can be and will be integrated (some during the IANOS project implementation), however Table 15 shows the generic values for the most common energy assets.

Table 15: CLEANWATTS' HEMS for the Residential Sector.

Residential Sector		
Asset Type	Maximum Limit Capacity	
	Monitor / Device	Manage / Device
Loads (sockets) – using Wi-Fi Plug	16A 3kW	16A 3kW
Loads (generic) – using DIN-rail Zigbee devices installed on distribution boards	From 16A to 32A	From 16A to 32A
Loads (generic) – using devices (meters and I/O + Contactors) installed on distribution boards	Direct measurement: 100A AC (1 Phase); 65A AC (3 Phase)	Control: 25A (1 Phase); 25A to 63A (3 Phase), others on request
Loads (smart appliances) – using Wi-Fi integration	Depends on appliance, typical: 2 kW	Depends on appliance, typical: 2 kW
Loads (HVAC) – using devices (meters and I/O) installed on distribution boards	Direct measurement: 100A AC (1 Phase); 65A AC (3 Phase)	Control: using digital output signal.
Loads (water heater)	16A 3kW	16A 3kW
Generation (solar PV) - using integration with inverter	Dependent on individual inverter rated capacity: (from 1.5 kW to 50 kW). Capacity can be increased by grouping inverters.	

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Storage (batteries) - using integration with inverter	Dependent on individual inverter rated capacity: (from 0.8 kVA to 10 kVA). Capacity can be increased by grouping inverters.

Installation Requirements

The HEMS platform will be installed on a cloud-based platform that will collect data from the local energy assets and then store it and provide it to the Enterprise Service Bus (ESB). It will communicate with the equipment through a central local unit (Gateway) that must be connected to an ethernet cable, which can communicate with local devices thought Zigbee or MODBUS TCP.

The HEMS kit to be installed in Terceira Pilot is composed of:

- 1 x Cloogy Gateway/Hub.
- 2 x Smart Plugs.
- 1 x Wi-Fi Energy Meter.

Concerning the hardware equipment installation requirements, these are as follows:

- The CLEANWATTS Gateway is much smaller than a common household internet router. It must be connected to a common household plug and to the internet through an ethernet cable. This operation must be performed by a qualified electrician.
- CLEANWATTS Smart Plugs have no special requirements in terms of installation procedures. They are plug and play devices that will automatically pair with the Gateway.
- CLEANWATTS Wi-Fi Smart Meters will need to be installed by a qualified electrician on the switch board and configured locally to have access to the Wi-Fi network. After the initial Wi-Fi connection procedure, they will automatically be paired with the Gateway.

The end-users will have access to an Android/iOS App that will give them information regarding their total energy consumption and individual load consumption connected to the smart plugs, which can also be controlled (e.g. On/Off).

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3.4 List of stakeholders

As it is displayed in Table 16, the majority of the technological solutions described in the previous subchapter will be installed in Terra Chã social neighbourhood. This neighbourhood has 250 houses and is located in Angra do Heroísmo county in an area of 10km^2. Terra Chã perfectly fits in the IANOS project, since it has enough population to engage and involve in Terceira's energy transition. The technologies to be installed in customer premises, such as the heat batteries, PV kits, HEMS, FEID-Plus, electrochemical batteries and water heaters, will be installed in the households of this neighbourhood.

The flywheel will be installed in the dairy factory Pronicol, also located in Angra do Heroísmo. Pronicol usually has some consecutive power failures that force the factory to stop producing the dairy products, which have a great economic impact. Thereby, the flywheel will play an important role by being able to regulate the voltage and provide flexibility to the system.

Due to the fact that EDA is both the DSO and TSO, it is the obvious stakeholder for the hybrid transformer. The V2G chargers will be installed in one of EDA's powerplants since they already have 2 EVs.

The Smart Energy Routers will also be installed in two customers' houses in Terceira, which have self-consumption and smart electrical appliances.

Table 16: List of stakeholders for the hardware solutions demonstrated in Terceira

	N# of units	Stakeholder
PV Panels with microinverters	40	Terra Chã
Electrochemical Batteries	16	Terra Chã
Heat Batteries	24	Terra Chã
Electric Water Heaters	5	To be defined
V2G chargers	2	EDA (Pico Alto geothermal power plant and EDA headquarters)
Flywheel	1	Pronicol

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Smart Energy Router	2	To be defined
Hybrid Transformer	1	EDA (distribution grid in Terra Chã)
FEID-PLUS	20	To be defined
HEMS	20	Terra Chã

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4 Ameland Demonstrator

4.1 General characterization

Ameland is one of the 5 inhabited Waddeneilanden (Wadden sea islands). The island's total size is 58.83 km^2 and consists mostly of sand dunes. It is the third major island of the West Frisians. Ameland is connected to the mainland electrical grid and to the mainland natural gas grid. There are four villages in Ameland: Hollum, Ballum, Nes and Buren with a total population of 3,673.

Figure 9: Ameland's location

Ameland has its own Energy Community: Amelander Energie Coöperatie (AEC) which delivers clean energy to its customers. Currently, AEC has 286 members and 993 customers being the main organization to participate in Renewable Energy projects, as well as in Energy Savings projects.

The larger part of Ameland consists of nature, with an immense variety of landscapes. Because of this variety there's an abundance of plants, but also many animals, like over 60 different species of birds.

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4.2 Site assessment and existing infrastructure

Ameland's current energy system state is described addressing the current energy supply and demand, as well as a detailed description of the electricity and natural gas grid of the island.

4.2.1 Supply and Demand

The total energy usage in Ameland is approximately 490 TJ per year, excluding the NAM-platform. The NAM-platform now uses the gas it produces for gas compression, which amounts up to 410 TJ/year. In 2022 the compressor will be replaced by an electrical compressor which increases the energy flow to the island with approximately 180 TJ/year.

The energy consumption fluctuates significantly every year and has been increasing in the past years. Figure 10 shows the energy usage per sector, where it can be observed that the building environment sector (in green) has always been the largest consumer, while the transport sector (in orange) has been increasing over the years. Industry, energy, waste and water (in red), agriculture and fishing (in dark blue) and Heat (in blue) have been stable over the years and have a relatively low consumption in the island.

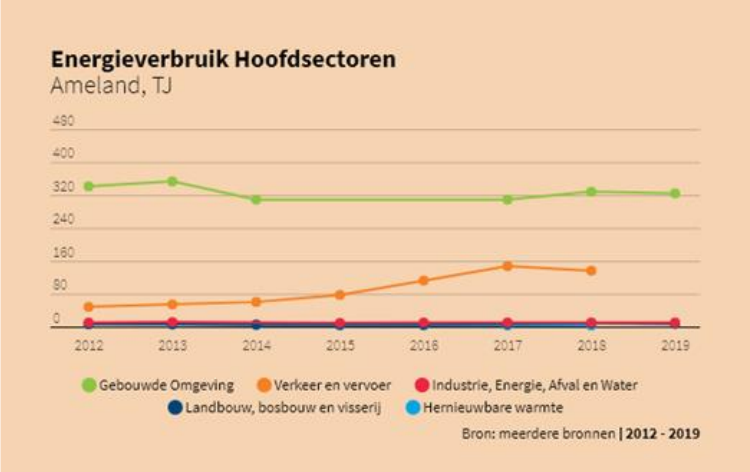

Figure 10: Energy consumption per sector in Ameland (2012-2019)

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According to Figure 11, most of the energy used in Ameland comes from the connections with the mainland. Nevertheless, the solar farm and the solar panels in customer premises also generate 10 TJ per year.

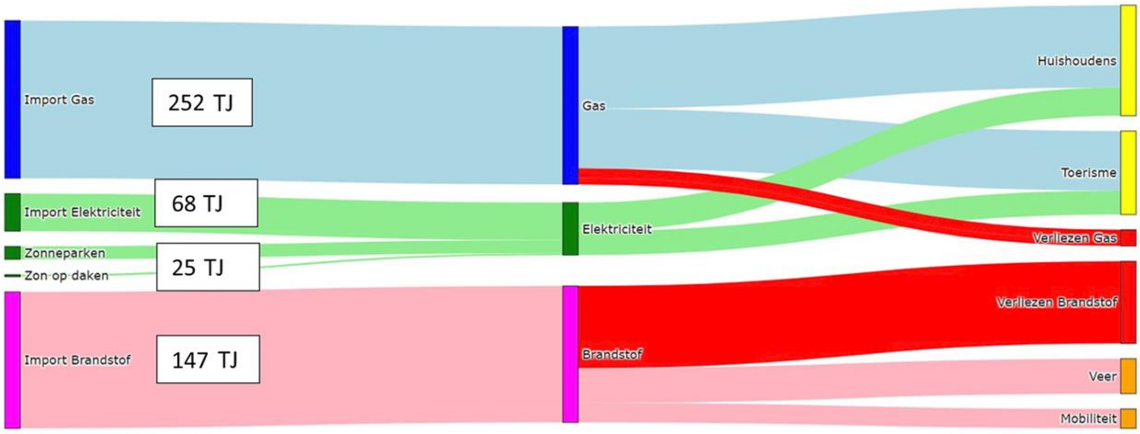

Figure 11: Energy consumption in Ameland

In most regions in the Netherlands, there is a decrease in natural gas and electricity usage in the summer. However, due to the large number of tourists visiting Ameland each year, this decrease is significantly smaller in Ameland.

In Figure 12, the power over the mainland connector is shown. Peak demand is around 6 MW (from the mainland to the island), while peak production (from the island to the mainland) is around 2.5 MW.

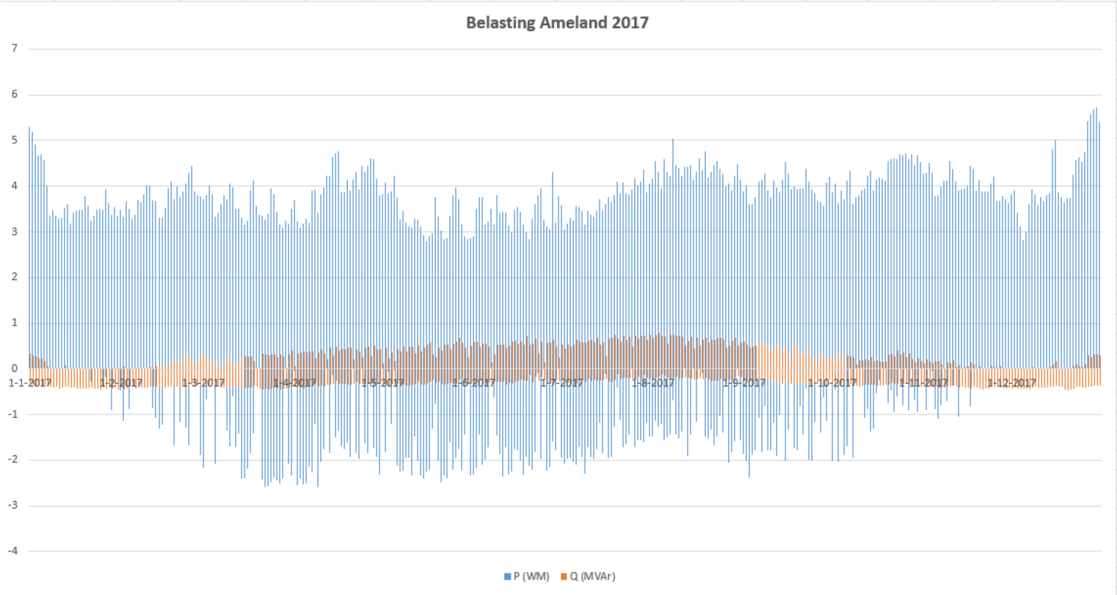

Figure 12: Power over the mainland connector in Ameland (2017)

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4.2.2 Electricity Grid

In Figure 13, the midvoltage grid of Ameland is shown. The 4 parallel lines in the lower right-hand corner depict the connection to the mainland. At present, there are 2 cables, but during 2021, 2 extra cables (the blue ones) will be installed.

Figure 13: Ameland's MV electricity grid

4.2.3 Natural Gas Grid

The Natural Gas Grid of Ameland consists of an 8 bar, a 3 bar and a 200 millibar grid. The gas is transported from the mainland gas grid by Stedin.

Figure 14: Ameland's gas grid

4.3 Equipment and system specification

In Ameland, some of the hardware solutions are already in operation while other solutions will still be installed. In this subchapter, a description of the technical and product specifications and the installation requirements of all the hardware solutions are presented. At the moment of writing this deliverable, obstacles were found to the realization of some of the technologies as expected and described in previous versions of the Use Cases. Thus, the descriptions of the technologies such as the water taxis, the electrolyser and the AHPD have been updated to take this into account. If needed, a new version of this report or a new deliverable will follow, in order to precisely specify the technologies that will be tested in Ameland, as well as their specifications.

4.3.1 Residential solar panels

There are several consumers who have solar panels installed on their roofs. However, it is not known which panels or inverters are installed.

4.3.2 Solar farm

In February 2016, the 6 MWp solar park started operating. In the last 5 years this solar park produced 6600 MWh per year on an average basis. This Park has 3 owners: the municipality of Ameland, Eneco and the Amelander Energy Cooperative. This was the first ground based solar park in the Netherlands. There are 23,000 REC 260PE solar panels installed together with 165 ABB TRIO 27.6 TL OUTD inverters. The electricity is transformed to 10KV by three transformers. The electricity runs from the solar park in Ballum to the distribution in Nes by a 6 km cable and is distributed to the households in Ameland.

Another Solar Park is planned to be installed in the Ballumerbocht with a capacity of 3MWp.

4.3.3 Micro-CHP

Three houses equipped with a battery pack (3.5kWh), solar panels (1kWe) and micro-CHP (5.5kWth) will be located at multiple locations in Ameland.

4.3.4 Private Methane Fuel Cells

Thirty-five privately owned Methane Fuel Cells (2 kW_e), fed by the methane district grid, on 35 individual homes are already in operation and funded by the National Project Slimme Stroom Ameland.

4.3.5 Fuel Cell

On the largest recreational park of the island, a 200 kWe Fuel Cell will be installed. This Fuel Cell will work as an innovative CHP where the heat produced by the Fuel Cell will be fed into an already existing local heat net. The capacity and location of this fuel cell are still to be defined.

4.3.6 Hybrid Heat Pumps

One hundred and thirty-five hybrid heat pumps are already installed in residential houses in Ameland. These hybrid heat pumps are fitted with a 20kWth boiler and a 1.1 kW_e/5 kW_{th} heat pump. The units can switch between natural gas and electricity independently depending on weather conditions. These hybrid heat pumps are prepared to run on biogas as well.

4.3.7 Biobased saline batteries

SuWoTec will install a 120kWh (50kW charging capacity) biobased battery.

Product specifications

Table 17 Technical specifications of the biobased saline batteries

Technical Specifications	Flywheel
Nominal voltage	552 V
Storage capacity	120 Ah 400 Vac
Maximum charging capacity	12 KW
Maximum discharging capacity	> 15 KW
Load efficiency	> 97% @ 20 °C
Discharge efficiency	> 96% @ 20 °C
Dimensions (L x W x H)	2,170mm x 1,654mm x 1,560mm
Weight	3,600 KG

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4.3.8 Hydrogen fuelled vehicles or other H2 usages

Due to a change of priorities for the shipowner external actor that was involved in the Ameland demonstrator, the water taxis cited in previous deliverables will no longer be used. The LH Island manager is now looking for alternatives for hydrogen usage, including the possibility of using Waste Trucks. The decided technologies will be described in further deliverables, if need be.

4.3.9 Tidal Kite

The TidalKite development, installation, testing and operation will be executed in a separate project. The IANOS scope focuses on integrating the TidalKite into the Ameland grid and in the central dispatcher. The SeaQurrent TidalKite technology is developed to harness energy from tidal flows. It consists of an underwater kite that makes it possible to cover a larger energy harvesting area, perpendicular to the flow.

The TidalKite test setup near Ameland consists of a monopile mooring that anchors the TidalKite system and a grid connection cable connected to Ameland's electricity grid as operated by Liander.

The grid connection will be realized by means of an HDD (horizontally directed drilling) under the sea dike, in order to place a tube in which the electricity cable can be placed. The offshore cable will be dug in.

The total TidalKite system is approximately 100m long. A standard TidalKite has a capacity of 500kW and is connected to the grid via a 10kV power cable.

4.3.10 Digester

The small-scale Auto-generative High-Pressure Digester (AHPD) described in previous versions of this report will no longer be realized due to financial and contractual obstacles. The digester solution to be implemented is now being decided by the LH managers and a further deliverable will describe it and its specifications, if need be.

4.3.11 Electrolyzer

A 200kW electrolyzer is planned to be installed. This will first be installed at Wetterskip Fryslân and then moved to the newly installed solarpark. Its H2 will be used by the waste trucks previously mentioned.

4.4 List of stakeholders

At this moment, the Municipality of Ameland, as well as Amelander Energie Coöperatie and its customers, are the main stakeholders for the new technologies.

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5 Fellow Islands

5.1 Lampedusa

5.1.1 General characterization

The islands of Lampedusa and Linosa, archipelago of the Pelagie Islands, located between Sicily and North Africa about 113 km from Tunisia and 205 km from Sicily, are administered by the City of Lampedusa and Linosa. From the last census, the islands are inhabited by 5,725 residents. Since 2003, the City of Lampedusa and Linosa manages the Marine Protected Area "Pelagie". Lampedusa covers a surface of about 20.2 km^2 and a coastline of about 26 km.

5.1.2 Site assessment and existing infrastructure

5.1.2.1 Supply and Demand

Energy consumption on the island is strongly influenced by its socio-economic system. The weather and climate conditions, the resident population, the fluctuating tourist population, the working activities and the use of the territory itself, are the main factors that influence the hourly demand curve. The local power plant is significantly oversized to have enough backup power in the case of failure. The energy demand varies considerably during the year, due to arrivals in the touristic season. The small size of the power system increases the cost of fuel transportation and the operative and maintenance costs. With the liberalization of the Italian energy sector in 2009, an incentive UC4 (now collapsed inside the incentive Arim) was introduced in the electricity bills to cover the higher costs for the electricity production in small islands. This way, whoever lives in small islands purchases electricity at the same price as someone on the mainland.

In 2020, the 24 installed photovoltaic systems fed 229,953 kWh (11.5%) into the island's grid, out of a total of 26,398,415 kWh of distributed electricity generated by the diesel thermoelectric power plant, as it is shown in Figure

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15. The renewable energy sources are extremely underdeveloped in this territory, as the environmental constraints hamper its use, like wind or photovoltaic panels (except the installation in an integrated solution with buildings). The fossil fuel is regularly transported by boat from Sicily, so prolonged adverse weather conditions represent an important risk for the energy supply of the island.

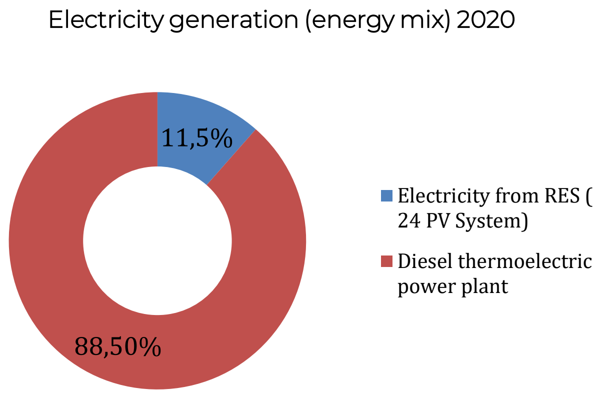

Figure 15: Electricity generation mix in Lampedusa, in 2020

The total electricity demand for the entire year was 32,871 MWh; the lowest peak was 2,012 MW and occurred on March 8 at 4:00 a.m.; the maximum peak was 8,864 MW and occurred on August 14 at 9:00 p.m. As expected, the minimum peak is observed when neither heating nor cooling is needed and the tourist season has not yet begun. On the other hand, the maximum peak occurred in the evening of August, when the island had the greatest number of tourists and the demand for air conditioning was at its peak. Between the winter period and the summer period the monthly value doubles, thus it is possible to affirm that the electric energy in summer is 4 times higher compared to the spring period.

The typical load demand curve is shown in Figure 16:

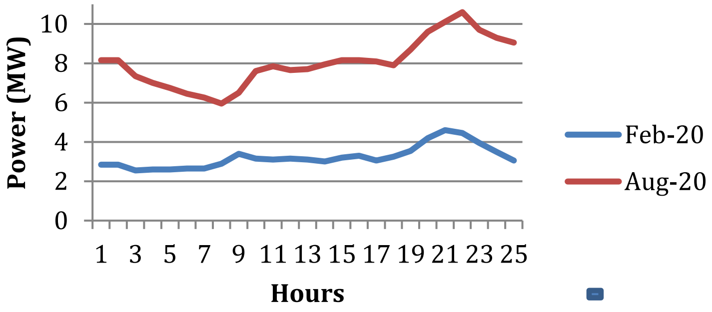

Figure 16: Typical Load Demand Curve for Lampedusa island

In Figure 17, the energy consumption per sector can be observed. The greatest weight corresponds to the residential load, which accounts for 29% of the total load, followed by the hotels' load, which, if added to that of residences intended for tourist accommodation, accounts for about 15% of the total load.

Energy Consumers	Electricity Demand (MWh)	%
Public lighting	855	3%
Residents	9438	29%
Non-resident	1403	4%
Tourist establishments	3302	10%
Tertiary activities	3084	9%
Tertiary activities such as bars, pizzerias and restaurants	1596	5%
Industries	1975	6%
Municipal users	322	1%
Water plant and sewage plant	366	1%
Desalination plant	3509	11%
Hospital	313	1%
Airport	1865	6%
Military areas and barracks	2453	7%
Self-consumption power plant	2389	7%

Figure 17: Energy consumption per sector in Lampedusa

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5.1.2.2 Electricity Grid

The power system of Lampedusa is isolated from the main national grid. The local Medium Voltage network is composed of 69 nodes, 39 kiosk and 13 pole-mounted (10 kV/400 V) substations as shown in Figure 18.

The electricity grid is composed of 5 main medium-voltage lines through which are distributed about 60 electrical conversion substation/cabins from medium to low voltage, which supply low voltage electricity to public and private users. The medium voltage network is realized with a ramified structure that allows, in cases of accidental blackouts, the isolation of the fault, avoiding current interruption on the whole island.

Map 1 Medium voltage power grid

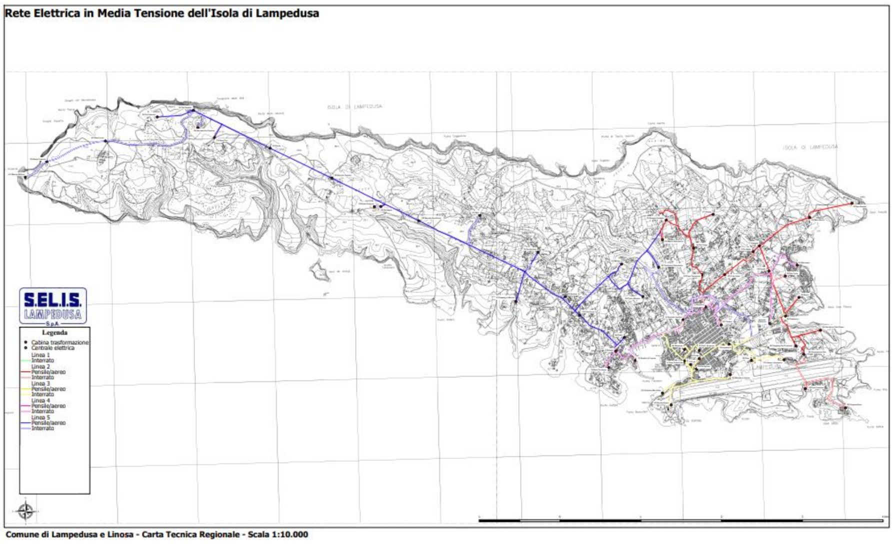

Figure 18: Lampedusa's electricity grid

The distribution chain of electrical energy on the island is produced by the alternators at 50 Hz. At a voltage between 400 V and 5,000 V, energy is transformed and introduced in the net at 10,000 V (medium voltage) and so transported to the distribution substation/cabins where it is transformed, again, to the national voltages of 220 V and 380 V (low voltage) and finally supplied to the users.

The current electrical network of the island of Lampedusa is designed so that the flow of energy moves in a unidirectional way, from the production place to the consumption one and, in that regard, the final user is only and exclusively a passive load. The implementation of new large-scale electricity

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production plants requires the modification of the electrical network of the island for the transition from passive to active. Moreover, since the locations identified for the installation are in areas currently not reached by the medium voltage distribution network, for their connection it will be necessary to provide the realization of special underground cables connected to the power plant.

The supply of energy, since there is no direct connection with the mainland, is provided through a diesel thermoelectric power plant managed by the company S.EL.IS. Lampedusa s.p.a. The company has a power plant located close to the town centre, in the district of Pisana, consisting of 8 generators coupled to an equal number of diesel engines with a total power of 22.5 MVA. The generators work with different scheduling according to the hourly electrical load and the engines work alternating between the primary energy production system and the storage system. The operational behaviour of the power plant engines is managed in a way, so that as soon as a motor runs for 10 minutes at 80% of its nominal power, a second motor is switched on and the power is distributed according to the distribution algorithms of the management system adopted by the company SELIS SpA. It is worth to consider that the fuel (diesel) needed for the regular operation of the plant is brought to the island by tankers from the mainland and since the plant is not located near the port, the fuel is then transported by road to the plant. Obviously, this solution is not sustainable from an environmental point of view, because of the emission of CO_2 and other pollutants caused by the diesel combustion in the local power plant. At present, the installed generator groups are the following:

S.EL.I.S. LAMPEDUSA S.p.A.

GR.	MOTORI	ALTERNATORI	POTENZA KW
1	MAN 18V28/32S - Matr. 40157 02 52	AVK - 750 g/1' - 11000 V DIG 156 N/8 - Matr. 8425109 B101	4100
2	MAN G8V 30/45ATL - Matr. 413746	GARBE LAHMEYER - 500 g/1' - 5000 V Smh 12/140-52 Matr. 4101415012 003	1328
3	WARTSILA NOHAB 6R25 - Matr. 3674	GARBE LAHMEYER - 1000 g/1' - 5000 V PA 1004115-80/6 R 9602 201	1470
4	WARTSILA NOHAB 16V25 - Matr. 3607	LEROY SOMER - 750 g/1' - 5000 V LSA 56L8/8P Matr. 159143/1	2800
5	MAN 9L 25/30 - Matr. 1040253	RELIANCE ELECTRIC - 1000 g/1' - 5000 V SDGB 6302-6 Matr. 185092 RR	1893
6	MAN 12V 32/36 - Matr. 1055000 (collaudo 4412 KW; targa 4440 kW)	UNELEC - 750 g/1' - 5000 V PA 160 G 95-65-8P Matr. 154/191/1	2998
7	WARTSILA NSD 16V25 - Matr. 4322	LEROY SOMER - 750 g/1' - 5000 V LSA 56 UL9/8P Matr. 166869/1	2935
8	WARTSILA 12V32 - Matr. 22360	ABB - 750 g/1' - 11000 V AMG0900LR08 DSE- Matr. 4575070	5040

Figure 19: Lampedusa's generators

All generator sets are equipped with a modern SCR - "Selective Catalytic Reduction" - type catalyst system for the reduction of pollutants /exhaust gases in particular NOx.

In Lampedusa, there is no gas grid. The heating of the houses is electric as for the hot water heating. Gas cylinders are used for the kitchens, transported by ship from Porto Empedocle (mainland).

All electric generators are equipped with both primary and secondary frequency control. The primary frequency/active power control keeps the frequency/active power stable according to a droop percentage, while the secondary frequency/active power system intervenes to keep the frequency within predetermined parameters and, if necessary, to correct the load distribution. The secondary frequency system distributes the active power in proportion to the rated power. For voltage regulation there is a primary and a secondary voltage/reactive power control. The primary voltage regulation/breakdown is done by voltage regulators working in droop, while the secondary one distributes the reactive power in proportion to the generator size. Concerning energy losses in the grid, in 2020 there were 15.69% of energy losses in the island. In terms of network congestion, no episodes were reported in the previous years.

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5.2 Bora-Bora

5.2.1 General characterization

Bora Bora is a small island located in the South Pacific Ocean in the Society's Archipelago in French Polynesia (270 km northwest of Tahiti, Oceania). This archipelago contains 14 islands and is divided into two groups, the Windward Islands (207,333 inhabitants) and the Leeward Islands (35,393 inhabitants), where Bora Bora is located. Bora Bora had a population of 10,605 in 2017 and covers 29 km^2, plus some 10 km^2 of islets adjacent to the coral reef, forming a lagoon. Bora Bora has a relatively temperate climate. Bora Bora is the most visited island after Tahiti (125,000 visitors/y). The island also contains a dormant volcano.

5.2.2 Site assessment and existing infrastructure

5.2.2.1 Supply and Demand

The total electricity produced in 2020 was 35.6 GWh, where 33.7 GWh was correspondent to thermal electricity. Most of the electricity production still comes from fossil fuels (94.6%). The small part that is generated from renewable energy sources is due to PV panels.

There are 3,198 clients on the island, with the low voltage for social use being the sector that consumes the most, as it can be observed in Table 18.

Table 18: Electricity consumers in Bora-Bora island

Number of clients	Low Voltage social use	Low Voltage Home	Low Voltage industries	Low Voltage EP	Medium Voltage	TOTAL
2020	1,811	975	347	34	31	3,198

The annual peak demands use to be around 6 or 7 MW. Figure 20 and Figure 21 show the typical demand curves for weekdays and weekends, respectively.

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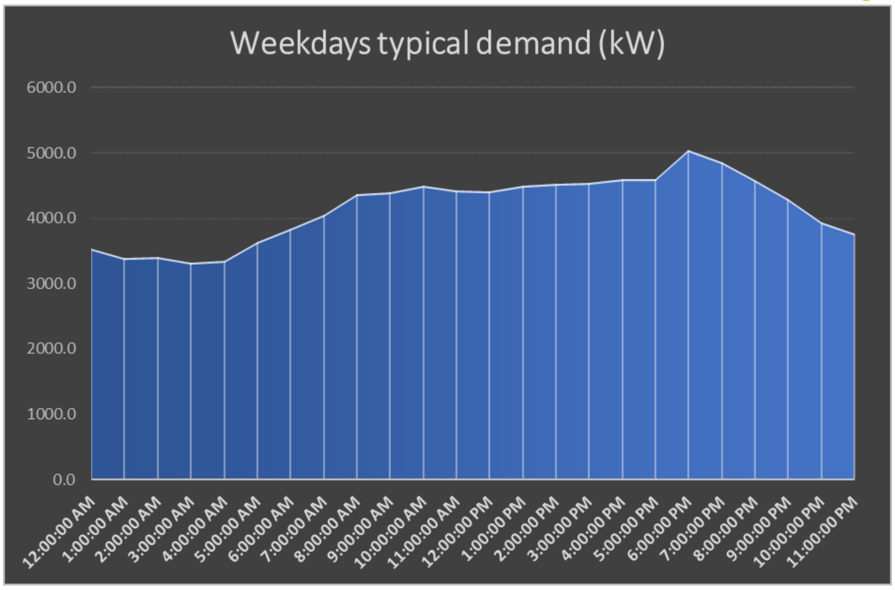

Figure 20: Typical demand curve for weekdays in Bora-Bora island

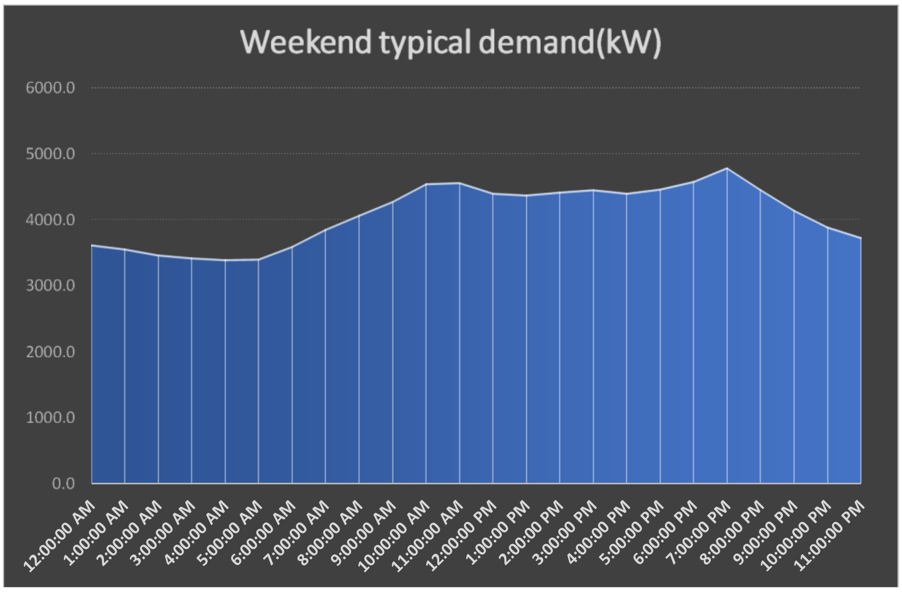

Figure 21: Typical demand curve for weekends in Bora-Bora island

5.2.2.2 Electricity Grid

Figure 22 illustrates the map of the power grid lines of Bora-Bora island.

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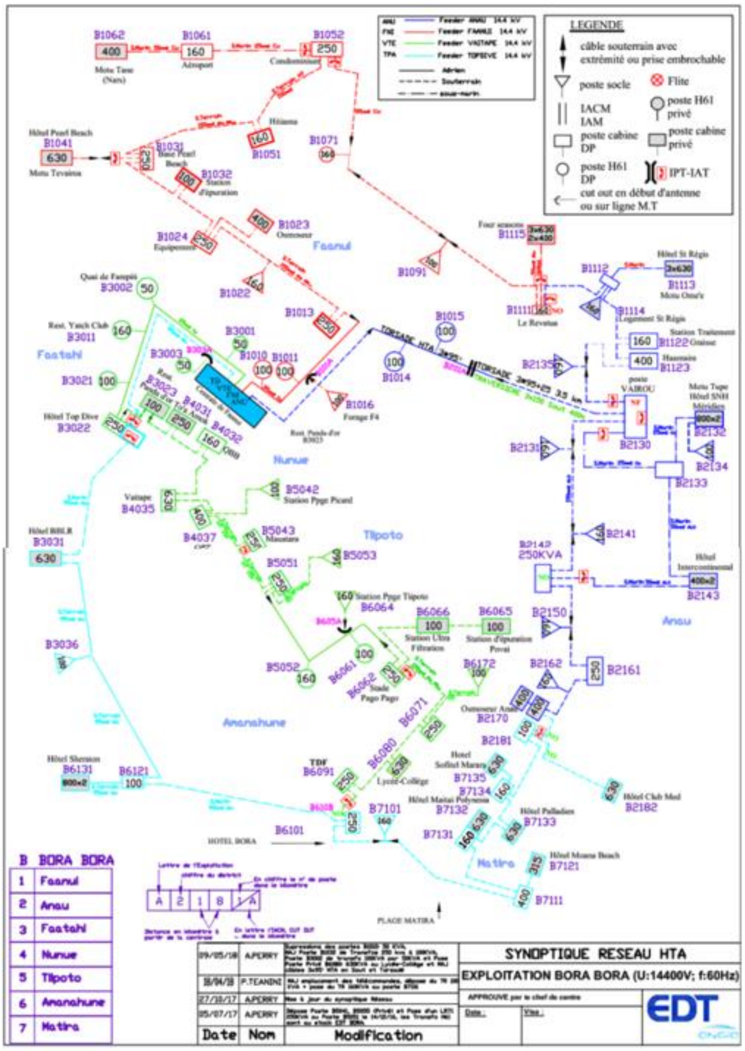

Figure 22: Bora-Bora's power grid

Table 19 displays the characterization of the distribution grid of Bora-Bora which has a total of 160 km. There is no transmission grid on the island.

Table 19: Bora-Bora's distribution grid

Distribution	Length of networks (km)				Voltage	Frequency
	Aerial	Buried	Sub-marine	Total		
HT	8.0	44.1	18.5	70.7	14,400 V	60 Hz
LT	26.0	64.1	0.0	90.1	220 - 380 V	
Total	34.0	108.2	18.5	160.7		

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Concerning power plants, the island has 8 generators with different nominal powers and installed in different years as displayed in Table 20.

Table 20: Diesel Generators of Bora-Bora

Diesel generators	Name	Brand	Nominal power (kW)	Continuous service power (kW)	Year of install
G1	G051	CUMMINS KTA50	1,000	640	1996
G3	G106	WARTSILA W200 V12	2,000	1,800	2001
G4	G224	WARTSILA W9L32	3,880	3,880	2011
G6	G074	WARTSILA 6R32	2,150	2,000	1998
G7	G110	WARTSILA W200	2,000	1,800	2002
G10	G064	WARTSILA 8R32	2,850	2,850	1997
G12	G094	WARTSILA W200	2,000	1,800	2000
G13	G225	WARTSILA W9L32	3,880	3,880	2011

The power grid of Bora-Bora has energy losses around 3% as shown in Table 21. Voltage and frequency fluctuation are usually controlled with diesel production and spinning reserve.

Table 21: Energy losses in Bora-Bora's island

Production	Gross genset production (GWh)	AUX consumption (%)	Max (kW)	Consumption (m^3)	Production yield	Network yield
2017	45.556	2.98	7,330	11,591	97.0%	97.2%
2018	44.758	2.62	7,680	11,408	97.4%	95.4%
2019	46.146	2.08	6,950	11,870	97.9%	96.6%
2020	34.678	2.73	6,860	9,098	97.3%	97.0%

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5.3 Nisyros

5.3.1 General characterization

Nisyros Island is composed of 4 villages: Mandraki (The biggest village), Nikeia, Emporeios and Paloi as described in

Figure 23. These villages are connected with specific electric cables and, in the villages, there are some stations for interconnection and distribution of the energy inside the villages and between them.

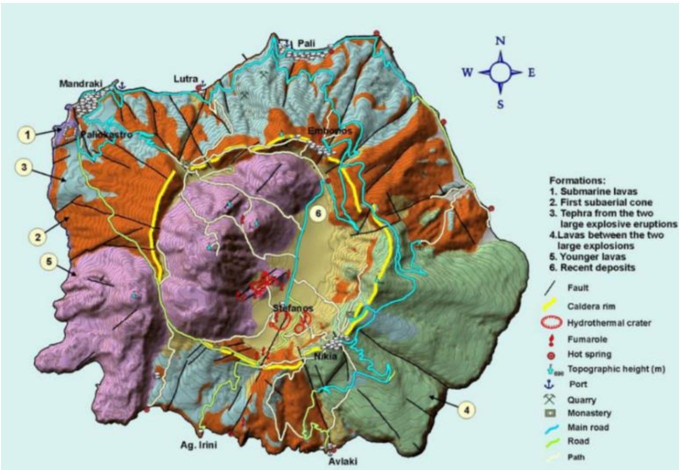

Figure 23: Nisyros' villages

5.3.2 Site assessment and existing infrastructure

Nisyros island belongs to the island complex of Dodecanese and covers its electricity needs as part of the "Kos-Kalymnos" autonomous microgrid as shown in Figure 24. Two oil-based APS (the first one operating in Kos island with rated power 102 MW and the second operating in Kalymnos island with rated power 18 MW) feed the autonomous microgrid and provide electrical energy to Nisyros through two Medium Voltage (MV) subsea cables that are terminated at the north part of the island (near the Mandraki village), through

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the Yali islet. Thereby, the electrical energy is fed through the power distribution overhead lines to other parts of the island, while from the south part of the island (near the Avlaki region), two independent MV subsea cables are feeding electricity to the south part of the specific microgrid (Tilos island).

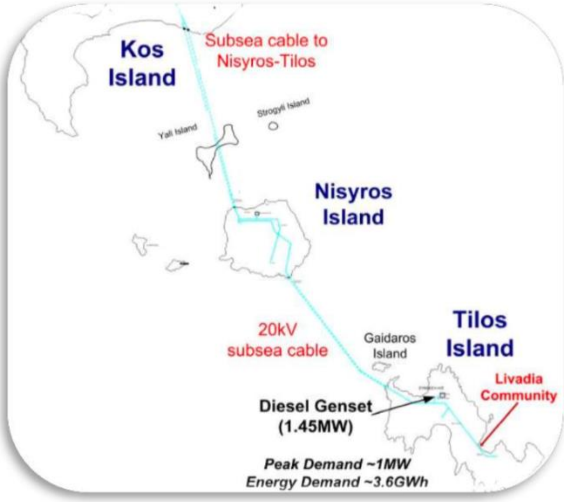

Figure 24: Autonomous microgrid of Kos-Kalymnos-Nisyros-Tilos.

The extensive and complex configuration of the “Kos-Kalymnos” autonomous microgrid has substantial repercussions on the quality of the electricity fed to Nisyros island, with frequent black-outs occurring mainly at the microgrid’s south part (which is comprised of Nisyros and Tilos), as also voltage and frequency stability issues.

Unfortunately, there does not exist a dedicated energy meter installed at the entry point of electricity at Nisyros island. As a result, a general overview of the island’s total electrical energy needs is not directly available.

Based on previous years’ historical data, Nisyros peak power demand is estimated at 1.2 MW. In addition, the desalination units, comprising of a main component of the load demand, operate on a constant water provision policy and, as a consequence, have constant power requirements and therefore do not affect the peak power demand. In order to visualize the aforementioned, Figure 25 presents the load demand measurements carried out for Tilos island during the time period 2015 - 2018. Thus, the load demand for Nisyros island will have an analogous profile, with its peak being multiplied by a factor of 1.5 or 1.7.

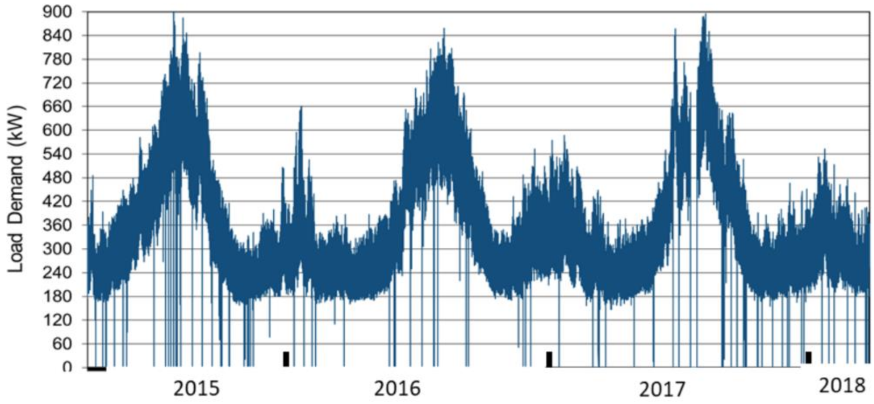

Figure 25: Electrical energy demand for Tilos island

Based on the available official data for the energy consumption of Nisyros island during the past decade (Figure 26), a significant fluctuation is noted, which is smoothed out the last three years (2017 – 2019). More precisely, the load demand was 4,000 MWh_e/year for 2010, while it surpasses 6,200 MWh_e/year for 2019, presenting a constantly increasing tendency.

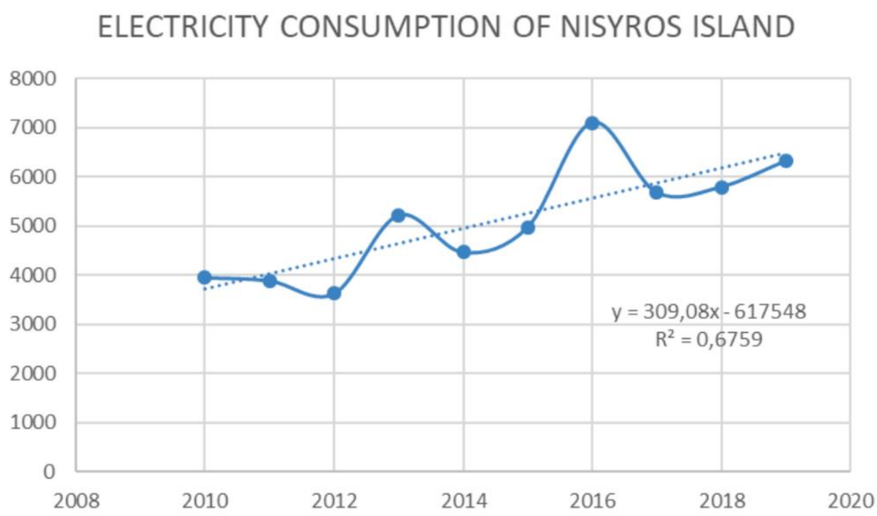

Figure 26: Nisyros island total electricity consumption (MWh_e) time evolution

Figure 27 describes the electricity consumption of Nisyros island for the different sectors. Accordingly, the main constituents of the electrical energy consumption are the domestic and the commercial sectors. The desalination units play a crucial role on the island's energy demand, as the electrical consumption was increased approximately by 1,000 MWh_e when the first unit begun to operate at 2013 and doubled at 2016, when the second unit was integrated. Following, a variation exists depending on the operational status of the two units. The third unit begun its operation at 2019 to replace the problematic first unit. Moreover, the lighting contribution is more than halved during the past decade and along with the public buildings and the public entities represent a small percentage of 6 - 7% of the island's total annual energy requirements.

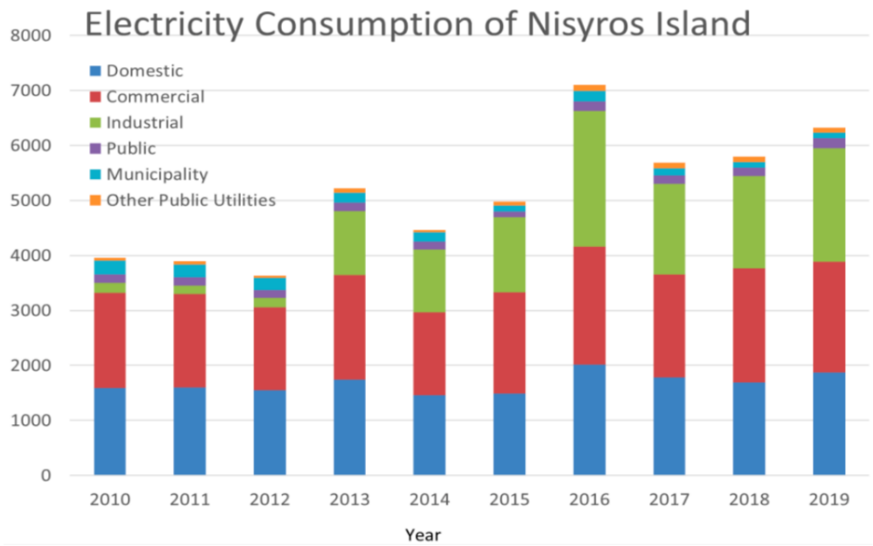

Figure 27: Electricity consumption of Nisyros per sector (2010-2019)

Finally, it can be stated that the electrical energy demand of Nisyros island presents the typical seasonal profile of all Greek islands located in the Aegean Archipelagos, with a peak power demand occurring during the summer (approximately during mid-August) and being equal to 1.5 MW. The greatest percentage of the electrical energy demand is due to the Mandraki region and is around 6,000 MWh_e, presenting a constantly increasing tendency, which is expected to be terminated the following years due to the pandemic impact on the economy. The whole electrical energy consumption is covered by the (double) subsea connection with the "Kos- Kalymnos" autonomous microgrid, which is characterized by the dominant presence of

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diesel oil-based power stations (at a percentage of 85%) and the pertinent environmental and macro-economic issues.

Consequently, any intervention for energy savings, as well as the installation of RES-based and environmentally friendly power stations, will enhance the energy security of the local habitants and alleviate from both the direct and indirect environmental impacts as also from the macro-economic charges on the Greek economy. Finally, in such a case, economic benefit could also be attained. The island does not have any power plants or substations for production of electricity.

6 Use Cases Definition

6.1 Transition Track 1: Use Cases

Transition Track 1 comprises of all the Use Cases that utilize high renewable energy penetration to provide energy services to the power system. The main aims of these Use Cases focus on reducing energy curtailment and on providing stability to the grid by avoiding challenges such as congestion and voltage variations. For this purpose, self-consumption maximization (UC1), use of flexibility from generation side (UC2) and provision of fast (UC3) and slow grid services (UC4) are demonstrated in four Use Cases.

6.1.1 Use case 1: Community demand-side driven self-consumption maximization

1 Description of the use case

1.1 Name of the use case

ID	*Area / Domain(s)*	*Name of Use Case*
1	Energy efficiency and grid support for extremely high-RES penetration.	Community demand-side driven self-consumption maximization.

1.2 Version management

Version Management			
Version No.	*Date*	*Name of Author(s)*	*Changes*
1	04.02.2021	Mónica Fernandes (EDP NEW)	First draft version.
2	05.02.2021	Nikolaos Nikolopoulos (CERTH), Dionisios	Comments and inputs on Diagrams, Actors, Scenarios, Information Exchanged.

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		Stefanitsis (CERTH)	Suggestion of inclusion of information regarding protocols for communication/information data exchange according to SGAM architecture.
3	10.02.2021	Carlos Patrão (CLEANWATTS)	Comments on Use Case conditions, Actors, References, Scenarios, Information Exchanged.
4	23.02.2021	Rui Lopes (UNINOVA)	Comments on Use Case conditions, Diagrams.
5	25.02.2021	Mónica Fernandes (EDP NEW)	Collect all the feedback and start second version. Add SGAM layers characterization. Improve diagrams, description, information exchanged and scenarios.
6	16.03.2021	Ioannis Moschos (CERTH)	iVPP Requirements.
7	21.04.2021	Denisa Ziu (ENGINEERING)	Scenario 2 – Self-consumption maximization through P2P energy trading based on DLT; Pure P2P approach.
8	29.04.2021	Mónica Fernandes (EDP NEW)	KPI's added from D2.3. Collecting the new feedback.
9	10.05.2021	Mónica Fernandes (EDP NEW)	Final Version.
10	01.04.2022	Mónica Fernandes (EDP NEW)	Minor updates on the actor of the Use Case.
11	11.07.2022	Ana Carvalho (EDP NEW)	Revision and start third version.

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12	15.07.2022	Ana Carvalho (EDP NEW)	Minor changes to Use Case Description correcting typos or providing more details.
13	16/09/2022	Vasilis Apostolopoulos (CERTH)	Corrections to KPI numbering according to final version of D2.9.

1.3 Scope and objectives of use case

Scope and Objectives of Use Case	
Scope	The scope of this Use Case is the optimization of behind-the-meter assets at residential consumer premises to maximize self-consumption from RES and thereby reducing energy curtailment. The ability of monitoring and control loads, PV generation and storage can allow consumers to explore the potential of self-consumption and electricity cost minimization. This Use Case is demonstrated in Local Energy Communities (if LEC already exist in the island) and the optimization of the assets will be performed in a local and a neighbourhood-level.
Objectives	This Use Case orients at optimizing and controlling the energy consumption in the local and neighbourhood level to achieve the following objectives: 1. Maximize self-consumption from renewable energy sources to allow the users (Terceira) or community (Ameland) level better exploit their assets, to avoid future grid transport costs to the mainland and to alleviate the grid in periods of excess of renewable generation. 2. Reduce energy curtailment by achieving a maximum renewable penetration possible. 3. Avoid grid challenges such as congestion and voltage variations.

1.4 Narrative of use case

Narrative of Use Case
Short description
This Use Case occurs in a Local Energy Community (LEC) and focuses on controlling and optimizing energy assets with the main purpose of matching the energy generation from PV panels and small wind turbines and storage with the consumption

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of end-user or community level assets including i) electrochemical and heat batteries, ii) electric water heaters, iii) heat pumps and iv) micro-CHP through an intelligent virtual power plant (iVPP). The iVPP computes the optimization of behind-the-meter assets based on several information-sources provided by localized energy management systems (Home Energy Management Systems and Fog-Enabled Intelligent devices). Thereby, the iVPP is capable of controlling storage and demand-side assets by, for instance, shifting demand for periods of renewable generation surplus.

Additionally, this use case comprises of the details regarding peer-to-peer energy trading schemes.

Complete description

The present Use Case describes the methods to control and optimize the consumption of the behind-the-meter assets in a Local Energy Community (LEC) or group of consumers, through an intelligent virtual power plant (iVPP).

The controlled and optimized assets will be: i) electrochemical and heat batteries, ii) electric water heaters, iii) heat pumps, iv) micro-CHP, v) EVs, vi) smart home appliances and smart plugs, vii) fuel cells, viii) hybrid heat pumps and ix) biobased saline batteries.

This optimization will be local and in the neighbourhood level with the goal of maximizing renewable energy sources (RES) self-consumption from PV panels and small wind turbines. The local optimization will consist of controlling the building loads and storage systems while the neighbourhood level optimization, either locally (in the case of Terceira) or centrally (in the case of Ameland), will allow to take advantage of load heterogeneity and enable to supply the generation surplus from certain buildings to buildings with higher energy demand at a specific time period. The iVPP will be able to perform the global control and energy dispatch while considering the comfort requirements of the energy users. For this purpose, the iVPP will be interfaced with localized energy management systems such as residential Home Management Systems (HEMS) and Fog-Enabled Intelligent Devices (FEID-Plus) in residential and other local Building Management Systems (BMS) in tertiary buildings.

The localized energy management systems will provide real-time data to the iVPP such as energy consumption, energy generation, batteries' state of charge, temperature and others. These data will be obtained through smart sensors, smart plugs, field-level interfaces or other well-known sources such as weather forecast websites.

Thereby, the iVPP will shift demand to periods where there is excess of renewable energy through the development of control algorithms. These algorithms will be based on several data such as: i) forecasted PV generation, ii) non-controllable and critical load which operation cannot be altered significantly and iii) controllable loads, such as electric water heaters or heat pumps, with flexibility margins depending on comfort restrictions and operation settings imposed by the users.

This optimization process will also contemplate any type of distributed storage such as batteries along with novel Phase Change Material (PCM) thermal storage, fuel cells and electric charging stations, always with the aim of achieving the maximum economic and environmental benefit for the end-user. For this purpose, an external forecast provider will supply production forecasts based on local meteorological forecasts while the iVPP, through its forecasting engine, aggregation and classification and centralized dispatcher modules, will utilize the following data: i) energy consumption forecasts based on historical load consumption and real-time measurements, ii) historical generation data, iii) artificial intelligence-based clustering of assets and iii) dispatching of evaluated flexibility strategies to optimize self-consumption on the community which will depend on the profile of the assets at-hand and the future time-slots' energy prices.

Moreover, this use case also includes the peer-to-peer (P2P) energy transactive framework, which aims at promoting self-consumption. This trading allows users to exchange flexible energy products with other prosumers and assets thereby contributing to maximize the penetration of renewables and avoid future grid transport costs.

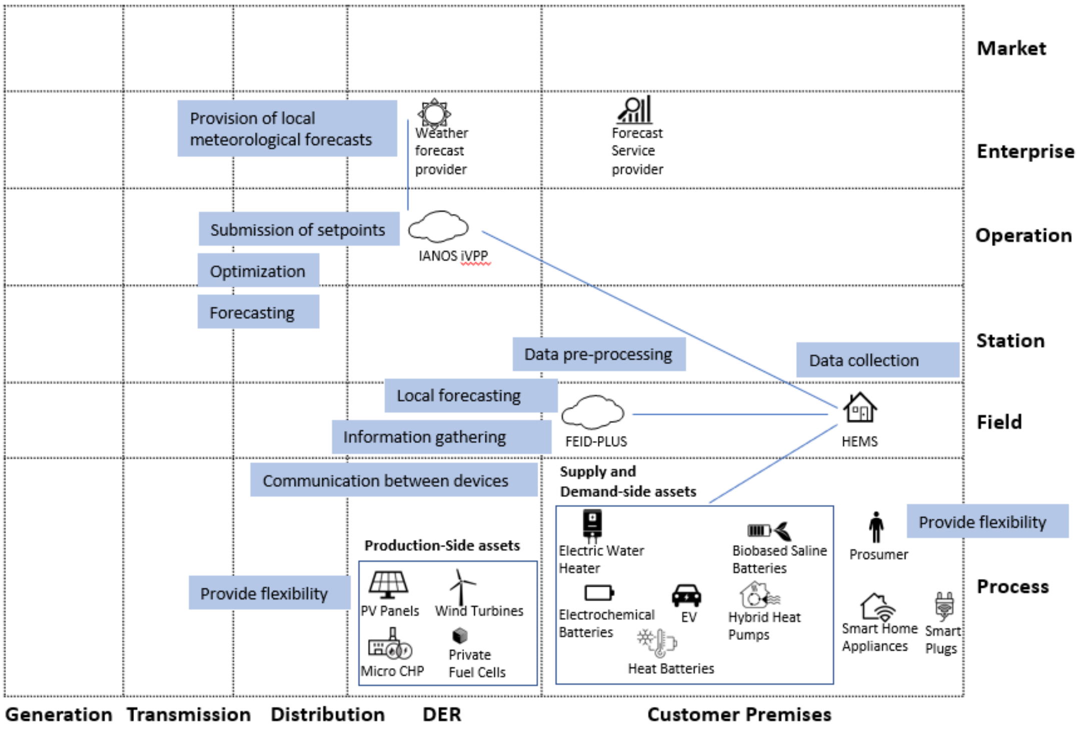
In this case, prosumers sell the excess energy in a P2P market. The market will leverage on self-enforcing smart contracts to manage, in a programmatic manner, the P2P energy-trading between prosumers.

Direct energy transactions in the community will be facilitated through the Distributed Ledger Technologies (DLT)-transactive logic implemented into the iVPP intelligence. The iVPP will realize the energy flexibility tokenization, through the implemented DLT-based energy credits' application mechanism through Smart Contracts.

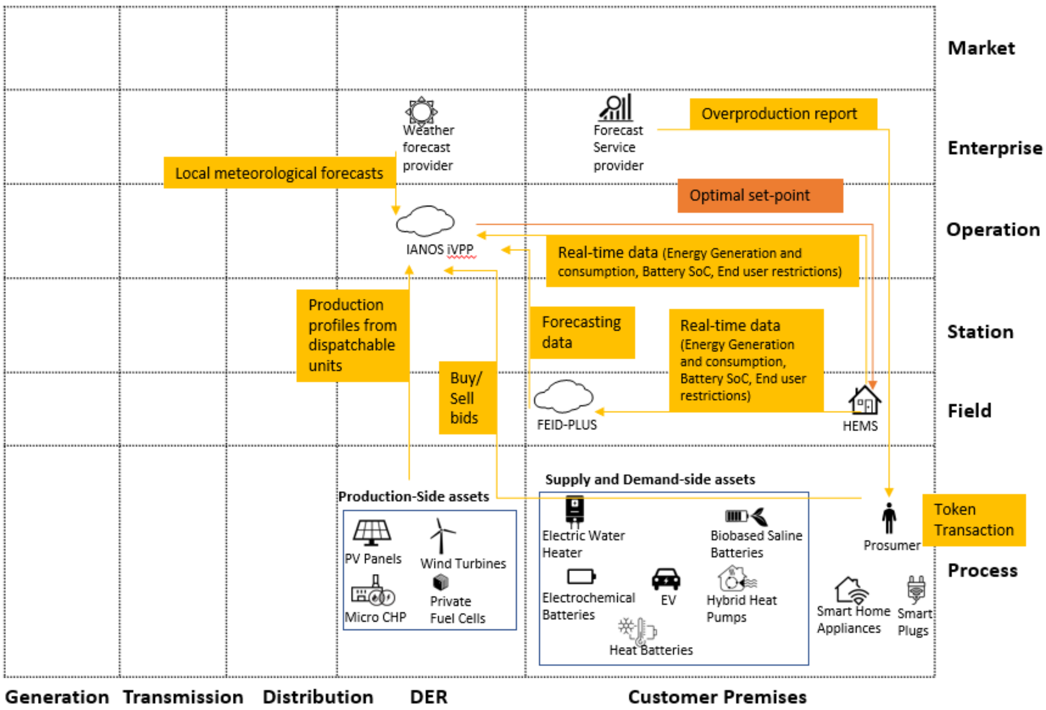
This part of the Use Case is described in more detail in *D4.9 - iVPP P2P transactive energy framework*.

SGAM LAYERS:

Function Layer



Information Layer



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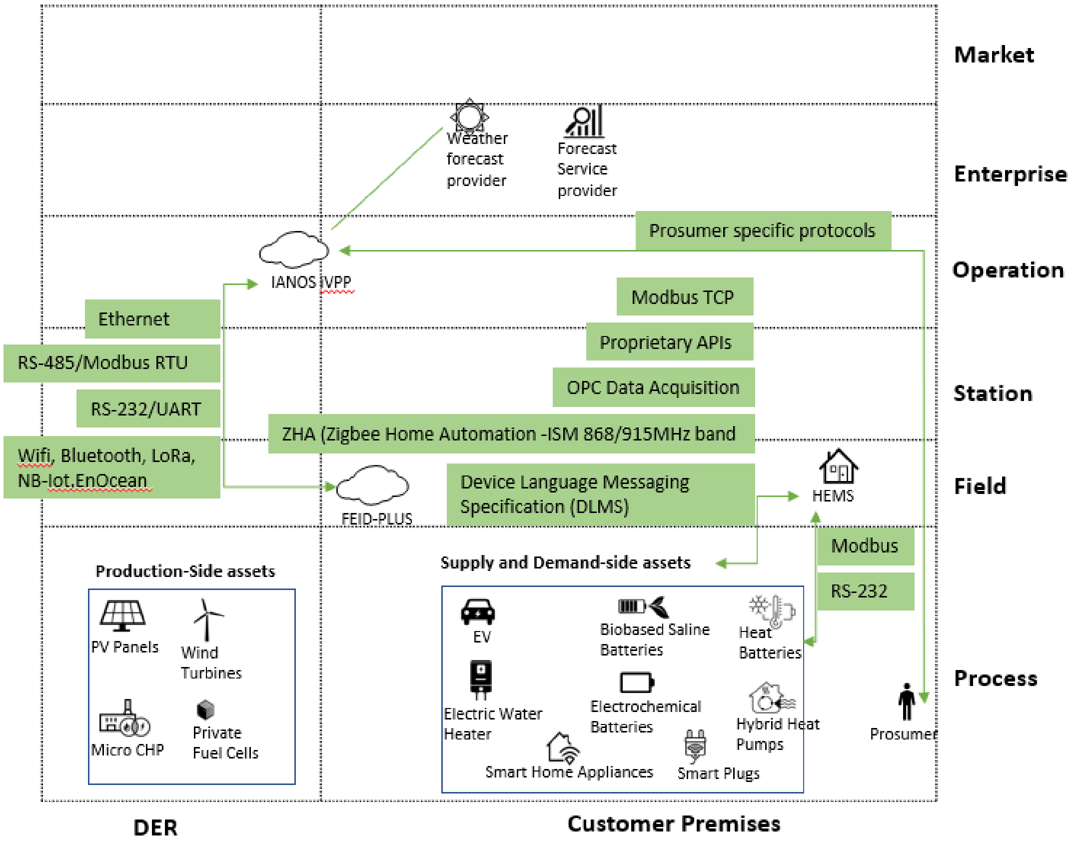
Communication Layer



Technological Solutions	Information / Communication Protocols	Terceira	Ameland
PV Panels		x	x
Wind Turbines			x
Micro CHP			x
Private Fuel Cells			x
Biobased Saline Batteries			x
Heat Batteries	RS-232; Modbus	x	
Electrochemical Batteries	-	x	
Hybrid Heat Pumps			x
Smart Plugs	-	x	

Electric Water Heaters	The protocol used can be adjusted according to the needs and specifications of the iVPP as long as it is supported by a Wi-Fi connection at the installation site.	x	
HEMS	·DLMS – (Device Language Messaging Specification) a protocol that is emerging as the worldwide standard of choice among smart meter designers for interoperability among all metering systems, including all energy types (electricity, gas, heat and water); ·Modbus TCP – Modbus version over TCP/IP; ·Proprietary APIs – proprietary APIs.	x	
FEID-PLUS	Wired communication protocols: Ethernet, RS-232/UART, RS-485/Modbus RTU Wireless communication protocols: WiFi, Bluetooth, LoRa, NB-Iot, EnOcean	x	x

1.5 Key performance indicators (KPIs)

ID	*Name*	*Description*	*Reference to mentioned use case objectives*
1.2	Energy Savings	Calculates the reduction of the energy consumption to reach the same services (e.g. Comfort levels) after the interventions, taking into consideration the energy consumption from the reference period.	1
1.7	Storage capacity of the island's energy grid per total island energy consumption	Compares the storage capacity with the total energy consumption of the island.	1,2,3
1.9	Peak Load Reduction	calculates the peak load reduction after the IANOS implementation (DSM programs and storage system management) compared to the baseline scenario (before the implementation)	3
1.12	Peak photovoltaic power installed per 100 inhabitants	Measures the installed capacity of photovoltaic interpolated to 100 inhabitants. To be assessed per sector (residential, tertiary, industrial and public).	1
2.2	Reduced fossil fuel consumption	Measures the amount of fossil fuels which is not consumed because of IANOS demonstrated solutions (e.g. Electrification of transport, RES penetration).	1,2
3.11	Energy Poverty	Assesses the change in percentage points of (gross) household income spent on energy bills since the beginning until the end of the project. Calculation of the reduction in consumer's electricity bill.	1

4.4	Increased hosting capacity for RES, electric vehicles and other new loads	Gives a statement about the additional loads and RES that can be installed in the system, when innovative solutions and energy management techniques are applied (e.g. VPP platform).	1,2,3
5.1	People Reached	Percentage of people in the target group that have been reached and/or are activated by the project.	1
7.1	Social Compatibility	Refers to the extent to which the project's solution fits with people's 'frame of mind' and does not negatively challenge people's values or the ways they are used to do things.	1
7.2	Technical compatibility	Examines the extent to which the smart grid solutions fit with the current existing technological standards/infrastructures.	1, 3

1.6 Use case conditions

Use case conditions

Assumptions

- Existence of distributed energy assets available in the island, capable of being integrated and remotely managed or controlled by the iVPP, such as PV panels, electrochemical and heat batteries, electric water heaters, smart home appliances, smart plugs, small wind turbines, fuel cells, heat pumps, hybrid heat pumps and biobased saline batteries.
- Smart meters and smart plugs are installed on buildings and on relevant energy assets, and their readings are available for the iVPP in real-time.

Prerequisites

- Availability of real time data from localized energy management systems.
- Availability of forecasting data to the iVPP: Solar Irradiation, Wind Potential, loads (heating, cooling, DHW, electricity) consumption profiles, including historical data.
- Definition of end-user levels of comfort.
- Definition of end-user critical loads.
- All available energy assets can be integrated on the iVPP platform.
- A (physical) hosting environment on which the iVPP can be established.

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1.7 Further Information to the use case for classification / mapping

Classification Information
Relation to other use cases
UC2: Community supply-side optimal dispatch and intra-day services provision. UC3: Island-wide, any-scale storage utilization for fast response ancillary services. UC4: Demand Side Management and Smart Grid methods to support Power quality and congestion management services. UC5: Decarbonization of transport and the role of electric mobility in stabilizing the energy system. UC9: Active Citizen and LEC Engagement into Decarbonization Transition.
Level of depth
Specialized use case
Prioritisation
High level of priority
Generic, regional or national relation
Generic
Nature of the use case
Technical use case
Further keywords for classification
Self-consumption, prosumers, Peer-to-peer, consumption optimization, supply and demand-side assets, iVPP, LEC

1.8 General Remarks

General Remarks
-

2 Diagrams of use case

Diagram(s) of use case
Use Case Diagram – Scenario 1

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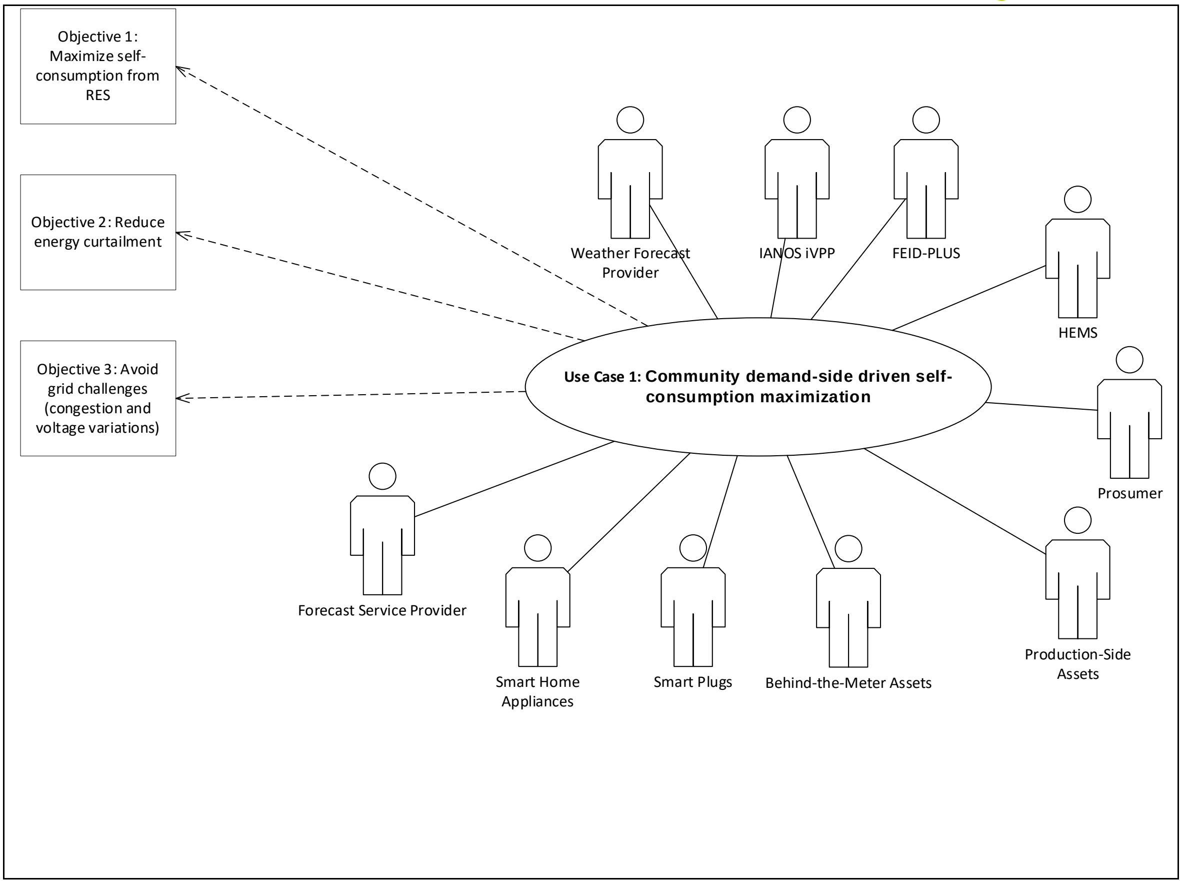

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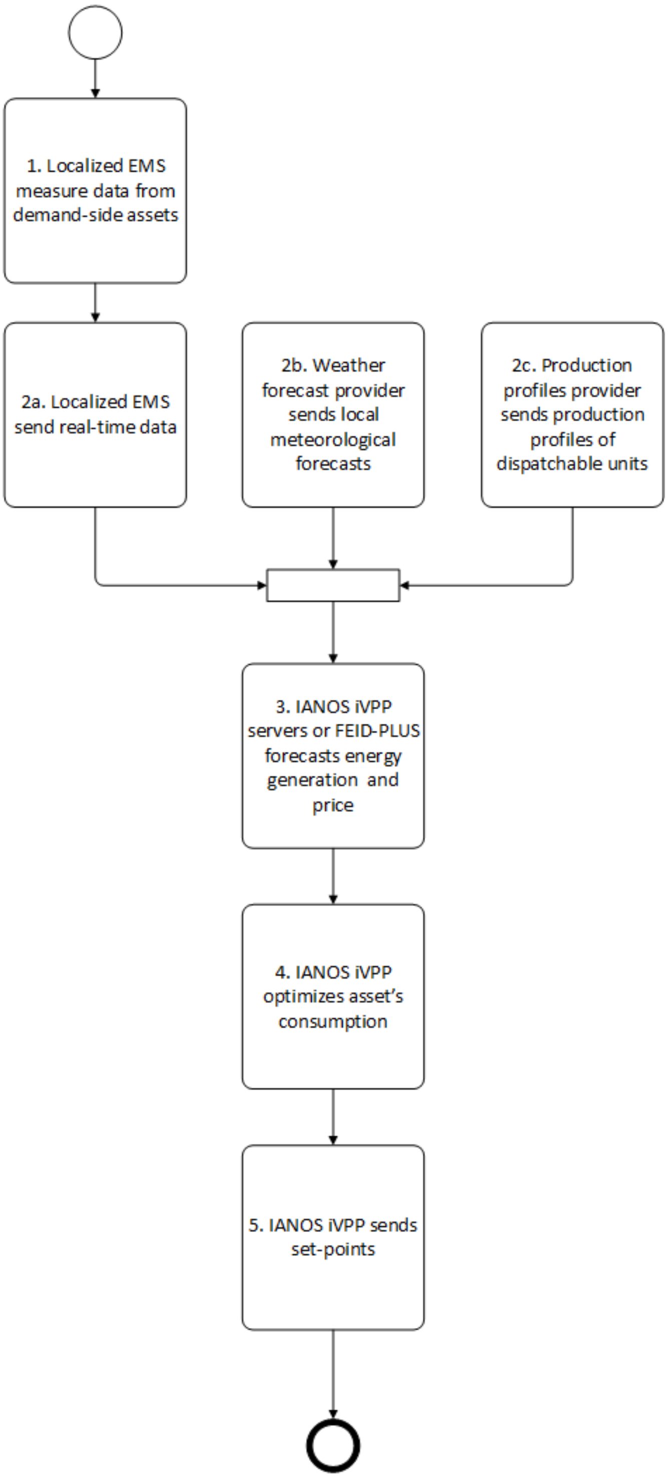
Activity Diagram – Scenario 1



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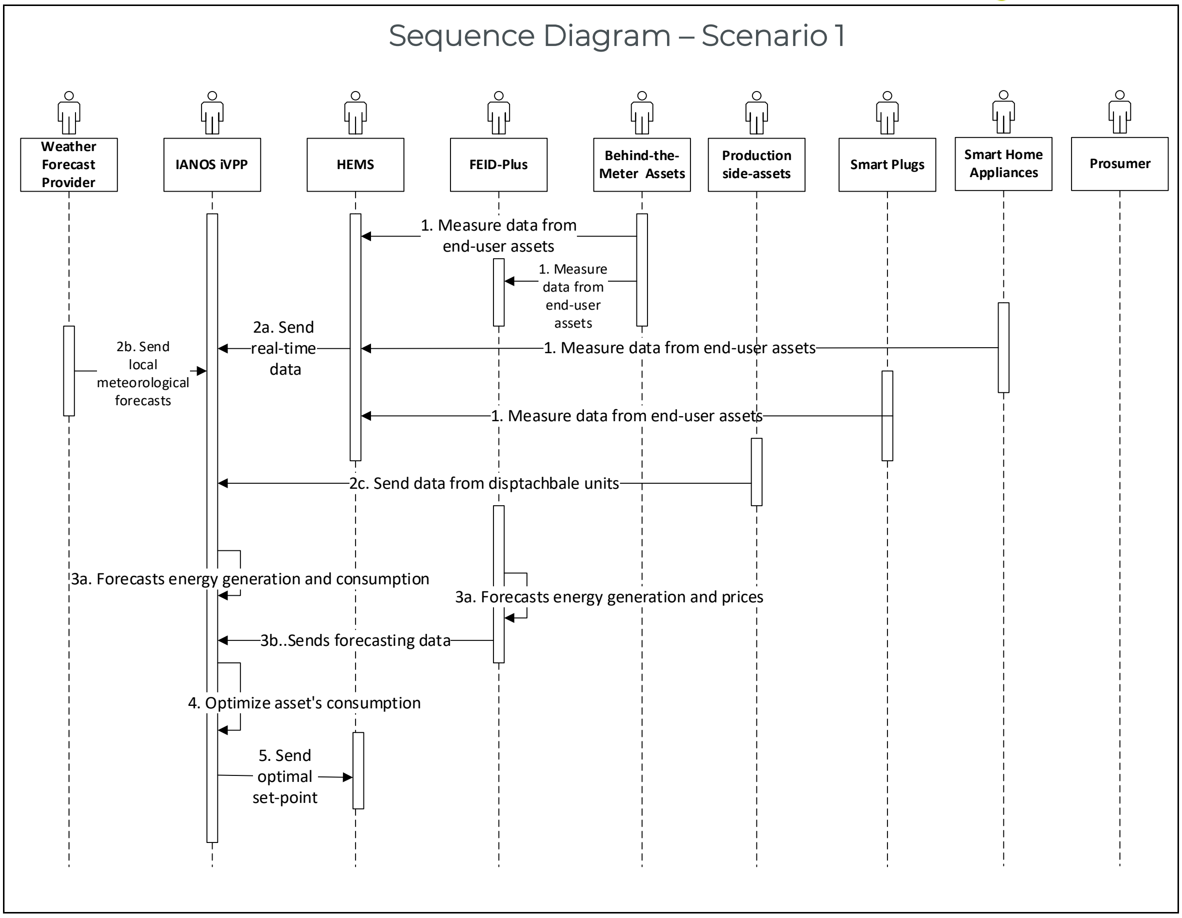

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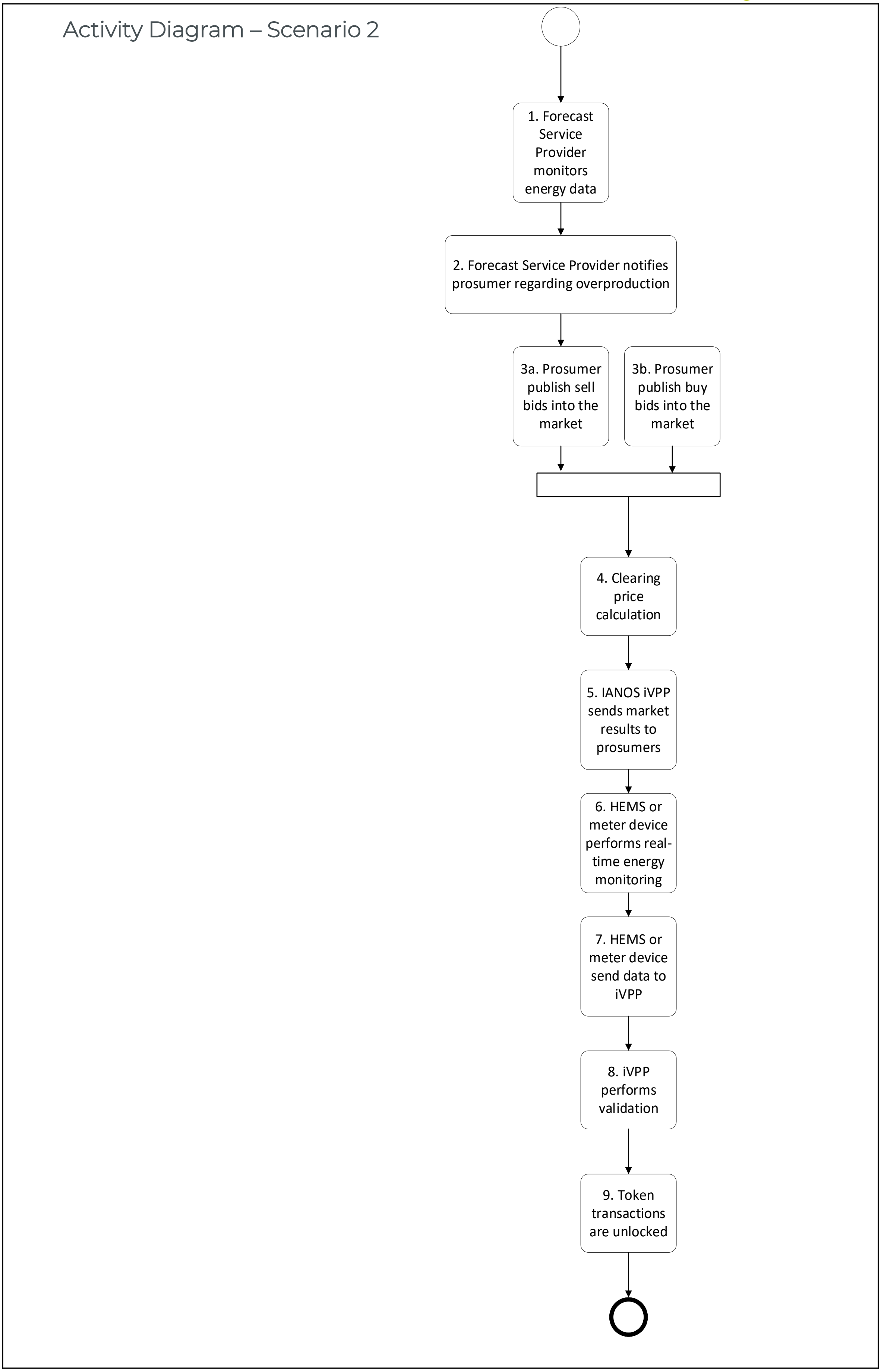

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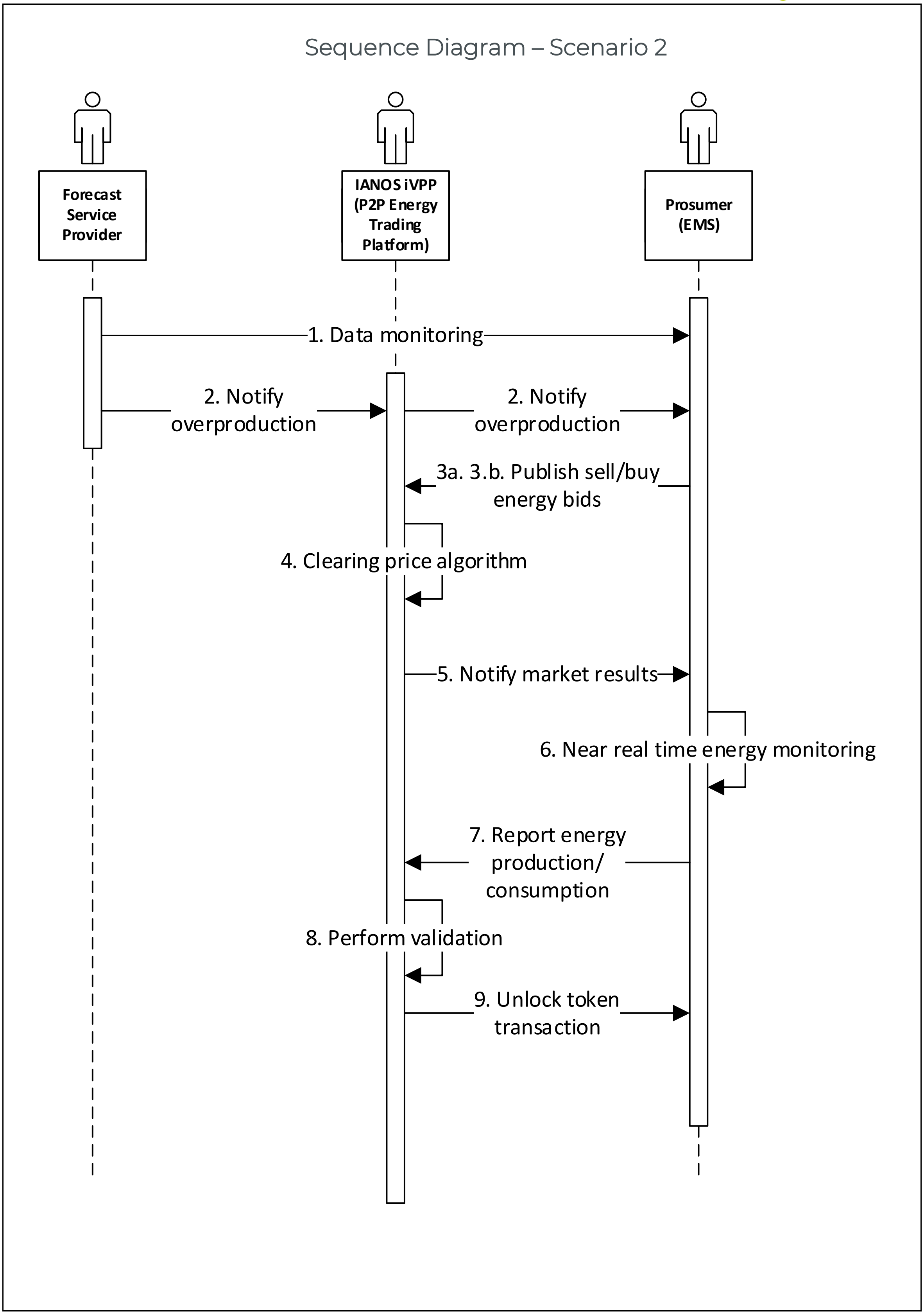

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3 Technical details

3.1 Actors

Actors		
Actor Name	*Actor Type*	*Actor Description*
IANOS iVPP	System	The IANOS iVPP sets up a virtual network of decentralized renewable energy resources, both non-dispatchable such as wind, solar, tidal resources and dispatchable ones such as geothermal and green gas CHP plants. Moreover, the iVPP comprises Energy Storage Systems (ESS), integrated as a single unit, providing flexibility services and fostering island renewable energy self-consumption. The optimal, autonomous, real-time iVPP operation will be driven by multi-level decision making intelligence, complemented by predictive algorithms for smart integration of grid assets into active network management based on relevant energy profiles. For this purpose, the iVPP is composed of 6 different modules: aggregation and classification, forecasting engine, centralized dispatcher, distributed ledger-based energy transactions, virtual energy console and secured enterprise service bus.
Fog Enabled Intelligent Device Plus (FEID-Plus)	Device	Device that performs resource-intensive functionalities such as computation, communication, storage, and analytics locally next to the end-user assets instead of forwarding data to cloud-based servers to be processed. The FEID-Plus is a fog-enabled computing device equipped with special functions to control I/O, phase width modulation and analog signals. It employs enough processing capacity for applying distributed computing

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		such as information capturing and storing, algorithms execution and control over the installation. Additionally, it also has the capacity to interface with several field elements for instance controllable building loads, storage and EV charging stations through appropriate protocols. Its functions are similar to a HEMS.
Home Energy Management System (HEMS)	System	Energy management system used for real time monitoring of energy consumption/generation, controlling domestic devices and electric circuits, accessing smart meter data and real time energy consumptions. HEMS is responsible for gathering flexibilities within the customer premises and providing them to the iVPP platform. Briefly, the system is composed of the hardware (Smart Meters, Sensors and Actuators), Data Management (Communication, Data Processing and other modules) and User Interfaces (UI).
Smart home appliances	Device	Devices which are interconnected through the internet, allowing the user to control functions remotely using a mobile or other networked device.
Smart Plugs	Device	Plugs which can be controlled remotely through a mobile and allow to control and automate small appliances and home devices.
Production-Side Assets	System	Residential PV panels and assets from community owned areas such as small wind turbines, fuel cells and micro-CHP systems.
Behind-the-Meter Assets	Device	Private end-user's energy assets such as electrochemical and heat batteries, electric water heaters, electric vehicles, smart home appliances and smart plugs. Additionally, it also comprises assets from community

		owned areas, for instance hybrid heat pumps and biobased saline batteries.
Prosumer	Role	End-user of electricity, gas, water or heat that can also generate energy using a Distributed Energy Resource.
Weather Forecast Provider	Role	Provides generation, consumption and weather-related operational risks, for a given location and a specific time horizon for non-dispatchable generation assets.
Forecast Service Provider	Role	Monitors energy data from prosumers and provides an overproduction report based on forecast performed for prosumer's energy consumption and production.

3.2 References

References						
No.	*References Type*	*Reference*	*Status*	*Impact on use case*	*Originator / organisation*	*Link*
1	Regulation	Decreto-Lei n.º 162/2019	Published	Approves the legal regime applicable to self-consumption of renewable energy, partially transposing Directive 2018/2001	Portuguese Government	https://data.dre.pt/eli/dec-lei/162/2019/10/25/p/dre

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4 Step by step analysis of use case

4.1 Overview of scenarios

Scenario conditions						
No.	Scenario name	Scenario description	Primary actor	Triggering event	Pre-condition	Post-condition
1	Self-consumption maximization through optimization of behind-the-meter assets	The iVPP receives several real-time data coming from localized energy management systems and the weather forecast provider. Along with its internal data, the iVPP performs optimization of behind-the-meter assets' consumption in order to maximize self-consumption. Lastly, the iVPP sends the setpoints to the localized management systems.	IANOS iVPP	Data gathering	Generation/Consumption of supply and demand-side energy assets is not optimized or controlled.	Energy assets optimization for supply and demand match maximization of self-consumption.
2	Self-consumption maximization through P2P energy trading based on DLT	An overproduction occurs due to excess production from renewables. Prosumers sell the excess energy in a P2P market. The market will leverage on self-enforcing smart contracts to manage, in a programmatic manner, the P2P energy-trading between prosumers.	IANOS iVPP	Over Production identification	The excess of energy generated from renewables is fed back into the grid.	The excess of energy generated from renewables is traded locally providing efficiency in the grid and token-based compensation among prosumers.

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4.2 Steps – Scenarios

Scenario							
Scenario name:		*No. 1 - Self-consumption maximization through optimization of behind-the-meter assets*					
Step No.	*Event*	*Name of process/ activity*	*Description of process/ activity*	*Service*	*Information producer (actor)*	*Information receiver (actor)*	*Information Exchanged (IDs)*
1	Behind-the-meter assets' data collection	Measure real-time data from supply and demand-side assets	Localized energy management systems such as FEID-Plus and HEMS (also interfacing with smart appliances and smart meters) collect real time data from behind-the-meter assets through smart sensors, smart plugs, smart meters and field-level interfaces.	GET	Supply and demand-Side Assets	HEMS, FEID-Plus	1,2,3,4
2a	Submission of data	Sends real-time data	HEMS, FEID-Plus or other localized energy management systems send real time data to the iVPP.	CREATE	HEMS	IANOS iVPP	1,2,3,4
2b	Submission of local weather forecasts	Sends local meteorological forecasts	Forecast Provider sends local meteorological forecasts.	CREATE	Weather Forecast Provider	IANOS iVPP	5
2c	Submission of data from dispatchable units	Send data from dispatchable units	Dispatchable units such as micro-CHP and fuel cells send production profiles to the iVPP.	GET	Production-Side Assets	IANOS iVPP	6

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3a	Data forecasting	Forecasts energy generation and prices	iVPP servers or the FEID-PLUS forecast energy generation and price	CREATE	IANOS iVPP, FEID-PLUS	IANOS iVPP	7, 8
3b	Submission of forecasting data	Sends forecasting data	FEID-PLUS sends forecasting data to the iVPP.	GET	FEID-PLUS	IANOS iVPP	
4	Optimization of asset's consumption	Optimizes asset's consumption	iVPP optimizes the consumption of all the demand-side assets in order to minimize energy curtailment, maximize self-consumption and meeting end-user consumption needs.	EXECUTE	IANOS iVPP	IANOS iVPP	-
5	Submission of optimal setpoints	Sends setpoint	iVPP sends the optimal setpoint to the HEMS, FEID-Plus or other localized management systems.	CREATE	IANOS iVPP	HEMS	9

Scenario							
Scenario name:		*No. 2 - Self-consumption maximization through P2P energy trading based on DLT*					
Step No.	*Event*	*Name of process/ activity*	*Description of process/ activity*	*Service*	*Information producer (actor)*	*Information receiver (actor)*	*Information Exchanged (IDs)*
1	Data monitoring	Data monitoring	Forecast Service Provider monitors energy data from	EXECUTE	Forecast Service	Prosumer	-

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			prosumers.		Provider		
2	Forecasting and overproduction detection	Notify overproduction	Forecast is calculated. Overproduction is detected and reported to prosumers.	REPORT	Forecast Service Provider	IANOS iVPP, Prosumer	10
3a	Submission of sell bids in the P2P market	Publish sell bids into the market	Prosumers decide to sell their excess of energy production submitting sell bids into the P2P market.	POST	Prosumer	IANOS iVPP	11
3b	Submission of buy bids in the P2P market	Publish buy bids into the market	Prosumers want to buy energy submitting sell bids into the P2P market.	POST	Prosumer	IANOS iVPP	12
4	Clearing price algorithm	A market clearing price mechanism fixes, at the end of the market session, the price of the energy at which quantity supplied is equal to quantity demanded	For clearing price calculation, the energy supply offers are sorted in ascending order and the energy demand bids in descending order. The intersection point between the two curves gives the market-clearing price.	CREATE	IANOS iVPP	IANOS iVPP	-
5	Submission of market results	Notify market results	The platform sends market results to prosumers.	REPORT	IANOS iVPP	Prosumer	13

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6	Near real-time monitoring	Near real-time monitoring	HEMS or meter device performs a real-time energy monitoring.	EXECUTE	Prosumer	Prosumer	-
7	Submission real time data	Report energy production/consumption data	The platform is able to access consumption and production data.	GET	Prosumer	IANOS iVPP	1, 2
8	Validation	Perform validation	iVPP performs validation.	EXECUTE	IANOS iVPP	IANOS iVPP	-
9	Settlement	Unlock token transactions	The system unlocks the tokens transactions between prosumers at delivery session end time.	EXECUTE	Prosumer	Prosumer	14

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5 Information exchanged

Information exchanged (ID)	*Name of information*	*Description of information exchanged*
1	Energy Consumption Data	Customer's energy consumption real-time data of the several supply and demand-side assets.
2	Energy Generation Data	Amount of energy generated (MWh) by the energy supply assets such as PV panels, wind turbines, Fuel Cells and micro-CHP systems.
3	Battery real-time data	State of charge and temperature of BESS.
4	End-User comfort restrictions and operation settings	Restrictions imposed by the user to increase the comfort regarding assets like heat pumps and water heaters.
5	Local meteorological forecasts	Expected irradiances and wind speeds for specific locations.
6	Production profiles	Production profiles from dispatchable units.
7	Forecasted Energy Consumption Data	Customer's forecasted energy consumption data of the several demand-side assets .
8	Forecasted Energy Generation Data	Forecasted energy supply data from production-side assets such as PV panels, wind turbines, Fuel Cells, micro-CHP.
9	Optimal Setpoints	Optimal power dispatch computed by the iVPP for the supply and demand-side assets. It corresponds to the amount of power for each asset and the corresponding time when it should be dispatched.
10	Overproduction Report	Overproduction report based on forecast performed for prosumer's energy consumption and production.
11	Sell Bid	Sell energy bid from prosumer.
12	Buy Bid	Buy energy bid from prosumer.

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13	Market Results	Market-clearing price.
14	Token Transaction	Token Transaction.

6 Requirements

Requirements		
Categories ID	Category name for requirements	Category description
R-FUN	Functional Requirement	Requirements that capture the intended behaviour of the system.
F-UI	User interface requirements	Requirements related to the iVPP user interface.
R-COM	Communication Requirement	Requirements related to communication aspects.
Requirement R-ID	Requirement name	Requirement description
R-FUN1	Day-ahead load and/or generation forecast	iVPP can predict the load and/or generation of its assets for the following day.
R-FUN2	Intraday load and/or generation forecast	iVPP can predict the load and/or generation of its assets within the day.
R-FUN3	Flexibility estimation	iVPP can estimate the prosumers' flexibility.
R-FUN4	Settlements of intra-iVPP energy transactions	Energy transactions are settled through Smart Contracts.
R-FUN5	Energy transactions recording	Data for Intra-VPP energy transactions are recorded on the blockchain.
R-UI1	Graphical visualization of iVPP operation	iVPP operation can be visually inspected through the use of KPIs.
R-UI2	Reporting	iVPP can produce reports on system performance upon iVPP Operator request.

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R-COM1	Common Information Model	iVPP adopts a common information model to exchange data ensuring interoperability.
R-COM2	Integration of energy assets	Communication and integrations between all energy assets and IVPP platform.

7 Common Terms and Definitions

Common Terms and Definitions	
Term	Definition
BESS	Battery Energy Storage System
BMS	Building Management Systems
CHP	Combined Heat and Power
DER	Distributed Energy Resources
DHW	Domestic Hot Water
DLT	Distributed Ledger Technology
ESS	Energy Storage System
EV	Electric Vehicle
FEID	Fog-Enabled Intelligent Device
GPDR	General Data Protection Regulation
HEMS	Home Energy Management System
ICT	Information and Communications Technology
IEPT	IANOS Energy Planning and Transition Suite
iVPP	Intelligent Virtual Power Plant
LEC	Local Energy Communities
P2P	Peer to Peer
PCM	Phase Change Material
RES	Renewable Energy Sources
SGAM	Smart Grid Architecture Model
SoC	State of Charge
UI	User Interface
V2G	Vehicle-to-grid

6.1.2 Use case 2: Community supply-side optimal dispatch and intra-day services provision

1 Description of the use case

1.1 Name of the use case

ID	Area / Domain(s)	Name of Use Case
2	Energy efficiency and grid support for extremely high-RES penetration	Community supply-side optimal dispatch and intra-day services provision.

1.2 Version management

Version Management			
Version No.	Date	Name of Author(s)	Changes
1	04.02.2021	EDP NEW	First draft.
2	05.02.2021	Nikolaos Nikolopoulos (CERTH), Dionisios Stefanitsis (CERTH)	Comments and inputs on related UCs, narrative of use case, Diagrams, Actors, Scenarios, Information Exchanged. Suggestion of inclusion of information regarding protocols for communication/information data exchange according to SGAM architecture.
3	09.02.2021	Carlos Patrão (CLEANWATTS)	Comments and inputs on narrative of use case, use case conditions, references and information exchanged.
4	25.02.2021	Mónica Fernandes (EDP NEW)	Collect all the feedback and start second version. Add SGAM layers characterization. Improve diagrams, description, information exchanged and scenarios.
5	16.03.2021	Ioannis Moschos (CERTH)	IVPP Requirements.

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6	29.04.2021	Mónica Fernandes (EDP NEW)	KPI's added from D2.3. Collecting the new feedback.
7	10.05.2021	Mónica Fernandes (EDP NEW)	Final Version.
8	01.04.2022	Mónica Fernandes (EDP NEW)	Minor changes on the complete description of the Use Case and update on the KPIs.
9	11.07.2022	Ana Carvalho (EDP NEW)	Revision and start third version. Specification on the works of the iVPP. Changes in the description of the Use Case
10	12.09.2022	Ana Carvalho (EDP NEW)	Updated information on Use Case description according to feedback form EDA. Slight change to Function Layer substituting EDA's Dispatch Centre by the Telemetry System.
11	16/09/2022	Vasilis Apostolopoulos (CERTH)	Corrections to KPI numbering according to final version of D2.9.

1.3 Scope and objectives of use case

Scope and Objectives of Use Case	
Scope	This Use Case utilizes the flexibility from utility-scale supply side-assets to minimize energy curtailment in periods of high renewable generation. For this purpose, it also considers various storage systems such as electrolysers and large-scale BESS to store the energy produced from dispatchable units and use it in periods of high demand.
Objective	The main goals of this use case are the following: 1. Provide flexibility on the generation-side. 2. Reduce energy curtailment. 3. Avoid grid challenges.

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1.4 Narrative of use case

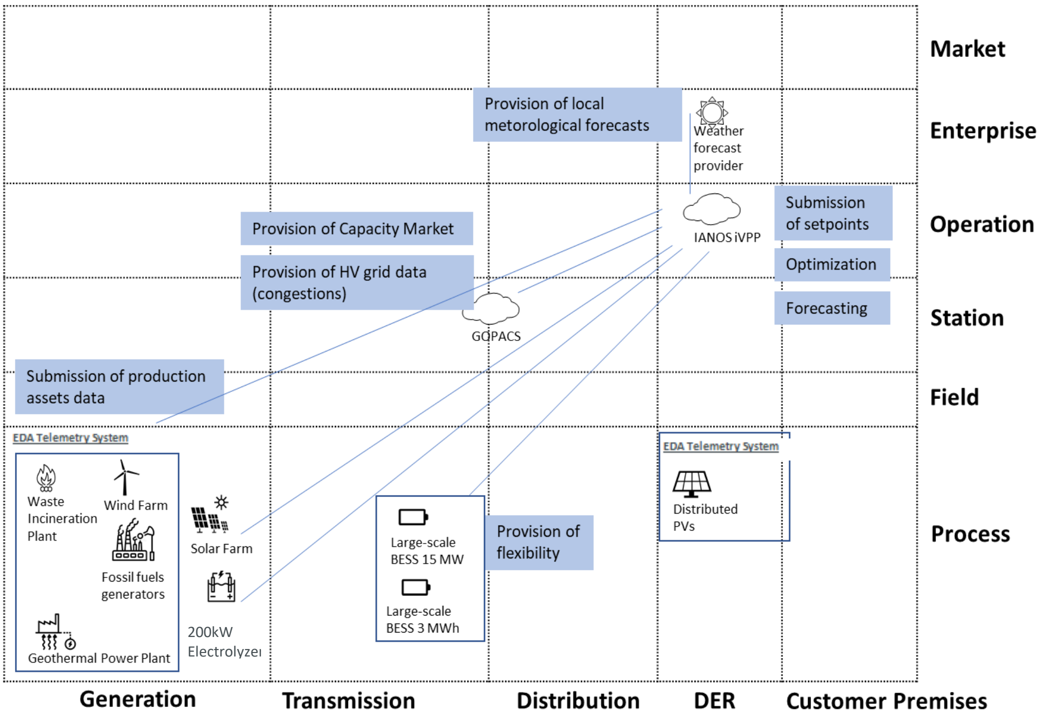
Narrative of Use Case
Short description
The present Use Case focuses on using the flexibility on the generation side, for utility-scale assets, to minimize energy curtailment in periods of renewable energy surplus. For this purpose, the intelligent Virtual Power Plant (iVPP) calculates the optimal day ahead dispatch and provides suggestions to the grid-assets with the intention of minimizing curtailment and delivering intra-day services to the grid. Accordingly, the iVPP considers three different types of utility-scale assets for this optimization: i) dispatchable assets, ii) non-dispatchable assets and iii) large-scale storage systems including both BESS and systems producing alternative fuels (electrolyzers), which support the decarbonization of islands with multi-purpose end uses. The iVPP computes the optimal dispatch set-point through provided information and delivers it to the dispatchable assets and large-scale storage systems in order to suggest behaviours to ensure the stability of the power system.
Complete description
This use case explores the potential of minimizing the energy curtailment in periods of excess of renewable energy generation by using the available flexibility on the generation side of utility-scale assets. In order to achieve this goal, the iVPP computes the optimal dispatch set-point, which aims at performing the day-ahead optimal dispatch, while providing intra-day balancing services to the power system. For this purpose, the iVPP, through its Utility-Scale Assets Scheduler, considers three categories of utility-scale assets: i) Dispatchable assets such as diesel engines, waste incinerators, geothermal power generators of utility-scale and any other utility-scale flexibility assets available. ii) Non-dispatchable assets as wind and solar PV generators. iii) Large-scale BESS and Power to Fuel (H2) storage systems such as electrolyzers. The calculation of the optimal dispatch is based on several information provided by the different assets. In the case of Terceira, the telemetry system of EDA will be sending the hard-technical constraints such as batteries' State of Charge, non-variable geothermal production and information regarding the waste incineration plant to the iVPP. While in Ameland, this information is obtained directly from the solar farm since the iVPP is directly connected to it. The iVPP is provided with total energy consumption forecasts on the islands, which is based on EDA's and

Alliander's historical load consumption and real-time measurements; and available flexibility forecast of the dispatchable sources. Specifically, for Ameland, the iVPP will be connected with the Grid Operation Platforms for Congestion Solutions interface (GOPACS) to exchange data with the Dutch TSO through the local DSO in order to mitigate grid congestion issues offering local energy producers revenues according to their available flexibility. Thereby, the GOPACS provides a capacity market on which the iVPP can trade.

The dispatchable and non-dispatchable assets supply its local energy generation prices to the iVPP. An external forecast provider is required to provide local energy production forecasts, based on local meteorological forecasts and historical generation data. With all these data provided to the iVPP along with its internal data, the iVPP computes the optimal power dispatch in order to assure the large-scale BESS and other storage systems have enough remaining capacity to maximize penetration of RES, to avoid energy curtailment by utilizing flexibility provided by the dispatchable assets and to procure intra-day services to the grid. Accordingly, the iVPP sends the set-points for the large-scale BESS, other storage systems and dispatchable assets. In Terceira, the iVPP will not interfere with the operation of the dispatchable production units. It will only perform the optimization and send suggestions to EDA and the solar farm.

SGAM LAYERS:

Function Layer



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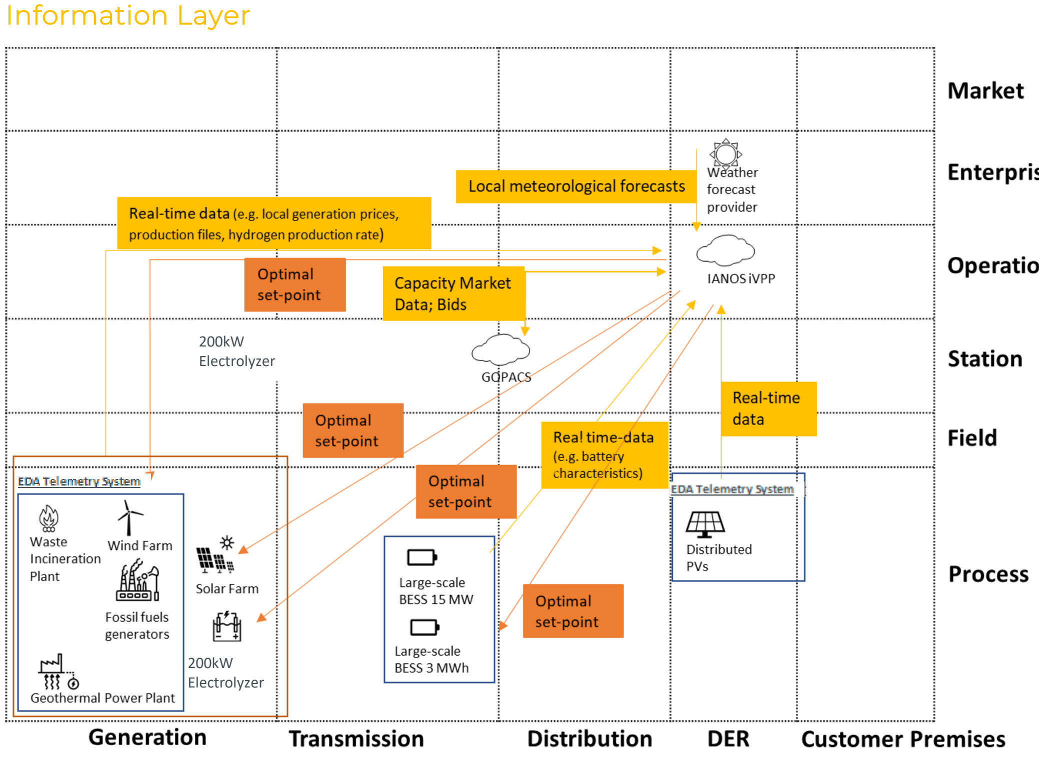

Technological Solutions	Information / Communication Protocols	Terceira	Ameland
Wind Farm	-	x	
Fossil Fuel Generators	-	x	
Geothermal Plant	-	x	
Electrolyser	-		x
Solar Farm	-		x
Waste incineration plant	-	x	
Small scale distributed PVs	-	x	
BESS 15 MW	-	x	
BESS 3 MWh	-		x
GOPACS	-		x

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1.5 Key performance indicators (KPIs)

ID	*Name*	*Description*	*Reference to mentioned use case objectives*
1.1	RES Generation	Calculates the increase of energy production from renewable energy sources integrated in the energy system compared to the baseline scenario without IANOS interventions.	2
1.7	Storage capacity in the energy grid per total island energy consumption	Compares the storage capacity with the total energy consumption of the island.	1
1.8	Reduced energy curtailment of RES and DER	Calculates the reduction of energy curtailment due to technical/operational problems.	2
1.10	Accuracy of energy supply and demand prediction	This KPI measures the gap between predicted and actual energy demand/supply at a given time	2,3
1.11	Unbalance of the 3-phase	Examines the quality of the power supplied by measuring the supply voltage gap between the three phases which should be 120 deg.	3
2.2	Reduced fossil fuel consumption	Measures the amount of fossil fuels which is not consumed because of IANOS demonstrated solutions (e.g. Electrification of transport, RES penetration).	2,3
4.1	Increased system flexibility for energy players	Indication of the ability of the system to respond to supply and demand in real time, as a measure of the demand side participation in energy markets and in energy efficiency intervention since the beginning until the end of the project.	1,3

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4.4	Increased hosting capacity for RES, electric vehicles and other new loads	Gives a statement about the additional loads and RES that can be installed in the system when innovative solutions and energy management techniques are applied (e.g. VPP platform). The calculation is realized by comparing the network capacity before and after IANOS implementation.	1
4.5	Increased Reliability	Measures the relative improvement in the number of interruptions.	3
7.2	Technical compatibility	Examines the extent to which the smart grid solutions fit with the current existing technological standards/infrastructures.	1,2,3

1.6 Use case conditions

Use case conditions
Assumptions
• In Ameland the Grid Operation Platforms for Congestion Solutions interface (GOPACS,) will be integrated with the iVPP decision making logic. GOPACS is a unique initiative in Europe and has resulted from active collaboration between the Dutch TSO and the DSOs. This platform is consistent with key European directives to mitigate grid congestion, while offering large and small market parties an easy way to generate revenues with their available flexibility and contribute to solving congestion situations. • Existence of distributed energy assets available in the island, capable of being integrated and remotely managed or controlled by the iVPP. • Bidirectional smart meters are installed on buildings and on relevant energy assets, and their readings are available for the iVPP in real-time.
Prerequisites
• Establish connection from the iVPP to the EDA's Dispatch Center (Terceira). • Direct Connection between iVPP and solar farm (Ameland). • A (physical) hosting environment on which the iVPP can be established.

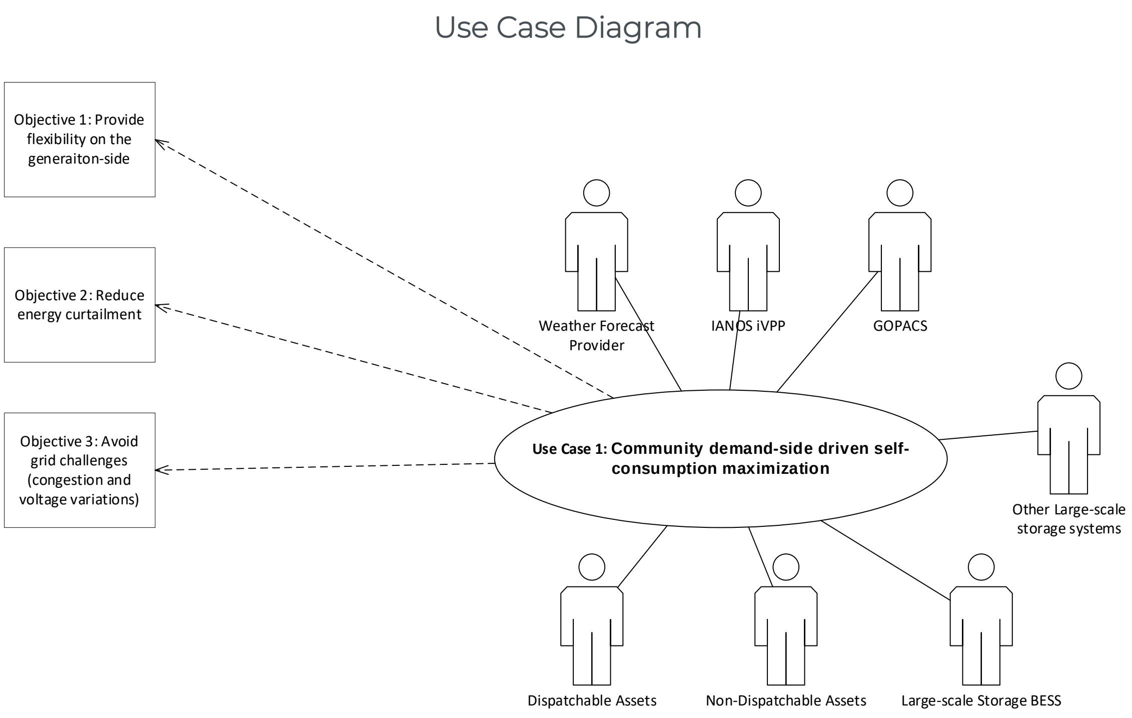
1.7 Further Information to the use case for classification/mapping

Classification Information
Relation to other use cases
UC1: Community demand-side driven self-consumption maximization. UC3: Island-wide, any-scale storage utilization for fast response ancillary services. UC4: DSM and smart grid methods to support power quality optimisation and congestion management services. UC7: Circular economy, the utilization of waste streams and connection to the local gas grid.
Level of depth
Specialized use case
Prioritisation
High level of priority
Generic, regional or national relation
Generic
Nature of the use case
Technical use case
Further keywords for classification
Large-scale storage, VPP, optimization, optimal day-ahead dispatch, intraday balancing services, supply-side, VPP utility scale assets scheduler, flexibility, minimize curtailment

1.8 General Remarks

General Remarks
-

2 Diagrams of use case

Diagram(s) of use case


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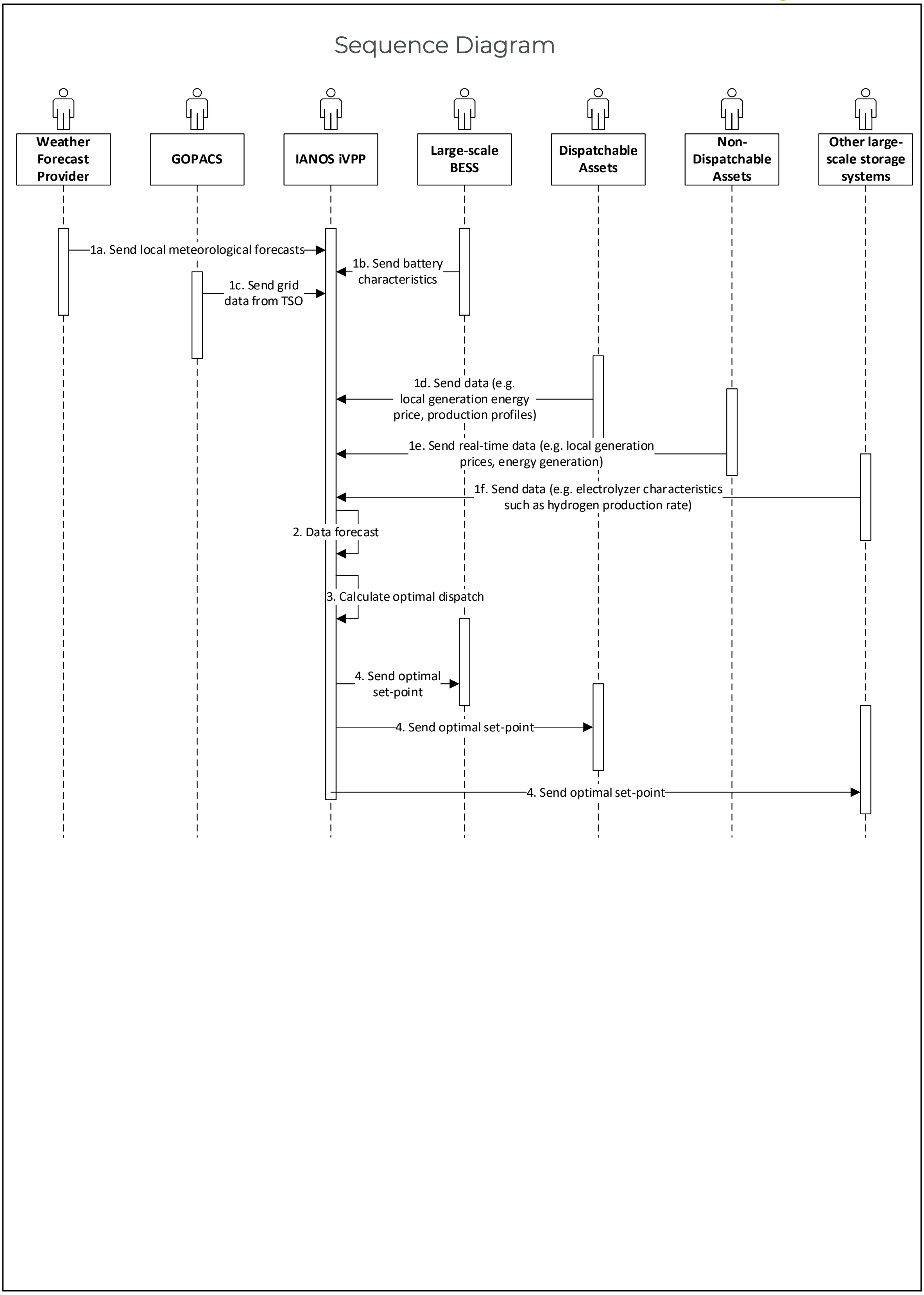

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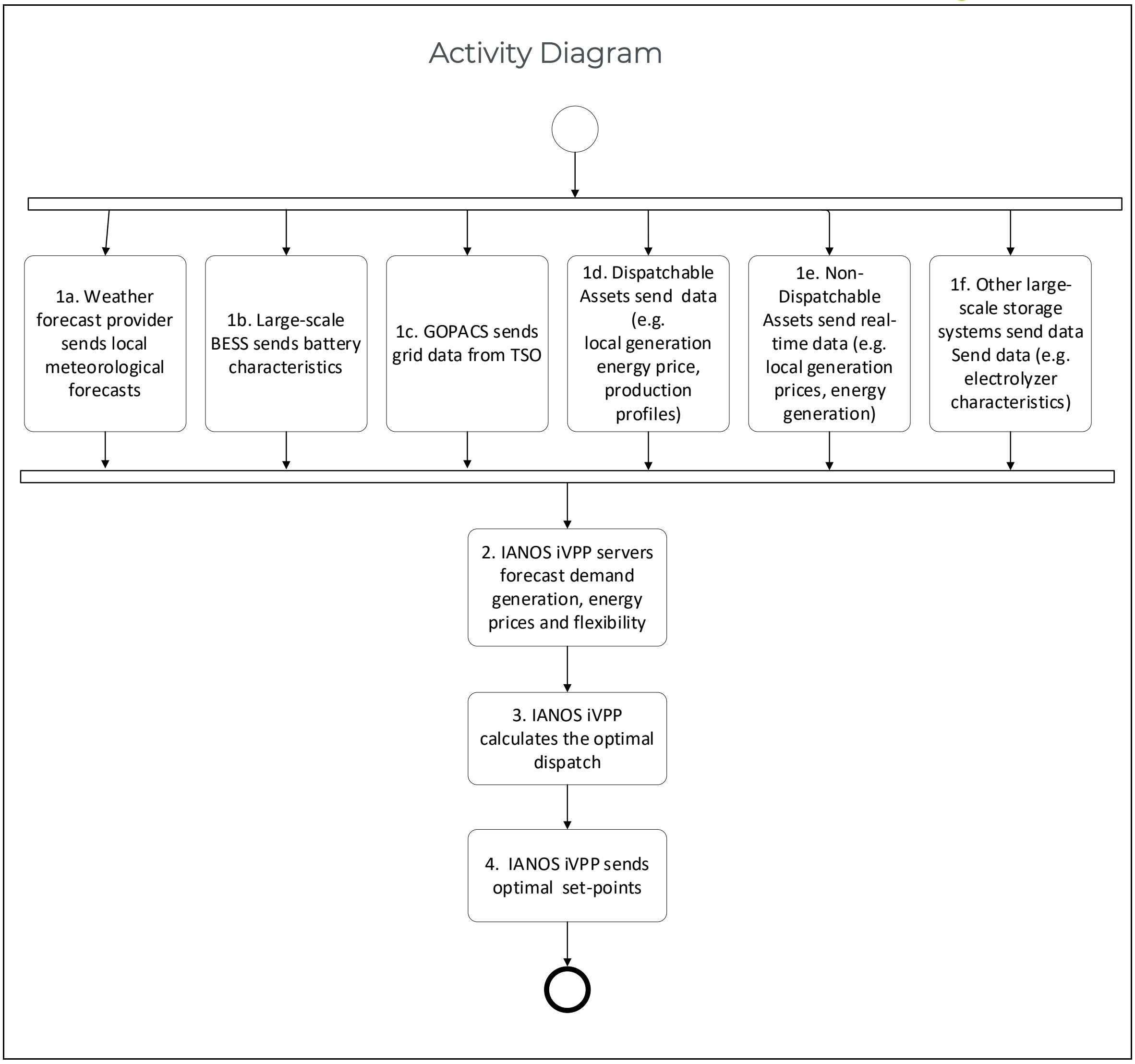
Activity Diagram
1a. Weather forecast provider sends local meteorological forecasts
1b. Large-scale BESS sends battery characteristics
1c. GOPACS sends grid data from TSO
1d. Dispatchable Assets send data (e.g. local generation energy price, production profiles)
1e. Non-Dispatchable Assets send real-time data (e.g. local generation prices, energy generation)
1f. Other large-scale storage systems send data Send data (e.g. electrolyzer characteristics)
2. IANOS iVPP servers forecast demand generation, energy prices and flexibility
3. IANOS iVPP calculates the optimal dispatch
4. IANOS iVPP sends optimal set-points

3 Technical details

3.1 Actors

Actors		
Actor Name	*Actor Type*	*Actor Description*
Weather Forecast Provider	Role	Provides generation, consumption and weather-related operational risks for a given location and a specific time horizon.
IANOS iVPP	System	The IANOS iVPP sets up a virtual network of decentralized renewable energy resources, both non-dispatchable such as wind, solar, tidal resources and dispatchable ones such as geothermal and green gas CHP plants. Moreover, the iVPP comprises of Energy Storage Systems (ESS), integrated as a single unit, providing flexibility services and fostering island renewable energy self-consumption. The optimal, autonomous, real-time iVPP operation will be driven by multi-level decision making intelligence, complemented by predictive algorithms for smart integration of grid assets into active network management based on relevant energy profiles. For this purpose, the iVPP is composed of 6 different modules: aggregation and classification, forecasting engine, centralized dispatcher, distributed ledger-based energy transactions, virtual energy console and secured enterprise service bus.
Large-scale BESS	System	Large-scale battery technology system (10.5MWh in Terceira and 3 MWh in Ameland) which stores energy to be used later. It is connected to distribution/transmission networks.
Other Large-scale storage systems	System	Other large-scale storage systems such as large-scale systems producing alternative fuels (electrolyzers). In Ameland, a 2MW electrolyzer is connected with the 3 MWh BESS using DC grid.

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Dispatchable assets	System	Power generation assets (geothermal power plant, waste incineration plant, fossil fuels generators), which power can be dispatched on demand at the request of grid operators when needed.
Non-Dispatchable assets	System	Power generation assets (Wind and Solar Farm) which power cannot be controlled by grid operators.
GOPACS	System	Grid Operation Platforms for Congestion Solutions interface (GOPACS) is a unique initiative in Europe and has resulted from active collaboration between the Dutch TSO and the DSOs. This platform is consistent with key European directives to mitigate grid congestion, while offering large and small market parties an easy way to generate revenues with their available flexibility and contribute to solving congestion situations.

3.2 References

References						
No.	*References Type*	*Reference*	*Status*	*Impact on use case*	*Originator / organisation*	*Link*
	Regulation	Decreto-Lei n.º 162/2019	Published	Approves the legal regime applicable to self-consumption of renewable energy, partially transposing Directive 2018/2001.	Portuguese Government	https://data.dre.pt/eli/dec-lei/162/2019/10/25/p/dre

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4 Step by step analysis of use case

4.1 Overview of scenarios

Scenario conditions						
No.	Scenario name	Scenario description	Primary actor	Triggering event	Pre-condition	Post-condition
1	Supply-side optimal dispatch	Performing the optimal day-ahead energy dispatch and provision of intra-day services to the grid in order to minimize energy curtailment and integrate the maximum RES by using the available flexibility on the generation side.	iVPP	Periodically	Power system requires balancing services	Optimal day-ahead dispatch calculated. Power system stable.

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4.2 Steps – Scenarios

Scenario							
Scenario name:		*No. 1 - Supply-side optimal dispatch*					
Step No.	*Event*	*Name of process/ activity*	*Description of process/ activity*	*Service*	*Information producer (actor)*	*Information receiver (actor)*	*Information Exchanged (IDs)*
1a	Submission of local weather forecasts	Send local meteorological forecasts.	Forecast Provider sends local meteorological forecasts.	CREATE	Weather Forecast provider	IANOS iVPP	1
1b	Submission of battery characteristics	Send battery characteristics	BESS sends battery characteristics to the iVPP.	GET	Large-scale BESS	IANOS iVPP	2,3
1c	Submission of grid data from TSO	Send grid data from TSO	GOPACS exchange high voltage grid data related to expected congestions with iVPP.	REPORT	GOPACS	IANOS iVPP	4
1d	Submission of dispatchable assets data	Send data	Dispatchable assets send hard technical constraints and local generation energy prices to the iVPP.	GET	Dispatchable Assets	IANOS iVPP	5, 6,7,8
1e	Submission of non-dispatchable assets data	Send data	Non-Dispatchable assets send hard technical constraints and local	GET	Non-Dispatchable Assets	IANOS iVPP	8,9

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			generation energy prices to the iVPP.				
1f	Submission of other large-scale storage systems data	Send data	Other large-scale storage systems send real-time data to the iVPP.	GET	Other large-scale storage system	IANOS iVPP	10
2	Data forecast	Forecasts	iVPP servers or the FEID-PLUS forecasts demand generation, price and flexibility.	EXECUTE	IANOS iVPP, FEID-PLUS	IANOS iVPP	11,12,13
3	Optimal Dispatch Calculation	Calculate the optimal dispatch	iVPP computes the optimal dispatch which aims to be the optimal day-ahead energy dispatch and to provide intra-day balancing services to the grid in order to minimize energy curtailment by using the available flexibility on the generation side.	EXECUTE	IANOS iVPP	IANOS iVPP	-
4	Submission of optimal set-points	Send set-points	iVPP sends the optimal setpoint to the generation and large-scale storage assets.	CREATE	IANOS iVPP	Dispatchable Assets, Large Scale BESS, Other large-scale storage systems	14,15,16

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5 Information exchanged

Information exchanged		
Information exchanged (ID)	*Name of information*	*Description of information exchanged*
1	Local meteorological forecasts	Expected irradiances and wind speeds for specific locations.
2	Battery real time-data	SoC, temperature, etc..
3	BESS hard technical constraints	Min and max SoC; Min and max charging and discharging power.
4	HV grid data	High voltage grid real-time data related with congestions; Bids.
5	Production profiles	Production profiles from dispatchable units.
6	Dispatchable assets real-time data	Amount of energy (MWh) being dispatched in real-time.
7	Dispatchable assets hard technical constraints	Maximum and minimum charging and discharging power.
8	Local Generation Energy Prices	Price of energy generated in a specific location (€/MWh).
9	Non-Dispatchable assets data	Amount of energy (MWh) generated by non-dispatchable generator assets at real-time.
10	Electrolyser characteristics	Hydrogen production rate, pressure, temperature, etc..
11	Forecasted Energy Generation Data	Forecasted energy supply data from production-side assets such as PV panels, wind turbines, Fuel Cells, micro-CHP.
12	Forecasted Energy Prices	Forecasted energy prices from the production assets.
13	Forecasted Flexibility Data	Forecasted flexibility from the several storage assets.

14	Optimal Set-points for dispatchable assets	Optimal power dispatch computed by the iVPP for generation dispatchable assets. It is the amount of power that should be generated and supplied to the grid from the dispatchable assets.
15	Optimal Set-points for BESS	Optimal power dispatch computed by the iVPP for large-scale BESS. It is the amount of power that should be provided to the grid for balancing services or stored for later use.
16	Optimal Set-points for other large-scale storage systems	Optimal power dispatch computed by the iVPP for other large-scale storage assets such as electrolyzers. It is the amount of power that should be stored to produce alternative fuels (hydrogen) thereafter.

6 Requirements

Requirements		
Categories ID	Category name for requirements	Category description
R-SEC.	Security Requirement	Requirements related to the safety issues.
R-UI	User Interface Requirement	Requirements related with the iVPP user interface.
R-FUN	Functional Requirement	Requirements that capture the intended behaviour of the system.
R-COM	Communication Requirement	Requirements related with communication aspects.
Requirement R-ID	Requirement name	Requirement description
R-SEC1	Access Control	iVPP functions are accessible from personnel with specialized authorization rights .
R-SEC2	iVPP cybersecurity	Utilization of good practices (e.g. secure communication bus) to enhance data cybersecurity.

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R-SEC3	iVPP data privacy	Utilization of good practices to ensure compliance with GDPR regulations.
R-UI1	Graphical visualization of iVPP operation	iVPP operation can be visually inspected through the use of KPIs.
R-UI2	Reporting	iVPP can produce reports on system performance upon iVPP Operator request.
R-FUN1	Day-ahead generation forecast	iVPP can predict the generation of its assets for the following day.
R-FUN2	Intraday generation forecast	iVPP can predict the generation of its assets within the day.
R-FUN3	Flexibility estimation	iVPP can estimate the dispatchable production units' flexibility.
R-FUN4	Dispatch prioritization	iVPP can select the most appropriate asset(s) to deliver the requested service.
R-COM1	Common Information Model	iVPP adopts a common information model to exchange data ensuring interoperability.
R-COM2	Integration of energy assets	Communication and integrations between all energy assets and IVPP platform.

7 Common Terms and Definitions

Common Terms and Definitions	
Term	**Definition**
BESS	Battery Energy Storage Systems
CHP	Combined Heat and Power
DSO	Distribution System Operator
GOPACS	Grid Operation Platforms for Congestion Solutions
GPDR	General Data Protection Regulation
iVPP	Intelligent Virtual Power Plant
RES	Renewable Energy Sources

SGAM	Smart Grid Architecture Model
SoC	State of Charge
TSO	Transmission System Operator
UC	Use Case
UI	User Interface

6.1.3 *Use case 3: Island-wide, any-scale storage utilization for fast response ancillary services*

1 Description of the use case

1.1 Name of the use case

ID	*Area / Domain(s)*	*Name of Use Case*
3	Energy efficiency and grid support for extremely high RES penetration	Island-wide, any-scale storage utilization for fast response ancillary services

1.2 Version management

Version Management			
Version No.	*Date*	*Name of Author(s)*	*Changes*
1	04.02.2021	EDP NEW	First draft.
2	05.02.2021	Nikolaos Nikolopoulos (CERTH)	Comments and inputs on Narrative of Use Case, Diagrams, Information Exchanged. Suggestion of inclusion of information regarding protocols for communication/information data exchange according to SGAM architecture.
3	09.02.2021	Carlos Patrão (CLEANWATTS)	Comments and inputs on Related Use Cases, Use Case conditions, References.
4	19.02.2021	Philippe Pépin (Teraloop)	Add flywheel requirements, and data exchanged.
5	25.02.2021	Mónica Fernandes (EDP NEW)	Collect all the feedback and start second version. Add SGAM layers characterization. Improve diagrams, description, information exchanged and scenarios.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 957810

6	16.03.2021	Ioannis Moschos (CERTH)	iVPP Requirements.
7	29.04.2021	Mónica Fernandes (EDP NEW)	KPIs added from D2.3. Collecting the new feedback.
8	10.05.2021	Mónica Fernandes (EDP NEW)	Final Version.
9	01.04.2022	Mónica Fernandes (EDP NEW)	Minor changes and updates on the KPIs.
10	12.04.2022	Ana Carvalho (EDP NEW)	Revision and minor changes.
11	16/09/2022	Vasilis Apostolopoulos (CERTH)	Corrections to KPI numbering according to final version of D2.9.

1.3 Scope and objectives of use case

Scope and Objectives of Use Case	
Scope	This Use Case demonstrates the provision of fast ancillary services to the grid, when grid reliability and safety is compromised, through storage systems of any-scale. These storage systems help balancing the power system by either storing energy for later use when there are high levels of energy generation or by providing energy to the grid in periods of high energy demand.
Objective(s)	This Use Case orients at providing fast ancillary services to the grid when required to achieve the following objectives: 1. Improve power quality and continuity of power supply. 2. Reduce energy curtailment. 3. Avoid grid challenges such as congestion and voltage variations.

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1.4 Narrative of use case

Narrative of Use Case
Short description
This use case focus on providing fast balancing services to the grid by capacitating the power system with storage technologies, including small and large-scale BESS, but also very fast responsive assets such as flywheels and other means of very flexible production units as those of Fuel Cells, fully dispatchable. Storage technologies allow to store energy in periods of renewable energy surplus that will be used afterwards to assist the grid by contributing to frequency and voltage control. The intelligent Virtual Power Plant (iVPP) is responsible for coordinating the energy fluxes between the grid and the storage assets.
Complete description
The present use case describes how the iVPP manages the provision of fast ancillary services to the grid when required through various storage assets of any-scale. These storage technologies have capabilities of frequency and voltage control allowing to improve the quality and stability of the power system. The storage technologies that will be used are centralized and distributed electrochemical batteries, flywheels and fuel cells. The iVPP aggregates the various storage systems to provide fast balancing services to the grid such as FFR (Fast Frequency Response) and voltage deviations. On the other hand, the iVPP needs to continually ensure that there is a pre-defined capacity reserved for these services, which can vary according to the status and situation forecast of the power system in a short window of time such as one day. Accordingly, the iVPP will be provided with data from the grid in order to be able to calculate the set-point for the storage assets which will supply energy to the grid when required. This set-point will work as a suggestion in order to not interfere with assets daily operations. Apart from the global optimization performed by the iVPP, a local optimization will also be executed through locally implemented actuators placed in the storage assets which will trigger the actual service when required.

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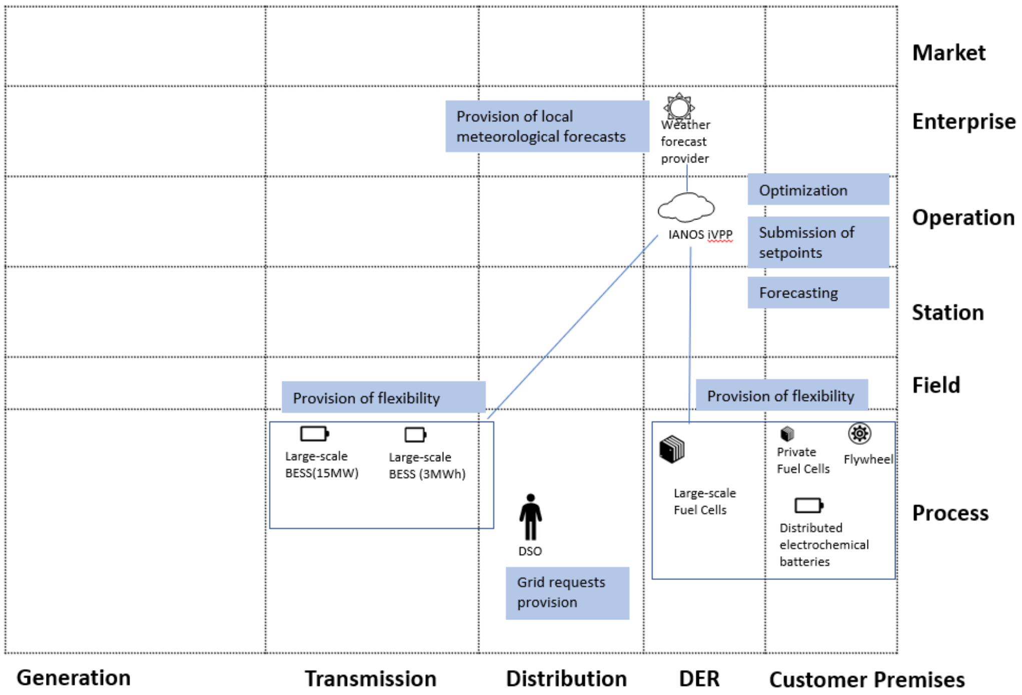
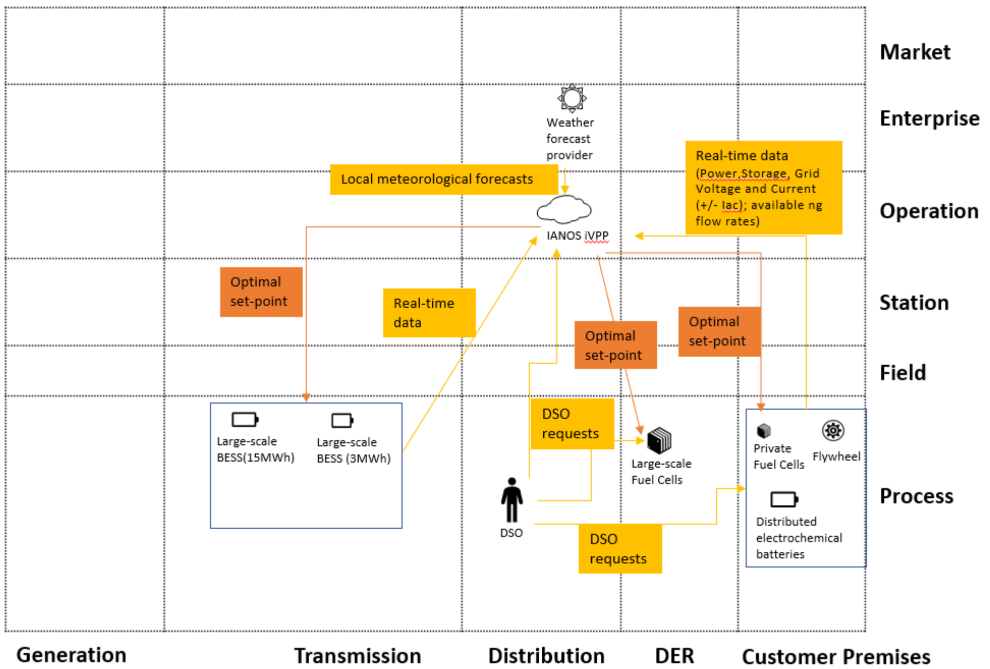
SGAM LAYERS:

Function Layer



Information Layer



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Technological Solutions	Information / Communication Protocols	Terceira	Ameland
Private Fuel Cells	-		x
Large-scale Fuel Cell	-		x
BESS (3MWh)	-		x
Flywheel	Data collection will be achieved through a TCP/IP as a hardware layer, provided by an outsourced vendor (e.g. Siemens), enhanced with multiple possible software protocols. However, the exact definition will be done in the course of IANOS."	x	
Distributed Electrochemical Batteries	-	x	
BESS (15MW)	-	x	

1.5 Key performance indicators (KPIs)

ID	*Name*	*Description*	*Reference to mentioned use case objectives*
1.7	Storage capacity of the island's energy grid per total island energy consumption	Compares the storage capacity with the total energy consumption of the island.	1,3
1.8	Reduced energy curtailment of RES and DER	KPI calculates the reduction of energy curtailment due to technical/operational problems.	
1.9	Peak Load Reduction	Calculates the peak load reduction before the IANOS implementation (baseline) and after its interventions (DSM programs and storage system management).	3
1.11	Unbalance of the 3-phase	Examines the quality of the power supplied by measuring the supply voltage gap between the three phases which should be 120 deg. Compares the results with the scenario before IANOS interventions.	1,3
4.5	Increased Reliability	Measures the relative improvement in the number of interruptions.	1,3
7.3	Ease of use for end users of the solution	Provides an indication of the complexity of the implemented solution within the IANOS project for the end-users.	1,2,3

1.6 Use case conditions

Use case conditions
Assumptions
• Existence of distributed energy assets available in the island, capable of being integrated and remotely managed or controlled by the iVPP.

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• Bidirectional smart meters capable of monitoring network voltage parameters are installed on buildings and on relevant energy assets, and their readings are available for the iVPP in real-time.
Prerequisites
• Establish connection between the iVPP and storage assets (global optimization). • Establish connection between grid and storage assets (local optimization). • A (physical) hosting environment on which the iVPP can be established.

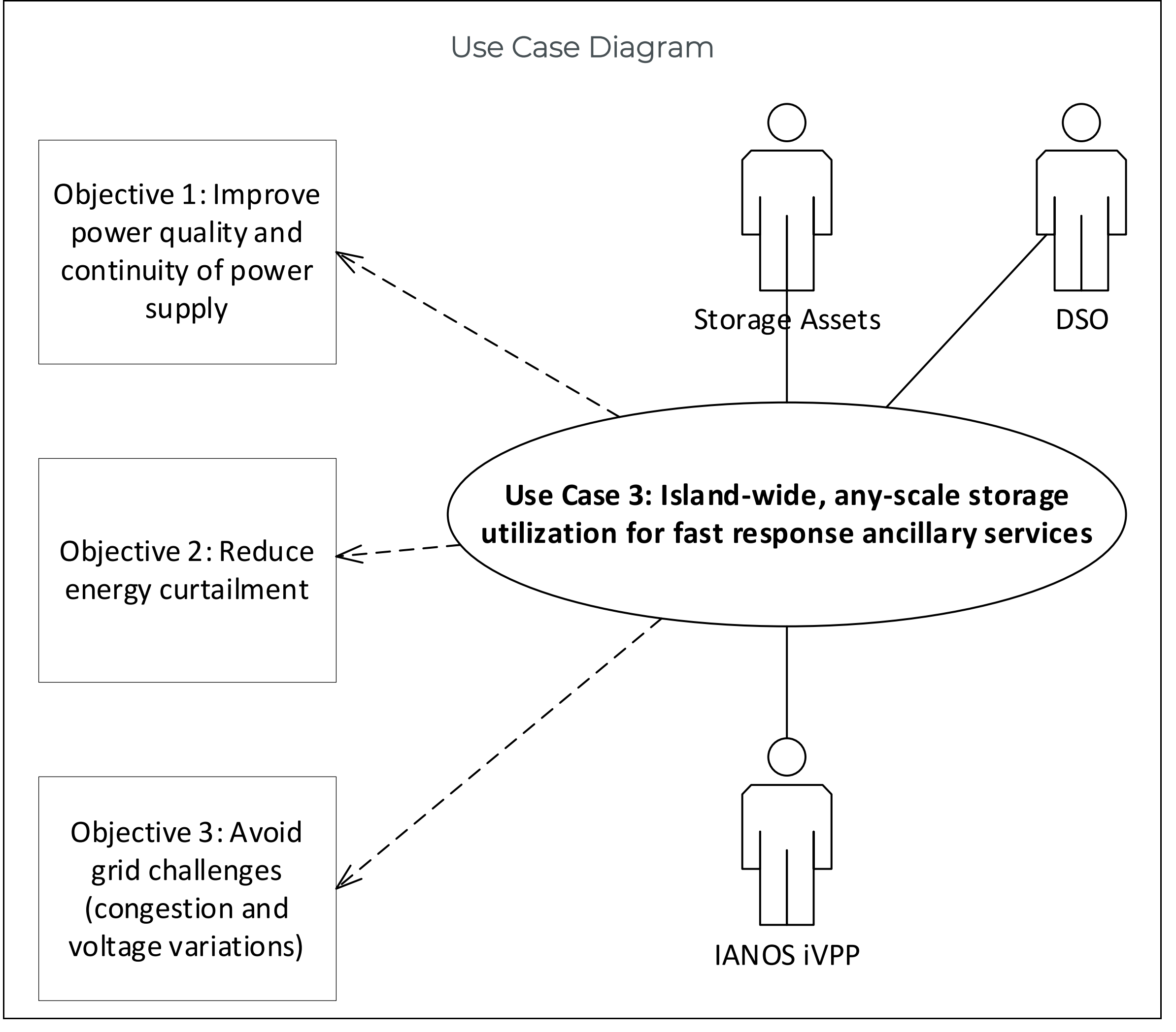
1.7 Further Information to the use case for classification / mapping

Classification Information
Relation to other use cases
UC1: Community demand-side driven self-consumption maximization. UC2: Community supply-side optimal dispatch and intra-day services provision. UC4: Demand Side Management and Smart Grid methods to support power quality and congestion management services.
Level of depth
Specialized use case
Prioritisation
High level of priority
Generic, regional or national relation
Generic
Nature of the use case
Technical use case
Further keywords for classification
Storage, balancing services, flywheels, batteries, fast ancillary services, CH4 fuel cells, distributed storage

1.8 General Remarks

General Remarks
-

2 Diagrams of use case

Diagram(s) of use case


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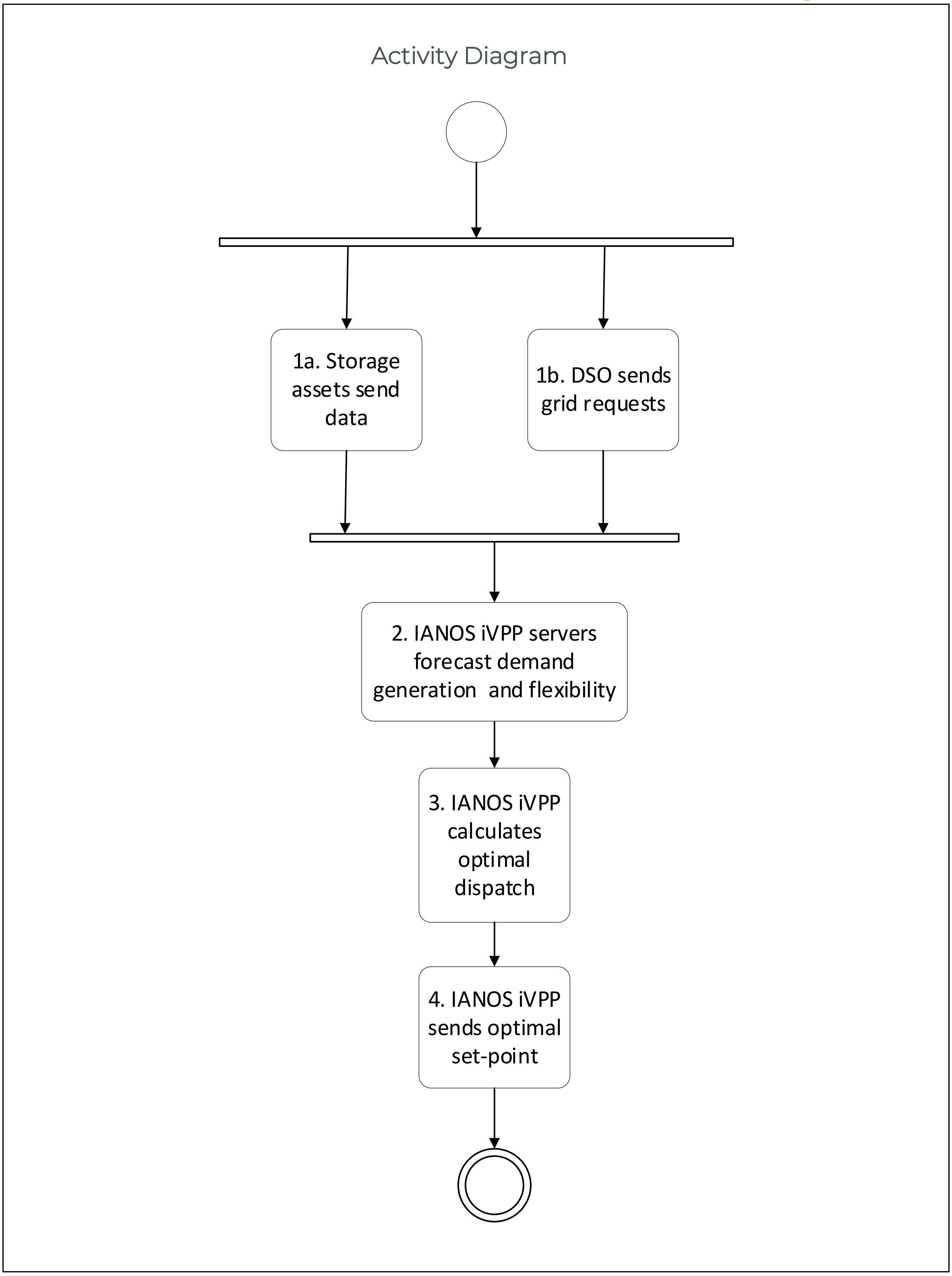

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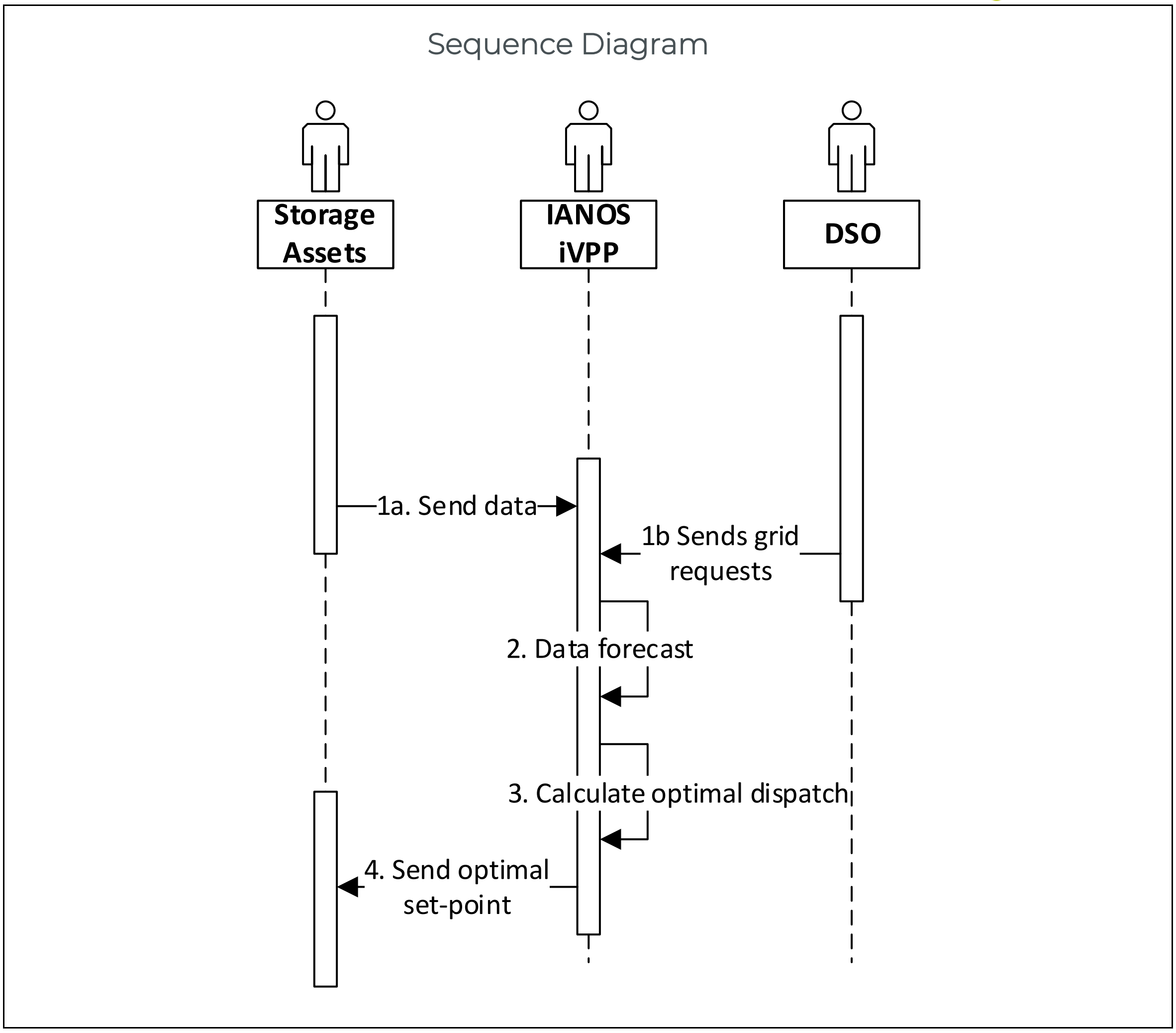

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3 Technical details

3.1 Actors

Actors		
Actor Name	*Actor Type*	*Actor Description*
Storage assets	System	Assets of any-scale that can store energy for later use such as flywheels, distributed and centralized electrochemical batteries. Other means of very flexible production units such as Fuel Cells are also included. These assets are aggregated and controlled by the IANOS iVPP.
IANOS iVPP	System	The IANOS iVPP sets up a virtual network of decentralized renewable energy resources, both non-dispatchable such as wind, solar, tidal resources and dispatchable ones such as geothermal and green gas CHP plants. Moreover, the iVPP comprises Energy Storage Systems (ESS), integrated as a single unit, providing flexibility services and fostering island renewable energy self-consumption. The optimal, autonomous, real-time iVPP operation will be driven by multi-level decision making intelligence, complemented by predictive algorithms for smart integration of grid assets into active network management based on relevant energy profiles. For this purpose, the iVPP is composed of 6 different modules: aggregation and classification, forecasting engine, centralized dispatcher, distributed ledger-based energy transactions, virtual energy console and secured enterprise service bus.
DSO	Role	Distribution System Operator

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3.2 References

References						
No	*References Type*	*Reference*	*Status*	*Impact on use case*	*Originator / organisation*	*Link*
1	European Standard	EN 50160	Revised 1 July 2010	Definition of the voltage characteristics of electricity supplied by public electricity networks.	CENELEC	https://www.cenelec.eu/dyn/www/f?p=104:110:959538371060101::::FSP_ORG_ID,FSP_LANG_ID,FSP_PROJECT:1258595,25,51993
2	Regulation	Decreto-Lei n.º 162/2019	Published	Approves the legal regime applicable to self-consumption of renewable energy, partially transposing Directive 2018/2001.	Portuguese Government	https://data.dre.pt/eli/dec-lei/162/2019/10/25/p/dre

4 Step by step analysis of use case

4.1 Overview of scenarios

Scenario conditions						
No.	Scenario name	Scenario description	Primary actor	Triggering event	Pre-condition	Post-condition
1	Provision of fast ancillary services through storage systems of any-scale	iVPP computes the optimal set-point for distributed storage technologies that provide fast ancillary services to the grid.	IANOS iVPP	Periodically	Power system requires balancing services. No power fluxes from decentralized storage systems.	Distributed storage systems allow the provision of fast ancillary services to the grid.

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4.2 Steps – Scenarios

Scenario							
Scenario name :		*No. 1 - Provision of fast ancillary services through storage systems of any-scale*					
Step No.	*Event*	*Name of process/activity*	*Description of process/ activity*	*Service*	*Information producer (actor)*	*Information receiver (actor)*	*Information Exchanged (IDs)*
1a	Submission of storage assets data	Sends data	Storage assets send data to the iVPP.	GET	Storage assets	IANOS iVPP	1,2,3,4,5,6
1b	Submission of grid requests	Sends grid requests	DSO sends grid requests to the iVPP.	GET	DSO	IANOS iVPP	7
2	Data forecasting	Forecasts	iVPP servers forecast demand generation and flexibility.	EXECUTE	IANOS iVPP	IANOS iVPP	8,9
3	Computation of optimal dispatch	Computes optimal dispatch	iVPP computes the optimal dispatch for the storage assets in order to assure the provision of fast balancing services to the grid. Moreover, the optimization performed by the iVPP also considers that must exist a pre-defined capacity reserved for the balancing services.	EXECUTE	IANOS iVPP	IANOS iVPP	-
4	Submission of optimal set-points	Sends set-points	iVPP sends the optimal setpoint to the storage assets.	CREATE	IANOS iVPP	Storage Assets	10

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5 Information exchanged

Information exchanged		
Information exchanged (ID)	*Name of information*	*Description of information exchanged*
1	Flywheel hard technical constraints	Minimum and maximum power rating (kW), energy capacity (kWh or kJ), efficiency (%), self-discharge time (h), operating temperature (°C), dimensions (m), weight (kg), noise (dBA), connectivity, maximum rotational speed (rpm).
2	Fuel Cells hard technical constraints	Minimum and maximum natural gas and hydrogen flow rates; temperature range, maximum total power output (kW).
3	BESS hard technical constraints	Minimum and maximum SoC, and charging and discharging power; temperature range.
4	Flywheel real-time data	Real-time Power (+/- kW) and Storage (kWh); Grid Voltage (Vac); Grid Current (+/- Iac); Grid Power (+/- kW); Flywheel System Warnings / Errors.
5	Fuel Cells real-time data	Available NG flow rates; temperature at FC Anode.
6	BESS real-time data	SoC, temperature.
7	Grid Requests	Grid requests.
8	Forecasted Energy Generation Data	Forecasted energy supply data from production-side assets such Fuel Cells.
9	Forecasted Flexibility Data	Forecasted flexibility from the several storage assets.
10	Optimal Setpoints	Optimal power dispatch computed by the iVPP for storage assets. It is the amount of power from the grid that will be stored in the storage assets or the amount of power sent to the grid from the storage assets to provide balancing services.

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6 Requirements

Requirements		
Categories ID	Category name for requirements	Category description
R-SEC.	Security Requirement	Requirements related to the safety issues.
R-BUS	Business Requirement	Business requirements to achieve operational state of iVPP per UC.
R-UI	User Interface Requirement	Requirements related to the iVPP UI.
R-FUN	Functional Requirement	Requirements that capture the intended behaviour of the system.
R-COM	Communication Requirement	Requirements related to communication aspects
R-CONF.	Configuration Requirement	Requirements applicable to the electrical, physical and digital configuration applicable to enable the asset's operation.
R-D	Data requirements and operation settings	Requirements related to data exchange and operation settings.
Requirement R-ID	Requirement name	Requirement description
R-SEC1	Access Control	iVPP functions are accessible from personnel with specialized authorization rights.
R-SEC2	iVPP cybersecurity	Utilization of good practices (e.g. secure communication bus) to enhance data cybersecurity.
R-SEC3	iVPP data privacy	Utilization of good practices to ensure compliance with GDPR regulations.
R-SEC4	Network security measures for data exchange with flywheel	Establishes the ways in which communication between the iVPP and the flywheel control system can be done safely,

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		mitigating risks of external interference.
R-SEC5	Flywheel site safety	Establishes the safety guidelines applicable to the physical location where the flywheel is installed. It further establishes the safety guidelines applicable to all personnel in the local vicinity to ensure safe operation of the flywheel.
R-BUS1	Assets optimal location	Specification of the candidate assets location in pilot sites.
R-BUS2	Physical installation and grid integration	The storage asset provider or operator or integrator will physically integrate the asset with the local energy system.
R-BUS3	Installation of monitoring infrastructure	The necessary monitoring infrastructure will be installed.
R-BUS4	Prequalification of asset with the transmission code requirements	Assets should follow grid code requirements according to the services to be provided.
R-UI1	Graphical visualization of iVPP operation	iVPP operation can be visually inspected through the use of KPIs.
R-UI2	Reporting	iVPP can produce reports on system performance upon iVPP Operator request.
R-FUN1	Receive Operator's requests	iVPP having the ability to receive requests for service activation (e.g. FRR) from System Operator (TSO or DSO).
R-FUN2	Capacity reserves allocation for fast ancillary services (AS)	iVPP can allocate storage Assets into different reserves/AS.
R-FUN3	Dispatch prioritization	iVPP can select the most appropriate asset(s) to deliver the requested service.

R-FUN4	Activation of iVPP distributed storage Asset to provide primary regulation	BESS/FC/Flywheel assets can be automatically triggered to provide Frequency Containment Reserves (FCR) automatically within seconds.
R-FUN5	Activation of iVPP distributed storage Asset to provide secondary regulation	iVPP having the ability to activate BESS/FC/Flywheel assets to provide Frequency Restoration Reserves (FRR) within 5-15 minutes.
R-FUN6	Activation of flywheel to provide voltage support	Flywheel can be automatically triggered to absorb/provide reactive power for voltage control within seconds.
R-FUN7	Activation of electrochemical storage inverters to provide voltage support	Assets' inverters can be automatically triggered to absorb/provide reactive power for voltage control within seconds.
R-COM1	Common Information Model	iVPP adopts a common information model to exchange data ensuring interoperability.
R-COM2	iVPP minimum communication requirements	Bandwidth and latency are ensured to follow min. requirements according to the level of service to be delivered (e.g. mFRR, aFRR).
R-CONF1	Flywheel electrical connection	Defines the electrical connection parameters required to integrate the flywheel to the End User and Grid's electricity network.
R-CONF2	Flywheel control communication	Defines how the iVPP communicates with the flywheel, either activating charge/discharge events, or idling mode.
R-D.1	Grid frequency and voltage real time data	Defines how the iVPP collects the electric grid's real time data.

7 Common Terms and Definitions

Common Terms and Definitions	
Term	Definition
BESS	Battery Energy Storage System
FFR	Firm Frequency Response
GPDR	General Data Protection Regulation
IoT	Internet of Things
IVPP	Intelligent Virtual Power Plant
PV	Photovoltaic
SGAM	Smart Grid Architecture Model
SoC	State of Charge
UC	Use Case
UI	User Interface
WT	Wind Turbine

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6.1.4 Use case 4: Demand Side Management and Smart Grid methods to support Power quality and congestion management services

1 Description of the use case

1.1 Name of the use case

ID	Area / Domain(s)	Name of Use Case
4	Energy efficiency and grid support for extremely high RES penetration	DSM and smart grid methods to support power quality optimization and congestion management services

1.2 Version management

Version Management			
Version No.	Date	Name of Author(s)	Changes
1	04.02.2021	EDP NEW	First draft.
2	05.02.2021	Nikolaos Nikolopoulos (CERTH)	Comments and inputs on the Narrative of the Use Case, Diagrams, Actors, Scenarios. Suggestion of inclusion of information regarding protocols for communication/information data exchange according to SGAM architecture.
3	10.02.2021	Carlos Patrão (CLEANWATTS)	Comments on Use Case conditions, References.
4	23.02.2021	Rui Lopes (UNINOVA)	Comments on the Narrative of the Use Case, Scenarios. Add assumptions and pre-requisites for the smart energy router. Add information exchanged from the smart energy router.

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5	23.03.2021	Andrea Soto (EFACEC Energia)	Add assumptions and pre-requisites for the hybrid transformer. Add information exchanged from the hybrid transformer.
6	25.02.2021	Mónica Fernandes (EDP NEW)	Collect all the feedback and start second version. Add SGAM layers characterization. Improve diagrams, description, information exchanged and scenarios.
7	16.03.2021	Ioannis Moschos (CERTH)	IVPP Requirements.
8	29.04.2021	Mónica Fernandes (EDP NEW)	KPIs added from D2.3. Collecting the new feedback.
9	11.05.2021	Mónica Fernandes (EDP NEW	Final Version.
10	01.04.2022	Mónica Fernandes (EDP NEW)	Minor changes on the description and the actors of the Use Case and updates on the KPIs.
11	15/07/2022	Ana Carvalho (EDP NEW)	Revision and start of the third version.
12	16/09/2022	Vasilis Apostolopoulos (CERTH)	Corrections to KPI numbering according to final version of D2.9.

1.3 Scope and objectives of use case

Scope and Objectives of Use Case	
Scope	The scope of this Use Case is the provision of slow ancillary services to the grid using available energy flexibility from demand resources of the island. Additionally, this Use Case also demonstrates smart grid methods with interesting functionalities for the stability of the power system such

	as allowing an optimised control of the user's local production and storage and also the ability to regulate active and reactive power.
Objectives	This Use Case is crucial when the optimal dispatch is not enough to assure the stability of the power system. The main objectives are the following: 1. Ensure stability of the power system. 2. Minimize energy curtailment. 3. Support congestion management services by utilizing demand flexibility as a mean to provide slow ancillary services to the grid.

1.4 Narrative of use case

Narrative of Use Case
Short description
This use case reports the methods to provide slow ancillary services to the power system through demand-side management and smart grid methods. The intelligent Virtual Power Plant (iVPP) performs a global optimization which will consider the 4 following assets: storage assets, fuel cells, hybrid transformer and smart energy router. For each one of these assets, the iVPP computes an optimal setpoint in order to ensure the stability and quality of the power system.
Complete description
The present use case describes the methods to support power quality optimization and congestion management services through demand-side management. For this purpose, the iVPP performs an optimization that considers 4 different types of assets: i) storage assets, not only electrochemical but also Power-to-X, (ii) other means of very flexible electric production units as those of Fuel Cells, fully dispatchable iii) hybrid transformer and iv) smart energy router. Accordingly, the iVPP computes the optimal dispatch for each one of these assets and delivers the respective set-point in order to ensure the stability and quality of the power system. The electrochemical storage assets considered are battery storage systems and biobased batteries while the Power-to-X ones are hybrid heat pumps. On top of those, fuel cells (both distributed of small-scale, but also centralized of large-scale) will offer slow ancillary services to the electricity grid. The optimization is performed by the iVPP through its DSM modules to optimize the energy dispatch of each client based on certain criteria (e.g. minimization of RES curtailment or reduction of system's operation cost) which must be defined by the system operator since the beginning of the implementation of the Use Case.

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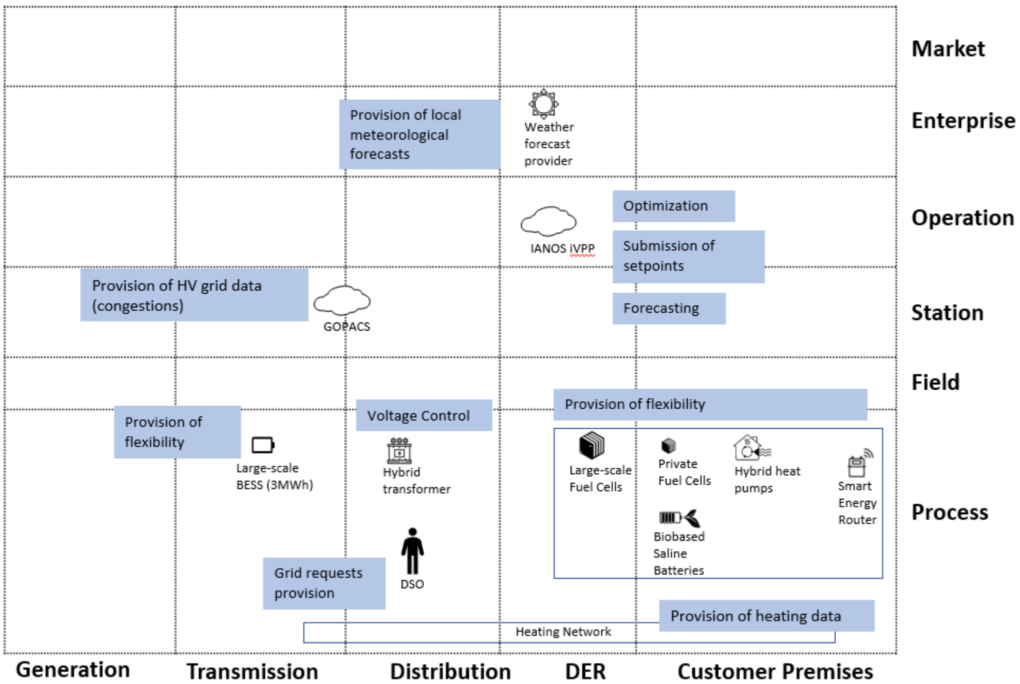
DSM modules use: i) energy consumption forecasts based on historical load consumption and real time measurements, ii) energy production forecasts based on local meteorological forecasts provided by an external forecast provider and iii) historical generation data from the available RES assets.

The hybrid transformer allows to fix the voltage between phases, provides reactive power regulation and thereby complies with the voltage setpoint computed by the iVPP.

The smart energy router controls power flows between the grid and its storage assets and enables the possibility of providing balancing services to the grid taking into consideration local restrictions from storage assets. The iVPP calculates the optimal dispatch for the smart energy router in order to manage the energy services provided to the grid and the consumer.

SGAM LAYERS:

Function Layer



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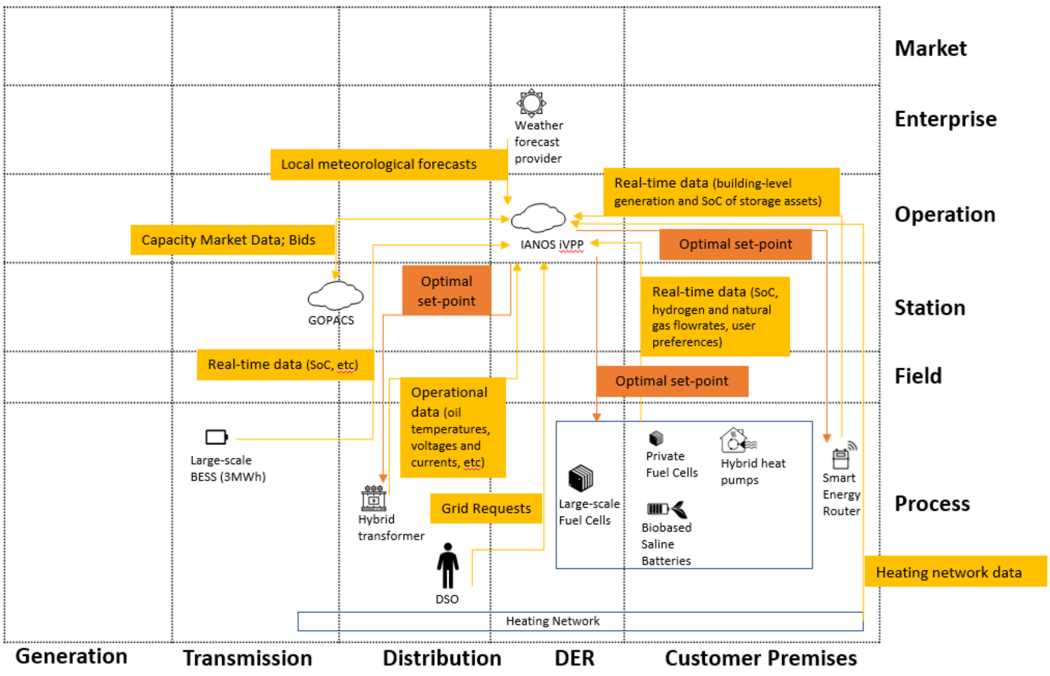
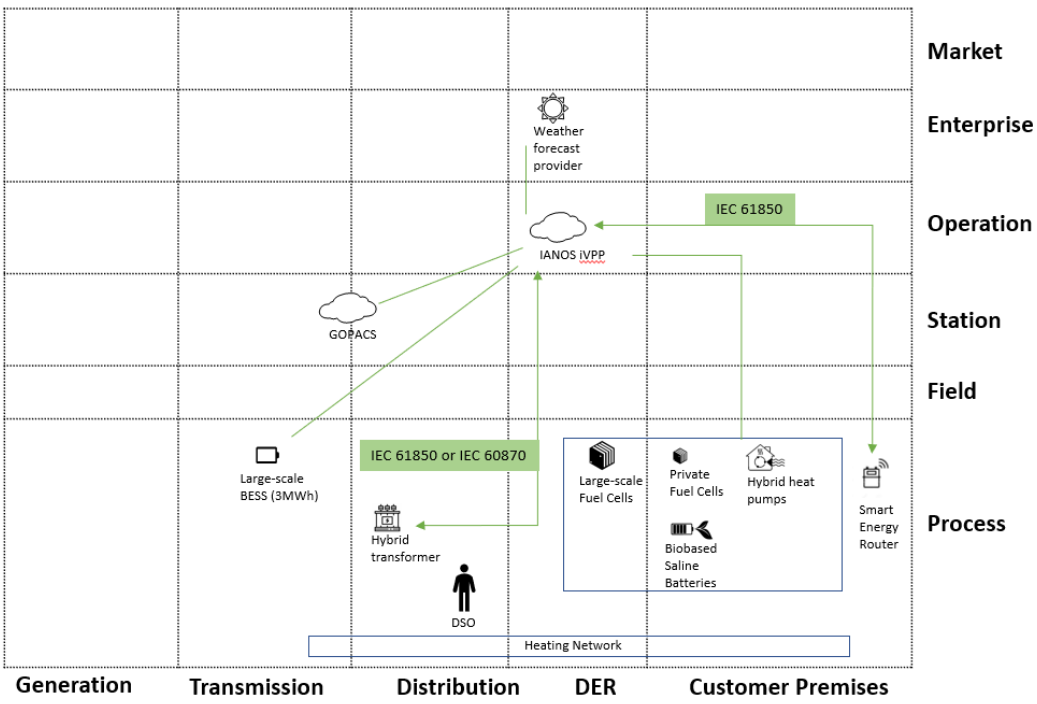
Information Layer



Communication Layer



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Technological Solutions	Information / Communication Protocols	Terceira	Ameland
Private Fuel Cells			x
Large-scale Fuel Cell			x
Hybrid Heat Pumps			x
Biobased Saline Batteries			x
BESS (3MWh)	-		x
BESS (15MW)		x	
Smart Energy Router	Uses the IEC 61850 protocol, nevertheless, the protocol used can be adjusted according to the needs and specifications of the iVPP as long as it is supported by a Wi-Fi connection at the installation site.	x	
Hybrid Transformer	Based in substation automation protocols (IEC 61850 or IEC 60870).	x	

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1.5 Key performance indicators (KPIs)

ID	*Name*	*Description*	*Reference to mentioned use case objectives*
1.3	System Average Interruption Frequency Index	Calculates the annual average number of power interruptions encountered by each end-user.	1
1.4	System Average Interruption Duration Index	Calculates the average time duration of the power interruptions encountered by the end-users each year.	1
1.8	Reduced energy curtailment of RES and DER	Calculates the reduction of energy curtailment due to technical/operational problems.	2
1.9	Peak Load Reduction	Calculates the peak load reduction before the IANOS implementation (baseline) and after its interventions (DSM programs and storage system management).	3
1.10	Accuracy of energy supply and demand prediction	This KPI measures the gap between predicted and actual energy demand/supply at a given time	2,3
1.11	Unbalance of the 3-phase	Examines the quality of the power supplied by measuring the supply voltage gap between the three phases which should be 120 deg.	1,3
4.1	Increased system flexibility for energy players	Indication of the ability of the system to respond to supply and demand in real time, as a measure of the demand side participation in energy markets and in energy efficiency intervention since the beginning until the end of the project.	1,3
4.5	Increased Reliability	Measures the relative improvement in the number of interruptions.	3

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5.1	People Reached	Percentage of people in the target group that have been reached and/or are activated by the project.	1,2,3
7.1	Social Compatibility	Refers to the extent to which the project's solution fits with people's 'frame of mind' and does not negatively challenge people's values or the ways they are used to do things.	1,2,3
7.2	Technical compatibility	Examines the extent to which the smart grid solutions fit with the current existing technological standards/infrastructures.	1,2,3
7.3	Ease of use for end users of the solution	Provides an indication of the complexity of the implemented solution within the IANOS project for the end-users.	1,2,3

1.6 Use case conditions

Use case conditions
Assumptions
• Access to DSO's energy data or retailer's smart meters capable of monitoring network voltage parameters according to the EN 50160 standard. • Existence of distributed energy assets available in the island, capable of being integrated and remotely managed or controlled by the iVPP. • End-user's permission to shift demand periods. • In Ameland the Grid Operation Platforms for Congestion Solutions interface (GOPACS,) will be integrated with the iVPP decision making logic. GOPACS is a unique initiative in Europe and has resulted from active collaboration between the Dutch TSO and the DSOs. This platform is consistent with key European directives to mitigate grid congestion, while offering large and small market parties an easy way to generate revenues with their available flexibility and contribute to solving congestion situations. • PV systems' power, voltage and current respect Smart Energy Router specifications. • Appliances and other loads to be managed by the Smart Energy Router have communication and interaction capabilities (e.g., REST API) so monitoring and control activities can be conducted.

• iVPP setpoints to Smart Energy Router take into consideration local restrictions such as storage devices' state of charge or maximum and minimum charging/discharging power. • Close surveillance of the hybrid transformer during operation on the grid.
Prerequisites
• The criteria for optimization must be defined by the system operator for each island. • Connection from the VPP to storage assets and power production units (hybrid heat pumps, fuel cells, BESS and biobased batteries) in Ameland. • Hybrid Transformer is connected to the iVPP. • Smart Energy Router is connected to the iVPP. • Acceptance and/or certification by the corresponding authority for the installation on the electric distribution grid of the hybrid transformer. • Hybrid transformer monitoring system communicates with EFACEC asset management platform with cellular communication connection. • A (physical) hosting environment on which the iVPP can be established.

1.7 Further Information to the use case for classification / mapping

Classification Information
Relation to other use cases
UC1: Community demand-side driven self-consumption maximization. UC2: Community supply-side optimal dispatch and intra-day services provision. UC3: Island-wide, any-scale storage utilization for fast response ancillary services distributed storage technologies to help balancing the grid; flywheels, batteries. UC5: Decarbonization of transport and the role of electric mobility in stabilizing the energy system. UC9: Active Citizen and LEC Engagement into Decarbonization Transition.
Level of depth
Specialized use case
Prioritisation
High level of priority
Generic, regional or national relation
Generic
Nature of the use case

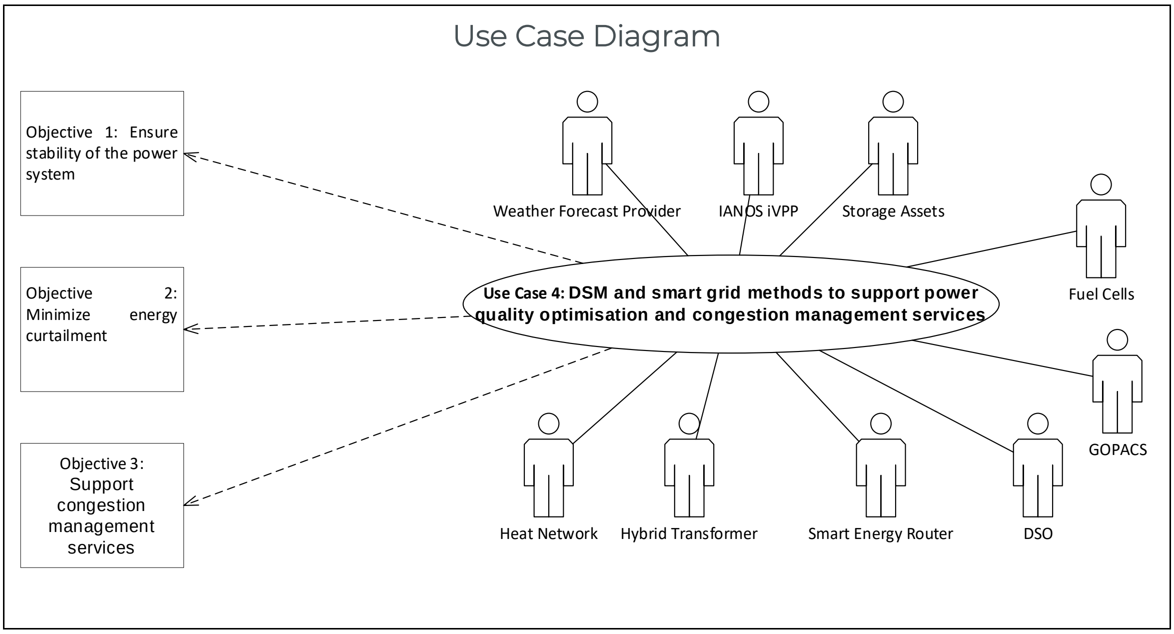
Technical use case
Further keywords for classification
Demand side management, smart grids, smart energy router, hybrid transformer, ancillary services, demand flexibility

1.8 General Remarks

General Remarks
-

2 Diagrams of use case

Diagram(s) of use case



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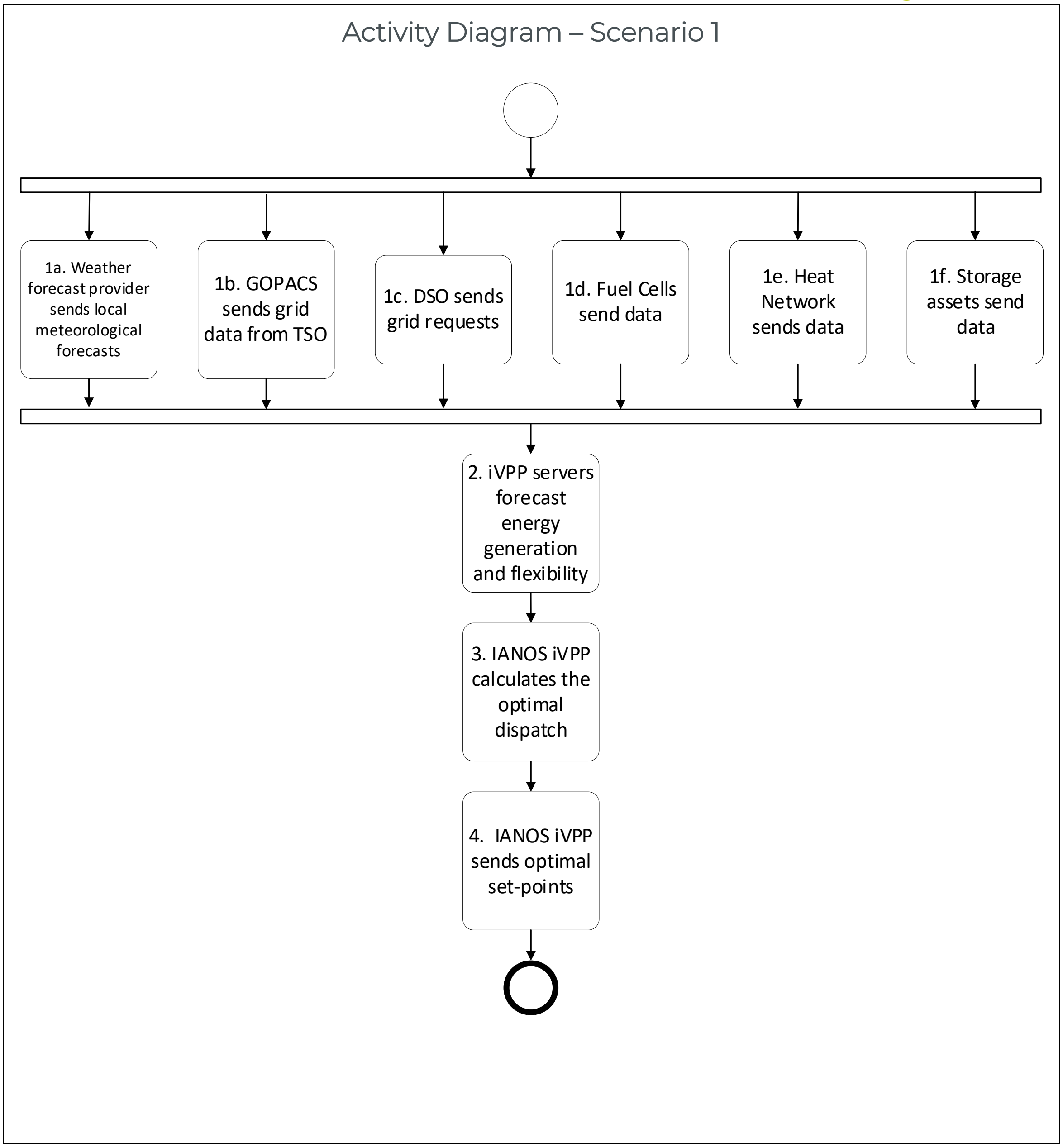

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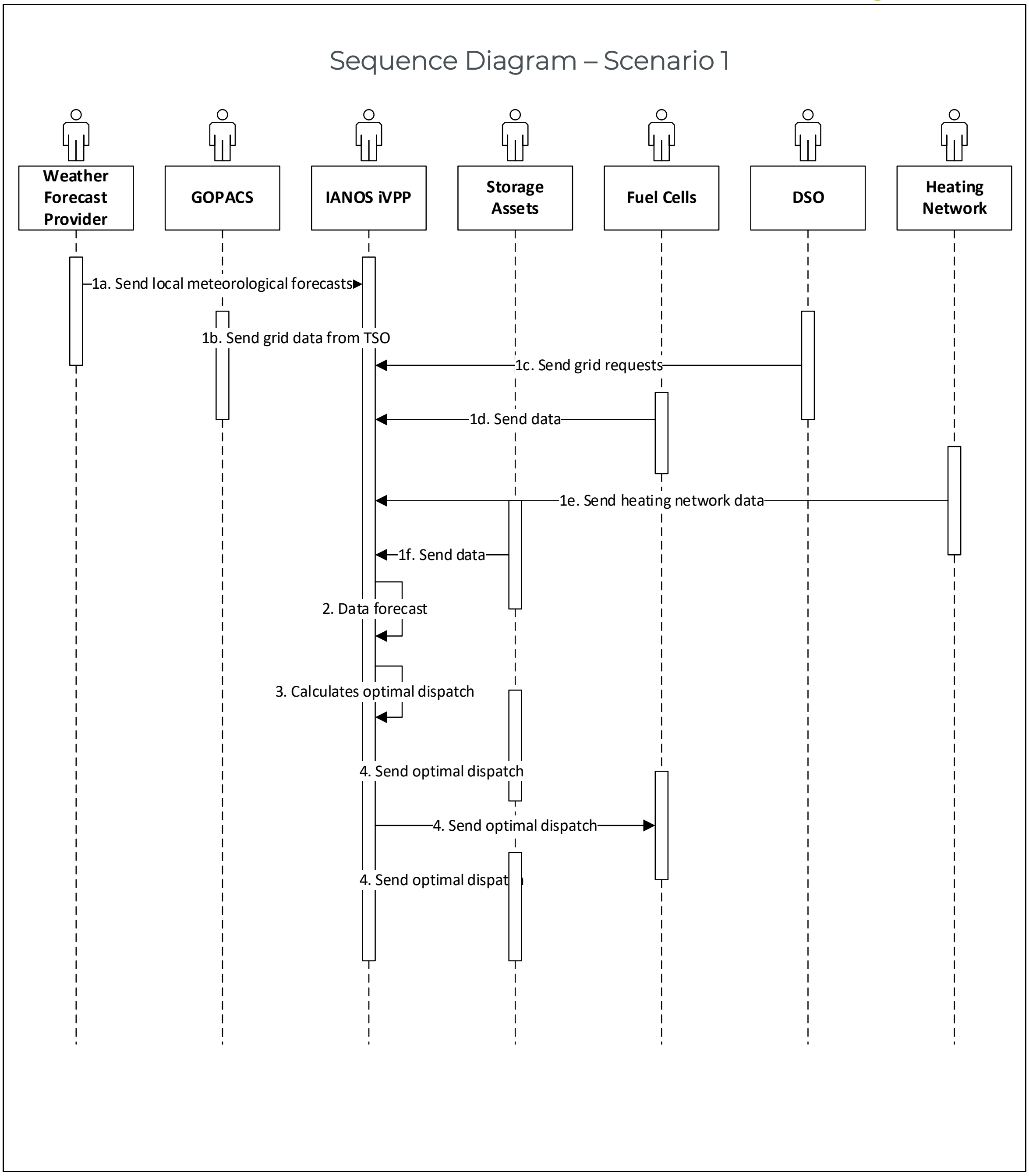
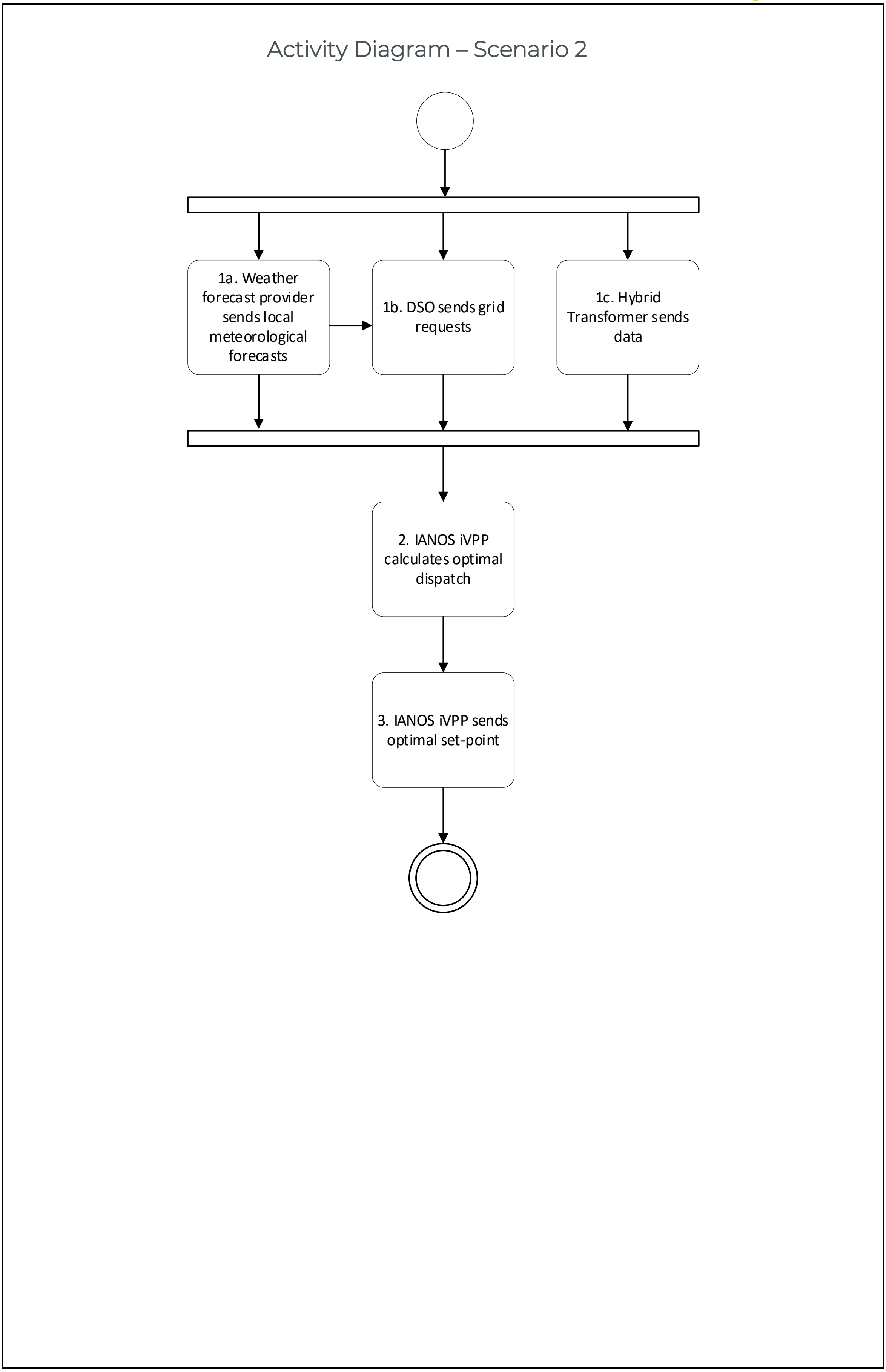

Sequence Diagram – Scenario 1
Weather Forecast Provider
GOPACS
IANOS iVPP
Storage Assets
Fuel Cells
DSO
Heating Network
1a. Send local meteorological forecasts
1b. Send grid data from TSO
1c. Send grid requests
1d. Send data
1e. Send heating network data
1f. Send data
2. Data forecast
3. Calculates optimal dispatch
4. Send optimal dispatch
4. Send optimal dispatch
4. Send optimal dispat



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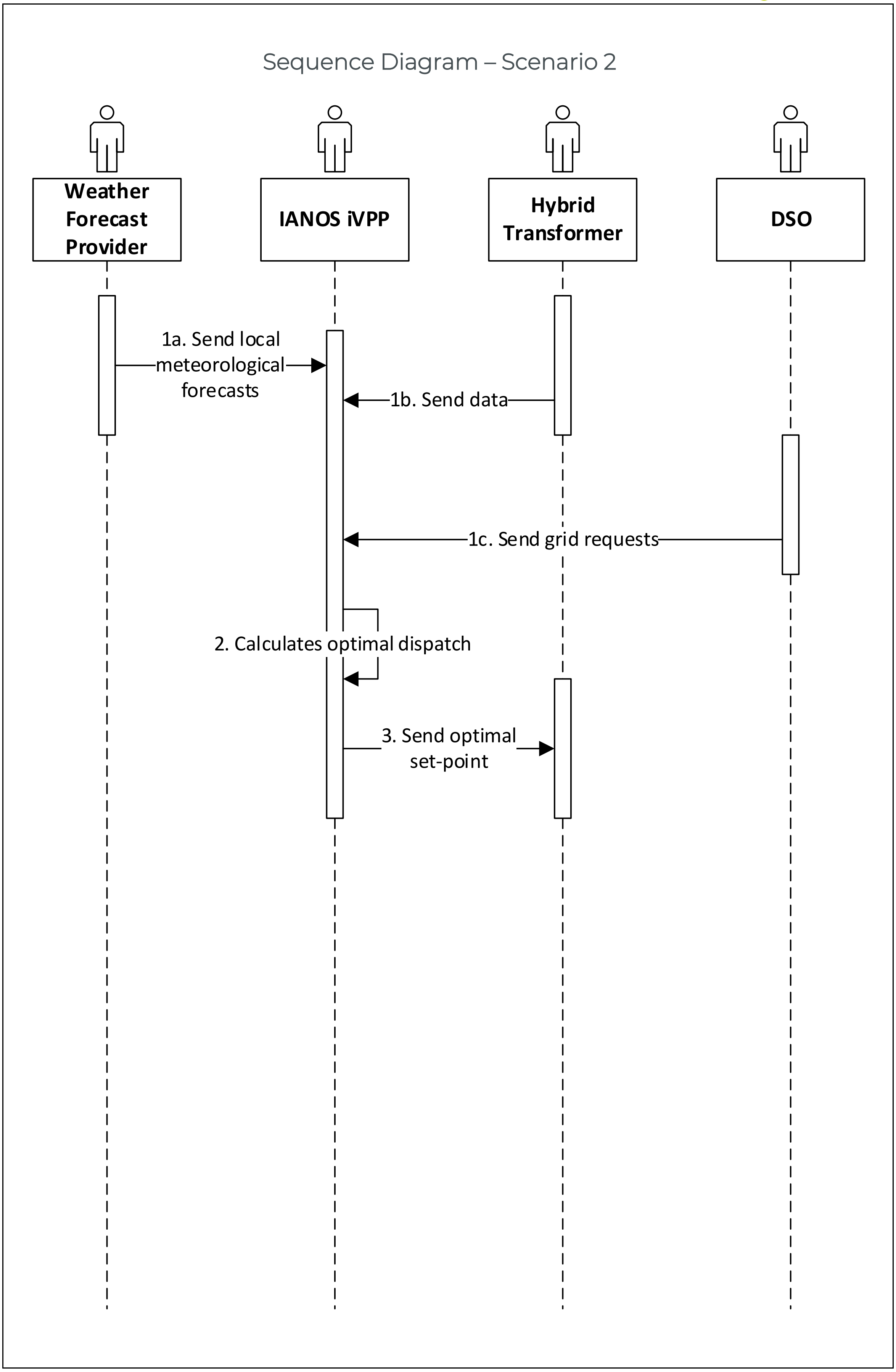

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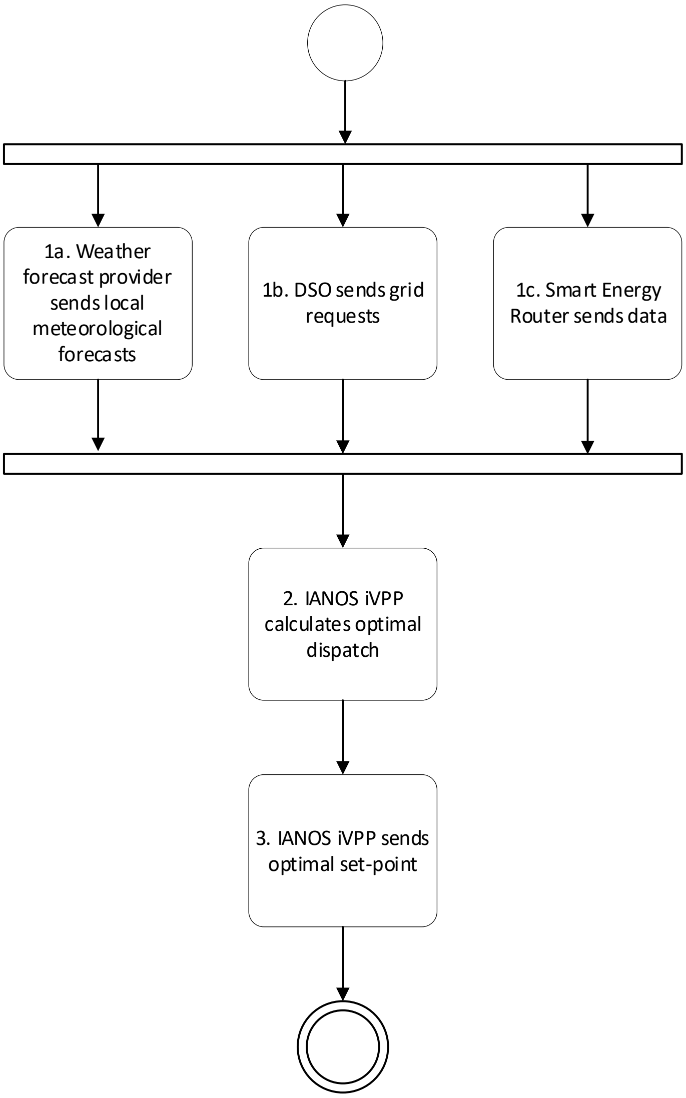
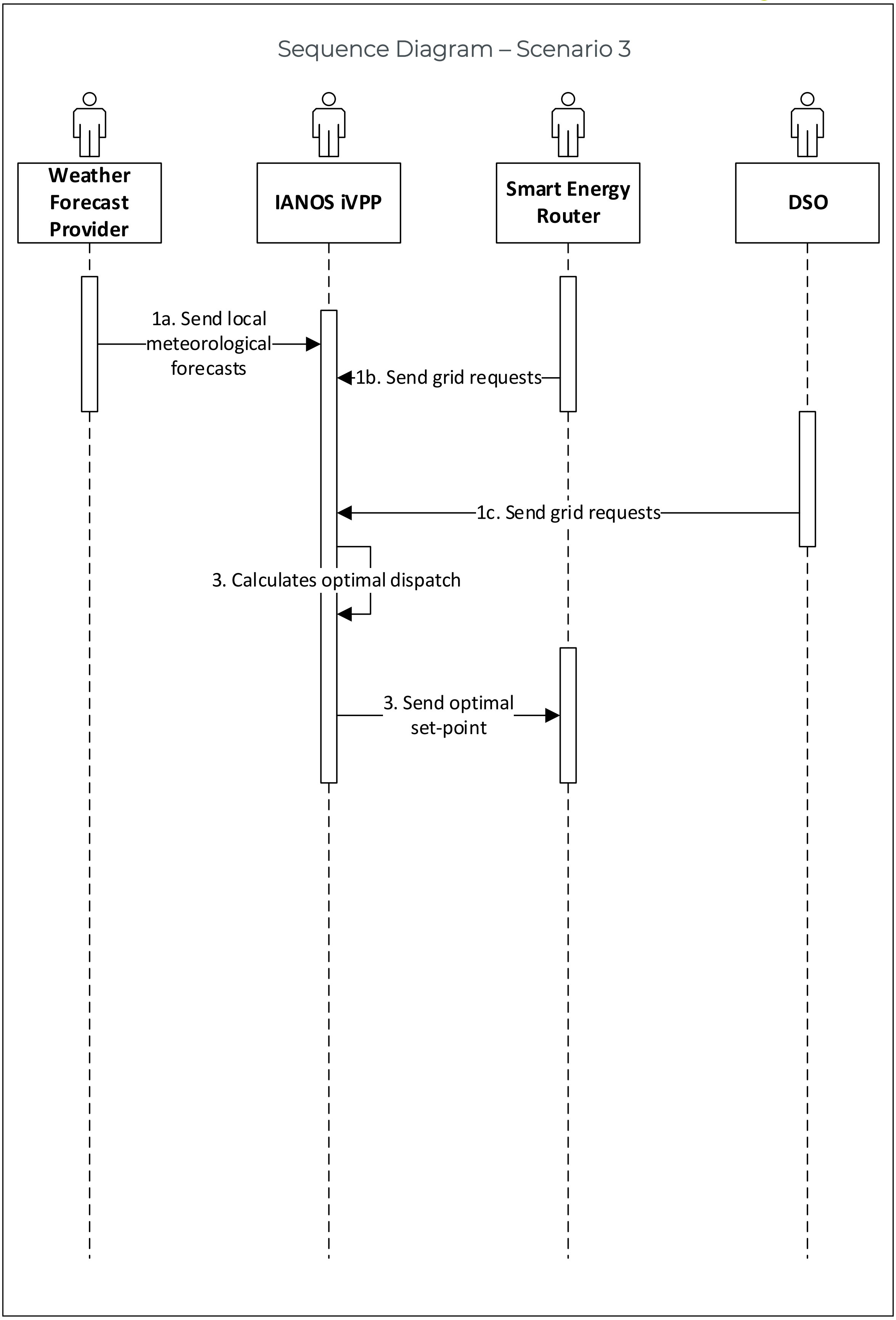
Activity Diagram – Scenario 3




Sequence Diagram – Scenario 3
Weather Forecast Provider
IANOS iVPP
Smart Energy Router
DSO
1a. Send local meteorological forecasts
1b. Send grid requests
1c. Send grid requests
3. Calculates optimal dispatch
3. Send optimal set-point

3 Technical details

3.1 Actors

Actors		
Actor Name	*Actor Type*	*Actor Description*
Weather Forecast Provider	Role	Provides generation, consumption and weather-related operational risks, for a given location and a specific time horizon.
IANOS iVPP	System	The IANOS iVPP sets up a virtual network of decentralized renewable energy resources, both non-dispatchable such as wind, solar, tidal resources and dispatchable ones such as geothermal and green gas CHP plants. Moreover, the iVPP comprises of Energy Storage Systems (ESS), integrated as a single unit, providing flexibility services and fostering island renewable energy self-consumption. The optimal, autonomous, real-time iVPP operation will be driven by multi-level decision making intelligence, complemented by predictive algorithms for smart integration of grid assets into active network management based on relevant energy profiles. For this purpose, the iVPP is composed of 6 different modules: aggregation and classification, forecasting engine, centralized dispatcher, distributed ledger-based energy transactions, virtual energy console and secured enterprise service bus.
Storage Assets	System	Assets with the ability of storing energy to be used later such as hybrid heat pumps, BESS and biobased batteries.
Fuel Cells	System	Assets with the ability of offering electricity, when necessary, while also supporting the synergy between energy grids (NG and electricity in the specific case).
Hybrid Transformer	Device	Device with the capability of regulating voltage during operation. This hybrid transformer employs independent control of each phase and features such as reactive

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		power or unbalanced compensation, which cannot be provided by conventional transformers. It is able to implement a dynamic voltage regulation actuation, in each phase, with unlimited number of operations and with the addition of other features such as the contribution to reactive power compensation, unbalance correction and improvement in the voltage profile quality.
Smart Energy Router	Device	Power electronic device that provides grid-to-grid communication, load management and integration of multiple generation and storage units, heterogeneous appliances and existing distribution grid. Moreover, it also allows to provide ancillary services to the grid.
DSO	Role	Distribution System Operator.
Heat Network	System	System which distributes centralized heat to consumers through a system of insulated pipes carrying hot water.
GOPACS	System	Grid Operation Platforms for Congestion Solutions interface (GOPACS) is an unique initiative in Europe and has resulted from active collaboration between the Dutch TSO and the DSOs. This platform is consistent with key European directives to mitigate grid congestion, while offering large and small market parties an easy way to generate revenues with their available flexibility and contribute to solving congestion situations.

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3.2 References

References						
No.	*References Type*	*Reference*	*Status*	*Impact on use case*	*Originator / organisation*	*Link*
1	European Standard	EN 50160	Revised, 1 July 2010	Definition of the voltage characteristics of electricity supplied by public electricity networks.	CENELEC	https://www.cenelec.eu/dyn/www/f?p=104:110:959538371060101::::FSP_ORG_ID,FSP_LANG_ID,FSP_PROJECT:1258595,25,51993
2	International Standard	IEC 60076-1:2011		Power transformers - Part 1: General.	International Electrotechnical Commission (IEC)	https://webstore.iec.ch/publication/588
3	Commission regulation (EU)	No 548/2014 of 21 May 2014		Commission regulation (EU) No 548/2014 of 21 May 2014 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to small, medium and large power transformers.		https://ec.europa.eu/growth/single-market/european-standards/harmonised-standards/ecodesign/transformers_en
4	International Standard	IEC 60076-24	Edition 1.0, 2020-07	Power transformers – Part 24: Specification of voltage regulating distribution transformers (VRDT).	International Electrotechnical Commission (IEC)	https://webstore.iec.ch/publication/30367

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4 Step by step analysis of use case

4.1 Overview of scenarios

Scenario conditions						
No.	Scenario name	Scenario description	Primary actor	Triggering event	Pre-condition	Post-condition
1	Demand-side management capable of providing slow ancillary services	The iVPP computes the optimal set-point which allows to provide slow balancing services to the grid through storage assets by using demand-side flexibility.	IANOS iVPP	Periodically	Power system requires balancing services. No power fluxes from or to storage assets.	Power system is stable and controlled.
2	Voltage control to support power quality optimisation and congestion management services	The hybrid transformer complies with the voltage setpoint computed by the iVPP in order to ensure a continuous power.	Hybrid Transformer	Periodically	Power system requires voltage control.	Voltage is regulated.
3	Localized energy routing management capable of providing ancillary services	iVPP calculates the optimal dispatch to the smart energy router which manages the energy transfer from and to different sources (RES	Smart Energy Router	Periodically	Power system requires balancing services. No power fluxes	Smart Energy Router contribute to stabilize and

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		generators and distribution grid), loads and storage systems in order to provide services to the grid and the consumer.			from or to storage assets.	control the power system.

4.2 Steps – Scenarios

Scenario								
Scenario name :	*No. 1 - Demand-side management capable of providing slow ancillary services*							
Step No.	*Event*	*Name of process/ activity*	*Description of process/ activity*	*Service*	*Information producer (actor)*	*Information receiver (actor)*	*Information Exchanged (IDs)*	*Requirement, R-IDs*
1a	Submission of local weather forecasts	Sends local meteorological forecasts	Weather forecast provider sends local meteorological forecasts.	CREATE	Weather forecast provider	IANOS iVPP	1	
1b	Submission of grid data from TSO	Send grid data from TSO	GOPACS exchange high voltage grid data related to congestions with iVPP.	REPORT	GOPACS	IANOS iVPP	2	
1c	Submission of grid requests	Sends data	DSO sends grid requests to the iVPP.	GET	DSO	IANOS iVPP	3	
1d	Submission of fuel cell's	Sends data	Fuel Cells send its data to the iVPP.	GET	Fuel Cells	IANOS iVPP	4,5	

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	data							
1e	Submission of heat network data	Sends data	Heat Network sends its data to the iVPP.	GET	Heat Network	IANOS iVPP	6	
1f	Submission of storage asset's data	Sends data	Storage assets send data to the iVPP.	GET	Storage assets	IANOS iVPP	7,8	
2	Data Forecasting	Forecasts energy generation and flexibility	iVPP servers forecast energy generation from production-side assets such as fuel cells and flexibility forecasts from storage assets	EXECUTE	IANOS iVPP	IANOS iVPP	9,10	
3	Calculation of optimal dispatch	Calculates optimal dispatch	iVPP computes the optimal dispatch for the storage assets considering the provision of slow balancing services to the grid.	EXECUTE	IANOS iVPP	IANOS iVPP	-	
4	Submission of optimal set-points	Sends set-points	iVPP sends the optimal setpoint to storage assets and fuel cells.	CREATE	IANOS iVPP	Storage Assets, Fuel Cells	11,12	

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Scenario					
No. 2 - Voltage control to support power quality optimisation and congestion management services					
Name of process/ activity	*Description of process/ activity*	*Service*	*Information producer (actor)*	*Information receiver (actor)*	*Information Exchanged (IDs)*
Sends local meteorological forecasts	Forecast Provider sends local meteorological forecasts.	CREATE	Forecast provider	IANOS iVPP	1
Sends requests	DSO sends grid requests to the iVPP.	GET	DSO	IANOS iVPP	3
Sends data	Hybrid Transformer sends data to the iVPP.	GET	Hybrid Transformer	IANOS iVPP	13
Calculates optimal dispatch	iVPP computes the optimal voltage dispatch for the hybrid transformer in order to fix the voltage between phases and regulate the voltage in the power system.	EXECUTE	IANOS iVPP	IANOS iVPP	-
Sends set-points	iVPP sends the optimal setpoint to the hybrid transformer.	CREATE	IANOS iVPP	Hybrid Transformer	14

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Scenario							
Scenario name :		*No. 3 - Localized energy routing management capable of providing ancillary services*					
Step No.	*Event*	*Name of process/ activity*	*Description of process/ activity*	*Service*	*Information producer (actor)*	*Information receiver (actor)*	*Information Exchanged (IDs)*
1a	Submission of local weather forecasts	Sends local meteorological forecasts	Forecast Provider sends local meteorological forecasts.	CREATE	Forecast provider	IANOS iVPP	1
1b	Submission of grid requests	Sends grid requests	DSO sends grid requests to the iVPP .	GET	DSO	IANOS iVPP	3
1c	Submission of smart energy router data	Sends data	Smart Energy Router sends data to the iVPP.	CREATE	Smart Energy Router	IANOS iVPP	15
2	Calculation of optimal dispatch	Calculates optimal dispatch	iVPP computes the optimal dispatch for the smart energy router.	EXECUTE	IANOS iVPP	IANOS iVPP	-
3	Submission of optimal set-point	Sends set-point	iVPP sends the optimal setpoint to the smart energy router.	CREATE	IANOS iVPP	Smart Energy Router	16

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5 Information exchanged

Information exchanged (ID)	*Name of information*	*Description of information exchanged*
1	Local meteorological forecasts	Expected irradiances and wind speeds for specific locations.
2	HV grid data	High voltage grid real-time data related with congestions; Bids.
3	Grid Requests	Grid requests.
4	Fuel Cells hard technical constraints	Minimum and maximum natural gas and hydrogen flow rates; temperature range, maximum total power output (kW).
5	Fuel Cells real-time data	Available NG flow rates; temperature at FC Anode.
6	Heating Network Data	Heating network status, real-time data.
7	Storage Assets hard technical constraints	Minimum and maximum SoC and charging and discharging power; User preferences.
8	Storage Assets real-time data	SoC, temperature, etc..
9	Forecasted Energy Generation Data	Forecasted energy supply data from production-side assets such as Fuel Cells.
10	Forecasted Flexibility Data	Forecasted flexibility from the several storage assets.
11	Optimal Set-points for storage assets	Optimal power dispatch computed by the iVPP for storage assets. It is the amount of power from the grid that will be stored in the storage assets or the amount of power sent to the grid from the storage assets to provide slow balancing services.
12	Optimal Set-points for fuel cells	Optimal power dispatch computed by the iVPP for fuel cells. It is the amount of power sent to the grid from fuel cells to provide balancing services.

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13	Hybrid Transformer real-time data	Operational data (oil temperatures and dissolved moisture; voltages and currents measured on LV side) and ambient related operational data (temperature and humidity; noise and vibration) from transformer to iVPP.
14	Optimal Set-point for hybrid transformer	Optimal voltage dispatch computed by the iVPP for the hybrid transformer. It corresponds to the voltage required to fix the voltage between phases.
15	Smart Energy Router Data	Real-time building-level generation and local storage state of charge data.
16	Optimal Set-point for Smart Energy Router	Optimal energy dispatch computed by the iVPP for the smart energy router. It corresponds to the amount of power that will be provided to the grid or to the loads or storage systems.

6 Requirements

Requirements		
Categories ID	Category name for requirements	Category description
R-SEC.	Security Requirement	Requirements related to the safety issues.
R-BUS	Business Requirement	Business requirements to achieve operational state of iVPP per UC.
R-FUN	Functional Requirement	Requirements that capture the intended behaviour of the system.
R-CONF.	Configuration Requirement	Requirements applicable to the electrical, physical and digital configuration applicable to enable the asset's operation.
R-UI	User Interface Requirement	Requirements related to the iVPP UI.

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R-USER	User requirement	Requirements related to the user.
R-COM	Communication Requirement	Requirements related to communication aspects.
Requirement R-ID	Requirement name	Requirement description
R-SEC1	Access Control	iVPP functions are accessible from personnel with specialized authorization rights.
R-SEC2	iVPP cybersecurity	Utilization of good practices (e.g. secure communication bus) to enhance data cybersecurity.
R-SEC3	iVPP data privacy	Utilization of good practices to ensure compliance with GDPR regulations.
R-SEC4	Network security measures for data exchange with hybrid transformer	Establishes the ways in which communication between the iVPP and the hybrid transformer system can be done safely.
R-SEC5	Hybrid transformer site safety	Establishes the safety guidelines applicable to the physical location where the hybrid transformer is installed.
R-BUS1	Assets optimal location	Specification of the candidate assets location in pilot sites.
R-BUS2	Physical installation and grid integration	Storage assets providers or operators or integrators will physically integrate the asset with the local energy system.
R-BUS3	Installation of monitoring infrastructure	The necessary monitoring infrastructure will be installed.
R-BUS4	Prequalification of asset with the transmission code requirements	Assets should follow grid code requirements according to the services to be provided.

R-FUN1	Day-ahead load and/or generation forecast	iVPP can predict the load and/or generation of its assets for the following day.
R-FUN2	Intraday load and/or generation forecast	iVPP can predict the load and/or generation of its assets within the day.
R-FUN3	Flexibility estimation	iVPP can estimate the prosumers' flexibility.
R-FUN4	Flexibility segmentation	iVPP can break down the total DR requirement into the available assets.
R-FUN5	3-phase balancing	Ability of Smart Energy Router to provide 3-phase load balancing.
R-FUN6	Dispatch prioritization	iVPP can select the most appropriate asset(s) to deliver the requested service.
R-CONF1	Hybrid transformer electrical connection	Defines the electrical connection parameters required to install the hybrid transformer to the grid.
R-CONF2	Hybrid transformer control communication	Defines how the iVPP communicates with the hybrid transformer.
R-UI1	Graphical visualization of iVPP operation	iVPP operation can be visually inspected through the use of KPIs.
R-UI2	Reporting	iVPP can produce reports on system performance upon iVPP Operator request.
R-USER1	Opt-out option from DR service	Prosumer having the option to opt-out from demand response service before activation (and a certain time).
R-COM1	Common Information Model	iVPP adopts a common information model to exchange data ensuring interoperability.
R-COM2	Smart Energy Router interaction with appliances and other loads	Appliances and other loads to be managed by the Smart Energy

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		Router have communication and interaction capabilities (e.g., REST API) so monitoring and control activities can be conducted.

7 Common Terms and Definitions

Common Terms and Definitions	
Term	**Definition**
BESS	Battery Energy Storage Systems
CHP	Combined Heat and Power
DR	Demand Response
DSM	Demand-Side Management
DSO	Distribution System Operator
FC	Fuel Cell
GDPR	General Data Protection Regulation
GOPACS	Grid Operation Platforms for Congestion Solutions
HVAC	Heating, Ventilating and Air Conditioning
iVPP	Intelligent Virtual Power Plant
LEC	Local Energy Communities
LV	Low Voltage
MV	Medium Voltage
NG	Natural Gas
RES	Renewable Energy Sources
SGAM	Smart Grid Architecture Model
SoC	State of Charge
TSO	Transmission System Operator
UC	Use Case
UI	User Interface

6.2 Transition Track 2: Use Cases

Transition Track 2 comprises of all the Use Cases that demonstrate the potential of electrification as a means to decarbonize relevant sectors along with non-emitting fuels utilization for cross-resource integration (e.g. hydrogen) and circular economy. Thereby, the decarbonization of the transport (UC5) and industry sector (UC6) as well as means to decarbonize the gas grid through the utilization of waste streams for energy production (UC7) and the heating network (UC8) are demonstrated in four Use Cases.

6.2.1 Use case 5: Decarbonization of transport and the role of electric mobility in stabilizing the energy system

1 Description of the use case

1.1 Name of the use case

ID	*Area / Domain(s)*	*Name of Use Case*
5	Energy efficiency and grid support for extremely high-RES penetration	Decarbonization of transport and the role of electric mobility in stabilizing the energy system

1.2 Version management

Version Management			
Version No.	*Date*	*Name of Author(s)*	*Changes*
1	04.02.2021	EDP NEW	First draft.
2	05.02.2021	Nikolaos Nikolopoulos (CERTH)	Comments and inputs on Actors, Scenarios Suggestion of inclusion of information regarding protocols for communication/information data exchange according to SGAM architecture.

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3	08.03.2021	Nuno Costa (EFACEC MOBILITY)	Comments on Use Case conditions Information Exchanged.
4	09.03.2021	Mónica Fernandes (EDP NEW)	Collect all the feedback and start second version. Add SGAM layers characterization. Improve diagrams, description, information exchanged and scenarios.
5	16.03.2021	Ioannis Moschos (CERTH)	iVPP Requirements.
6	29.04.2021	Mónica Fernandes (EDP NEW)	KPIs added from D2.3. Collecting the new feedback.
7	10.05.2021	Mónica Fernandes (EDP NEW)	Final Version.
8	01.04.2022	Mónica Fernandes (EDP NEW)	Minor changes and updates on the KPIs. Changes on the description of the Use Case and in the scenarios.
9	15.04.2022	Ana Carvalho	Revision and start of third version.
10	16/09/2022	Vasilis Apostolopoulos (CERTH)	Corrections to KPI numbering according to final version of D2.9.

1.3 Scope and objectives of use case

Scope and Objectives of Use Case	
Scope	The scope of this Use Case is the decarbonization of the transport sector. Accordingly, it aims to install electric chargers in the islands to promote electric mobility. Moreover, it also aims to demonstrate the provision of grid services from electric vehicles leveraging charging stations with V2G capabilities.

	Apart from electrification, this use case also demonstrates other alternative fuels such as hydrogen to fuel vehicles.
Objectives	This Use Case focuses on the decarbonization of the transport sector on the islands, therefore it has the following objectives: 1. Present a clear roadmap to decarbonize the transport sector. 2. Study the potential of electric chargers, hydrogen fuelled vehicles, V2G and smart charging schemes to reach decarbonization targets. 3. Offer flexibility in the electricity grid.

1.4 Narrative of use case

Narrative of Use Case
Short description
This Use Case aims to define a roadmap to reach decarbonization in the transport sector on the islands. Moreover, it explores the growth potential of EV chargers with or without V2G capabilities and smart charging schemes. The Intelligent Virtual Power Plant (iVPP) will manage the power flows of these chargers in order to ensure the stability of the power system.
Complete description
This Use Case intends to define a roadmap to decarbonize the transport sector of Ameland and Terceira islands, while also offering flexibility in the electricity grid. For this purpose, EV charging stations are installed to evaluate its growth potential. All the EV charging stations are connected to the iVPP which controls their charging and discharging modes. Some of these charging stations have V2G technology and therefore allow the provision of grid services such as load shifting and demand side management. Apart from V2G charging stations, smart charging schemes will also be analysed with the aim of providing flexibility to the power system. Since the iVPP will not receive real-time data from EDA dispatch center, the optimal setpoints will be sent as a suggestion to the V2G chargers. Moreover, this Use Case will also study the potential of hydrogen fuelled vehicles, to support the decarbonization of the transport sector, taking advantage of the hydrogen produced from the electrolyser in the case of Ameland (UC2).

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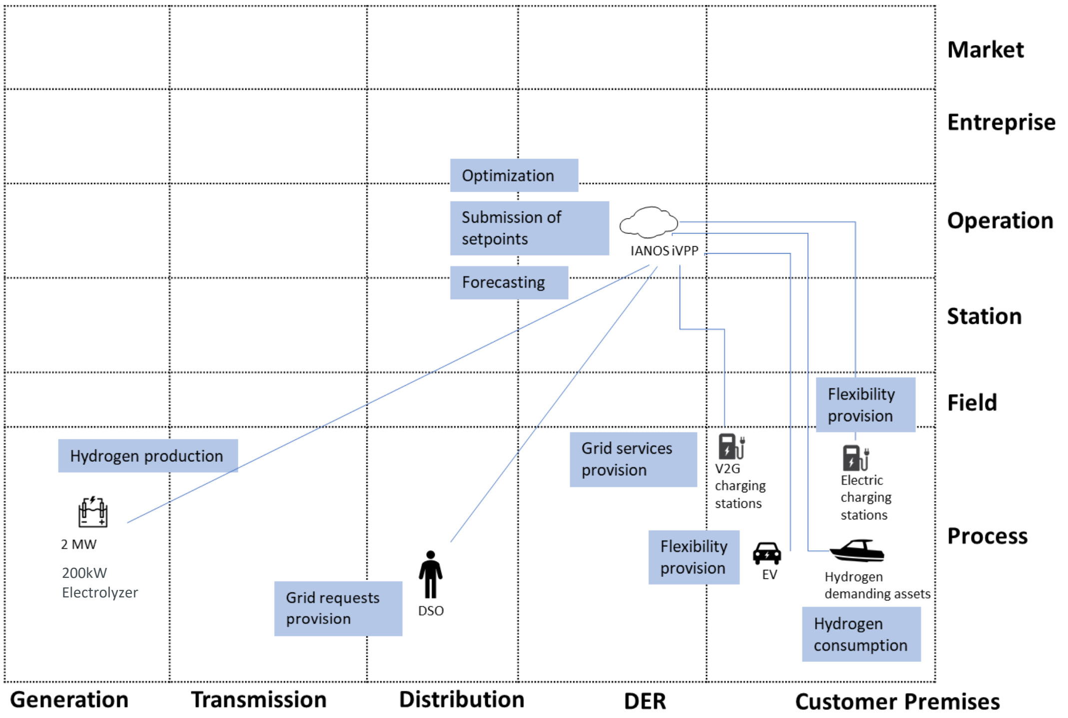
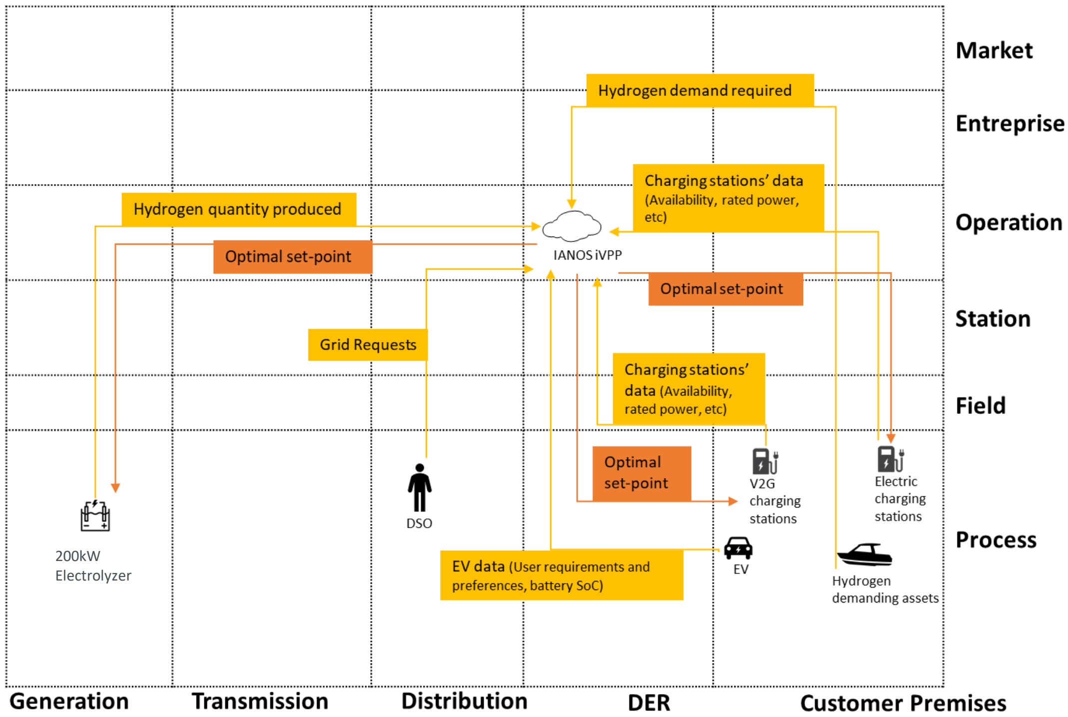
SGAM LAYERS

Function Layer



Information Layer



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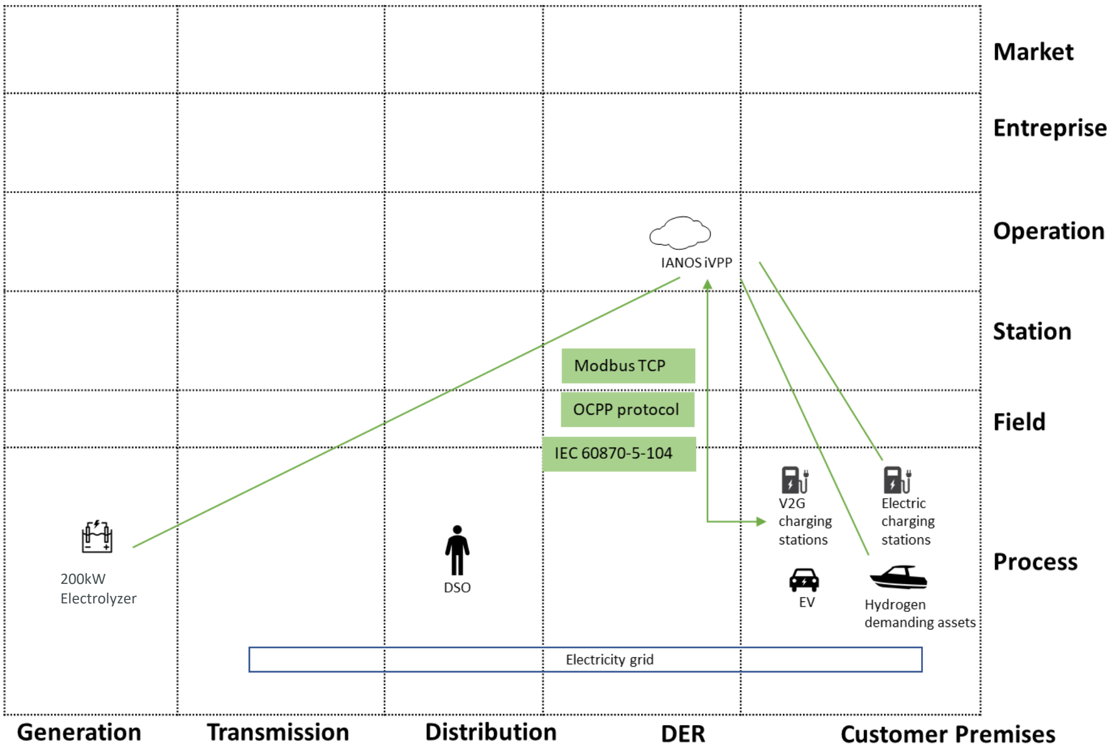
Communication Layer



Technological Solutions	Information / Communication Protocols	Terceira	Ameland
Electric charging stations			X
V2G charging stations	Usually, the EV Chargers are equipped with the OCPP protocol. These V2G chargers also support some field buses (Modbus TCP) for the interface with other management systems. Automation	X	

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	protocols such as the IEC 60870-5-104 can also be considered.		
EV	-	x	
Hydrogen Demanding Assets (such as vehicles)			X
Electrolyser			X

1.5 Key performance indicators (KPI)

ID	*Name*	*Description*	*Reference to mentioned use case objectives*
1.11	Unbalance of the 3-phase	Examines the quality of the power supplied by measuring the supply voltage gap between the three phases which should be 120 deg.	3
2.1	Reduced Greenhouse Gas Emissions	The greenhouse gas emissions of a system correspond to the emissions that are caused by different areas of application. In different variants of this indicator the emissions caused by the production of the system components are included or excluded. In this case it measures the reduction in GHG emissions due to the transport sector.	1,2
2.2	Reduced fossil fuel consumption	Measures the amount of fossil fuels which is not consumed anymore in the transport sector because of IANOS demonstrated	1,2

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		solutions (electric chargers, V2G chargers, hydrogen fuelled vehicles).	
4.1	Increased system flexibility for energy players	Indication of the ability of the system to respond to supply and demand in real time, as a measure of the demand side participation in energy markets and in energy efficiency intervention, from the beginning until the end of the project.	2,3
4.5	Increased Reliability	Measures the relative improvement in the number of interruptions.	3
7.1	Social Compatibility	Refers to the extent to which the project's solution fits with people's 'frame of mind' and does not negatively challenge people's values or the ways they are used to do things.	1,2,3
7.2	Technical compatibility	Examines the extent to which the smart grid solutions fit with the current existing technological standards/infrastructures.	1,2,3
7.3	Ease of use for end users of the solution	Provides an indication of the complexity of the implemented solution within the IANOS project for the end-users.	1,2,3

1.6 Use case conditions

Use case conditions
Assumptions
• Existence of distributed energy assets available in the island, capable of being integrated and remotely managed or controlled by the iVPP. • Bidirectional smart meters are installed on buildings and on relevant energy assets, and their readings are available for the iVPP. • There are EVs and charging stations on the islands, including models with the V2G operation mode. • Some charging stations have V2G technology.
Prerequisites
• All available energy assets can be integrated on the iVPP platform. • Communication between charging station and EV is established for all EV types.

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• For the V2G scenario, the EV allows the bidirectional power flow with the grid and is authorized to operate on this mode. • Connection between iVPP and the EV manufacturer API with the battery SoC information. • Communication between all energy assets and the iVPP. • Connection between iVPP and charging stations. • A (physical) hosting environment on which the iVPP can be established.

1.7 Further Information to the use case for classification / mapping

Classification Information
Relation to other use cases
UC1: Community demand-side driven self-consumption maximization. UC4: Demand Side Management and Smart Grid methods to support Power quality and congestion management services.
Level of depth
High level use case
Prioritisation
High level of priority
Generic, regional or national relation
Generic
Nature of the use case
Technical use case
Further keywords for classification
Electric vehicles, V2G, decarbonization, transport sector, smart charging, EV chargers, hydrogen taxis, electric mobility

1.8 General Remarks

General Remarks
-

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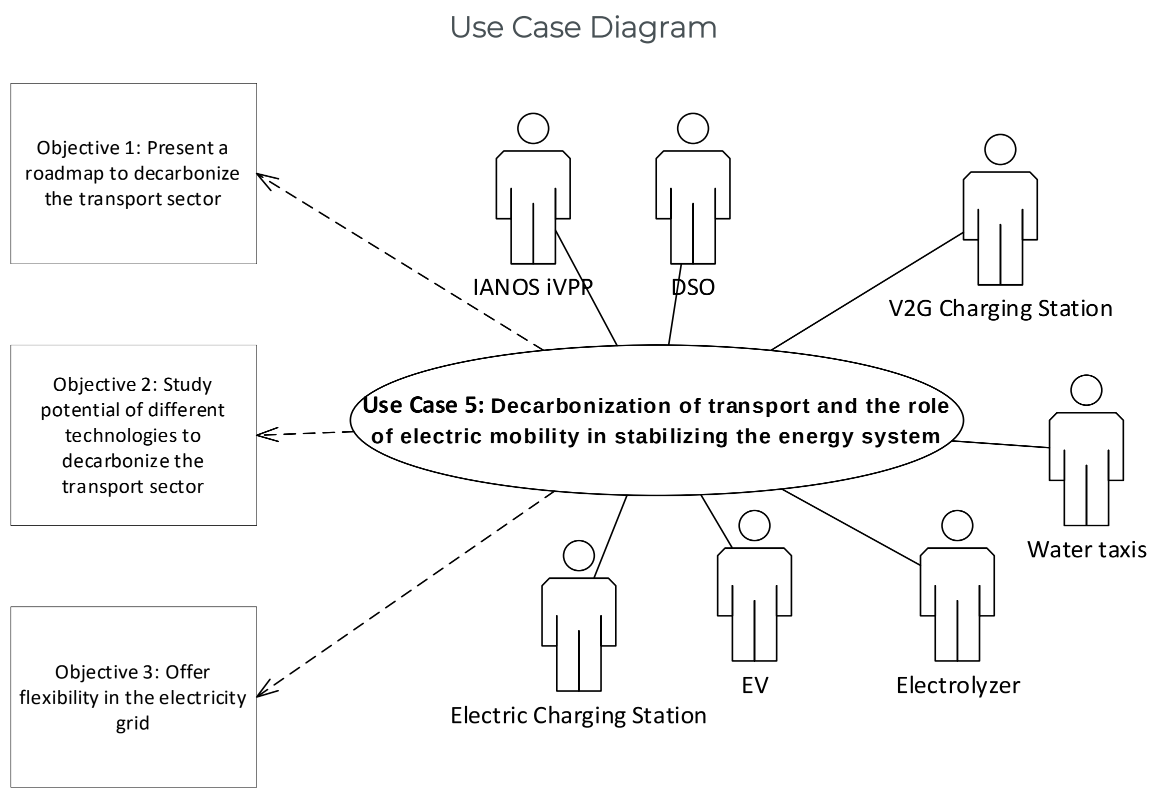
2 Diagrams of use case

Diagram(s) of use case


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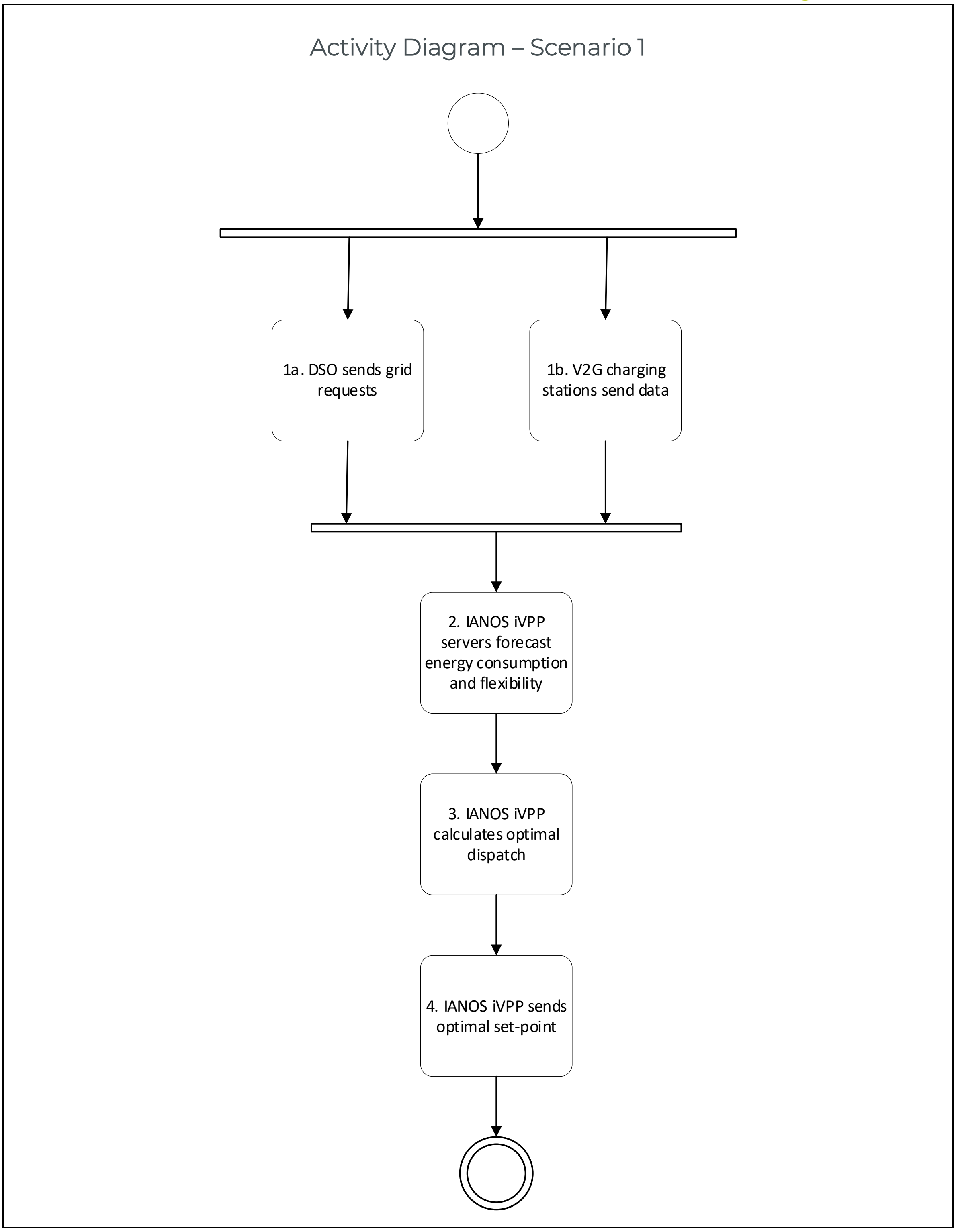

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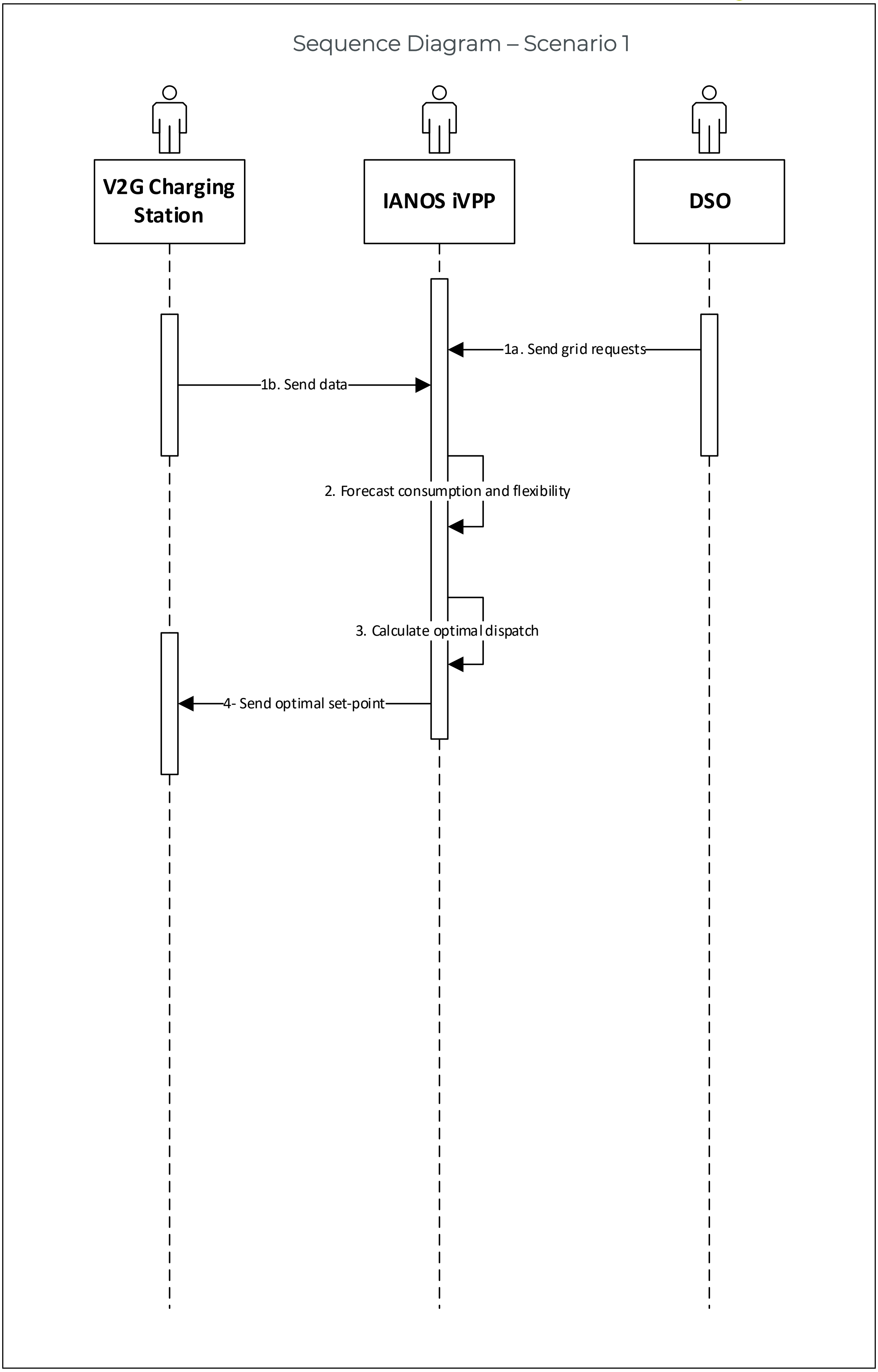

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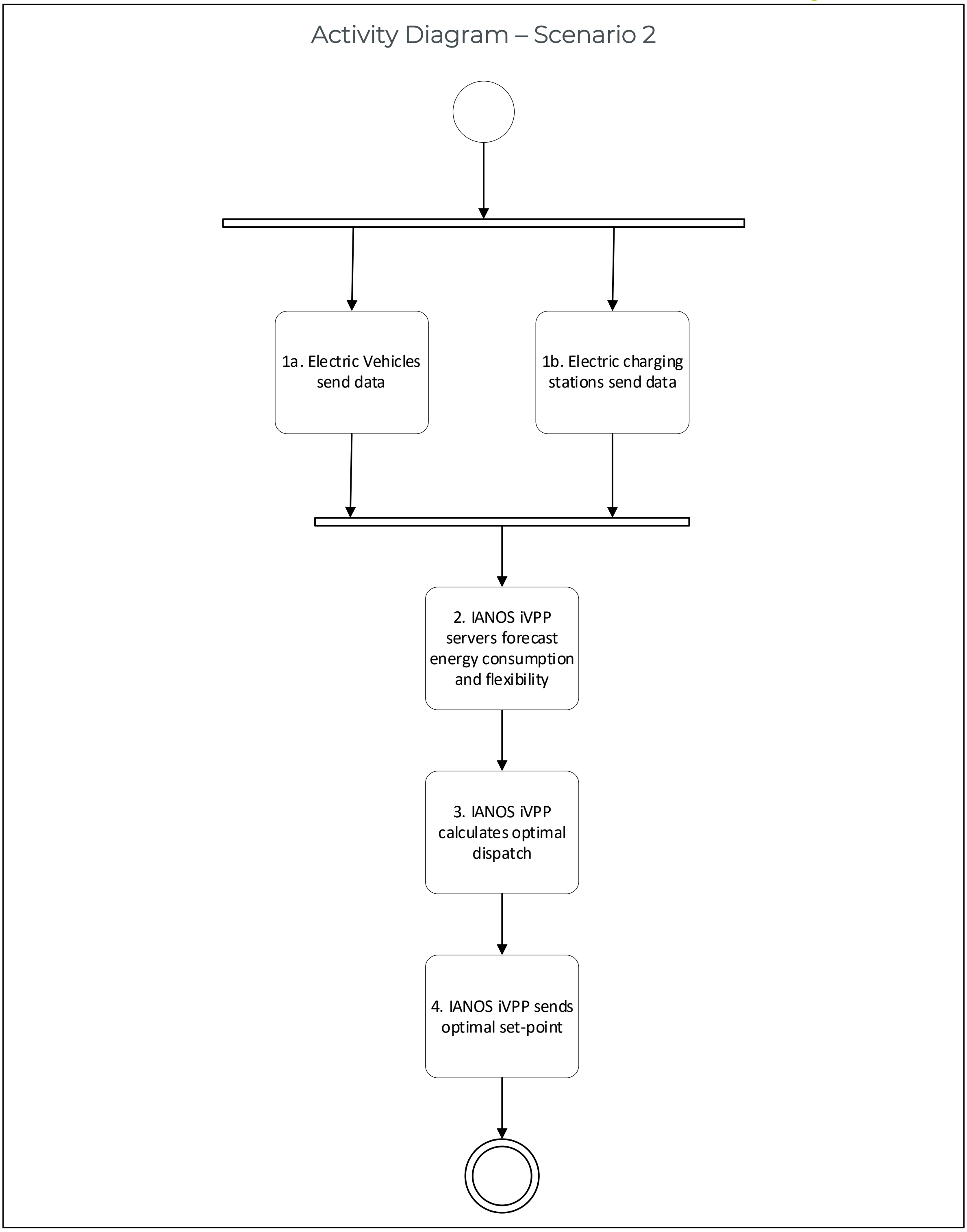

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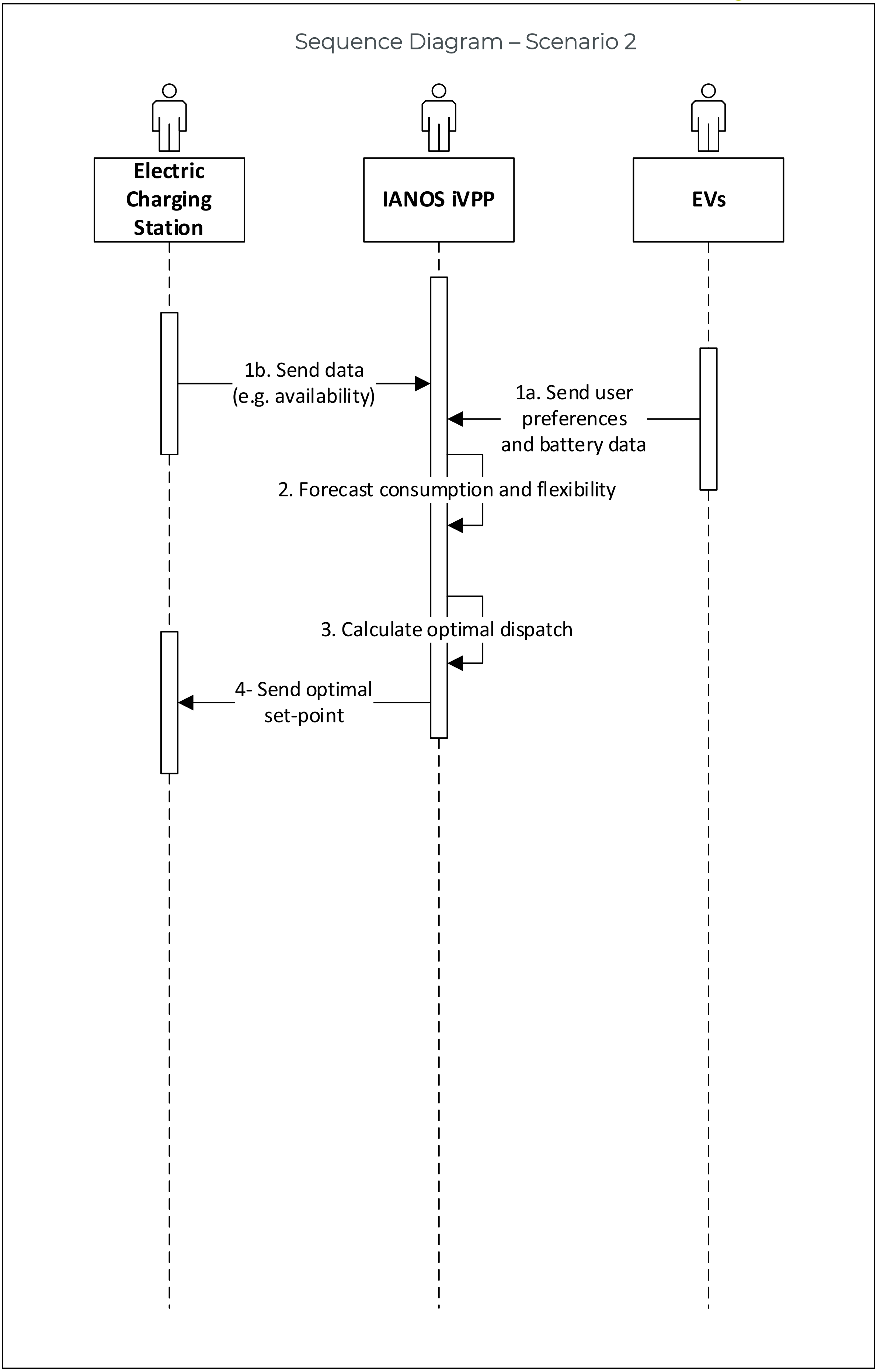

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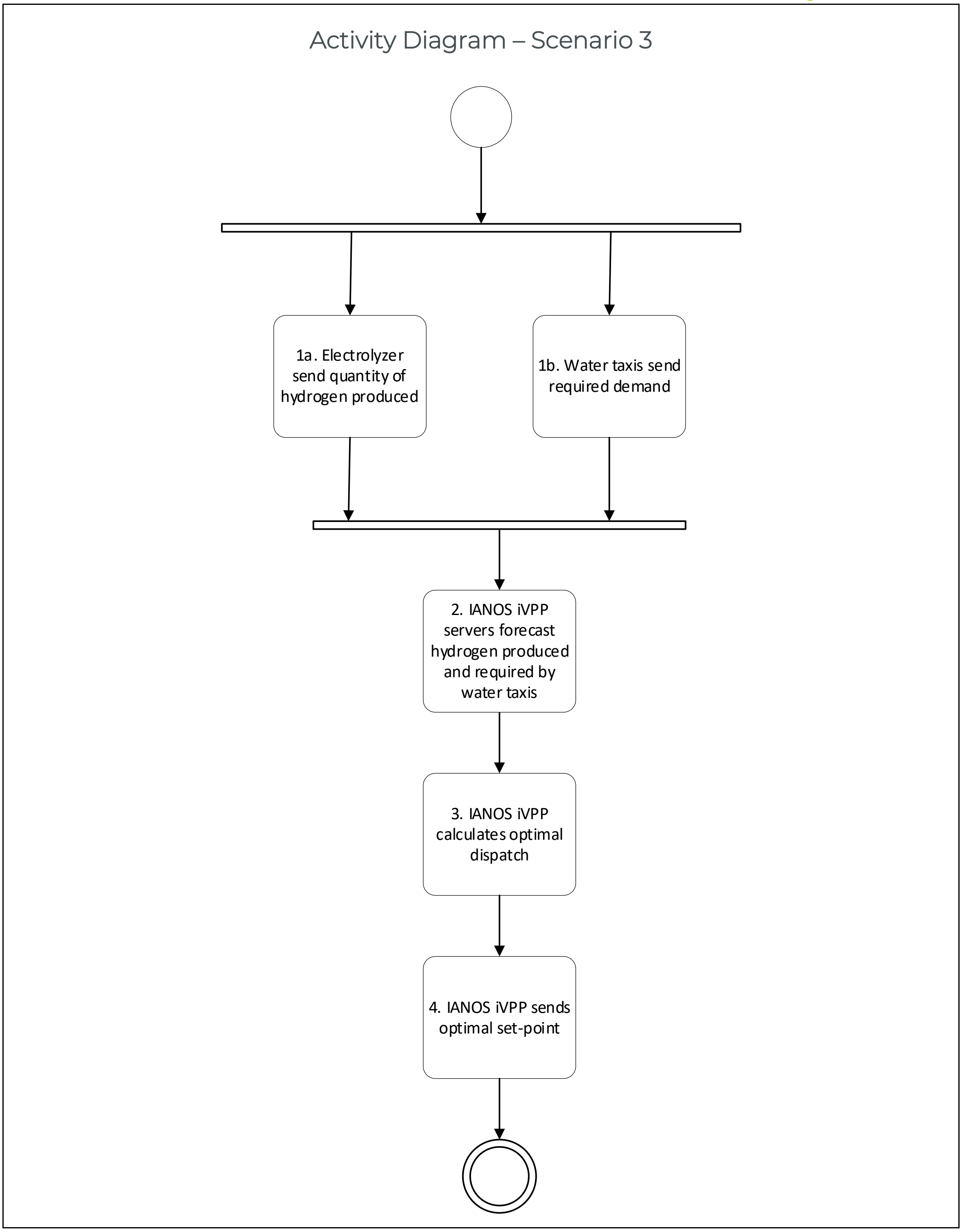
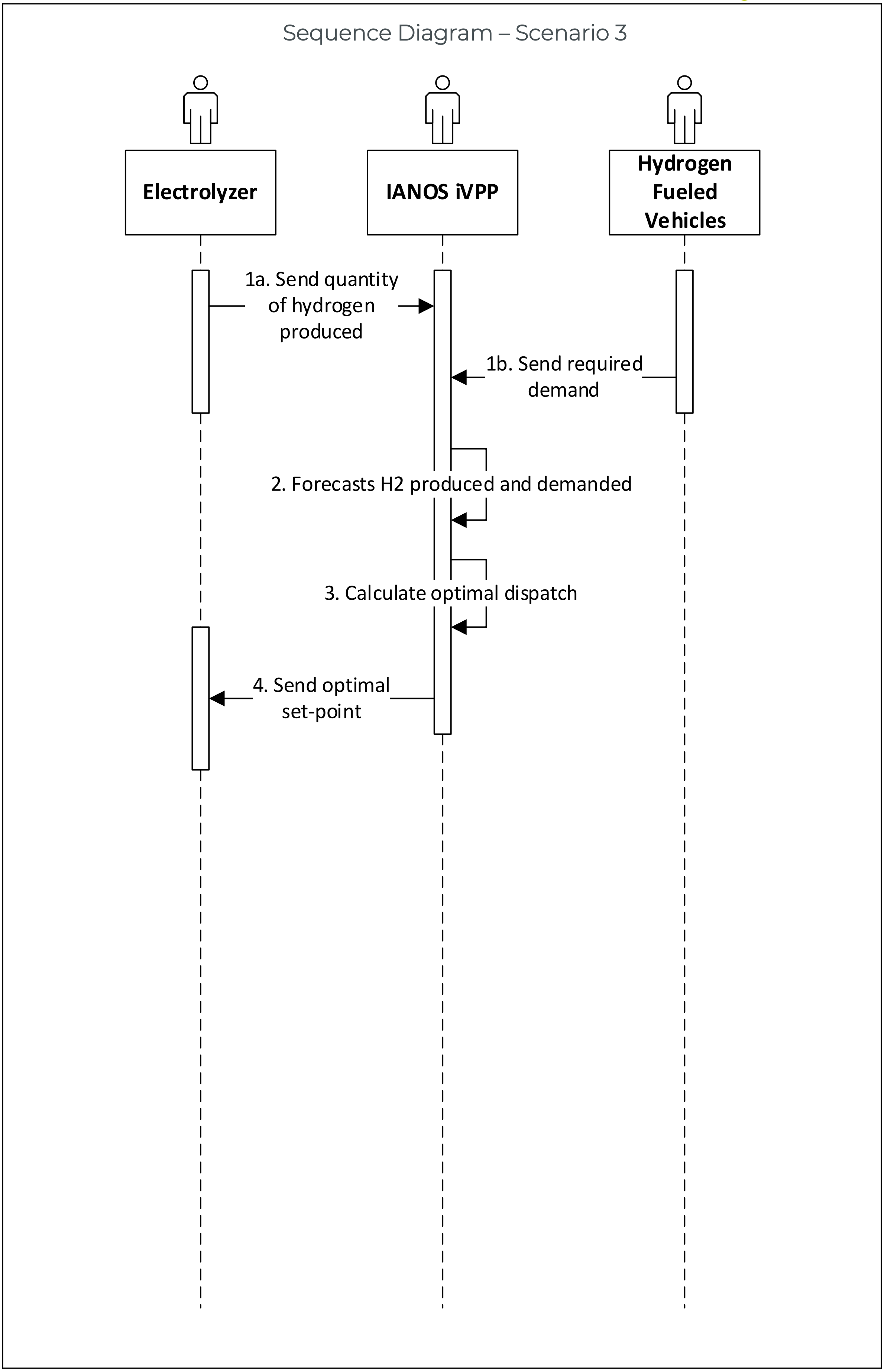

Activity Diagram – Scenario 3
1a. Electrolyzer send quantity of hydrogen produced
1b. Water taxis send required demand
2. IANOS iVPP servers forecast hydrogen produced and required by water taxis
3. IANOS iVPP calculates optimal dispatch
4. IANOS iVPP sends optimal set-point


Sequence Diagram – Scenario 3
Electrolyzer
IANOS iVPP
Hydrogen Fueled Vehicles
1a. Send quantity of hydrogen produced
1b. Send required demand
2. Forecasts H2 produced and demanded
3. Calculate optimal dispatch
4. Send optimal set-point

3 Technical details

3.1 Actors

Actors		
Actor Name	*Actor Type*	*Actor Description*
IANOS iVPP	System	The IANOS iVPP sets up a virtual network of decentralized renewable energy resources, both non-dispatchable such as wind, solar, tidal resources and dispatchable ones such as geothermal and green gas CHP plants. Moreover, the iVPP comprises of Energy Storage Systems (ESS), integrated as a single unit, providing flexibility services and fostering island renewable energy self-consumption. The optimal, autonomous, real-time iVPP operation will be driven by multi-level decision making intelligence, complemented by predictive algorithms for smart integration of grid assets into active network management based on relevant energy profiles. For this purpose, the iVPP is composed of 6 different modules: aggregation & classification, forecasting engine, centralized dispatcher, distributed ledger-based energy transactions, virtual energy console and secured enterprise service bus.
DSO	Role	Distribution System Operator.
V2G Charging Station	System	Bidirectional system that connects an electric vehicle (EV) to a source of electricity. Besides recharging the vehicle's battery, it enables the provision of balancing services.
Electric Charging Station	System	A system that connects an electric vehicle (EV) to a source of electricity to recharge the vehicle's battery.
Electric Vehicle	System	A vehicle with an electric drive and a battery which can be charged at a charging station.

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Electrolyser	System	A system which produces hydrogen from electricity through water electrolysis.
Water Taxis	System	Hydrogen fueled water taxis with a capacity of 12 people.

3.2 References

References						
No.	*References Type*	*Reference*	*Status*	*Impact on use case*	*Originator / organisation*	*Link*

4 Step by step analysis of use case

4.1 Overview of scenarios

Scenario conditions						
No.	Scenario name	Scenario description	Primary actor	Triggering event	Pre-condition	Post-condition
1	The use of V2G for power system stabilization	iVPP is connected to V2G charging stations and manages power fluxes allowing the provision of balancing services to the grid.	IANOS iVPP	EV is connected to the charging station.	Power system requires balancing services. No power fluxes between the grid and the charging station.	V2G charging station charges EVs or provides energy to the grid for balancing services. Power system is stable.

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2	The use of smart charging for power system stabilization	iVPP is connected to electric charging stations and manages power fluxes from the grid to the station considering the end-user profile and ensuring the stability of the power system.	IANOS iVPP	EV is connected to the charging station.	No power fluxes between the electric charging station and the EV.	Electric charging station charges the EV.
3	The use of hydrogen for mobility in order to decarbonize the transport sector	iVPP is connected to the electrolyzer and manages the hydrogen quantity which can be used to fuel hydrogen water taxis and the possible transport mean to transport the hydrogen to water taxis (e.g. trucks).	IANOS iVPP	Available H2 quantities.	Water taxis need to be fuelled.	Transport of H2 from the electrolyser to the water taxis harbour.

4.2 Steps – Scenarios

Scenario							
Scenario name :		*No. 1 - The use of V2G for power system stabilization*					
Step No.	*Event*	*Name of process/ activity*	*Description of process/ activity*	*Service*	*Information producer (actor)*	*Information receiver (actor)*	*Information Exchanged (IDs)*
1a	Submission of grid data	Sends grid requests	DSO sends grid requests to the iVPP.	GET	DSO	IANOS iVPP	1

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1b	Submission of V2G charging station data	Sends data	V2G charging station sends data to the iVPP.	GET	V2G charging station	IANOS iVPP	2,3
2	Data forecast	Forecasts	iVPP servers forecast energy consumption and flexibility.	EXECUTE	IANOS iVPP	IANOS iVPP	4,5
3	Calculation of optimal dispatch	Calculates the optimal dispatch	iVPP computes the optimal dispatch for V2G charging stations in order to ensure energy supply to EVs and also the provision of balancing services to the grid by the V2G chargers when required.	EXECUTE	IANOS iVPP	IANOS iVPP	-
4	Submission of optimal set-points	Sends set-points	iVPP sends the optimal setpoint to the V2G charging stations.	CREATE	IANOS iVPP	V2G charging stations	6

Scenario							
Scenario name :	*No. 2 - The use of smart charging for power system stabilization*						
Step No.	*Event*	*Name of process/ activity*	*Description of process/ activity*	*Service*	*Information producer (actor)*	*Information receiver (actor)*	*Information Exchanged (IDs)*
1a	Submission of EV's data	Send user preferences and battery data	EVs send user preferences and battery data such as SoC.	REPORT	EV	IANOS iVPP	7

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1b	Submission of electric charging station data	Sends data	Electric charging station sends data to the iVPP.	GET	Electric charging station	IANOS iVPP	8,9
2	Data forecast	Forecasts	iVPP servers forecast energy consumption and flexibility.	EXECUTE	IANOS iVPP	IANOS iVPP	4,5
3	Calculation of optimal dispatch	Calculates the optimal dispatch	iVPP computes the optimal dispatch for electric charging stations in order to stabilize the energy system while simultaneously ensuring user's preferences and requirements.	EXECUTE	IANOS iVPP	IANOS iVPP	-
4	Submission of optimal set-points	Sends set-point	iVPP sends the optimal set-point to the electric charging stations.	CREATE	IANOS iVPP	Electric charging stations	10

Scenario							
Scenario name :		*No. 3 - The use of hydrogen for mobility in order to decarbonize the transport sector*					
Step No.	*Event*	*Name of process/ activity*	*Description of process/ activity*	*Service*	*Information producer (actor)*	*Information receiver (actor)*	*Information Exchanged (IDs)*
1a	Submission of electrolyser data	Send quantity of hydrogen produced	Electrolyser sends quantity of hydrogen produced to the iVPP.	GET	Electrolyser	IANOS iVPP	11

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1b	Submission of hydrogen fuelled vehicles data	Sends required demand	Hydrogen fuelled vehicles send required demand to the iVPP.	GET	Water Taxis	IANOS iVPP	12
2	Data forecast	Forecasts	iVPP servers forecast hydrogen produced and hydrogen required for transportation.	EXECUTE	IANOS iVPP	IANOS iVPP	13,14
3	Calculation of optimal dispatch	Calculates the optimal dispatch	iVPP computes the optimal dispatch for the electrolyser in order to ensure hydrogen fuelled vehicles demand.	EXECUTE	IANOS iVPP	IANOS iVPP	-
4	Submission of optimal set-points	Sends set-points	iVPP sends the optimal setpoint to the electrolyser.	CREAT	IANOS iVPP	Electrolyser	15

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5 Information exchanged

Information exchanged		
Information exchanged (ID)	*Name of information*	*Description of information exchanged*
1	Grid Requests	Grid requests.
2	V2G charging station real-time data	Availability, EV battery state of charge, charging current, etc..
3	V2G charging station hard technical constraints	Rated power, etc..
4	Forecasted Energy Consumption Data	EV's forecasted energy consumption data.
5	Forecasted Flexibility Data	Forecasted flexibility from EVs.
6	Optimal Setpoints for V2G charging stations	Optimal energy dispatch computed by the iVPP for V2G charging stations. It is the amount of power from the grid that will be provided to the V2G charger to charge EVs or to be stored for later use. Moreover, it may also represent the amount of energy used for providing balancing services to the grid from the V2G charger (if the EV allows the bidirectional power flow with the grid and is authorized to operate on this mode).
7	EV data	User preferences, battery SoC.
8	Electric charging station real-time data	Availability, charging current, etc..
9	Electric charging station hard technical constraints	Rated power, etc..
10	Optimal Setpoints for electric charging stations	Optimal energy dispatch computed by the iVPP for electric charging stations. It is the amount of power from the grid that will be provided to the

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		electric charger to charge EVs or to be stored for later use. Additionally, it may also represent the start and the end of the charging and discharging modes.
11	Hydrogen quantity	Hydrogen produced at real-time.
12	Hydrogen fuelled vehicles demand	Hydrogen consumption and expected demand from hydrogen fuelled vehicles.
13	Forecasted H2 production	Forecasted hydrogen production from the electrolyser.
14	Forecasted H2 demand	Forecasted hydrogen demand from water taxis.
15	Optimal Set-point for electrolyser	Optimal power dispatch computed by the iVPP for the electrolyser. It corresponds to the amount of hydrogen that should be transported to hydrogen fuelled vehicles to meet their demand.

6 Requirements

Requirements		
Categories ID	Category name for requirements	Category description
R-FUN	Functional Requirement	Requirements that capture the intended behaviour of the system.
R-COM	Communication Requirement	Requirements related to communication aspects.
R-UI	User Interface Requirement	Requirements related to the iVPP UI.
R-SEC.	Security Requirement	Requirements related to the safety issues.
Requirement R-ID	Requirement name	Requirement description
R-FUN1	Charging/discharging constraints	Defines the period for charging/discharging the EV, including the considerations related to the user authorisation

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		and battery SoC expectation after the charging process.
R-FUN2	Receive Operator's requests	iVPP having the ability to receive requests for service activation (e.g. congestion management) from System Operator (TSO or DSO).
R-FUN4	Activation of iVPP EV assets to provide secondary regulation	iVPP having the ability to activate EVs to provide Frequency Restoration Reserves (FRR) within 5-15 minutes.
R-FUN5	Activation of iVPP EV assets to provide voltage support	EV battery inverter can be automatically triggered to provide voltage control within seconds.
R-COM1	Common Information Model	iVPP adopts a common information model to exchange data ensuring interoperability
R-COM2	iVPP minimum communication requirements	Bandwidth and latency are ensured to follow min. requirements according to the level of service to be delivered (e.g. mFRR, aFRR).
R-UI1	Graphical visualization of iVPP operation	iVPP operation can be visually inspected through the use of KPIs.
R-UI2	Reporting	iVPP can produce reports on system performance upon iVPP Operator request.
R-SEC1	Access Control	iVPP functions are accessible from personnel with specialized authorization rights.
R-SEC2	iVPP cybersecurity	Utilization of good practices (e.g. secure communication bus) to enhance data cybersecurity.

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R-SEC3	iVPP data privacy	Utilization of good practices to ensure compliance with GDPR regulations.

7 Common Terms and Definitions

Common Terms and Definitions	
Term	**Definition**
DER	Distributed Energy Resource
EV	Electric Vehicle
GDPR	General Data Protection Regulation
iVPP	Intelligent Virtual Power Plant
LV	Low Voltage
MV	Medium Voltage
RES	Renewable Energy Sources
SGAM	Smart Grid Architecture Model
SoC	State of Charge
UC	Use Case
UI	User Interface
V2G	Vehicle-to-grid

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6.2.2 Use case 6: Decarbonising large industrial continuous loads through electrification and locally induced generation

1 Description of the use case

1.1 Name of the use case

ID	*Area / Domain(s)*	*Name of Use Case*
6	Decarbonization through electrification and support from non-emitting fuels	Decarbonising large industrial continuous energy consumers through electrification and local generation

1.2 Version management

Version Management			
Version No.	*Date*	*Name of Author(s)*	*Changes*
1	04.02.2021	EDP NEW	First draft.
2	05.02.2021	Nikolaos Nikolopoulos (CERTH)	Comments and inputs on the Narrative of the Use Case, Diagrams Suggestion of inclusion of information regarding protocols for communication/information data exchange according to SGAM architecture.
3	12.02.2021	Bastiaan Vreijsen (NEROA), Luuk Meijer (NEROA)	Comments on the Narrative of the Use Case, Diagrams.
4	25.02.2021	Mónica Fernandes (EDP NEW)	Collect all the feedback and start second version. Add SGAM layers characterization and requirements. Improve diagrams, description, information exchanged and scenarios.

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5	29.04.2021	Mónica Fernandes (EDP NEW)	KPIs added from D2.3. Collecting the new feedback.
6	10.05.2021	Mónica Fernandes (EDP NEW)	Final Version.
7	01.04.2022	Mónica Fernandes (EDP NEW)	Minor changes and updates on the KPIs.
8	15.04.2022	Ana Carvalho (EDP NEW)	Revision and start of the third version.
9	16/09/2022	Vasilis Apostolopoulos (CERTH)	Corrections to KPI numbering according to final version of D2.9.

1.3 Scope and objectives of use case

Scope and Objectives of Use Case	
Scope	The scope of this Use Case is to use electrification and local generation for decarbonizing large industrial energy consumers located in the islands. This Use Case is limited to the decarbonization of the natural gas platform located off the coast of Ameland.
Objective	This Use Case orients at decarbonising large industrial sites which tend to be very difficult sites to eliminate emissions, due to their requirements for stable electricity. Therefore, the main objectives are the following: 1. Maximize consumption from local RES. 2. Decarbonize the industrial sector.

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1.4 Narrative of use case

Narrative of Use Case
Short description
The present use case aims to decarbonize large industrial continuous and power intensive energy consumers, either located in the island or interconnected as in the case of the AWG natural gas platform off the coast of Ameland. The electrification and local renewable generation will be the main drivers to reach decarbonization in this site and will allow the maximization of renewable sources in the local grid.
Complete description
This use case intends to explore means to decarbonize large industrial sites which have a huge impact on global emissions due to their high levels of energy consumption. In Ameland, there is the AWG natural gas platform which is located off the coast of Ameland and will be electrified until the end of 2022. For this purpose, its gas-powered modules will be replaced by electric drives and the facilities will be connected to Ameland's electricity grid. This use case focuses on supporting the decarbonization process of the AWG platform, by exploring the potential of local renewable generation such as tidal, wind and solar to replace fossil-based power consumed by the platform. Furthermore, fuel cells and CHP also contribute to the provision of flexibility to the system and thereby allowing the maximization of renewable energy penetration. The intelligent Virtual Power Plant (iVPP) is responsible for distributing energy throughout the whole of Ameland. Since the demand of electricity from the AWG platform has a big impact on the energy supply of the island, the iVPP needs to safeguard a steady flow of energy to this platform. The iVPP has a facilitating role in making the AWG platform as green as possible by contributing to the maximization of renewable energy utilization. For this purpose, the iVPP optimizes energy flows to the platform by sending set-points to the dispatchable assets (fuel cells and CHP) according to the data that will be received from the platform, the dispatchable and the non-dispatchable assets.

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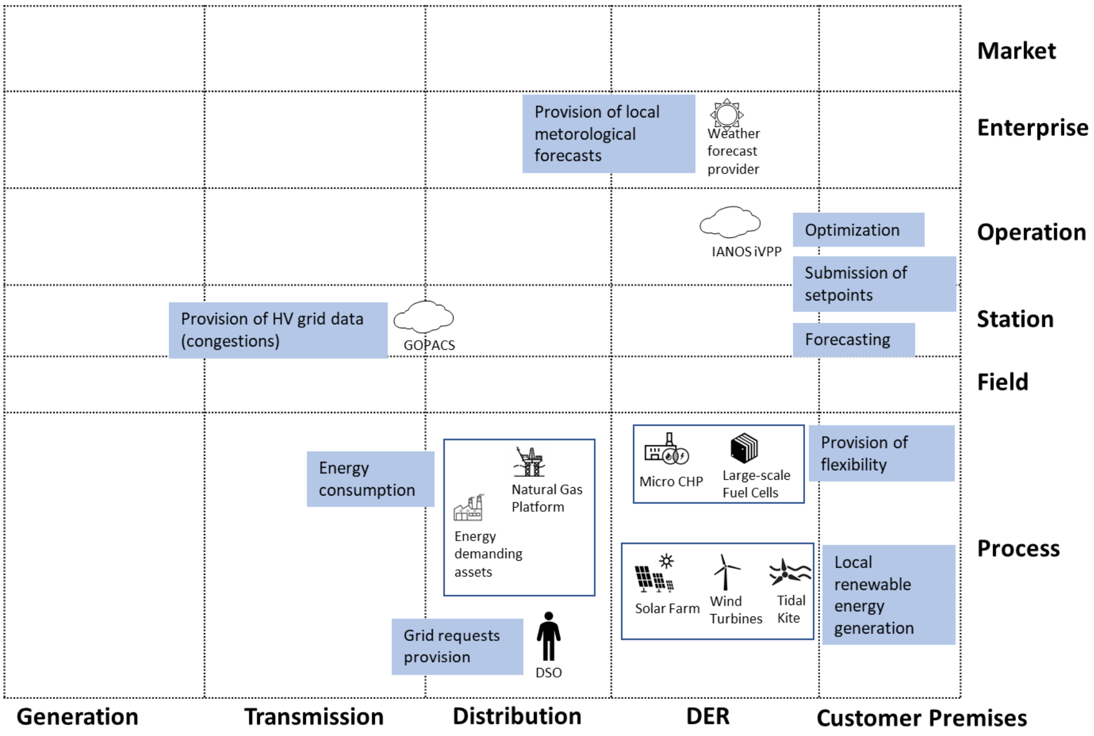
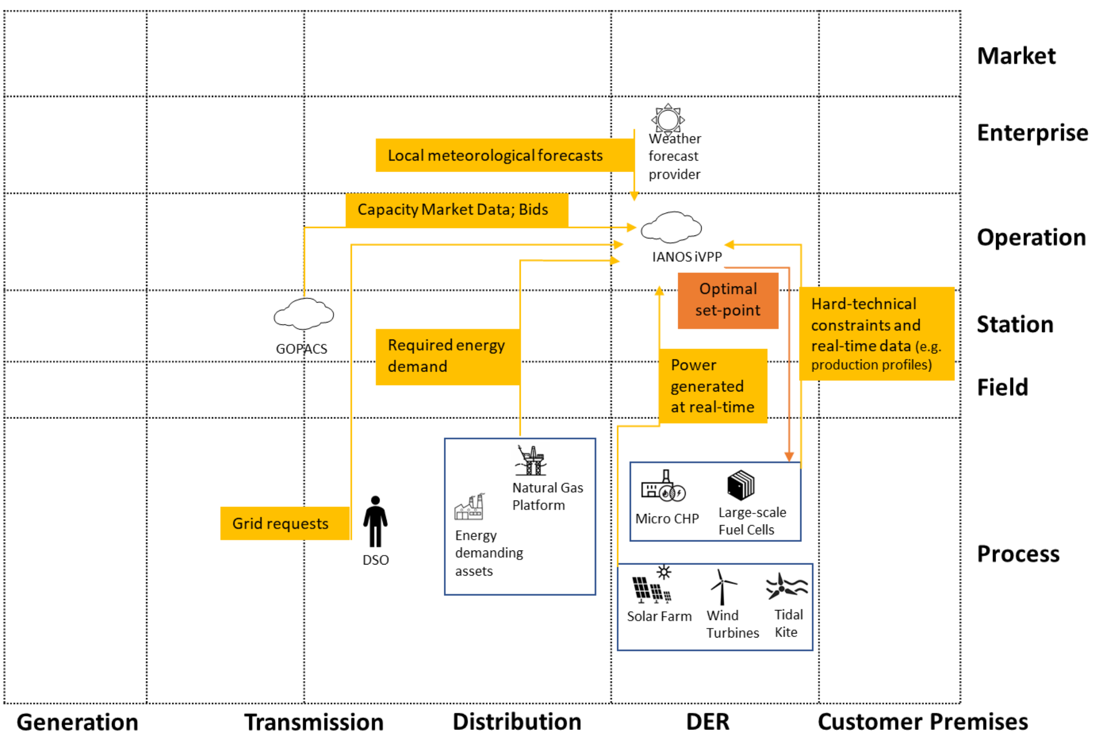
SGAM LAYERS:

Function Layer



Information Layer



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Technological Solutions	Information / Communication Protocols	Ameland
Large-scale Fuel Cell	-	x
Micro CHP	-	x
Solar Farm	-	x
Wind Turbines	-	x
Tidal Kite	-	x
AWG Natural Gas Platform	-	x

1.5 Key performance indicators (KPI)

ID	*Name*	*Description*	*Reference to mentioned use case objectives*
1.5	Degree of energetic self-supply by RES	Ratio of locally produced energy from RES and the final energy consumption over a period of time (e.g. month, year).	1
2.1	Reduced Greenhouse Gas Emissions	In different variants of this indicator the emissions caused by the production of the system components are included or excluded. In this case, it measures the reduction of greenhouse gas emissions in the industrial sector.	2
2.2	Reduced fossil fuel consumption	Measures the amount of fossil fuels which is now not consumed in the industrial sector because of IANOS demonstrated solutions.	2
7.2	Technical compatibility	Examines the extent to which the smart grid solutions fit with the current existing technological standards/infrastructures.	2
7.3	Ease of use for end users of the solution	Provides an indication of the complexity of the implemented solution within the IANOS project for the end-users.	2

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1.6 Use case conditions

Use case conditions
Assumptions
• It is considered that the island has a natural gas platform. • The connection between the platform and the electricity grid of Ameland is established. • The platform will be electrified in the end of 2021.
Prerequisites
• Direct connection between the iVPP, the solar farm and the platform. • Direct connection between the iVPP, the tidal kite and the platform. • Direct connection between the iVPP, the small turbines and the platform. • Direct connection between the iVPP, the CHP systems and Fuel cells and the platform. • A (physical) hosting environment on which the iVPP can be established.

1.7 Further Information to the use case for classification / mapping

Classification Information
Relation to other use cases
-
Level of depth
Specialised use case
Prioritisation
High level of priority
Generic, regional or national relation
Generic
Nature of the use case
Technical use case
Further keywords for classification
Decarbonization, industry, natural gas platform, tidal kite, local renewable generation, wind turbines, solar farm, grid connection, electrification

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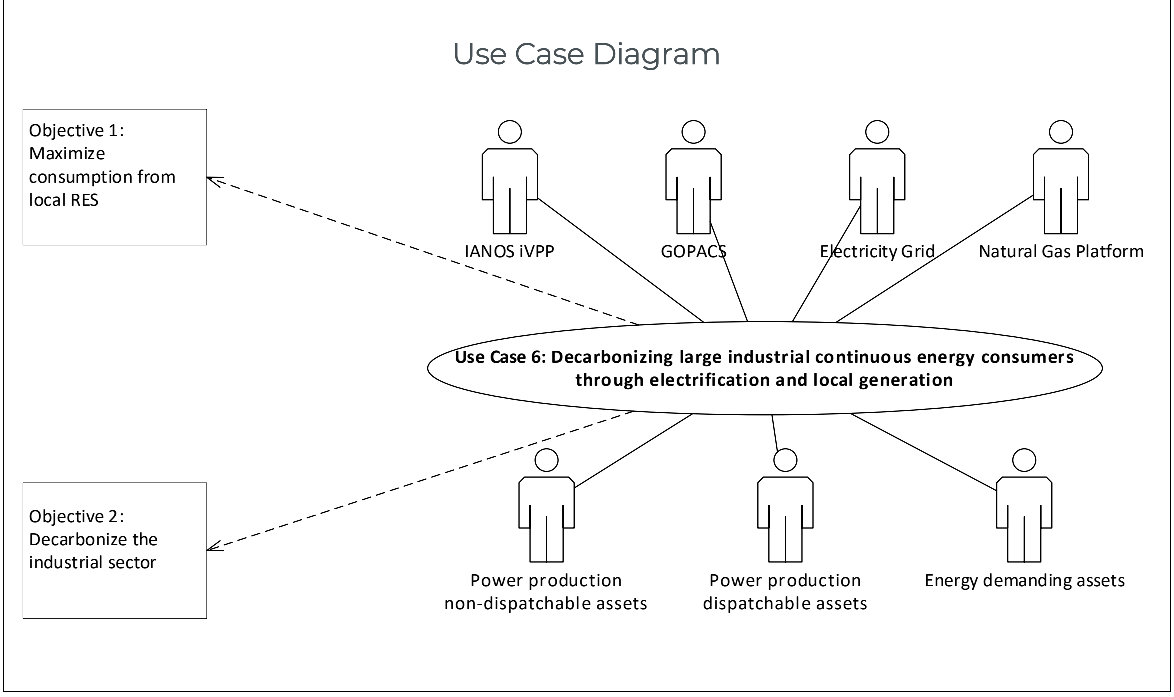
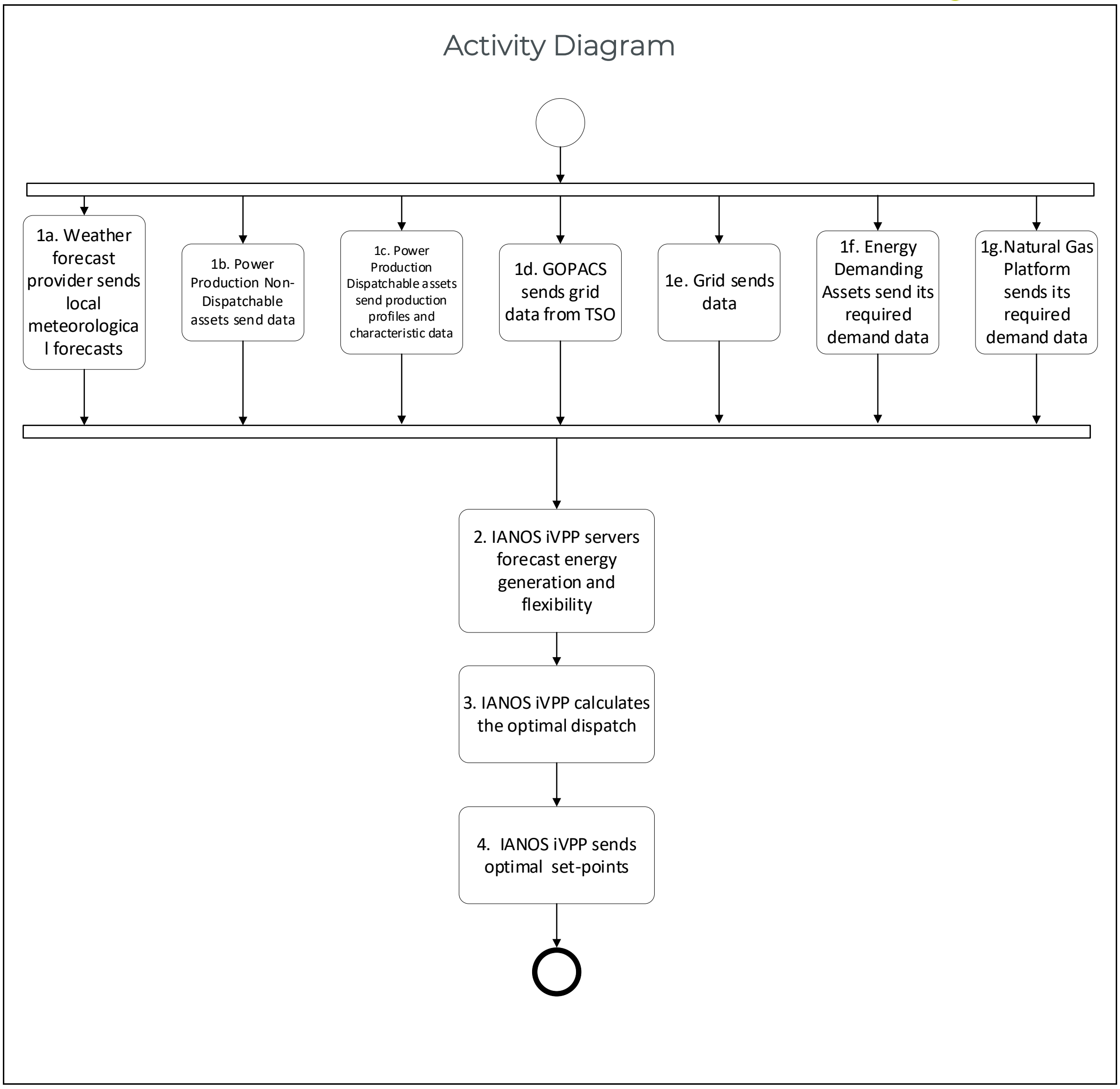
1.8 General Remarks

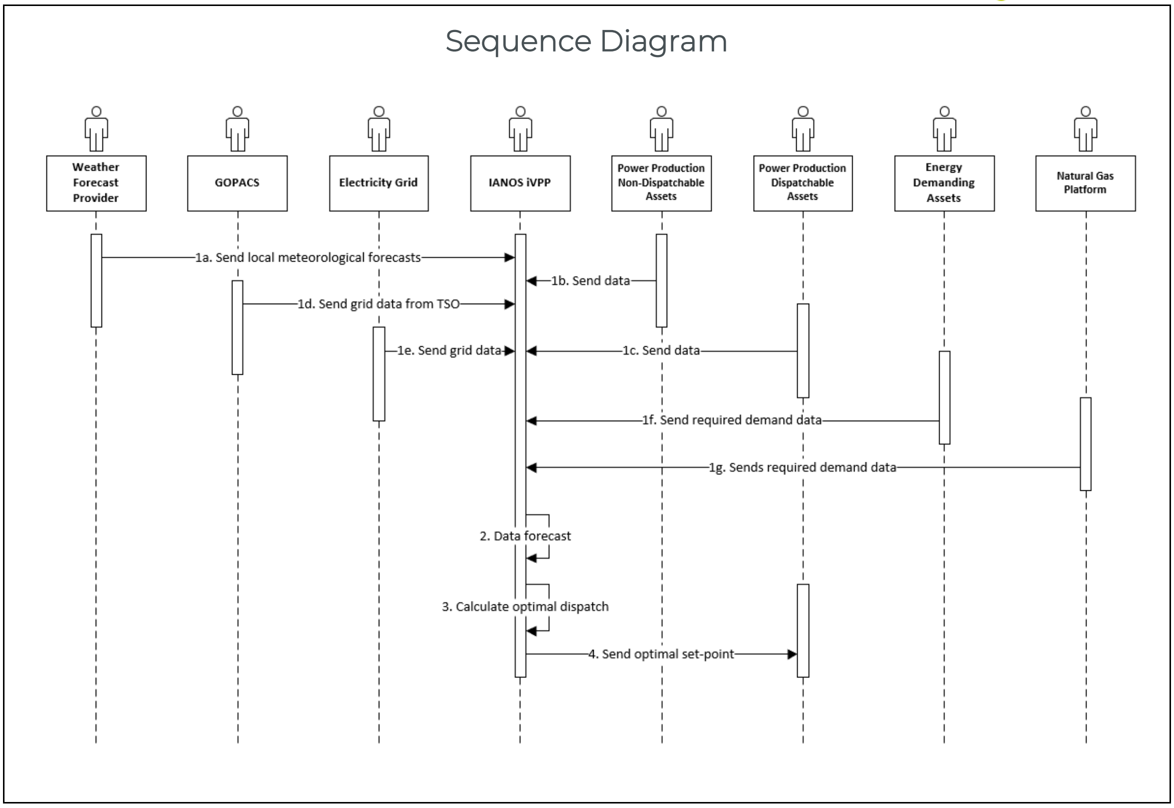
General Remarks
-

2 Diagrams of use case

Diagram(s) of use case




Activity Diagram
1a. Weather forecast provider sends local meteorologica l forecasts
1b. Power Production Non-Dispatchable assets send data
1c. Power Production Dispatchable assets send production profiles and characteristic data
1d. GOPACS sends grid data from TSO
1e. Grid sends data
1f. Energy Demanding Assets send its required demand data
1g.Natural Gas Platform sends its required demand data
2. IANOS iVPP servers forecast energy generation and flexibility
3. IANOS iVPP calculates the optimal dispatch
4. IANOS iVPP sends optimal set-points



Sequence Diagram
Weather Forecast Provider
GOPACS
Electricity Grid
IANOS iVPP
Power Production Non-Dispatchable Assets
Power Production Dispatchable Assets
Energy Demanding Assets
Natural Gas Platform
1a. Send local meteorological forecasts
1b. Send data
1d. Send grid data from TSO
1e. Send grid data
1c. Send data
1f. Send required demand data
1g. Sends required demand data
2. Data forecast
3. Calculate optimal dispatch
4. Send optimal set-point

3 Technical details

3.1 Actors

Actors		
Actor Name	*Actor Type*	*Actor Description*
Weather Forecast Provider	Role	Provides generation, consumption and weather-related operational risks, for a given location and a specific time horizon.
IANOS iVPP	System	The IANOS iVPP sets up a virtual network of decentralized renewable energy resources, both non-dispatchable such as wind, solar, tidal resources and dispatchable ones such as geothermal and green gas CHP plants. Moreover, the iVPP comprises of Energy Storage Systems (ESS), integrated as a single unit, providing flexibility services and fostering island renewable energy self-consumption. The optimal, autonomous, real-time iVPP operation will be driven by multi-level decision making intelligence, complemented by predictive algorithms for smart integration of grid assets into active network management based on relevant energy profiles. For this purpose, the iVPP is composed of 6 different modules: aggregation and classification, forecasting engine, centralized dispatcher, distributed ledger-based energy transactions, virtual energy console and secured enterprise service bus.
GOPACS	System	Grid Operation Platforms for Congestion Solutions interface (GOPACS) is a unique initiative in Europe and has resulted from active collaboration between the Dutch TSO and the DSOs. This platform is consistent with key European directives to mitigate grid congestion, while offering

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		large and small market parties an easy way to generate revenues with their available flexibility and contribute to solving congestion situations.
Electricity Grid	System	Power system including power generation units, transmission system and MV/LV distribution grids.
Natural Gas Platform	System	Power intensive energy consumers from the industrial sector. In the case of Ameland, there is a Natural gas platform located in Ameland's coast which has been operated by the Nederlandse Aardolie Maatschappij (NAM) since 1986. Current natural gas production is close to 1 million m^3/day, of which 100k m^3/day is used as fuel to power the platform (mainly compression).
Energy demanding assets	System	Energy demanding assets of the island.
Power production dispatchable assets	System	Assets whose power can be dispatched on demand at the request of grid operators when needed. For instance fuel cells and CHPs.
Power production non-dispatchable assets	System	Local power generation assets whose power cannot be controlled by grid operators such as wind, solar and tidal power generators.

3.2 References

References						
No.	*References Type*	*Reference*	*Status*	*Impact on use case*	*Originator / organisation*	*Link*

4 Step by step analysis of use case

4.1 Overview of scenarios

Scenario conditions						
No.	Scenario name	Scenario description	Primary actor	Triggering event	Pre-condition	Post-condition
1	Electrification of Natural gas Platform	iVPP computes the optimal setpoint for production dispatchable assets to supply energy to all energy demanding assets present in the island (including the natural gas platform), while ensuring the maximization of renewable penetration in the power system.	IANOS iVPP	Natural Gas Platform runs on electricity.	Natural Gas Platform requires electricity to operate.	Steady energy flux of natural gas platform.

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4.2 Steps – Scenarios

Scenario								
Scenario name :		*No. 1 - Reference scenario*						
Step No.	*Event*	*Name of process/ activity*	*Description of process/ activity*	*Service*	*Information producer (actor)*	*Information receiver (actor)*	*Information Exchanged (IDs)*	*Requirement, R-IDs*
1a	Submission of local weather forecasts	Send local meteorological forecasts	Weather Forecast Provider sends local meteorological forecasts.	CREATE	Weather Forecast provider	IANOS iVPP	1	
1b	Submission of power production non-dispatchable assets data	Sends data	Power Production Non-Dispatchable Assets send real-time data to the iVPP regarding its status.	GET	Power Production Non-Dispatchable Asses	IANOS iVPP	2	
1c	Submission of power production dispatchable assets data	Sends data	Power Production Dispatchable Assets send real-time data to the iVPP regarding its status.	GET	Power Production Dispatchable Asses	IANOS iVPP	3,4	
1d	Submission of	Send grid data	GOPACS exchange high voltage	REPORT	GOPACS	IANOS	5	

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	grid data from TSO	from TSO	grid data with iVPP.			iVPP		
1e	Submission of grid data	Send grid data	Grid sends data regarding its status to the iVPP.	GET	Electricity Grid	IANOS iVPP	6	
1f	Submission of required demand data from energy demanding assets	Send data	Energy demanding assets send its required demand data to the iVPP.	REPORT	Energy Demanding Assets	IANOS iVPP	7	
1g	Submission of required demand data from the natural gas platform	Sends data	Natural Gas platform sends data regarding its required demand to the iVPP.	REPORT	Natural gas platform	IANOS iVPP	8	
2	Data forecast	Forecasts	iVPP servers forecast energy generation and flexibility.	EXECUTE	IANOS iVPP	IANOS iVPP	9,10	
3	Calculation of optimal dispatch	Calculates the optimal dispatch	iVPP computes the optimal dispatch for the dispatchable assets in order to ensure a steady energy flux for all the assets present in the island and a maximum penetration of the RES in the power system.	EXECUTE	IANOS iVPP	IANOS iVPP	-	

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4	Submission of optimal set-points	Sends set-points	iVPP sends the optimal setpoint to the dispatchable assets.	CREATE	IANOS iVPP	Dispatch able Assets	11	

5 Information exchanged

Information exchanged		
Information exchanged (ID)	*Name of information*	*Description of information exchanged*
1	Local meteorological forecasts	Expected irradiances and wind speeds for specific locations.
2	Non-Dispatchable assets data	Amount of energy (MWh) generated by non-dispatchable generator assets (wind, solar and tidal) in real-time.
3	Fuel Cells and CHP hard technical constraints	Maximum power, electrical and thermal efficiency, heat to power ratio and operating temperature.
4	Fuel Cells and CHP real-time data	Amount of existent fuel (hydrogen or methane) and production profiles.
5	HV grid data	High voltage grid real-time data.
6	Grid data	Grid status.
7	Energy demanding data	Required demand from energy demanding assets.
8	Natural gas platform required demand	Energy consumption and required demand from natural gas platform.
9	Forecasted Energy Generation Data	Forecasted energy supply data from production-side assets (wind, solar and tidal generators, fuel cells and micro CHP).
10	Forecasted Flexibility Data	Forecasted flexibility from production units and energy demanding assets.
11	Optimal Setpoints	Optimal power dispatch computed by the iVPP for dispatchable assets such as fuel cells and CHPs.

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6 Requirements

Requirements		
Categories ID	Category name for requirements	Category description
R-SEC.	Security Requirement	Requirements related to the safety issues.
R-UI	User Interface Requirement	Requirements related to the iVPP UI.
R-FUN	Functional Requirement	Requirements that capture the intended behaviour of the system.
R-COM	Communication Requirement	Requirements related to communication aspects.
Requirement R-ID	Requirement name	Requirement description
R-SEC1	Access Control	iVPP functions are accessible from personnel with specialized authorization rights.
R-SEC2	iVPP cybersecurity	Utilization of good practices (e.g. secure communication bus) to enhance data cybersecurity.
R-SEC3	iVPP data privacy	Utilization of good practices to ensure compliance with GDPR regulations.
R-UI1	Graphical visualization of iVPP operation	iVPP operation can be visually inspected through the use of KPIs.
R-UI2	Reporting	iVPP can produce reports on system performance upon iVPP Operator request
R-FUN1	Day-ahead generation forecast	iVPP can predict the generation of its assets for the following day.
R-FUN2	Intraday generation forecast	iVPP can predict the generation of its assets within the day.

R-FUN3	Flexibility estimation	iVPP can estimate the dispatchable production units' flexibility.
R-COM1	Common Information Model	iVPP adopts a common information model to exchange data ensuring interoperability.

7 Common Terms and Definitions

Common Terms and Definitions	
Term	**Definition**
CHP	Combined Heat and Power
DER	Distributed Energy Resources
GOPACS	Grid Operation Platforms for Congestion Solutions
GPDR	General Data Protection Regulation
iVPP	Intelligent Virtual Power Plant
SGAM	Smart Grid Architecture Model
TSO	Transmission System Operator
UC	Use Case
UI	User Interface

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6.2.3 Use case 7: Circular economy, utilization of waste streams and gas grid decarbonization

1 Description of the use case

1.1 Name of the use case

ID	Area / Domain(s)	Name of Use Case
7	Decarbonization through electrification and support from non-emitting fuels	Circular economy, the utilisation of waste streams and connection to the local gas grid

1.2 Version management

Version Management			
Version No.	Date	Name of Author(s)	Changes
1	04.02.2021	EDP NEW	First draft.
2	05.02.2021	Nikolaos Nikolopoulos (CERTH)	Comments and inputs on the Narrative of the Use Case, Diagrams, Actors, Scenarios Suggestion of inclusion of information regarding protocols for communication/information data exchange according to SGAM architecture.
3	15.02.2021	Johan Boekema (AME)	Comments and inputs on Scope and Objectives of Use Case, the Narrative of the Use Case, Diagrams, Scenarios, Information Exchanged. Add digester's data.
4	25.02.2021	Mónica Fernandes (EDP NEW)	Collect all the feedback and start second version. Add SGAM layers characterization and requirements.

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			Improve diagrams, description, information exchanged and scenarios.
5	29.04.2021	Mónica Fernandes (EDP NEW)	KPIs added from D2.3. Collect the new feedback.
6	10.05.2021	Mónica Fernandes (EDP NEW)	Final Version.
7	01.04.2022	Mónica Fernandes (EDP NEW)	Minor changes and updates on the KPIs. Changes on the description of the Use Case.
8	18.07.2022	Ana Carvalho (EDP NEW)	Revision and start of the third version.
	16.09.2022	Vasilis Apostolopoulos (CERTH)	Corrections to KPI numbering according to final version of D2.9.

1.3 Scope and objectives of use case

Scope and Objectives of Use Case	
Scope	This use case is limited to the use of the small-scale digester in Ameland and the research into remaining waste streams with potential to produce green energy.
Objective	The main objectives of this Use Case are the following: 1. Reduce the negative impact of waste streams produced on the island by reusing them to produce green energy. 2. Foster gas and electricity grid decarbonization.

1.4 Narrative of use case

Narrative of Use Case
Short description
The present use case describes how waste streams are used to produce renewable energy and help to decarbonize the local grid, either for electricity production and/or heating purposes, using green natural gas. Therefore, a demonstration of a digester will occur at Ameland to exploit the potential of converting organic waste into green

natural gas, while hydrogen produced from the Electrolyser (using excess of RES) can be used to upgrade the remaining CO2 in the digester to natural gas.

Moreover, an investigation regarding the potential of technologies to process biomass for using the remaining streams is also performed.

Complete description

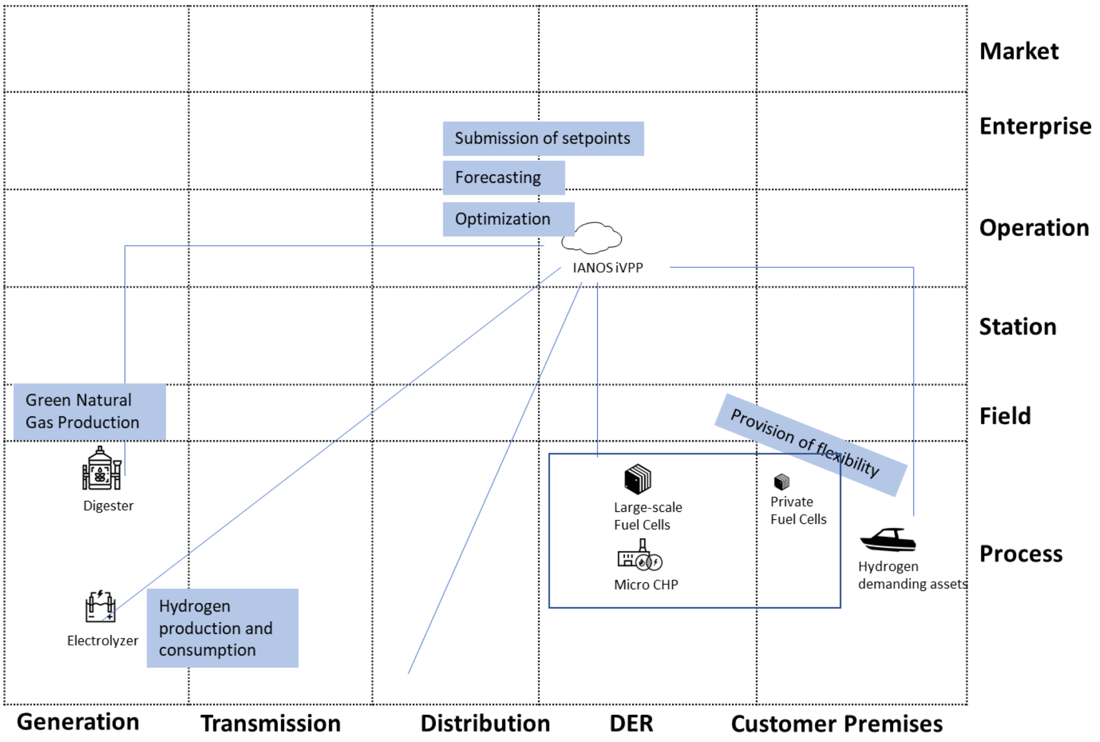
This use case focuses on exploring methods to manage waste streams produced on islands by reusing them to produce renewable energy and allow the decarbonization of the local grid.

Accordingly, a small-scale digester is used in Ameland which allows the conversion of i) sewage from households and businesses, ii) swill from catering industry and hospitals and iii) other organic waste into green natural gas. Moreover, some hydrogen produced from the electrolyser, despite being stored, may also supply the digester in order to convert the CO2 that remains in the digester to natural gas. This green natural gas will feed the gas grid where it is used in Fuel Cells and CHPs. For this purpose, the iVPP is responsible for sending the necessary setpoints to the digester, including any available excess of H2 produced and not consumed by the hydrogen fuelled vehicles. The by-product of the digestion process, the digestate, will be used as fertiliser.

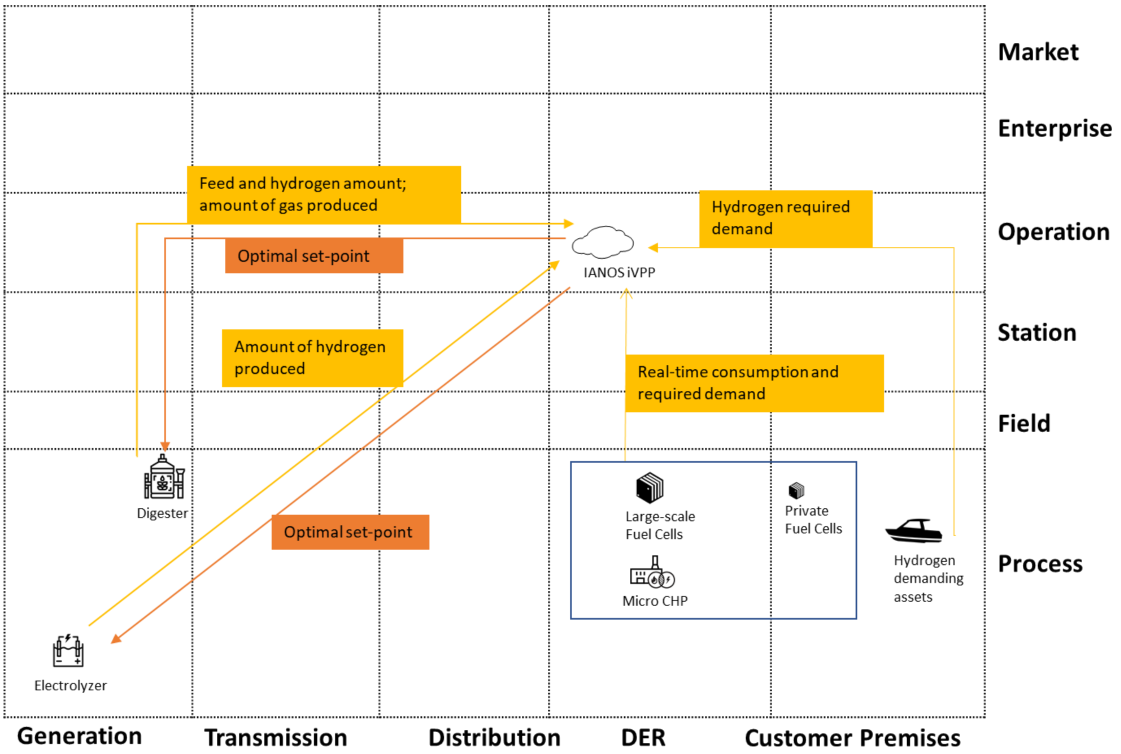
Additionally, this use case also intends to investigate the potential of the remaining waste streams. The main goals consist of mapping all the waste streams, identifying the technologies to process these biomass types, analysing the respective business models and selecting the best ones. This process must occur with the engagement of the local citizens.

SGAM LAYERS

Function Layer



Information Layer



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Technological Solutions	Information / Communication Protocols	Ameland
Private Fuel Cells	-	x
Large-scale Fuel Cell	-	x
Hydrogen Demanding Assets (Water Taxis)	-	x
Micro CHP	-	x
Small scale AHPD digester	-	x
Electrolyzer	-	X

1.5 Key performance indicators (KPI)

ID	*Name*	*Description*	*Reference to mentioned use case objectives*
1.6	Percentage of total amount of waste that is used to generate energy.	This KPI calculates the percentage of the total amount of waste in the island or district which is used to generate thermal or electrical energy.	1
2.1	Reduced Greenhouse Gas Emissions	In different variants of this indicator the emissions caused by the production of the system components are included or excluded. Measures the reduction of greenhouse gas emissions in the electricity and gas grid in order to assess the viability to reach decarbonization targets.	2
2.2.	Reduced fossil fuel consumption	Measures the amount of fossil fuels which is not consumed because of IANOS demonstrated solutions (e.g. production of green natural).	2
2.3	Electrical and thermal energy produced from	Computes the amount of electrical and thermal energy that is produced	1

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	solid waste or other liquid waste treatment per capita per year	by the waste exploitation and compares it with the base scenario without any IANOS interventions.	
2.5	Reduction in the amount of unsorted waste collected	Calculates the percentage reduction in the amount of unsorted waste collected due to the project.	1

1.6 Use case conditions

Use case conditions
Assumptions
• The feedstock for the digester will be usual post treated sludge and swill from catering industry and hospitals.
Prerequisites
• A small-scale AHPD digester is available. • Community involvement in the research for the use of the remaining streams. • Communication between the iVPP and the digester is established. • Information on flexibility and availability of the digester required. • The digester is connected to the electrolyser. • A (physical) hosting environment on which the iVPP can be established.

1.7 Further Information to the use case for classification / mapping

Classification Information
Relation to other use cases
UC2: Community supply-side optimal dispatch and intra-day services provision.
Level of depth
Specialized use case
Prioritisation
High level of priority
Generic, regional or national relation
Generic
Nature of the use case
Technical
Further keywords for classification

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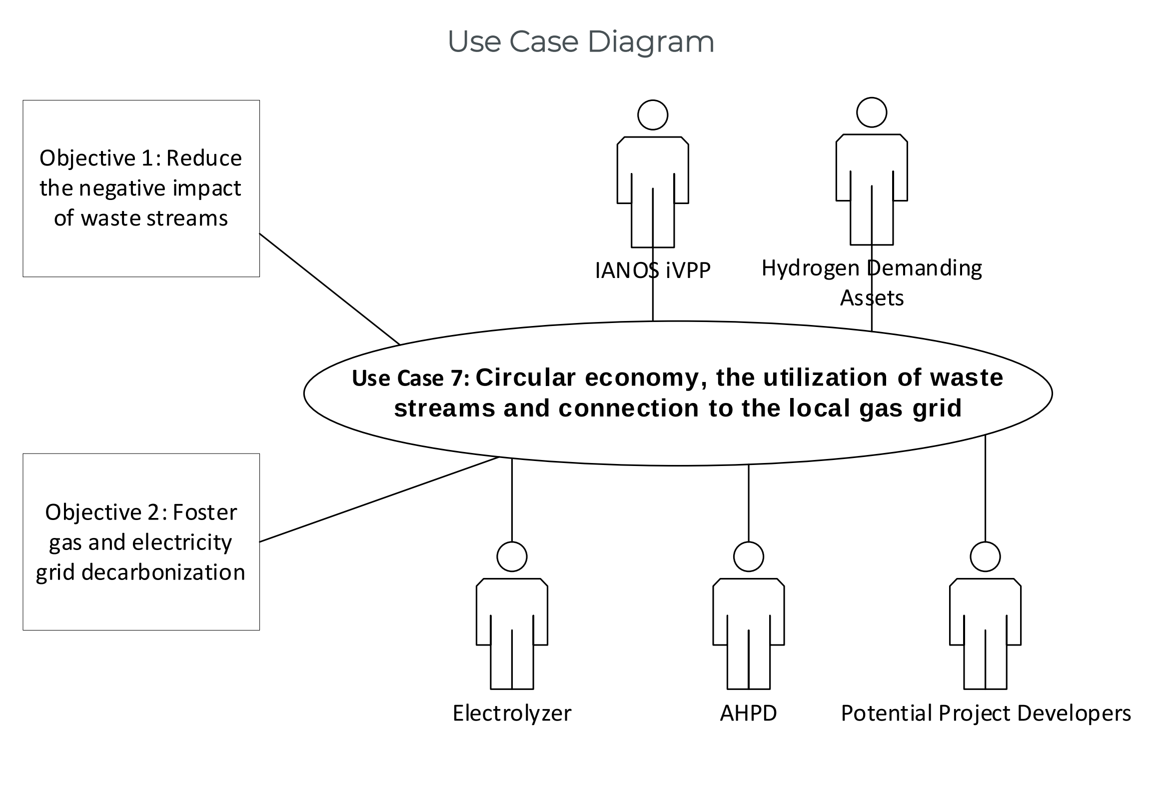
small scale digester, circular economy, waste, green natural gas, gas grid decarbonization, hydrogen

1.8 General Remarks

General Remarks
-

2 Diagrams of use case

Diagram(s) of use case



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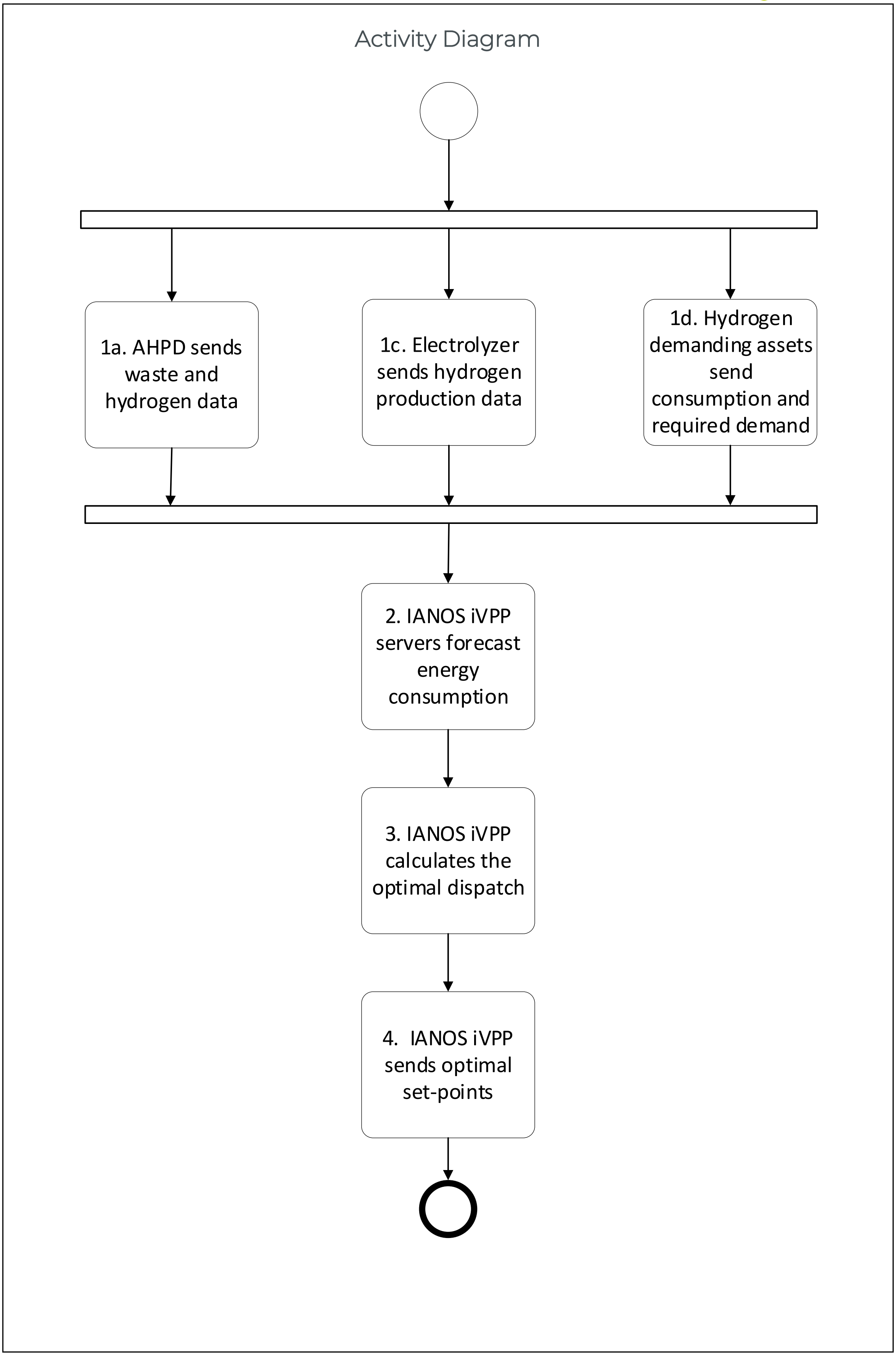

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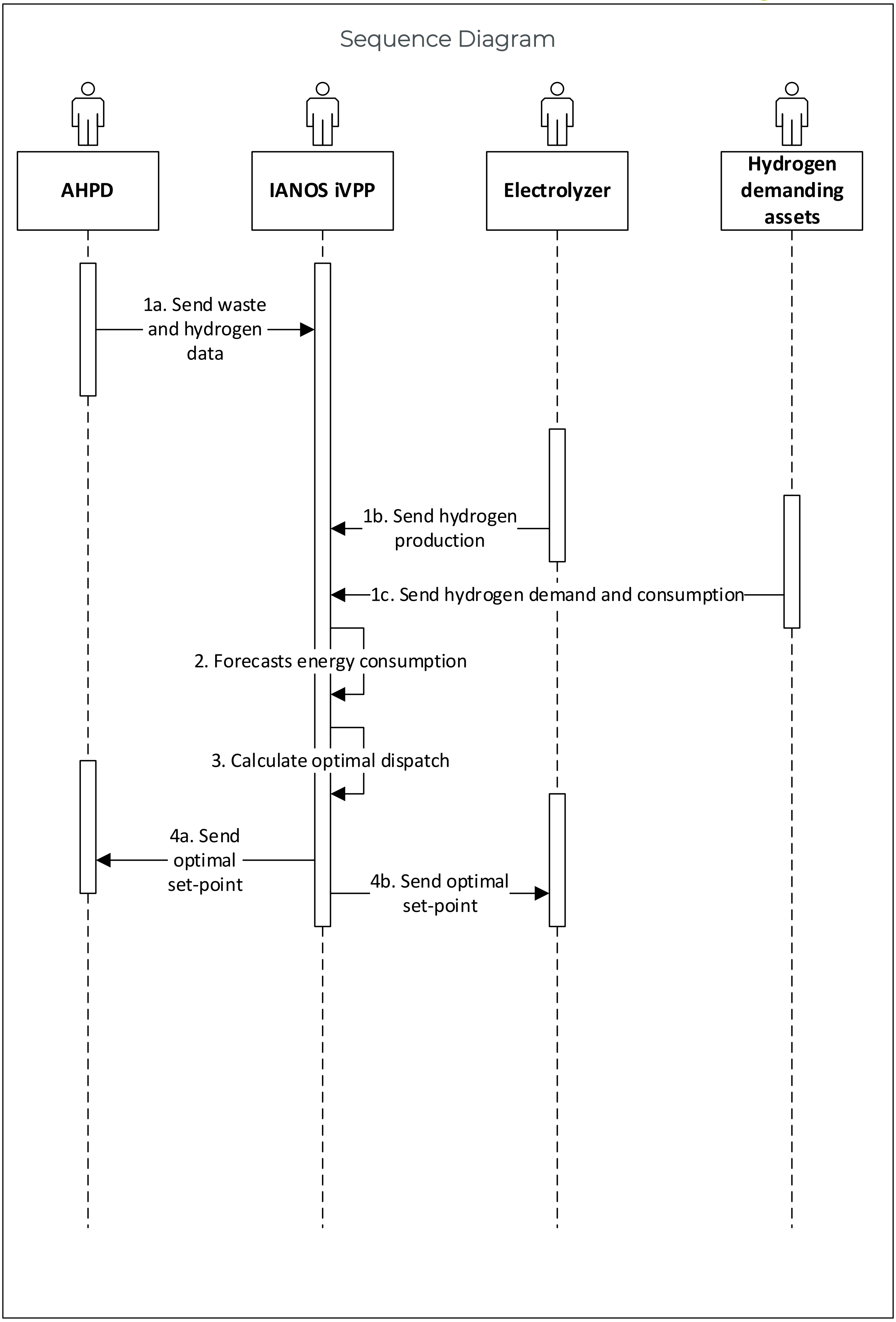

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3 Technical details

3.1 Actors

Actors		
Actor Name	*Actor Type*	*Actor Description*
Small-scale AHPD digester	System	Digester which converts sewage, swill and other organic waste into green natural gas at high pressure, thus allowing the production of high methane content (90% of methane). It produces 110.000 Nm^3 of green gas from 300 tons of dry substance. This digester can also use hydrogen as substrate.
Electrolyzer	System	The 200kWe BESS-Electrolyser DC connected system, will be used to supply green H2 to the digestion process.
IANOS iVPP	System	The IANOS iVPP sets up a virtual network of decentralized renewable energy resources, both non-dispatchable such as wind, solar, tidal resources and dispatchable ones such as geothermal and green gas CHP plants. Moreover, the iVPP comprises of Energy Storage Systems (ESS), integrated as a single unit, providing flexibility services and fostering island renewable energy self-consumption. The optimal, autonomous, real-time iVPP operation will be driven by multi-level decision making intelligence, complemented by predictive algorithms for smart integration of grid assets into active network management based on relevant energy profiles. For this purpose, the iVPP is composed of 6 different modules: aggregation and classification, forecasting engine, centralized dispatcher, distributed ledger-based energy transactions, virtual energy console and secured enterprise service bus.

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Hydrogen demanding assets	System	Assets which consume hydrogen, such as water taxis.
Potential Project Developers	Role	Project Developers interested in applying biomass technologies to reduce waste streams.

3.2 References

References						
No.	*References Type*	*Reference*	*Status*	*Impact on use case*	*Originator / organisation*	*Link*

4 Step by step analysis of use case

4.1 Overview of scenarios

Scenario conditions						
No.	Scenario name	Scenario description	Primary actor	Triggering event	Pre-condition	Post-condition
1	Green natural gas production from waste streams	iVPP computes the optimal dispatch for the electrolyzer and for the small-scale digester regarding the respective amounts of gas to be supplied.	Digester, IANOS iVPP	Significant costs of waste treatment (economic and environmental).	No use of waste streams for energy production. No power flows in the digester.	Green natural gas to feed the gas grid.

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2	Research on biomass processing technologies	Investigate the most suitable technologies to process biomass for the remaining waste streams of the islands.	NEC	Earthquakes (due to natural gas extraction) and climate policies force us to minimize the use of natural gas.	Natural gas is the main source for heating the built environment on the Island.	Biogas is the main source for heating the built environment on the Island.

4.2 Steps – Scenarios

Scenario							
Scenario name :		*No. 1 - Green natural gas production from waste streams*					
Step No.	*Event*	*Name of process/ activity*	*Description of process/ activity*	*Service*	*Information producer (actor)*	*Information receiver (actor)*	*Information Exchanged (IDs)*
1a	Submission of digester data	Sends waste and hydrogen data	Digester sends the data regarding its status to the iVPP.	GET	Digester	IANOS iVPP	1,2
1b	Submission of Electrolyser data	Sends data	Electrolyzer sends the amount of hydrogen produced to the iVPP.	GET	Electrolyser	IANOS iVPP	3
1c	Submission of hydrogen	Send hydrogen demand and	Hydrogen demanding assets send their hydrogen demand and	REPORT	Demanding	IANOS iVPP	4

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	demanding assets	consumption	consumption to the iVPP.		Assets		
2	Data forecast	Forecasts	iVPP servers forecast energy consumption.	EXECUTE	IANOS iVPP	IANOS iVPP	5
3	Calculation of optimal dispatch	Calculates the optimal dispatch	iVPP computes the optimal dispatch for the digester in order to ensure the delivery of green natural gas to feed the gas grid. Moreover, the iVPP also calculates the optimal dispatch for the electrolyzer.	EXECUTE	IANOS iVPP	IANOS iVPP	-
4a	Submission of optimal set-points	Sends set-points	iVPP sends the optimal setpoint to the digester.	CREATE	IANOS iVPP	Digester	6
4b	Submission of optimal set-points	Sends set-points	iVPP sends the optimal setpoint to the electrolyzer.	CREATE	IANOS iVPP	Electrolyzer	7

Scenario							
Scenario name :		*No. 2 - Research on biomass processing technologies*					
Step No.	*Event*	*Name of process/ activity*	*Description of process/ activity*	*Service*	*Information producer (actor)*	*Information receiver (actor)*	*Information Exchanged (IDs)*
1	Identification of	Makes inventory	Identifying the available biomass	CREATE	NEC	Potential	8

	biomass/waste streams	of available biomass streams	streams on the islands.			project developers	
2	Investigation of biomass processing technologies	Investigates technologies	Investigating the most suitable technologies for biomass processing.	EXECUTE	NEC	Potential project developers	9
3	Technology Selection	Select best technologies	Selecting the most interesting business cases related to specific biomass/technology combinations.	REPORT	NEC	Potential project developers	10

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5 Information exchanged

Information exchanged		
Information exchanged (ID)	*Name of information*	*Description of information exchanged*
1	Digester hard technical constrains	Maximum and minimum feed per hour and in total, maximum and minimum gas production, maximum and minimum hydrogen addition.
2	Digester real-time data	Quality and quantity of feed in digester, amount of hydrogen in digester, amount of hydrogen being added, gas production.
3	Hydrogen production	Amount of hydrogen produced.
4	Hydrogen demanding assets data	Hydrogen demand and consumption in real-time.
5	Forecasted Energy Consumption Data	Loads forecasted energy consumption data.
6	Digester Optimal Set-point	Optimal setpoint computed by the iVPP for the digester which corresponds to the amount of natural gas that will feed the gas grid.
7	Electrolyzer Optimal Set-point	Optimal setpoint computed by the iVPP for the electrolyzer which corresponds to the amount of hydrogen to be sent to the digester.
8	Biomass Streams	Database with biomass streams and quantities.
9	Biomass Technologies	Technology overview with bio/syngas potential.
10	Selected technologies	Description of the top 3 business cases for bio/syngas production on the island.

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6 Requirements

	Requirements	
Categories ID	Category name for requirements	Category description
R-SEC.	Security Requirement	Requirements related to the safety issues.
R-UI	User Interface Requirement	Requirements related to the iVPP UI.
R-FUN	Functional Requirement	Requirements that capture the intended behaviour of the system.
R-COM	Communication Requirement	Requirements related to communication aspects.
Requirement R-ID	Requirement name	Requirement description
R-SEC1	Access Control	iVPP functions are accessible from personnel with specialized authorization rights.
R-SEC2	iVPP cybersecurity	Utilization of good practices (e.g. secure communication bus) to enhance data cybersecurity.
R-SEC3	iVPP data privacy	Utilization of good practices to ensure compliance with GDPR regulations.
R-SEC4	Network security measures for data exchange with digester	Establishes the ways in which communication between the iVPP and the digester control system can be achieved safely, mitigating risks of external interference.
R-SEC5	Digester site safety	Establishes the safety guidelines applicable to the physical location where the digester is installed. It further establishes the safety guidelines applicable to all personnel in the local vicinity to ensure safe operation of the digester.

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R-UI1	Graphical visualization of iVPP operation	iVPP operation can be visually inspected through the use of KPIs.
R-UI2	Reporting	iVPP can produce reports on system performance upon iVPP Operator request
R-FUN1	Day-ahead generation forecast	iVPP can predict the generation of its assets for the following day.
R-FUN2	Intraday generation forecast	iVPP can predict the generation of its assets within the day.
R-FUN3	Flexibility estimation	iVPP can estimate the dispatchable production units' flexibility.
R-COM1	Common Information Model	iVPP adopts a common information model to exchange data ensuring interoperability.

7 Common Terms and Definitions

Common Terms and Definitions	
Term	**Definition**
BESS	Battery Energy Storage Systems
CHP	Combined Heat and Power
CO2	Carbon Dioxide
DER	Distributed Energy Resource
FC	Fuel Cells
GDPR	General Data Protection Regulation
H2	Hydrogen
iVPP	Intelligent Virtual Power Plant
LEC	Local Energy Community
NEC	New Energy Coalition
NG	Natural Gas
RES	Renewable Energy Sources
SGAM	Smart Grid Architecture Model
UC	Use Case
UI	User Interface

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6.2.4 Use case 8: Decarbonization of heating network

1 Description of the use case

1.1 Name of the use case

ID	*Area / Domain(s)*	*Name of Use Case*
8	Decarbonization through electrification and support from non-emitting fuels	Decarbonization of heating network

1.2 Version management

Version Management			
Version No.	*Date*	*Name of Author(s)*	*Changes*
1	04.02.2021	EDP NEW	First draft.
2	25.02.2021	Mónica Fernandes (EDP NEW)	Collect all the feedback from relevant partners and start second version. Add SGAM layers characterization. Improve diagrams, description, information exchanged and scenarios. Add iVPP requirements.
3	29.04.2021	Mónica Fernandes (EDP NEW)	KPIs added from D2.3.
4	10.05.2021	Mónica Fernandes (EDP NEW)	Final Version.
5	01.04.2022	Mónica Fernandes (EDP NEW)	Minor changes and updates on the KPIs.
6	18.07.2022	Ana Carvalho (EDP NEW)	Revision and start of the third version.

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7	16.09.2022	Vasilis Apostolopoulos (CERTH)	Corrections to KPI numbering according to final version of D2.9.

1.3 Scope and objectives of use case

Scope and Objectives of Use Case	
Scope	The scope of this Use Case is to decarbonize the heating network in Ameland which currently runs on natural gas. For this purpose, this Use Case focuses on the installation of equipment that allows the reduction of emissions such as hybrid heat pumps to be powered by local RES. Moreover, it also explores further possibilities to phase-out natural gas of certain villages.
Objective	This Use Case aims to decarbonize the existent heating grid in Ameland which currently mainly uses natural gas as fuel (Objective 1).

1.4 Narrative of use case

Narrative of Use Case
Short description
This Use Case focuses on decarbonizing the existent heating network in Ameland which currently mainly runs on natural gas. Therefore, this Use Case explores different strategies such as installation of heat pumps and hybrid heat pumps powered by local RES and research work regarding the potential of phasing-out natural gas in particular sites.
Complete description
The present use case describes the methods that aim to decarbonize the existent heating network in Ameland, which currently mainly runs on natural gas. Accordingly, 4 strategies are implemented to achieve this goal. Firstly, hybrid heat pumps composed of a 20kW$_{th}$ boiler and a 1.1kW$_{e}$/5kW$_{th}$ heat pump each, are installed in residential neighbourhoods. The intelligent Virtual Power Plant (iVPP) manages the power fluxes of these hybrid heat pumps according to the data received from them. Moreover, the Klein Vaarwater holiday park will create an integrated design of a 500kW$_{e}$ fuel cell, H_2 storage and additional heat pumps for peak demands which

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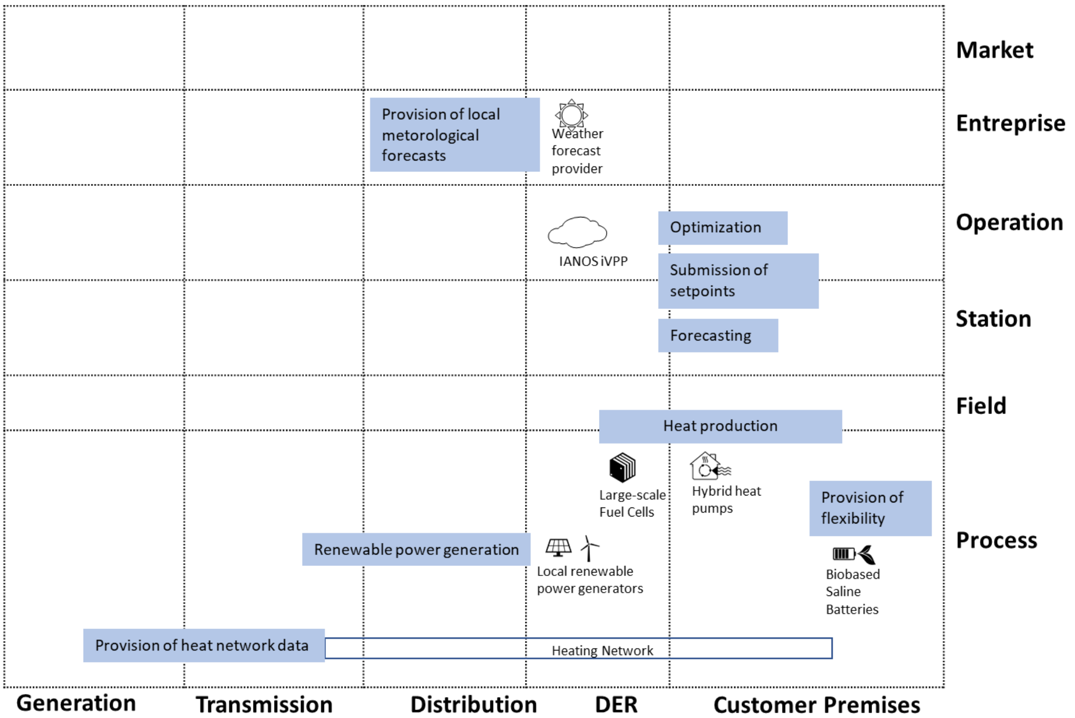
allow the expansion of the current heating grid in the site. The fuel cell will provide heat and electricity to support the heating network.

Another strategy is to study different means of phasing out natural gas from Buren Aardgasvrij village by selecting a technical approach with communities' collaboration.

Finally, the last strategy consists of installing an innovative heating grid infrastructure in Nes city by using heat pumps that are powered by local RES. Furthermore, an organic hybrid battery will be used to store excess energy in periods of high levels of renewable generation. The iVPP is responsible for sending the set-points to the heat pumps and storage assets as well as from the local RES assets, according to the data provided.

SGAM LAYERS

Function Layer



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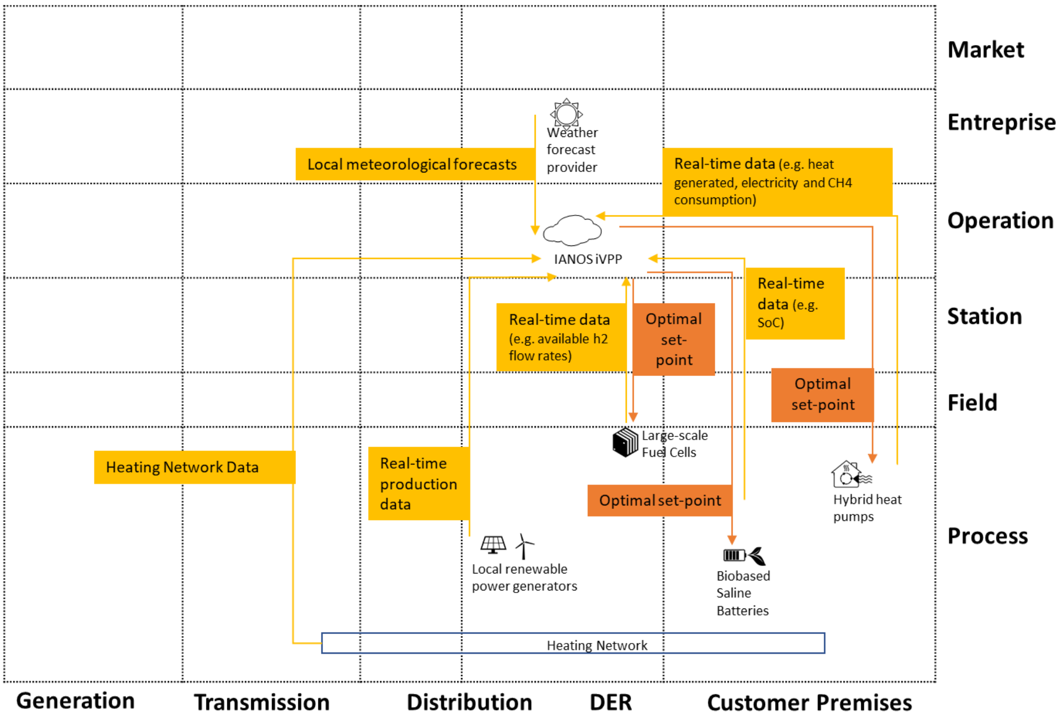
Information Layer



Technological Solutions	Information / Communication Protocols	Ameland
Large-scale Fuel Cell	-	X
Biobased saline batteries	-	X
Hybrid Heat Pumps	-	X

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1.5 Key performance indicators (KPI)

ID	*Name*	*Description*	*Reference to mentioned use case objectives*
1.5	Degree of energetic self-supply by RES	Ratio of locally produced energy from RES and the final energy consumption over a period of time for the heating sector (e.g. month, year).	1
2.1	Reduced Greenhouse Gas Emissions	In different variants of this indicator the emissions caused by the production of the system components are included or excluded. In this case, it measures the reduction of greenhouse gas emissions in the heating grid.	1
2.2	Reduced fossil fuel consumption	Measures the amount of fossil fuels which is not consumed anymore for heating purposes because of IANOS demonstrated solutions (e.g. hybrid heat pumps, fuel cells, etc.).	1
5.1	People Reached	Percentage of people in the target group that have been reached and/or are activated by the project.t	1
5.2	Thermal Comfort	Estimates the quality of the delivered heating/cooling service.	1
6.1	Involvement of the island administration	Examines the extent to which the local authority is involved in the development of the project, other than financial, and how many departments are contributing.	1
7.1	Social Compatibility	Refers to the extent to which the project's solution fits with people's 'frame of mind' and does not negatively challenge people's values or the ways they are used to do things.	1
7.2	Technical compatibility	Examines the extent to which the smart grid solutions fit with the current existing technological standards/infrastructures.	1

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7.3	Ease of use for end users of the solution	Provides an indication of the complexity of the implemented solution within the IANOS project for the end-users.	1

1.6 Use case conditions

Use case conditions
Assumptions
• Community engagement for studying the possibilities for phasing out natural gas from Buren Aardgasvrij village. • Local RES supply electricity to heat pumps.
Prerequisites
• Direct connection between the iVPP, the heat pumps and the hybrid heat pumps. • Connection between the iVPP and the biobased saline batteries. • A (physical) hosting environment on which the iVPP can be established.

1.7 Further Information to the use case for classification / mapping

Classification Information
Relation to other use cases
-
Level of depth
High level use case
Prioritisation
High level of priority
Generic, regional or national relation
Generic
Nature of the use case
Technical use case
Further keywords for classification
Heating network, hybrid heat pumps, fuel cell, phasing out natural gas, local RES

1.8 General Remarks

General Remarks
-

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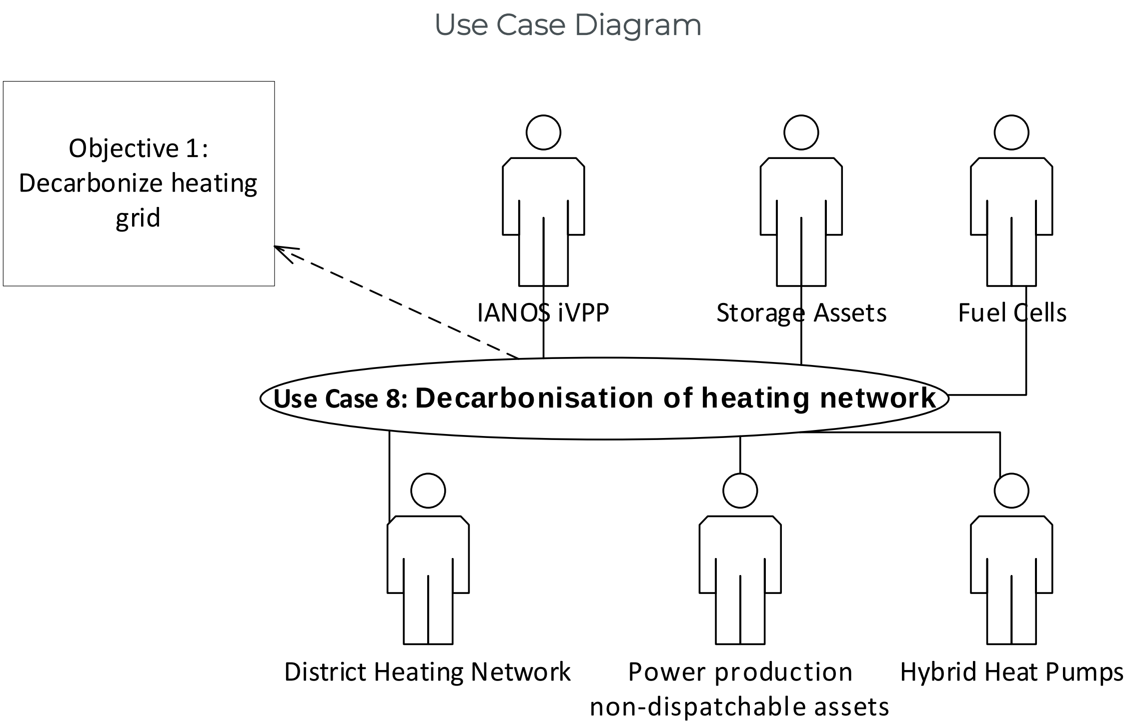
2 Diagrams of use case

Diagram(s) of use case


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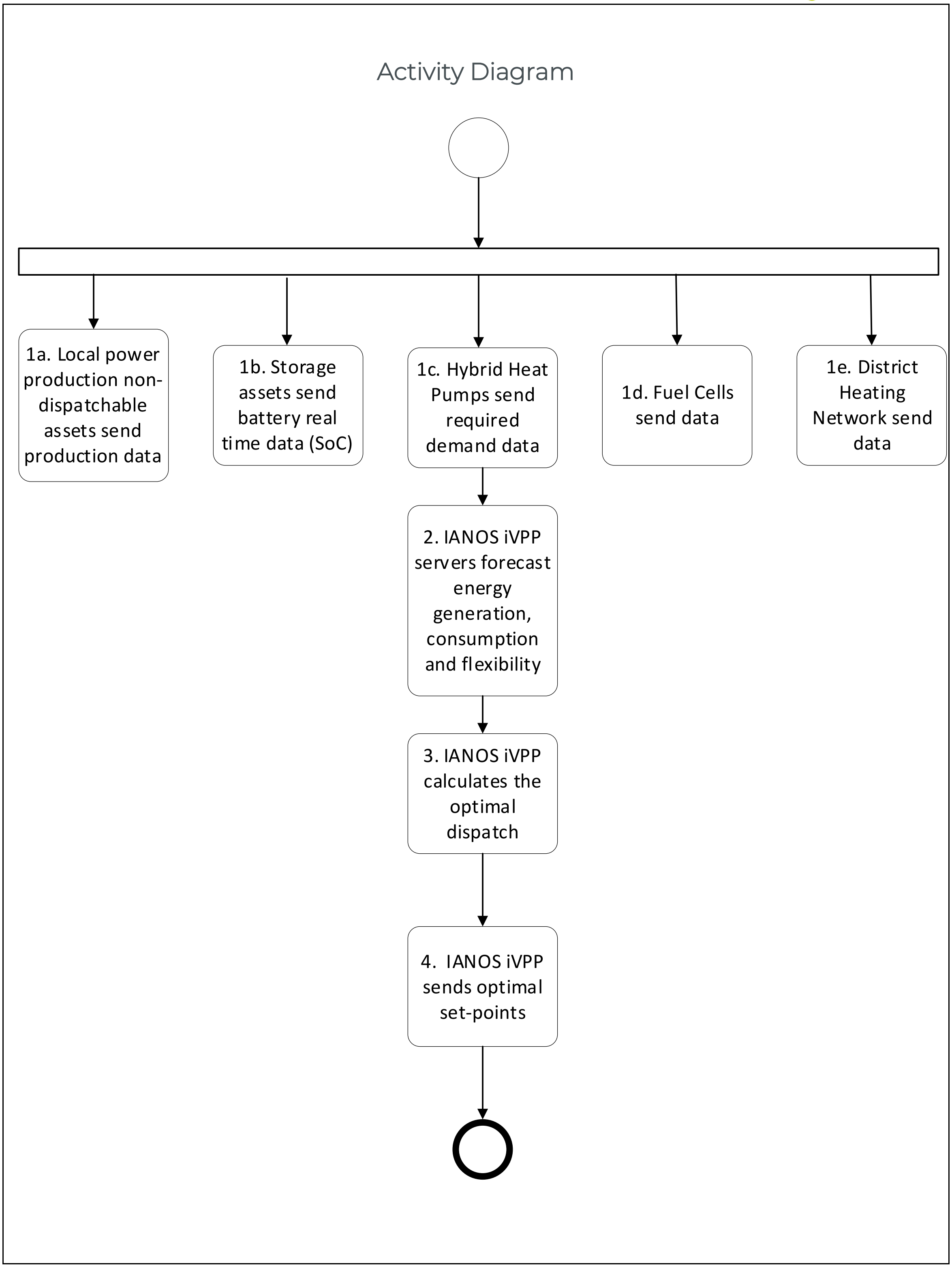

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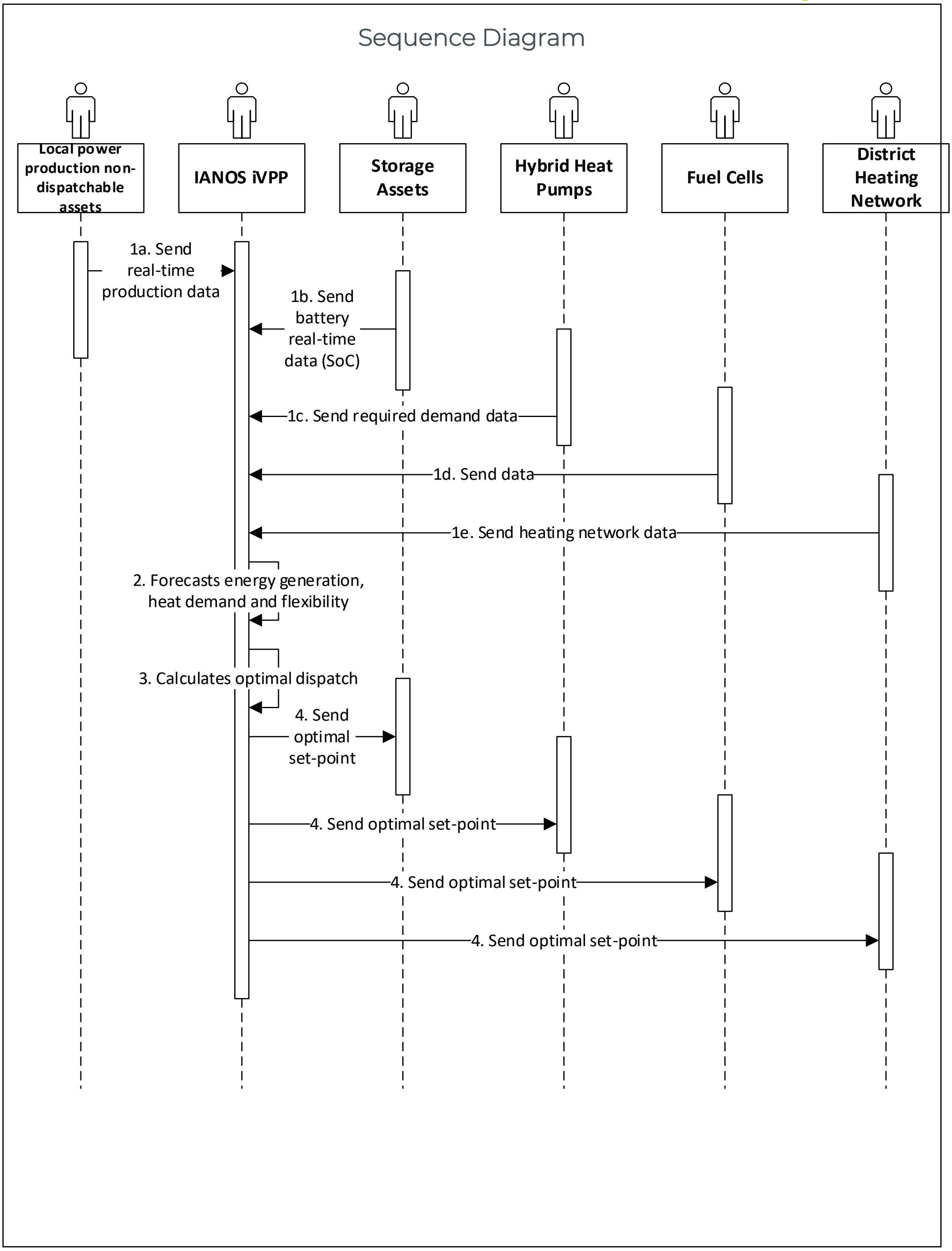

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3 Technical details

3.1 Actors

Actors		
Actor Name	*Actor Type*	*Actor Description*
IANOS iVPP	System	The IANOS iVPP sets up a virtual network of decentralized renewable energy resources, both non-dispatchable such as wind, solar, tidal resources and dispatchable ones such as geothermal and green gas CHP plants. Moreover, the iVPP comprises of Energy Storage Systems (ESS), integrated as a single unit, providing flexibility services and fostering island renewable energy self-consumption. The optimal, autonomous, real-time iVPP operation will be driven by multi-level decision making intelligence, complemented by predictive algorithms for smart integration of grid assets into active network management, based on relevant energy profiles. For this purpose, the iVPP is composed of 6 different modules: aggregation and classification, forecasting engine, centralized dispatcher, distributed ledger-based energy transactions, virtual energy console and secured enterprise service bus.
Storage Assets	System	Assets, such as biobased saline batteries that store energy in periods of energy excess to be used later by the dispatchable assets, such as hybrid heat pumps.
Fuel Cells	System	Assets with the ability of offering electricity or heat, when necessary.
Hybrid Heat Pumps	System	Hybrid heat pumps run on both electricity and natural gas and are composed of a 20 kW_{th} boiler and a 1.1kW_e/5kW_{th} heat pump, thereby allowing switching between gas and electricity operation. Hybrid heat pumps can also run on biogas.

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Local power production non-dispatchable assets	System	Local power generation assets whose power cannot be controlled by grid operators, such as wind and solar power generators.
District Heating Network	System	Pipe network which provides heating and hot water from a central power plant for connected consumers.

3.2 References

References						
No.	*References Type*	*Reference*	*Status*	*Impact on use case*	*Originator / organisation*	*Link*

4 Step by step analysis of use case

4.1 Overview of scenarios

Scenario conditions						
No.	Scenario name	Scenario description	Primary actor	Triggering event	Pre-condition	Post-condition
1	Decarbonization of heating network	Decarbonization of the heating network by installing heat and hybrid pumps, which use electricity generated by local RES. The iVPP manages the steady energy flow from the	IANOS iVPP	Periodically	No power fluxes between dispatchable assets and local	District heating network is stable and energy

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		local RES to the heat pumps, ensuring heat and hot water is provided to the buildings.			renewable generators.	curtailment is avoided.

4.2 Steps – Scenarios

Scenario							
Scenario name :		*No. 1 - Reference scenario*					
Step No.	*Event*	*Name of process/ activity*	*Description of process/ activity*	*Service*	*Information producer (actor)*	*Information receiver (actor)*	*Information Exchanged (IDs)*
1a	Submission of Local Power Production Assets	Send real-time production data	Local Power Production Non-Dispatchable Assets send real-time production data to the iVPP.	GET	Local power production non-dispatchable assets	IANOS iVPP	1
1b	Submission of Storage Assets data	Send battery real-time data	Storage assets send battery real-time data (e.g. SoC) to the iVPP.	GET	Storage Assets	IANOS iVPP	2,3
1c	Submission of Hybrid Heat Pumps data	Send required demand data	Hybrid Heat Pumps send required demand data to the iVPP.	GET	Hybrid Heat Pumps	IANOS iVPP	4

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1d	Submission of Fuel Cells' data	Send data	Fuel Cells send data regarding their status to the iVPP.	GET	Fuel Cells	IANOS iVPP	5,6
1e	Submission of heating network data	Send heating network data	District Heating Network sends data regarding its status to the iVPP.	GET	District Heating Network	IANOS iVPP	7
2	Data Forecast	Forecasts energy generation, consumption and flexibility	iVPP servers forecast energy generation from production-side assets, consumption from heat demanding assets and flexibility forecasts from storage assets.	EXECUTE	IANOS iVPP	IANOS iVPP	8, 9,10
3	Calculation of optimal dispatch	Calculates the optimal dispatch	iVPP computes the optimal dispatch for the dispatchable and storage assets in order to ensure a steady heat and hot water supply for the community and also to avoid energy curtailment by utilizing local renewable energy as a fuel for hybrid and heat pumps.	EXECUTE	IANOS iVPP	IANOS iVPP	-
4	Submission of optimal set-points	Sends set-points	iVPP sends the optimal setpoint to the dispatchable and storage assets.	CREATE	IANOS iVPP	Dispatchable Assets, Storage Assets	11, 12,13

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5 Information exchanged

Information exchanged		
Information exchanged (ID)	*Name of information*	*Description of information exchanged*
1	Local power production non-dispatchable assets data	Amount of energy generated by non-dispatchable generator assets (MWh) in real-time.
2	Storage Assets hard technical constraints	Min and Max SoC, Min and max charging and discharging power.
3	Storage Assets real-time data	SoC, temperature, etc..
4	Heat and hybrid pumps real-time data and hard technical constraints	Electricity and natural gas consumption. Heat generated.
5	Fuel Cells and CHP hard technical constraints	Minimum and maximum natural gas and hydrogen flow rates, temperature range, maximum total power output (kW).
6	Fuel Cells and CHP real-time data	Available natural gas and hydrogen flow rates, temperature at FC Anode.
7	District Heating Network data	District Heating Network status.
8	Forecasted Energy Generation Data	Forecasted energy supply data from production-side assets such as Fuel Cells.
9	Forecasted required demand data	Forecasted required demand from heat demanding assets which are present in the district heating network.
10	Forecasted Flexibility Data	Forecasted flexibility from storage assets.
11	Storage Assets Optimal Set-point	Optimal power dispatch computed by the iVPP for storage assets such as biobased saline batteries. It corresponds to the power generated by RES that will be stored or provided to the dispatchable assets such as hybrid and heat pumps.
12	Hybrid Heat Pumps Optimal Set-points	Optimal power dispatch computed by the iVPP for heat and hybrid heat pumps. It

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		corresponds to the power used for hybrid and heat pumps to generate heat.
13	Fuel Cells Optimal Set-points	Optimal power dispatch computed by the iVPP for fuel cells. It corresponds to the amount of hydrogen used to produce a certain amount of heat.

6 Requirements

Requirements		
Categories ID	Category name for requirements	Category description
R-SEC.	Security Requirement	Requirements related to the safety issues.
R-UI	User Interface Requirement	Requirements related to the iVPP UI.
R-FUN	Functional Requirement	Requirements that capture the intended behaviour of the system.
R-COM	Communication Requirement	Requirements related to communication aspects.
Requirement R-ID	Requirement name	Requirement description
R-SEC1	Access Control	iVPP functions are accessible from personnel with specialized authorization rights.
R-SEC2	iVPP cybersecurity	Utilization of good practices (e.g. secure communication bus) to enhance data cybersecurity.
R-SEC3	iVPP data privacy	Utilization of good practices to ensure compliance with GDPR regulations.
R-UI1	Graphical visualization of iVPP operation	iVPP operation can be visually inspected through the use of KPIs.

R-UI2	Reporting	iVPP can produce reports on system performance upon iVPP Operator request
R-FUN1	Day-ahead generation forecast	iVPP can predict the generation of its assets for the following day.
R-FUN2	Intraday generation forecast	iVPP can predict the generation of its assets within the day.
R-FUN3	Flexibility estimation	iVPP can estimate the dispatchable production units' flexibility.
R-COM1	Common Information Model	iVPP adopts a common information model to exchange data ensuring interoperability

7 Common Terms and Definitions

Common Terms and Definitions	
Term	**Definition**
CHP	Combined Heat and Power
GDPR	General Data Protection Regulation
iVPP	Intelligent Virtual Power Plant
RES	Renewable Energy Sources
SGAM	Smart Grid Architecture Model
SoC	State of Charge
UC	Use Case
UI	User Interface

6.3 Transition Track 3: Use Cases

Transition Track 3 includes the Use Case 9 related with Local Energy Communities engagement and involvement of local citizens into island's energy transition.

6.3.1 Use case 9: Active Citizen and LEC Engagement into Decarbonization Transition

1 Description of the use case

1.1 Name of the use case

ID	*Area / Domain(s)*	*Name of Use Case*
9	Empowered LECs	Active Citizen and LEC Engagement into Decarbonization Transition

1.2 Version management

Version Management			
Version No.	*Date*	*Name of Author(s)*	*Changes*
1	04.02.2021	EDP NEW	First draft.
2	11.05.2021	EDP NEW	Final version.
3	18.07.2022	Ana Carvalho (EDP NEW)	Revision.
4	16.09.2022	Vasilis Apostolopoulos (CERTH)	Corrections to KPI numbering according to final version of D2.9.

1.3 Scope and objectives of use case

Scope and Objectives of Use Case	
Scope	The scope of this Use Case is the promotion of citizen engagement in the local community by involving them in the island's energy transition. The maximum reach of the use case refers to the whole island's inhabitants (both permanent or otherwise), while the first target will be

	just a part of them, directly involved with the IANOS activities. Technical staff and IANOS partners will facilitate the activities and the community engagement, supported by the relevant local authorities.
Objectives	The main goals of this use case focus on: 1. Promoting the engagement of the local community in island's energy transition. 2. Raising customer's environmental and energy efficiency awareness. 3. Supporting local generation. 4. Promoting DSM programs.

1.4 Narrative of use case

Narrative of Use Case
Short description
This Use Case aims to promote an active role and engagement of the community in the island's energy transition. Accordingly, it uses Local Energy Cooperatives to fulfil this purpose where various strategies will be applied, such as involving the community in DSM programs and raising the customer's environmental and energy efficiency awareness through dissemination actions for local homeowners and young people.
Complete description
This Use Case describes the methodologies that will be used to promote the engagement of local communities in the island's energy transition. For this purpose, a Local Energy Cooperative is simulated (in the case of Terceira) or improved (in the case of Ameland) that fosters local generation and the participation of its members in DSM programs. The Local Energy Cooperative aims to increase local renewable generation by cooperative members through the organization of group meetings, workshops and discussions. Moreover, it would allow the connection of members to the local DSM programs, through the development of useful indicators and the provision of interfaces to monitor their power consumption (carefully respecting data ownership) and providing them with an economic/environmental feedback signal for their actions. Furthermore, in the case of Ameland, a new cooperatively owned DC-solar farm combined with storage will also be developed. A business model value will be

demonstrated where revenues coming from the solar farm will be reinvested into green energy projects on the island. Additionally, this Use Case also focuses on raising the customer's environmental and energy efficiency awareness and therefore intends to provide capacity building and training for local homeowners and children through targeted promotion campaigns.

1.5 Key performance indicators (KPI)

ID	*Name*	*Description*	*Reference to mentioned use case objectives*
1.5	Degree of energetic self-supply by RES	Measures the increase on the ratio of locally produced energy from RES and the final energy consumption over a period of time (e.g. month, year) in the LEC or in the target residential area.	3
1.12	Peak photovoltaic power installed per 100 inhabitants	Measures the installed capacity of photovoltaic interpolated to 100 inhabitants. To be assessed per sector (residential, tertiary, industrial and public).	1,3
4.2	Data privacy - Data Safety and Level of Improvement (Improved Data Privacy)	This indicator analyses the extent to which regulations on data protection are followed and to which proper procedures to protect personal or private data are implemented.	4
5.1	People Reached	Percentage of people in the target group that have been reached and/or are activated by the project.	1,2,4
5.6	Increased citizen awareness of the potential of smart grid projects	Measures the increased citizen awareness of the socio-cultural potential of smart city projects and of the environmental and energy efficiency challenges.	1,2

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7.1	Social Compatibility	Refers to the extent to which the project's solution fits with people's 'frame of mind' and does not negatively challenge people's values or the ways they are used to do things.	1,2,3,4

1.6 Use case conditions

Use case conditions
Assumptions
• A national regulation for LEC should be in place before the use case reaches its objectives, while it could be initiated without it being fully developed.
Prerequisites
• The materials for the group meetings and workshops should be developed as far as possible in the local language to maximize its reach and guarantee the inclusion of the citizens.

1.7 Further Information to the use case for classification / mapping

Classification Information
Relation to other use cases
UC1: Community demand-side driven self-consumption maximization. UC4: Demand Side Management and Smart Grid methods to support Power quality and congestion management services.
Level of depth
High level use case
Prioritisation
High level of priority
Generic, regional or national relation
Generic
Nature of the use case
Social use case
Further keywords for classification
Local energy cooperative, community engagement, local generation, DSM programs, local community, training, raising awareness

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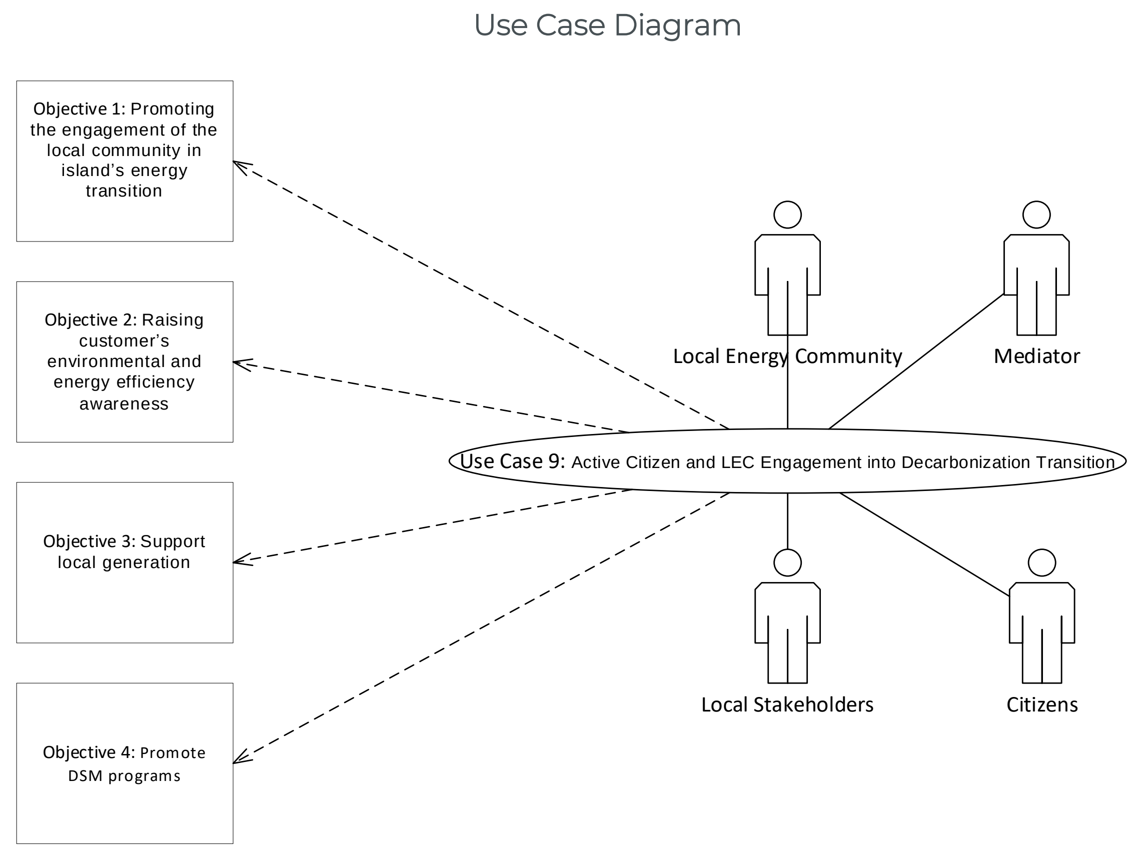
1.8 General Remarks

General Remarks
-

2 Diagrams of use case

Diagram(s) of use case


3 Technical details

3.1 Actors

Actors		
Actor Name	*Actor Type*	*Actor Description*
Local Energy Community	Role	Decentralized cooperatives of local communities and citizens that promote the production and consumption of local energy. Local energy communities share a common long-term goal for a sustainable future of energy and work to advance the transition through active citizenship engagement. In Terceira there is not a LEC yet, while in Ameland one already exists.
Mediator (e.g. local authority)	Role	A person who helps connecting the community and the project.
Citizens	Role	Citizens who live in the community.
Local Stakeholders	Role	Local stakeholders present in the community.

3.2 References

References						
No.	*References Type*	*Reference*	*Status*	*Impact on use case*	*Originator / organisation*	*Link*
	Decree-Law no. 15/2022, 14th January	Legal documentation		9	Council of Ministers	https://files.dre.pt/1s/2022/01/01000/0000300185.pdf

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4 Common Terms and Definitions

Common Terms and Definitions	
Term	Definition
LEC	Local Energy Communities
DSM	Demand Side Management

7 Conclusions and Next Steps

This deliverable identifies the requirements for each Lighthouse Island to deploy all the hardware solutions in the demonstrator sites. Additionally, it defines the 9 Use Cases of IANOS project in detail according to IEC-62559 standards.

The requirements for the LH islands are defined for each hardware solution that will be demonstrated. Most of the solutions are innovative elements and therefore some might be tested for the first time, therefore it is crucial to list all the requirements needed for the LH islands to ensure that the implementation of the solutions in their pilot sites runs smoothly and most of the risks are mitigated.

The Use Cases of IANOS describe the functionality level of the system, therefore they are technical use cases. All the Use Cases (except UC9) are connected to the intelligent Virtual Power Plant (iVPP) platform and what differentiates them is their scope and aim. The Use Cases are divided into 3 Transition Tracks which represent the main areas that IANOS addresses: #TT1: Energy efficiency and grid support for extremely high-RES penetration, #TT2: Decarbonization through electrification and support from non-emitting fuels and #TT3: Empowered LECs. The Use Cases might be implemented in both LH islands or in only one of them.

The Use Cases are defined in a general way to ensure the possibility of replicability in different islands. Thereby, these Use Cases will also be replicated in some of the Fellow Islands (Lampedusa, Bora-Bora and Nisyros). The success of these Use Cases implementation should be measured using the indicated KPIs, as well as the success of the project in itself can be measure using the PSIs presented in Deliverable D2.9.

The present deliverable D2.3 is being developed at a stage of the project in which technologies are being tested and their deployment is being prepared. Developments have been made to the use cases since the first

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version and first update of the report and have been reported in this last version. Further developments to the technologies and Use Cases are still under evaluation and, if need so, will be described in a latter update of this deliverable.

The descriptions of the use cases, list of actors, scenarios, information exchanged, and requirements represent a quality foundation for other tasks in this Work Package and others. They enable the definition of the System's Architecture (T2.5), the development of the Decarbonization Master Plan (T2.4), the definition of the multi-layer iVPP operational framework (T4.1, T4.3, T4.4) and the realization of the Use Cases (T5.1, T5.2, T5.3, T6.1, T6.2, T6.3).

8 References

1. CEN-CENELEC-ETSI Smart Grid Coordination Group (SG-CG), “Smart Grid Architecture Model (SGAM) Reference Architecture,” 2012.

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9 Annex I

1 Description of the use case

Use case describes functions of a system in a technology-neutral way. It identifies participating actors who can for instance be other systems or human actors which are playing a role within a use case. Use cases can be specified on different levels of granularity and are, according to their level of technological abstraction and granularity, either described as High Level Use Cases (HL-UCs) or Primary Use Cases (PUCs).

1.1 Name of the use case

ID	*Area / Domain(s)*	*Name of Use Case*
	Select from: (1) Energy efficiency and grid support for extremely high RES penetration; (2) Decarbonization through electrification and support from non-emitting fuels; (3) Empowered Local Energy Communities;	

1.2 Version management

Version Management			
Version No.	*Date*	*Name of Author(s)*	*Changes*
	DD.MM.YYYY		

1.3 Scope and objectives of use case

Scope and Objectives of Use Case	
Scope	The scope defines the limits of the use case.
Objective(s)	List of objectives of the use case.
Related business case(s)	Provides a description or reference with some rationale for the suggested use case. Usually the business case is related to several use cases. Therefore, an external reference or link to a business case/business requirements might be more efficient and can be added here.

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1.4 Narrative of use case

Narrative of Use Case
Short description
Short text intended to summarize the main idea as service for the reader who is searching for a use case or looking for an overview. Recommendation: This short description should not have more than 150 words.
Complete description
Complete Description provides a complete narrative of the use case from a user's point of view, describing what occurs, when, why, with what expectation, and under what conditions. This narrative should be written in plain text so that non-domain experts can understand it. The complete description of the Use Case can range from a few sentences to a few pages. This section often helps the domain expert to think through the user requirements for the function before getting into the details required by the next sections of the Use Case.

1.5 Key performance indicators (KPIs)

The KPIs defined in the D2.3 will be used in this Section.

ID	*Name*	*Description*	*Reference to mentioned use case objectives*
		The description specifies the KPI and may include specific targets in relation to one of the objectives of the use case and the calculation of these targets.	Here is the link to one of the objectives which are specified in the targets and the KPI before.

1.6 Use case conditions

Use case conditions
Assumptions
May be used to define further, general assumption for this use case. In some use cases, it is critical to understand which preconditions or other assumptions are being made. • Any assumptions shall be identified, such as: which systems already exist, which contractual relations exist, and which configurations of systems are probably in place. • Any initial states of information exchanged in the steps in the next section shall be identified.
Prerequisites
Describes what condition(s) should have been met prior to the initiation of the use case, such as prior state of the actors and activities.

1.7 Further Information to the use case for classification / mapping

Classification Information
Relation to other use cases
Known relations to other use cases can be provided here.
Level of depth
Defines the level of depth of the use case: High level use case (HL-UC): use case which describes a general requirement, idea or concept independently from a specific technical realization, like an architectural solution. Primary use case (PUC): use case which describes in detail the functionality of (a part of) a business process. Specialized use case (SUC): use case which is using specific technological solutions/implementations.
Prioritisation
Considering a larger number of use cases, it might be interesting to cluster them according to priority. This prioritisation might be different for each country.
Generic, regional or national relation
Generic, regional or national relation: On international level, the use case description might be generic enough to describe a use case in a more general way, independently from the national or regional market design. But use cases might be used to describe regional or national specific circumstances, like laws or even project-specific details. If the use case reflects those circumstances, it should be characterized accordingly. Note: Use Cases demonstrated in more than one DSO (country) should be classified and written as Generic.
Nature of the use case
This field can help to classify the main focus of the use case. EXAMPLE: Technical/system use case, business use cases (e.g. market processes), political, test use cases.
Further keywords for classification
Keywords can be defined in order to support extended search functionalities within a use case repository. Multiple keywords should be provided as a comma-separated list. EXAMPLE: Smart grid, electric vehicles, loading of vehicles, electricity metering, storage, renewables.

1.8 General Remarks

General Remarks
Is used for further comments which are not considered elsewhere.

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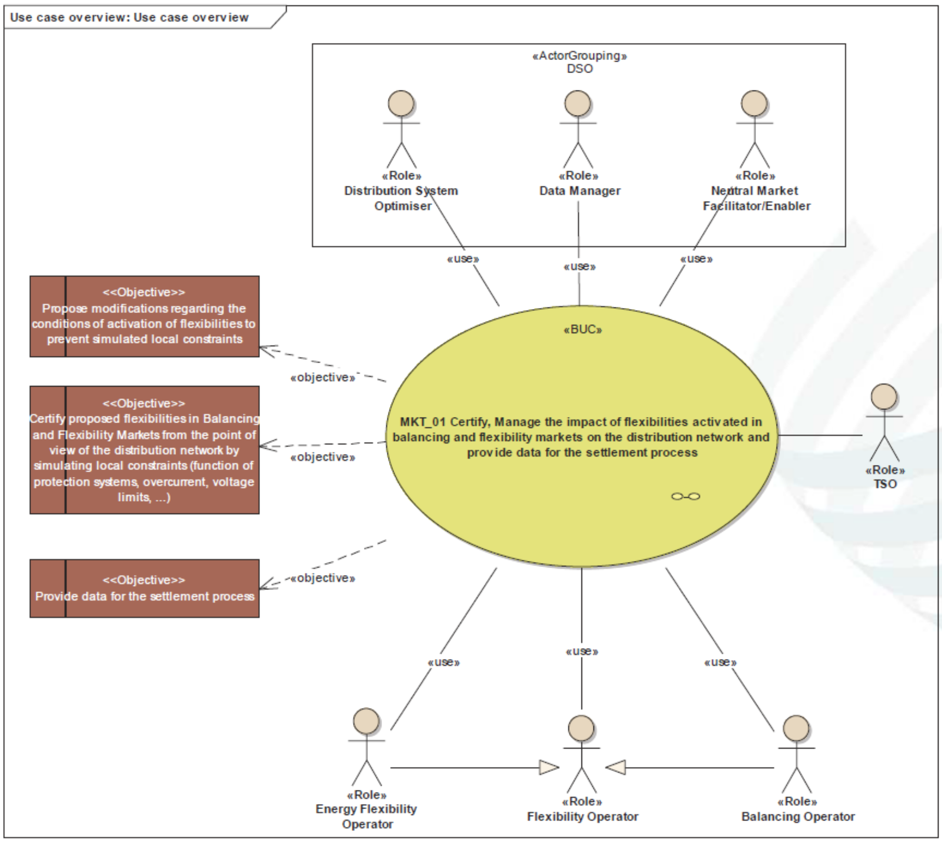
2 Diagrams of use case

For clarification, in general, it is recommended to provide drawing(s) by hand, by a graphic or as UML graphics. The drawing should show interactions which identify the steps where possible.

Diagram(s) of use case
Please paste below the <u>Use Case Diagram</u>: shows how actors interact within the Use Case by participating in the technical functions.  *Please paste below the <u>HLUC-PUC Relations Diagram</u>: shows which primary use cases (PUC) are used by the High Level Use Case (HLUC). <u>This is diagram is only included in HLUC.</u>*

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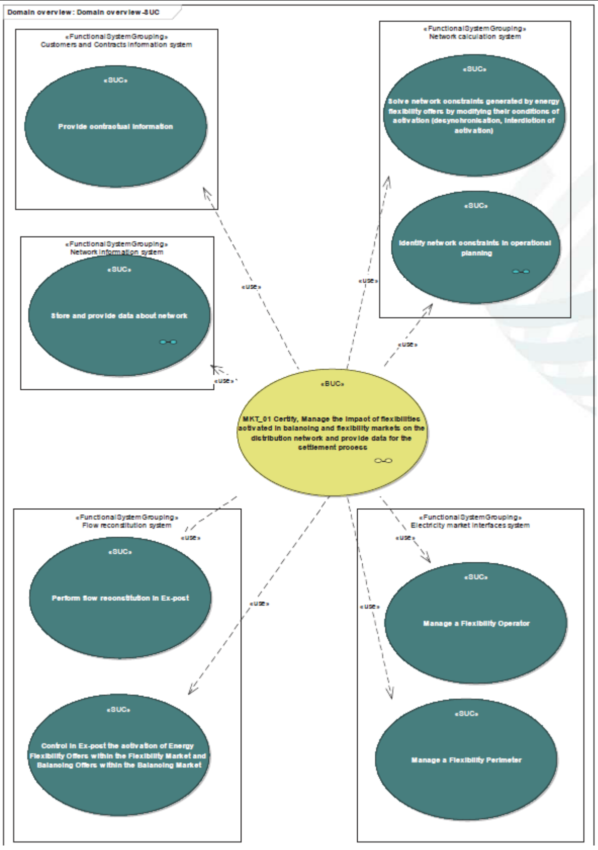

Please paste below the <u>Sequence Diagram</u>: shows the dynamic sequence of the activities (information exchanges/internal operations) required in the sub-functionality.

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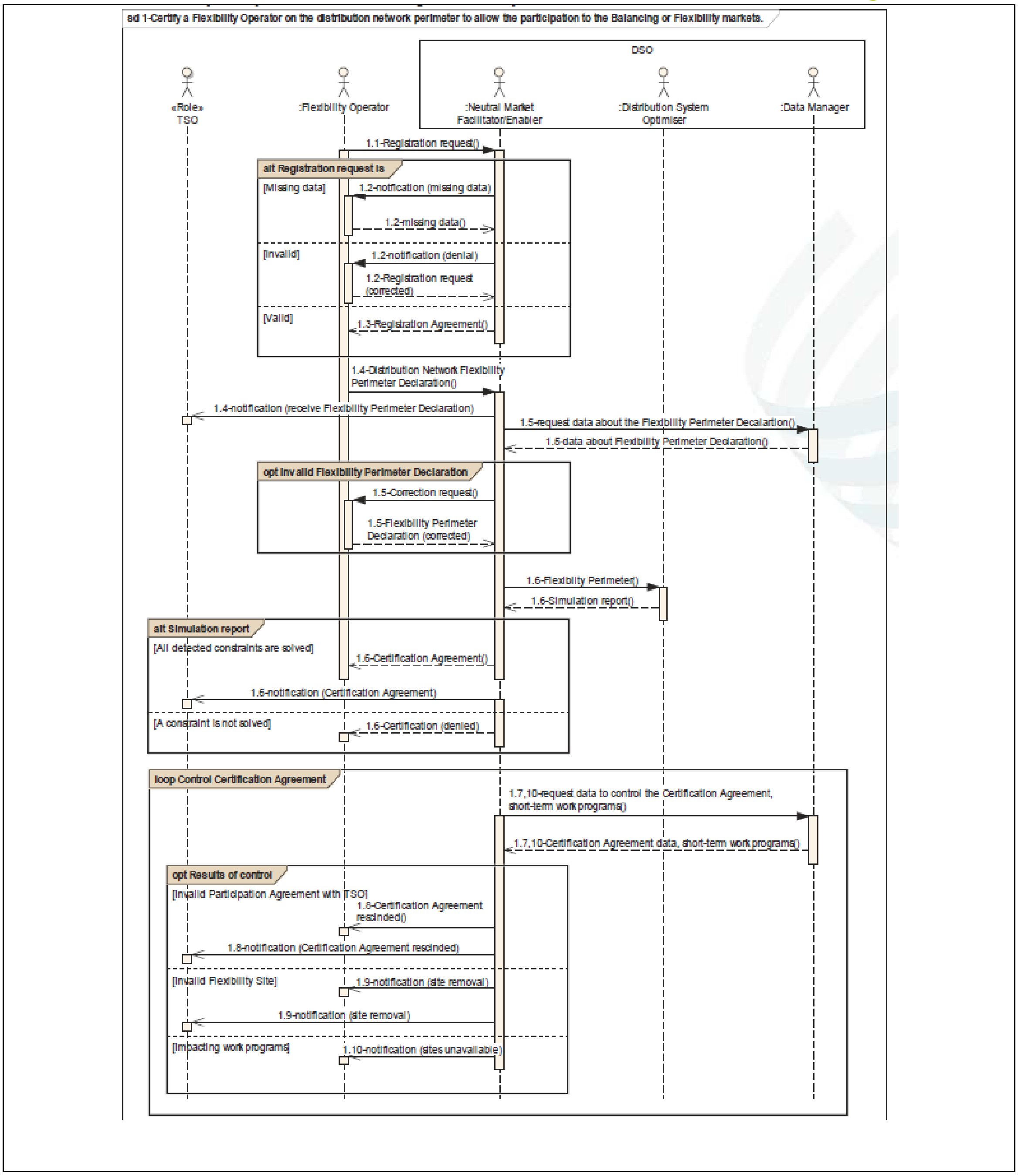

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3 Technical details

3.1 Actors

In this section 3.1, actors who are involved in the use case are listed and described. These can for instance include roles, systems, applications, databases, devices, etc.

Actors		
Actor Name	*Actor Type*	*Actor Description*

3.2 References

References (which are standards, reports, mandates and regulatory constraints) associated with the Use Case. The writers must identify the standards that should be used to realize the Use Case and improve the replicability of the solution.

Identify any legal issues that might affect the design and requirements of the function, including contracts, regulations, policies, financial considerations, engineering constraints, pollution constraints and other environmental quality issues.

References						
No.	*References Type*	*Reference*	*Status*	*Impact on use case*	*Originator / organisation*	*Link*
			The status of the referenced document.	e.g. copy right, IPR		

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4 Step by step analysis of use case

Template section 4 focuses on describing scenarios of the use case with a step-step analysis (sequence description). There should be a clear correlation between the narrative and these scenarios and steps.

4.1 Overview of scenarios

The table provides an overview of the different scenarios of the use case like normal and alternative scenarios which are described in section 4.2 of the template.

In general, the writer of the use case starts with the normal sequence (success). In case precondition or post-condition does not provide the expected output (e.g. no success = failure), alternative scenarios have to be defined.

Scenario conditions						
No.	Scenario name	Scenario description	Primary actor	Triggering event	Pre-condition	Post-condition
			Refers to the actor that triggers the scenario. For instance, a function called “Protection” would probably be triggered by an “Intelligent Electronic Device (IED)”.	Event that triggers the scenario. It can be a real event such as, “a fault occurs in the grid”, or it is also possible to define scenarios that occur periodically.	Describes the state of the system before the scenario starts.	Describes the expected state of the system after the scenario is realized.

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4.2 Steps – Scenarios

For this scenario, all the steps performed shall be described going from start to end using simple verbs like – get, put, cancel, subscribe etc. Steps shall be numbered sequentially – 1, 2, 3 and so on. Further steps can be added to the table, if needed (number of steps is not limited). Should the scenario require detailed descriptions of steps that are also used by other use cases, it should be considered creating a new "sub" use case, then referring to that "subroutine" in this scenario.

Scenario								
Scenario name :		*No. 1 - Reference scenario*						
Step No.	*Event*	*Name of process/ activity*	*Description of process/ activity*	*Service*	*Information producer (actor)*	*Information receiver (actor)*	*Information Exchanged (IDs)*	*Requirement, R-IDs*
	Event that triggers the activity. This triggering event can be an event, such as "a fault that occurs in the grid", or it may refer to an activity that occurs "periodically".	Label that would appear in a process diagram. Action verbs should be used when naming activity. EXAMPLE: "Fault occurs in the grid".	This describes what action takes place in this step. The focus should be less on the algorithms of the applications and more on the interactions and information flows between actors.	Identifies the nature of flow of information and the originator of the information (*).	Name of the actor that produces the information.	Name of the actor that receives the information.	Here the information can use a short ID referring to template section 5 for further details. Several information exchanged IDs can be listed, comma separated.	

(*) Available options are:

- CREATE means that an information object is to be created at the Producer.

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- GET (this is the default value if none is populated) means that the Receiver requests information from the Producer (default).
- CHANGE means that information is to be updated. Producer updates the Receiver's information.
- DELETE means that information is to be deleted. Producer deletes information from the Receiver.
- CANCEL, CLOSE imply actions related to processes, such as the closure of a work order or the cancellation of a control request.
- EXECUTE is used when a complex transaction is being conveyed using a service, which potentially contains more than one verb.
- REPORT is used to represent transferral of unsolicited information or asynchronous information flows. Producer provides information to the Receiver.
- TIMER is used to represent a waiting period. When using the TIMER service, the Information Producer and Information Receiver fields shall refer to the same actor.
- REPEAT is used to indicate that a series of steps is repeated until a condition or trigger event. The condition is specified as the text in the "Event" column for this row or step. Following the word REPEAT, shall appear, in parenthesis, the first and last step numbers of the series to be repeated in the following form REPEAT(X-Y) where X is the first step and Y is the last step.

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5 Information exchanged

These information objects are corresponding to the "Name of Information" of the "Information Exchanged" column referenced in the scenario steps in template section 4 "Step by Step Analysis". If appropriate, further requirements to the information objects can be added.

Information exchanged			
Information exchanged (ID)	*Name of information*	*Description of information exchanged*	*Requirement, R-IDs*
Refers to an identifier used in the field "Information Exchanged" of Table 4.2.	Is a unique ID which identifies the selected information in the context of the use case.	Brief description. In case of a reference to existing data models/information classes should be added. Using existing canonical data models is recommended.	Can be used to define requirements referring to the information and not to the step as in the step by step analysis (see template section 6 below): EXAMPLE: Data protection class corresponding to this information object.

6 Requirements

This table summarizes the requirements of all steps in the use case and it is linked to template section 4 "Step by Step Analysis".

Requirements		
Categories ID	Category name for requirements	Category description
Unique identifier for the category.	Name for the category of requirements.	Description of the requirement category.
Requirement R-ID	Requirement name	Requirement description
Unique identifier which identifies the requirement within its	A name for the requirement.	Description of the requirement (this might be populated automatically from the repository, if the requirement has already been described in the external document before).

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category and which can link the requirement to an external requirement document.		

7 Common Terms and Definitions

Should be defined in a common glossary for all use cases. Here relevant terms belonging to this use case are listed. Using a database repository for the glossary, the definitions might be filled automatically based on existing information.

Common Terms and Definitions	
Term	Definition

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